SAFETY INVESTIGATION REPORT

Malaysia Airlines Boeing B777-200ER (9M-MRO)
08 March 2014

By

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II. SYNOPSIS

On 08 March 2014, a scheduled passenger flight from Kuala Lumpur to Beijing, operated by Malaysia Airlines (MAS) and designated flight MH370, went missing soon after a routine handover from the Malaysian Air Traffic Control (ATC) to Viet Nam ATC. The aircraft operating the flight was a Boeing 777-200 ER, registered as 9M-MRO. On board the aircraft were 12 crew and 227 passengers (239 persons in total). A review of available radar and satellite communications indicated that the aircraft flew back across the Malaysian Peninsula and subsequently travelled to the southern Indian Ocean. Despite an extensive air and sea search, the location of the aircraft and occupants remains unknown. However, some debris have been recovered consistent with having drifted over nearly two years from the area in which impact is thought to have occurred.

By international convention, the investigation of aircraft accidents and incidents is conducted in accordance with Annex 13 to the Convention on International Civil Aviation, *Aircraft Accident and Incident Investigation.* The Standards and Recommended Practices (SARPs) in Annex 13 are applied in Malaysia through Part XII of the Malaysian Civil Aviation Regulations (MCAR) 1996.

In accordance with the MCAR 1996, an independent international investigation team (The Team) comprising 19 Malaysians and 7 Accredited Representatives (ARs) of 7 safety investigation authorities from 7 countries was established by the Malaysian Minister of Transport to investigate the disappearance of MH370. The ARs appointed are from the:

- Air Accidents Investigation Branch (AAIB) of United Kingdom
- Australian Transport Safety Bureau (ATSB) of Australia;
- Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (BEA) of France;
- Civil Aviation Administration of the People's Republic of China (CAAC);
- National Transportation Safety Board (NTSB) of United States of America;
- National Transportation Safety Committee (NTSC) of Indonesia; and
- Transport Safety Investigation Bureau (TSIB) of Singapore (formerly Air Accident Investigation Bureau [AAIB]).

Advisors to the ARs were appointed from the States' investigation agencies, as well as the aircraft, engine and satellite communications systems manufacturers.

While this investigation report documents the safety investigation aspects as noted above, the Team is aware of other investigations being undertaken for other purposes, including criminal investigations.

Investigation Organisation

The investigation was organised in accordance with the ICAO Manual of Accident Investigation and Incident Investigation (Doc. 9756-AN965) practices and comprised an Investigator-in-Charge (IIC) and three main Committees, comprising:

- Airworthiness;
- Flight Operations; and
- Medical/Human Factors.

Preliminary Report

On 09 April 2014, the Malaysian Ministry of Transport released the **Preliminary Report** into the investigation activities at that time. The Preliminary Report contained a Safety Recommendation to ICAO in regard to in-flight tracking of large commercial aircraft. A copy of the **Preliminary Report** is available on the Department of Civil Aviation website here:

- *http://www.dca.gov.my/wp-content/uploads/2015/02/Preliminary-Report1.pdf*

1st Interim Statement and Factual Information Report

On 08 March 2015, the Team released the **1st Interim Statement** and a **Factual Information Report** detailing the factual information available at that time. The report contained no analysis, findings/conclusions or safety recommendations. Copies of both the **Interim Statement** and the **Factual Information Report** are available from the Malaysian Ministry of Transport's two websites here:

- *http://mh370.mot.gov.my*
- *http://www.mh370.gov.my*

2nd Interim Statement

On 08 March 2016, the Team released the **2nd Interim Statement**.

3rd Interim Statement

On 08 March 2017, the Team released the ***3rd Interim Statement***.

4th Interim Statement

On 08 March 2018, the Team released the ***4th Interim Statement.***

Safety Investigation Report

This **Safety Investigation Report** (Report) builds on the previous ***Factual Information Report*** and extends the available information publicly released to include analysis, findings/conclusions and safety recommendations. Recognising that at the time of issue of this Report, the main aircraft wreckage, including the aircraft's Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) have not yet been located, this Report will necessarily be limited by a significant lack of evidence.

Based on the available evidence, the analysis of factors considered relevant to the disappearance of MH370 include:

- Diversion from Filed Flight Plan Route;
- Air Traffic Services Operations;
- Flight Crew Profile;
- Airworthiness & Maintenance and Aircraft Systems;
- Satellite Communications;
- Wreckage and Impact Information;
- Organisation and Management Information of DCA and MAS; and
- Aircraft Cargo Consignment.

Other factors examined by the investigation and not considered relevant include the aircraft weight and balance, the amount and quality of fuel on-board and meteorological conditions.

Significant Issues and Safety Recommendations

In the analysis of the above factors, several significant issues were identified that could affect the safety of international commercial aviation, including the lack of effectiveness of certified Emergency Locator Transmitters (ELT) if a large commercial aircraft ditches or crashes into the ocean.

While this issue is currently being addressed by ICAO and the international aviation industry, the Team is of the view that work needs to be expedited in this area to implement effective changes to enhance aviation safety into the future.

Additionally, a number of issues were identified that could affect the monitoring and timely initiation of search and rescue of commercial aircraft in Malaysian airspace by the Air Navigation Services provider. Issues were also identified in the Airline Operations. They include the following:

- Malaysian and adjacent air traffic management;
- Cargo screening;
- Flight crew medical and training records;
- Reporting and following-up of crew mental health;
- Flight following system;
- Quick reference for operations control; and
- Emergency locator transmitter effectiveness.

As a result of the issues identified in the investigation and in accordance with para. 6.8 of Annex 13 which states that: "*At any stage of the investigation of an accident or incident, the accident investigation authority of the State conducting the investigation shall recommend in a dated transmittal correspondence to the appropriate authorities, including those in other States, any preventive action that it considers necessary to be taken promptly to enhance aviation safety",* a number of safety recommendations (*Section 4 - Safety Recommendations),* have been made to the Department of Civil Aviation (DCA), Civil Aviation Authority of Viet Nam, Malaysian Airlines Berhad (MAB, formerly MAS), the Malaysia Airports Holdings Berhad (MAHB) and the International Civil Aviation Organization (ICAO) to enhance aviation safety.

III. DEDICATION

This report is dedicated to the memory of the 239 passengers and crew missing on MH370 (9M-MRO) on 08 March 2014. They will be forever missed by their families, friends and colleagues, but never forgotten.

IV. ACKNOWLEDGEMENT

The Malaysian ICAO Annex 13 Safety Investigation Team for MH370 would like to acknowledge the work carried out by the Search Strategy Group in the analysis of the satellite data and the search teams involved in the search for MH370. The search was unprecedented in its scale and their dedication was a remarkable effort.

We trust that MH370 will be located to provide answers to the families of the passengers and crew of MH370 and bring closure to this event.

V. OBJECTIVE

The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

Annex 13, Section 3.1 page 3-1

VI. DISCLAIMER

This **Safety Investigation Report** contains facts which have been determined up to the time of issue and is published to inform the aviation industry and the public of the safety investigation and the safety issues raised thus far. Therefore, the report may be subject to alteration or correction if additional and credible evidence becomes available.

Extracts can be published without specific permission providing that the source is duly acknowledged.

VII. GLOSSARY OF TERMS

When the following terms are used, they have the following meaning:

Accident

An occurrence associated with the operation of an aircraft which, in the case of a manned aircraft, takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, or in the case of an unmanned aircraft, takes place between the time the aircraft is ready to move with the purpose of flight until such time as it comes to rest at the end of the flight and the primary propulsion system is shut down, in which:

a) a person is fatally or seriously injured as a result of:

- being in the aircraft, or
- direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or
- direct exposure to jet blast,

Except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; or

b) the aircraft sustains damage or structural failure which:

- adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component,

  except for engine failure or damage, when the damage is limited to a single engine (including its cowlings or accessories), to propellers, wing tips, antennas, probes, vanes, tires, brakes, wheels, fairings, panels, landing gear doors, windscreens, the aircraft skin (such as small dents or puncture holes), or for minor damages to main rotor blades, tail rotor blades, landing gear, and those resulting from hail or bird strike (including holes in the radome); or

c) The aircraft is missing or is completely inaccessible.

Note 1 - For statistical uniformity only, an injury resulting in death within thirty days of the date of the accident is classified, by ICAO, as a fatal injury.

Note 2 - An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

cont...

Note 3 - The type of unmanned aircraft system to be investigated is addressed in Annex 13, para 5.1.

Note 4 - Guidance for the determination of aircraft damage can be found in Annex 13, Attachment E.

Accredited Representative

A person designated by a State, on the basis of his or her qualifications, for the purpose of participating in an investigation conducted by another State. Where the State has been established an accident investigation authority, the designated accredited representative would normally be from that authority.

Advisor

A person appointed by a State, on the basis of his or her qualifications, for the purpose of assisting its accredited representative in an investigation.

Aeronautical fixed telecommunication network (AFTN)

A worldwide system of aeronautical fixed circuit provided, as part of the aeronautical fixed service, for the exchange of messages and/or digital data between aeronautical fixed stations having the same or compatible communications characteristics.

Air-ground communication

Two-way communication between aircraft and stations or locations on the surface of the earth.

Aircraft

Any machine that can give derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

Alert Phase

A situation wherein apprehension exists as to the safety of an aircraft and its occupants.

Alerting Post

Any facility intended to serve as an intermediary between a person reporting an emergency and a rescue co-ordination centre or rescue sub-centre.

cont...

Blind Transmission

A transmission from one station to another station in circumstances where two-way communication cannot be established but where it is believed that the called station is able to receive the transmission.

Cabin Crew Member

A crew member who performs, in the interest of safety passengers, duties assigned by the operator or the pilot-in-command of the aircraft, but who shall not act as a flight crew member.

Cargo

Any property carried on an aircraft other than mail, stores and accompanied or mishandled baggage.

Causes

Actions, omissions, events, conditioning, or a combination of thereof, which led to the accident or incident. The identification of causes does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

Co-ordinated Universal Time (UTC)

International term for time at the prime meridian.

Conversion Training

Training required when a pilot is posted to a different aircraft type or model

DETRESFA

The code word used to designate a distress phase

Distress Phase

A situation wherein there is reasonable certainty than an aircraft and its occupants are threatened by grave and imminent danger or require immediate assistance.

Emergency Phase

A generic term meaning, as the case may be, uncertainty phase, alert phase or distress phase

cont...

Filed Flight Plan

The flight plan as filed with an ATS unit by the pilot or a designated representative, without any subsequent changes.

Flight Plan

Specified information provided to air traffic units, relative to an intended flight or portion of a flight of an aircraft.

Flight Recorder

Any type of recorder installed in the aircraft for the purpose of complementing accident/incident investigation - *Annex 6, Parts I, II and III, for specifications relating to flight recorders.*

Incident

An occurrence, other than an accident, associated with the operation of an aircraft which affects or could affect the safety of operation.

Note: *The types of incidents which are of main interest to the International Civil Aviation Organization for accident prevention studies are listed in Accident/Incident Reporting Manual (Doc. 9156).*

Investigation

A process conducted for the purpose of accident prevention which includes the gathering and analysis of information, the drawing of conclusions, including the determination of causes and/or contributing factors and, when appropriate, the making of safety recommendations.

Investigator-in-Charge

A person charged, on the basis of his or her qualifications, with the responsibility for the organisation, conduct and control of an investigation

Note - *Nothing in the above definition is intended to preclude the functions of an investigator-in-charge being assigned to a commission or other body.*

Knot (kt)

A unit of speed equal to one nautical mile per hour.

cont...

NOTAM

A notice distributed by means of telecommunication containing information concerning the establishment, condition of change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to personnel concerned with flight operations.

Operator

A person, organization or enterprise engaged in or offering to engage in an aircraft operation.

Pilot-in-Command

The pilot responsible for the operation and the safety of the aircraft during flight time.

Safety Recommendation

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies. *(Annex 13, Chapter 1, page 1-3).*

State of Design

The State having jurisdiction over the organization responsible for the type design.

State of Manufacture

The State having jurisdiction over the organization responsible for the final assembly of the aircraft.

State of Occurrence

The State in the territory of which an accident or incident occurs.

State of the Operator

The State in which the operator's principal place of business is located or, if there is no such place of business, the operator's permanent residence.

cont...

State of Registry

The State on whose register the aircraft is entered.

Note: *In the case of the registration of aircraft of an international operating agency on other than a national basis, the States constituting the agency are jointly and severally bound to assume the obligations which, under the Chicago Convention, attach to a State of Registry. See, in this regard, the Council Resolution of 14 December 1967 on Nationality and Registration of Aircraft Operated by International Operating Agencies which can be found in Policy and Guidance Material on the Economic Regulation of International Air Transport (Doc 9587).*

State Safety Programme (SSP)

An integrated set of regulations and activities aimed at improving safety.

Uncertainty Phase

A situation wherein doubt exists as to the safety of an aircraft or marine vessel, and of the persons on board.

VIII. ABBREVIATIONS & CODES

A

A300	Airbus 300
A/P	Autopilot
A-SAR	Aeronautical Search and Rescue
A/T	Autothrottle
AAIB	Air Accidents Investigation Branch (United Kingdom)
AC	Alternating Current
ACARS	Aircraft Communications Addressing and Reporting System
ACC	Area Control Centre
ACD	Airways Clearance Delivery
ACE	Actuator Control Electronic
ACIPS	Airfoil Cowl Ice Protection System
ACMP	Alternating Current Motor Pump
ACMS	Aircraft Condition Monitoring System
ACP	Audio Control Panel
AD	Airworthiness Directive
ADF	Automatic Direction Finder
ADFR	Automatic Deployable Flight Recorder
ADI	Attitude Director Indicator
ADIRS	Air Data Inertial Reference System
ADIRU	Air Data Inertial Reference Unit
ADM	Airworthiness Departmental Manual
ADP	Air Driven Pump
ADS-B	Automatic Dependent Surveillance-Broadcast
ADS-C	Automatic Dependent Surveillance-Contract
AED	Airworthiness Engineering Division
AEG	Airline Engineering Group
AES	Airborne Earth Station
AFD	Assistant Flight Data
AFDC	Autopilot Flight Director Computer
AFDS	Autopilot Flight Director System
AFS	Aeronautical Fixed Service
AFTN	Aeronautical Fixed Telecommunication Network
AIC	Aeronautical Information Circular
AID	Airworthiness Inspection Division
AIMS	Airplane Information Management System
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service

A ***(cont…)***

A (cont...)

ALERFA	Alert Phase
ADF	Automatic Direction Finder
ALR	Alerting
ALT	Altitude
AM	Amplitude Modification
AMC	Acceptable Means of Compliance
AMEL	Aircraft Maintenance Engineer's Licence
AMO	Approved Maintenance Organisation
AMU	Audio Management Unit
AN	Aircraft Number; Airworthiness Notice
ANS	Air Navigation Services
AOA	Angle of Attack
AOC	Air Operator Certificate
AOR	Area of Responsibility
APP	Approach
APU	Auxiliary Power Unit
APUC	Auxiliary Power Unit Controller
AR	Accredited Representative/s
AR	Approach Radar
ARCC	Aeronautical Rescue Coordination Centre
ARSC	Aeronautical Rescue Sub-Centre
ARINC	Aeronautical Incorporated
ASB	Amanah Saham Bumiputra (A People's Trust Council of the Malaysian Government)
ASDI	Aircraft Situation Display Information
ASL	Air Service Licence
ASN	Amanah Saham Nasional (a Government-back National Trust Fund)
ASR	Air Safety Report
ASCPC	Air Supply Cabin Pressure Controller
ATC	Air Traffic Control
ATC	Air Traffic Controller/s
ATC-ATO	Air Traffic Control - Approved Training Organisation
ATCC	Air Traffic Control Centre
ATCO	Air Traffic Control Officer
ATD	Actual Time of Departure
ATI	Air Traffic Inspectorate
ATIS	Automatic Terminal Information Broadcast
ATM	Air Traffic Management
ATSB	Australian Transport Safety Bureau
ATN	Aeronautical Telecommunication Network
ATO	Approved Training Organisation

A *(cont).*

A *(cont...)*

ATPL	Air Transport Pilot Licence
ATS	Air Traffic Services
ATSC	Air Traffic Services Centre
ATSU	Air Traffic Service Unit
ATTN	Attenuator
AUTO	Automatic
AVBL	Available
AWL	Airworthiness Limitation
AWY	Airway

B

BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (France)
BER	Bit Error Rate
BEW	Basic Empty Weight
BFO	Burst Frequency Offset
BKK	IATA Airport Designator for Suvarnahbumi International Airport
BITE	Built In Test Equipment
BOI	Board of Inquiry
BSCU	Brake System Control Unit
BSU	Beam Steering Unit
BTO	Burst Timing Offset

C

C	Degree Celsius (Centigrade)
C of A	Certificate of Airworthiness
C of G	Centre of Gravity
C of R	Certificate of Registration
CA	Collective Agreement
CAA	Civil Aviation Act
CAAC	Civil Aviation Authority of the Republic of China
CAAS	Civil Aviation Authority Singapore
CAM	Cockpit Area Microphone
CAR 1996	Civil Aviation Regulations 1996

A *(cont...)*

A *(cont...)*

CAR 2016	Civil Aviation Regulations 2016
CAS	Calibrated Airspeed
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Requirements
CAT	Clear Air Turbulence
CB	Circuit Breaker
CCD	Cursor Control Device
CCTV	Closed Circuit Television
CDS	Central Deposit System
CDU	Control Display Unit
CEO	Chief Executive Officer
CHIRPS	Confidential Human Factors Accident Incident Reporting System
CLB	Climb
Cm	Centimetre
CMCS	Central Maintenance Computing System
CMR	Certificate Maintenance Requirement
CMS	Central Maintenance System
COSPAS	Space System for Search of Vessels in Distress
CPA	Crew Performance Appraiser
CPDLC	Controller Pilot Data Link Communications
CPL	Commercial Pilot Licence
CPM	Core Processor Module
CPMU	Cabin Passenger Management Unit
CRM	Crew Resource Management
CRZ	Cruise
CSR	Cabin Safety Report
CTR	Control Zone
CTRL	Control
CTU	Cabin Telecommunications Unit
CVR	Cockpit Voice Recorder
CX	C Extended
CWP	Controller Working Position

D

DARD	Direct Access Radar Data
dB	decibel

A (cont...)

A (cont...)

DC	Direct Current
DCGF	Data Conversion Gateway Function
DCMF	Data Communication Management Function
DCMS	Data Communication Management System
Deg	Degree
DEOR	Daily Engineering Operations Report
DES	Descent
DETRESFA	Distress Phase
DFDAF	Digital Flight Data Acquisition Function
DFDAU	Digital Flight Data Acquisition Unit
DG	Dangerous Goods
DGCA	Director General of Civil Aviation
DGTA	General Delegate of Armament Aeronautical Technique
DIP	Diplexer
DLNA	Diplexer Low Noise Amplifier
DME	Distance Measuring Equipment
DOW	Dry Operating Weight
DTG	Date-Time-Group

E

EASA	European Aviation Safety Agency
ECL	Electronic Checklist
EDIU	Engine Data Interface Unit
EDP	Engine Driven Pump
EEC	Electronic Engine Control
EFIS	Electronic Flight Instrument System
EFS	Electronic Flight Strips
EHM	Engine Health Monitoring
EICAS	Engine Indicating and Crew Alerting System

E (cont...)

ELMS	Electrical Load Management System

E *(cont…)*

ELP	English Language Proficiency
ELT	Emergency Locator Transmitter
EMD	Engineering & Maintenance Department
EMS	Engineering Maintenance System
ENR	En-route
EOL	End-of-Lease
EEZ	Exclusive Economic Zone
EPF	Employees Provident Fund
EPR	Engine Pressure Ratio
EQIS	Fuel Quantity Indicating System
EST	Estimate
ETA	Estimated Time of Arrival
ETOPS	Extended Twin Engine Operations
EXT	External

F

FAA	Federal Aviation Administration
FANS 1/A	Future Air Navigation System 1/A
FAR	Federal Aviation Regulations
FDEVSS	Flight Deck Entry Video Surveillance System
FDP	Flight Data Processing/Flight Duty Period
FDR	Flight Data Recorder
FFS	Flight-Following System
FPL	Filed Flight Plan (*message type designator – used in AFS message)*
FIR	Flight Information Region
FIS	Flight Information Service
FL	Flight Level
FMC	Flight Management Computer
FLCH	Flight Level Change
FMCF	Flight Management Control Function
FMCS	Flight Management Control System
FMS	Flight Management System
FO	Flight Officer

F *(cont…)*

F (cont…)

FOQA	Flight Operations Quality Assurance
FOS	Flight Operations Sector
FOSI	Flight Operations Surveillance Inspector
FPA	Flight Path Angle
FSCU	Flap Slat Control Unit
FSEU	Flap Slat Electronic Unit
FPS	Flight Progress Strip
FS	Flight Steward
FSS	Flight Stewardess
ft	Feet (*dimensional unit*)
FTL	Flight Time Limitation

G

G/S	Glide Slope
GA	Go Around
GADSS	Global Aeronautical Distress and Safety System
GCC	Golden Class Club
GEN	Generator
GES	Ground Earth Station
GHz	Giga Hertz
GM	Guidance Material
GMT	Greenwich Mean Time
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GSP	Ground Service Provider
GSR	Ground Safety Report
GWT	Gross Weight

H

hPa	Hectopascal
HPA	High Power Attenuator
HCM	IATA Airport Designator for Ho Chi Minh International Airport
HDG	Heading
HF	High Frequency
HF/AMSS	High Frequency Aeronautical Mobile Service Station
HGA	High Gain Antenna
HLCS	High Lift Control System
HPA	High Power Amplifier
HR	Hours
HYDIM	Hydraulic Interface Module
Hz	Hertz
HZR	Hazard Report

I

i.u.	Index unit
IAMSAR	International Aeronautical and Maritime Search and Rescue
IMARSAT	International Mobile Satellite Organisation
IAS	Indicated Airspeed
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation
ID	Identification
IDG	Integrated Drive Generator
IFE	In-flight Entertainment
IFS	In-flight Supervisor
IGV	Inlet Guide Vane
ILS	Instrument Landing System
IMO	International Maritime Organisation
In.	Inches
INCERFA	Uncertainty Phase
IOM	Input/output Module
IOR	Indian Oceanic Region
IRP	Incident Review Panel
IRP	Integrated Refuel Panel
ISLN	Isolation

J

JATCC	Joint Air Traffic Control Centre

K

KHz	Kilo Hertz
KLIA	KL International Airport
kg	Kilogram
KPI	Key Performance Indicator
kt	Knot
km^2	Kilometer square
KVA	Kilo Volt Ampere

L

LAME	Licenced Aircraft Maintenance Engineer
LAT	Latitude
lb	Pound
LDW	Landing Weight
LFA	Langkawi Flying Academy
LGA	Low Gain Antenna
LH	Left Hand
LLAR	Lower Lobe Attendant Rest
LNA	Low Noise Amplifier
LNAV	Lateral Navigation
LOA	Letters of Agreement
LOC	Localiser
LONG	Longitude

L (cont...)

LOPA	Lay Out of Passenger Accommodation
LOSA	Line Operations Safety Audit
LRM	Line Replaceable Module
LRU	Line Replaceable Unit
LS	Leading Steward
LSS	Leading Stewardess
LR	Lumpur Radar
LT	Lumpur Tower

M

M	Metre
MAB	Malaysia Airlines Berhad (formerly MAS)
MAC	Mean Aerodynamic Chord
MAHB	Malaysia Airports Holdings Berhad
MAL	Malaysia Airways Limited
MARA	Majlis Amanah Rakyat (An agency of the Malaysian Government)
MAS	Malaysia Airlines (now Malaysia Airlines Berhad [MAB])
MASEU	Malaysia Airlines Employees Union
MATS	Manual of Air Traffic Services
MCC	Maintenance Control Centre
MCDU	Multi-purpose/function Control Display Unit
MCE	Malaysian Certificate of Education
MCP	Mode Control Panel
MEC	Main Equipment Centre
MEL	Minimum Equipment List
MET	Meteorological or meteorology
METAR	Aerodrome routine meteorological report
MFA	Malaysian Flying Academy
MFD	Multi-Function Display
MGSCU	Main Gear Steering Control Unit
MHz	Megahertz
Min	Minute

M *(cont.)*

M (cont.)

MMEA	Malaysian Maritime Enforcement Agency
MMOE	Maintenance Management Organisation Exposition
MNPS	Minimum Navigation Performance Specification
MOC	MAS Operations Centre
MOR	Mandatory Occurrence Report
MOU	Memorandum of Understanding
MPD	Maintenance Planning Document
MR1	Maintenance Report 1
MR2	Maintenance Report 2
MRB	Maintenance Review Board
MRO	Maintenance Repair and Overhaul
MRCC	Maritime Rescue Coordination Centre
MRSC	Maritime Rescue Sub-Centre
ms	meter per second
MSA	Malaysia-Singapore Airlines
MSRR	Maritime Search and Rescue Region
MTSAT	Multifunctional Transport Satellites of Japan Meteorological Agency (JMA)
MU	Management Unit
MYT	Malaysia Time

N

NCR	Non Compliance Record
ND	Navigation Display
NDB	Non-directional Beacon
NDT	Non Destructive Testing
nm	Nautical Mile
NOTAM	Notice to Airmen
NOTOC	Notice to Crew
NSC	National Security Council
NTC	Notes to Crew
NTSB	National Transportation Safety Board (United States of America)
NTSC	National Transportation Safety Committee (Indonesia)

O

OCC	Operations Control Centre
OCXO	Oven Controlled Crystal Oscillator
ODA	Organization Designation Authorisation
OPR	Operator
OPS	Operations
OOOI	Out, Off, On, In

P

P/N	Part Number
PAN-ATM	Procedures for Air Navigation Services - Air Traffic Management
PASS	Passenger(s)
PBN	Performance-based Navigation
PCU	Power Control Units
PDS	Primary Display System
PDU	Power Drive Unit
PFC	Primary Flight Computer
PFCS	Primary Flight Control System
PFD	Primary Flight Display
PIC	Pilot in Command
PLN	Flight Plan
PMG	Permanent Magnet Generator
POA	Production Organisation Approval
POB	Person on Board
POR	Pacific Oceanic Region
ppm	parts per million
PSA	Power Supply Assembly
PSEU	Proximity Switch Electronic Unit
psi	Pounds per square inch
PSR	Primary Surveillance Radar
PSU	Passenger Service Unit
PTT	Push to Talk
PWR	Power
PWS	Predictive Windshear

Q

QA	Quality Assurance
Q & A	Questions and Answers
QAE	Quality Assurance Engineer

R

RAT	Ram Air Turbine
RCC	Rescue Coordination Centre
RDP	Radar Data Plot
REF	Reference
RF	Radio Frequency
RF ATTN	Radio Frequency Attenuator
RFS	Radio Frequency Splitter
RFU	Radio Frequency U nit
RH	Right Hand
RHP	Radar Data Head Processor
rms	Root Mean Square
R n R	Rest and Recreation
RTP	Radio Tuning Panel
RVSM	Reduced Vertical Separation Minima
RQS	Request Supplementary Flight Plan
RADAR	Radio Detection and Ranging
RSC	Rescue Sub-Centre
RMAF	Royal Malaysia Air Force
RNAV	Area Navigation
RTP	Radio Tuning Panel
RVSM	Reduced Vertical Separation Minima
RWY	Runway

S

SAP	Safety Awareness Programme
SAR	Search and Rescue
SAREX	Search and Rescue Exercise
SARPs	Standard and Recommended Practices
SARSAT	Search and Rescue Satellite-Added Tracking
SAT	Static Air Temperature
SATCOM	Satellite Communications
SC	SAR Coordinator
SCP	Safety Change Process
SCSC	South China Sea Corridor
SDU	Satellite Data Unit
SEA 1	South East Asia 1
SEA 2	South East Asia 2
SEL	Select
SELCAL	Selective Calling System
SEP	Safety Engineering Procedures
SIGMET	Significant meteorological information
SIGWX	Significant weather chart
SMC	Search and Rescue Mission Coordinator
SME	Site Maintenance Engineer
SOC	Statement of Compliance
SOI	Supplementary Operations Instructions
SOP	Standard Operating Procedures
SPD	Speed
SR	Safety Recommendations
SRB	Safety Review Boards
SRR	Search and Rescue Region
SSM	Sign Status Matrix
SSP	State Safety Programme
SSR	Secondary Surveillance Radar
STC	Supplemental Type Certificate
STRIDE	Science & Technology Research Institute for Defence
SZB	Subang Airport

T

T	Tonne
TAC	Thrust Augmentation Computer
TAT	Total Air Temperature
TCAS	Traffic Collision Avoidance System
TCP	Transfer of Control Point
THDG	True Heading
TMA	Terminal Control Area
TMCF	Thrust Management Computing Function
THR	Thrust
THR REF	Thrust Reference
TMCF	Thrust Management Control Function
TO	Take-off
TOTFW	Total Remaining Fuel Weight
TRE	Type Rating Examiner
TRI	Type Rating Instructor
TRK	Track
TRTO	Type Rating Training Organization
TRU	Transformer Rectifier Unit
TSIB	Transport Safety Investigation Bureau of Singapore (formerly Air Accident Investigation Bureau [AAIB])
TSO	Technical Standard Order

U

UA	Unstabilized Approach
UAI	Unit Administrative Instruction
UHF	Ultra High Frequency
ULB	Underwater Locator Beacon
ULD	Unit Load Device
USB	Upper Side Band
UTC	Coordinated Universal Time

V

V	Volt
V/S	Vertical Speed
VAAC	Volcanic Ash Advisory Centre
VDL	VHF Digital Link
VHF	Very High Frequency
VNAV	Vertical Navigation
VOR	VHF Omni Directional Radio Range

W

W	Watt
WAFC	World Area Forecast Centre
WHCU	Window Heat Control Unit
WINDIR	Wind Direction
WINDSP	Wind Speed
WMKC	ICAO 4-letter location indicator for Kota Bharu Airport
WMKK	ICAO 4-letter location indicator for KL International Airport WMKN
WMKN	ICAO 4-letter location indicator for Kuala Terengganu Airport
WMKP	ICAO 4-letter location indicator for Penang International Airport
WS	Watch Supervisor
WSSS	ICAO 4-letter location indicator for Changi International Airport Singapore
WWW	Worldwide web
WXR	Weather (Meteorological messages)
WX	Weather

X - Y - Z

ZBAA	ICAO 4-letter location indicator of Peking-Capital International Airport
ZFW	Zero Fuel Weight
Z	Coordinated Universal Time (*in meteorological messages)*

IX. THE MALAYSIAN ICAO ANNEX 13 SAFETY INVESTIGATION TEAM FOR MH370 (9M-MRO)

- **The Malaysian Members**

Dato' Ir. Kok Soo Chon	Investigator-in-Charge
Capt. Abdul Wahab Ibrahim	Senior Investigator/ Chairman of Operations Committee
Mr. Mohan Suppiah	Senior Investigator/ Chairman of Airworthiness Committee
Datuk Dr. Mohd Shah Mahmood	Senior Investigator/ Chairman of Medical/Human Factors Committee
Assoc. Prof. Ir. Abu Hanifah Hj Abdullah	Investigator, Airworthiness
Mr. Amirudin Ab Ghani	Investigator, Airworthiness
Mr. Aslam Basha Khan	Investigator, Airworthiness
Dato' Capt. Jalil Mat Dom	Investigator, Operations
Mr. Khaw Sim Min	Investigator, Operations
Ms. Khoo Lay See	Investigator, Medical/Human Factors
Mr. Lim Kim Seang	Investigator, Operations
Dato' SAC Mohd Rafique Ramli Ariffin	Investigator, Operations
Mr. Muhammad Imran Ismail	Investigator, Operations
Ms. Norwalena Abdul Wahab	Investigator, Operations
Prof. Dr. Pathmanathan Rajadurai	Investigator, Medical/Human Factors
Dato' Dr. Suarn Singh A/L Jasmit Singh	Investigator, Medical/Human Factors
Ms. Swandra Kim Chu Ramachandran	Investigator, Operations (from January 2018)
Mr. Tan Huvi Vein	Investigator, Operations
Dr. Toh Chin Lee	Investigator, Medical/Human Factors
Capt. Abdul Razak Hashim	Investigator, Operations (April 2014 - April 2015)

- **The Accredited Representatives**

Air Accidents Investigation Branch (AAIB)	United Kingdom
Australian Transport Safety Bureau (ATSB)	Australia
Bureau d'Enquêtes et d'Analyses pour la sécurité d l'aviation civile (BEA)	France
Civil Aviation Administration of the People's Republic of China	China
National Transportation Safety Board (NTSB)	United States of America
National Transportation Safety Committee (NTSC)	Indonesia
Transport Safety Investigation Bureau (TSIB) (*formerly Air Accident Investigation Bureau [AAIB])*	Singapore

SECTION 1 – FACTUAL INFORMATION

1.1 HISTORY OF THE FLIGHT

1.1.1 Introduction

On 07 March 2014 at 1642 UTC[1] [0042 MYT, 08 March 2014], Malaysia Airlines (MAS) Flight MH370 Beijing-bound international scheduled passenger flight departed from Runway 32 Right, KL International Airport (KLIA) with a total of 239 persons on board (227 passengers and 12 crew). The aircraft was a Boeing 777-200ER, registered as 9M-MRO.

The Pilot-in-Command (PIC) signed in for duty at 1450 UTC [2250 MYT], 07 March 2014 followed by the First Officer (FO) who signed in 25 minutes later. The MAS Operations Despatch Centre (ODC) released the flight at around 1515 UTC [2315 MYT].

The PIC, an authorised examiner for the Department of Civil Aviation (DCA), Malaysia, was conducting the last phase of line training for the FO, who was transitioning to the Boeing 777 (B777) aircraft type from the Airbus A330. As the FO was certified functional during his last line training flight, no additional pilot was required as safety pilot on MH370. It has been established that the PIC had assigned the FO to be the Pilot Flying for this flight.

The PIC ordered 49,100 kilograms (kg) of fuel for the flight that gave an endurance of 07 hours and 31 minutes including reserves (as per computerised flight plan). The planned flight duration was 05 hours and 34 minutes.

The recorded radio transmissions between the Air Traffic Controllers at Kuala Lumpur Area Control Centre (KL ACC) and the FO showed that an airways clearance request to Lumpur Airways Clearance Delivery was made at 1625:52 UTC [0025:52 MYT] and a pushback and start clearance request to Lumpur Ground was made at 1627:37 UTC [0027:37 MYT].

Note:

In accordance with the Standard Operating Procedures (SOP) of MAS, radio

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[1] Unless specified, all times in this report are in Coordinated Universal Time (UTC). The Malaysian Time (MYT) is UTC+08 hours.

communication on the ground is the responsibility of the FO. In the air, the role is reversed when the assigned pilot flying is the FO.

Lumpur Tower cleared MH370 for take-off at 1640:37 UTC [0040:37 MYT]. At 1642:53 UTC [0042:53 MYT] Lumpur Departure cleared MH370 to climb to Flight Level (FL) 180 (the aviation term for 18,000 feet [ft.]) and to cancel the Standard Instrument Departure (SID) clearance by tracking direct to waypoint[2] IGARI.

At 1643:31 UTC [0043:31 MYT], KL ACC Sector 3 Planner coordinated with Ho Chi Minh (Viet Nam) Area Control Centre (HCM ACC) on the Direct Speech Circuit (direct telephone line) relaying the estimated time of arrival (ETA) of MH370 for waypoint IGARI as 1722 UTC [0122 MYT] and the assigned Secondary Surveillance Radar (SSR) transponder code A2157.

MH370 was transferred to Lumpur Radar at 1646:39 UTC [0046:39 MYT].

At 1646:58 UTC [0046:58 MYT], MH370 was cleared to climb to FL250 and subsequently to FL350 at 1650:08 UTC [0050:08 MYT]. MH370 reported maintaining FL350 at 1701:17 UTC [0101:17 MYT] and reported maintaining FL350 again at 1707:56 UTC [0107:56 MYT].

At 1719:26 UTC [0119:26 MYT], MH370 was instructed to contact HCM ACC on the radio frequency 120.9 MHz.

At 1719:30 UTC [0119:30 MYT], MH370 acknowledged with "*Good night Malaysian Three Seven Zero*". This was the last recorded radio transmission from MH370.

Radar recording showed that MH370 passed through waypoint IGARI at 1720:31 UTC [0120:31 MYT].

Based on the reconstruction of the flight profile conducted on the B777 simulator, the flight would be at waypoint IGARI one minute earlier than the original ETA of 1722 UTC [0122 MYT].

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[2] Waypoint - A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Waypoints are identified as either:

- *Fly-by waypoint - A waypoint which requires turn anticipation to allow tangential interception of the next segment of a route or procedure, or*
- *Flyover waypoint - A waypoint at which a turn is initiated in order to join the next segment of a route or procedure.*

The Mode S symbol of MH370 dropped off from radar display at 1720:36 UTC [0120:36 MYT], and the last secondary radar position symbol of MH370 was recorded at 1721:13 UTC [0121:13 MYT].

The disappearance of the radar position symbol of MH370 was captured by the KL ACC radar at 1721:13 UTC [0121:13 MYT]. The Malaysian military radar and radar sources from two other countries, namely Viet Nam and Thailand, also captured the disappearance of the radar position symbol of MH370. The Bangkok radar target drop occurred at 1721:13 UTC [0121:13 MYT] and Viet Nam's at 1720:59 UTC [0120:59 MYT].

The last Aircraft Communication Addressing and Reporting System (ACARS) (refer to *Section 1.9.4 - ACARS*) transmission was made through the aircraft's satellite communication system at 1707:29 UTC [0107:29 MYT].

Figure 1.1A (below) shows the *Chronological Sequence of Events of the Disappearance of MH370 (in pictorial form and not to scale)*

1.1.2 Actions by HCM ACC and KL ACC

At 1739:06 UTC [0139:06 MYT] HCM ACC queried KL ACC on the whereabouts of MH370. KL ACC contacted MAS ODC to check on the whereabouts of MH370.

HCM ACC had also contacted Hong Kong (China) ACC and Phnom Penh (Cambodia) ACC in an attempt to establish the location of MH370. However, no contact had been established by any of the ATC units.

Kuala Lumpur Aeronautical Rescue Coordination Centre (KL ARCC) was activated at 2130 UTC [0530 MYT]. There is no evidence to show HCM ACC activated its Rescue Coordination Centre.

1.1.3 Diversion from Filed Flight Plan Route

1) Malaysian Military Radar

The Military radar data provided more extensive details of what was termed as "Air Turn Back". It became very apparent, however, that the recorded altitude and speed change "blip" to "blip" were well beyond the capability of the aircraft. It was highlighted to the Team that the altitude and speed extracted from the data are subjected to inherent error. The only useful information obtained from the Military radar was the latitude and longitude position of the aircraft as this data is reasonably accurate.

At 1721:13 UTC [0121:13 MYT] the Military radar showed the radar return of MH370 turning right but shortly after, making a constant left turn to heading of 273°, flying parallel to Airway M765 to VKB (Kota Bharu).

Between 1724:57 UTC [0124; 57 MYT] to 1737:35 UTC [0137:35 MYT] the "blip" (a spot of light on a radar screen indicating the position of a detected aircraft) made heading changes that varied between 8° and 20°, and a ground speed that varied from 451 kt to 529 kt. The Military data also recorded a significant height variation from 31,150 to 39,116 ft.

The Military data further identified the "blip" on a heading of 239° at 1737:59 UTC [0137:59 MYT] parallel to Airway B219 towards VPG (VOR Penang). Heading of this "blip" varied from 239° to 255° at a speed from 532 to 571 kt. The height of this "blip" was recorded between 24,450 ft and 47,500 ft.

At 1752:31 UTC [0152:31 MYT] the "blip" was observed to be at 10 nm south of Penang Island on a heading of 261°, speed of 525 kt and at a height of 44,700 ft.

At 1801:59 UTC [0201:59 MYT] the data showed the "blip" on a heading of 022°, speed of 492 kt and altitude at 4,800 ft. This is supported by the "blip" detected by Military radar in the area of Pulau Perak at altitude 4,800 ft at 1801:59 UTC [0201:59 MYT]. At 1803:09 UTC [0203:09 MYT] the "blip" disappeared, only to reappear at 1815:25 UTC [0215:25 MYT] until 1822:12 UTC [0222:12 MYT], about 195 nm from Butterworth, on a heading of 285°, speed of 516 kt and at an altitude of 29,500 ft.

9	At 1721:13 UTC [0121:13 MYT], 3.2 nm after passing IGARI, the radar position symbol of MH370 dropped off
8	MH370 Mode S symbol dropped off at 1720:36 UTC [0120:36 MYT]
7	MH370 over waypoint IGARI at 1720:31 UTC [0120:31 MYT]
6	At 1719:26 UTC [0119:26 MYT], 8.6 nm to waypoint IGARI, KL ACC instructed MH370 to contact HCM ACC MH370 acknowledged with '*Good night Malaysian Three Seven Zero*' at 1719:30 UTC [0119:30 MYT]
5	MH370 maintaining FL350 at 1701:17 UTC [0101:17 MYT] MH370 reported again maintaining FL350 at 1707:56 UTC [0107:56 MYT]
4	MH370 climbing to FL350 at 1650:11 UTC [0050:11 MYT]
3	MH370 climbing to FL250 at 1647:03 UTC [0047:03 MYT]
2	MH370 climbing to FL180 at 1643:01 UTC [0043:01 MYT]
1	Lumpur Tower cleared for take-off at 1640:37 UTC [0040:37 MYT] and MH370 departed at 1642 UTC [0042 MYT]

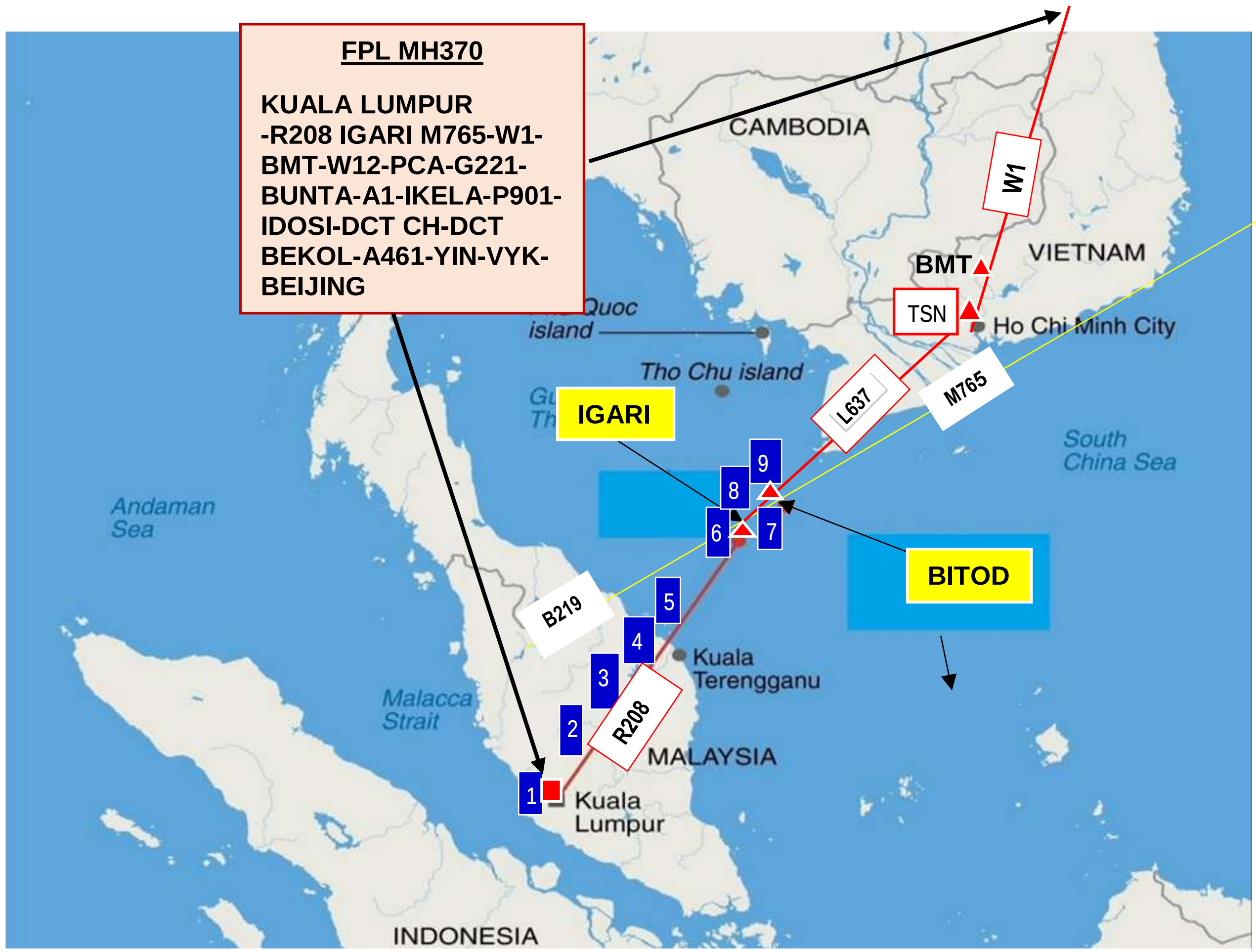


Figure 1.1A - Chronological Sequence of Events of Disappearance of MH370 (in pictorial form and not to scale)

Figure 1.1A – Chronological Sequence of Events of Disappearance of MH370 (in pictorial form and not to scale)

The tracking by the Military continued as the "blip" was observed to be heading towards waypoint MEKAR on Airway N571 when it finally disappeared at 1822:12 UTC [0222:12 MYT], 10 nm after waypoint MEKAR.

On the day of the disappearance of MH370, the Military radar system recognised the 'blip' that appeared west after the left turn over IGARI was that of MH370. Even with the loss of SSR data, the Military long range air defence radar with Primary Surveillance Radar (PSR) capabilities affirmed that it was MH370 based on its track behaviour, characteristics and constant/continuous track pattern/trend. Therefore, the Military did not pursue to intercept the aircraft since it was 'friendly' and did not pose any threat to national airspace security, integrity and sovereignty.

Based on the Malaysian Military data, a reconstruction of the profile was conducted on a Boeing 777 simulator. *Figure 1.1B* (below) in chart form shows the *Profile Chart of Data from Malaysian Military Radar.* Some of the speed and height variations were not achievable even after repeated simulator sessions.

It was also noted that, in the absence of autopilot or continuous manual control, an aircraft is very unlikely to maintain straight and level flight. Further, it is extremely unlikely for an aircraft to enter and maintain a turn and then return to straight and level flight for any significant period of time.

2) DCA Civilian Radar Data from Kota Bharu - Sultan Ismail Petra Airport Runway

The aircraft diversion from the filed flight plan route was recorded on the DCA radar playback:

a) From 1730:37 UTC [0130:37 MYT] to 1744:52 UTC [0144:52 MYT] a primary aircraft target was captured by the Terminal Primary Approach Radar located to the south of the Kota Bharu – Sultan Ismail Petra Airport runway.

b) The appearance of an aircraft target on the KL ACC radar display, coded as P3362, was recorded at 1730:37 UTC [0130:37 MYT] but the aircraft target disappeared from the radar display at 1737:22 UTC [0137:22 MYT].

c) At 1738:56 UTC [0138:56 MYT] an aircraft target, coded as P3401, appeared on the KL ACC radar display and disappeared at 1744:52 UTC [0144:52 MYT].

d) At 1747:02 UTC [0147:02 MYT] an aircraft target, coded as P3415, appeared on the KL ACC radar display but disappeared at 1748:39 UTC [0148:39 MYT], which appeared to be the continuity of the same target.

e) At 1751:45 UTC [0151:45 MYT] an aircraft target, coded as P3426, appeared on the KL ACC radar display but disappeared at 1752:35 UTC [0152:35 MYT].

Figure 1.1C (below) shows *Diversion from Filed Flight Plan Route (in pictorial form and not to scale).*

It has been confirmed by DCA and its radar maintenance contractor, Advanced Air Traffic Systems (M) Sdn. Bhd. (AAT), that it was the 60 nm Terminal Primary Approach Radar, co-mounted with 200 nm monopulse SSR[3] located to the south of Kota Bharu - Sultan Ismail Petra Airport runway, which captured the above-mentioned primary aircraft targets.

[3] *SSR (Secondary Surveillance Radar) - A surveillance radar system which uses transmitters/receivers system (interrogators) and transponders*.

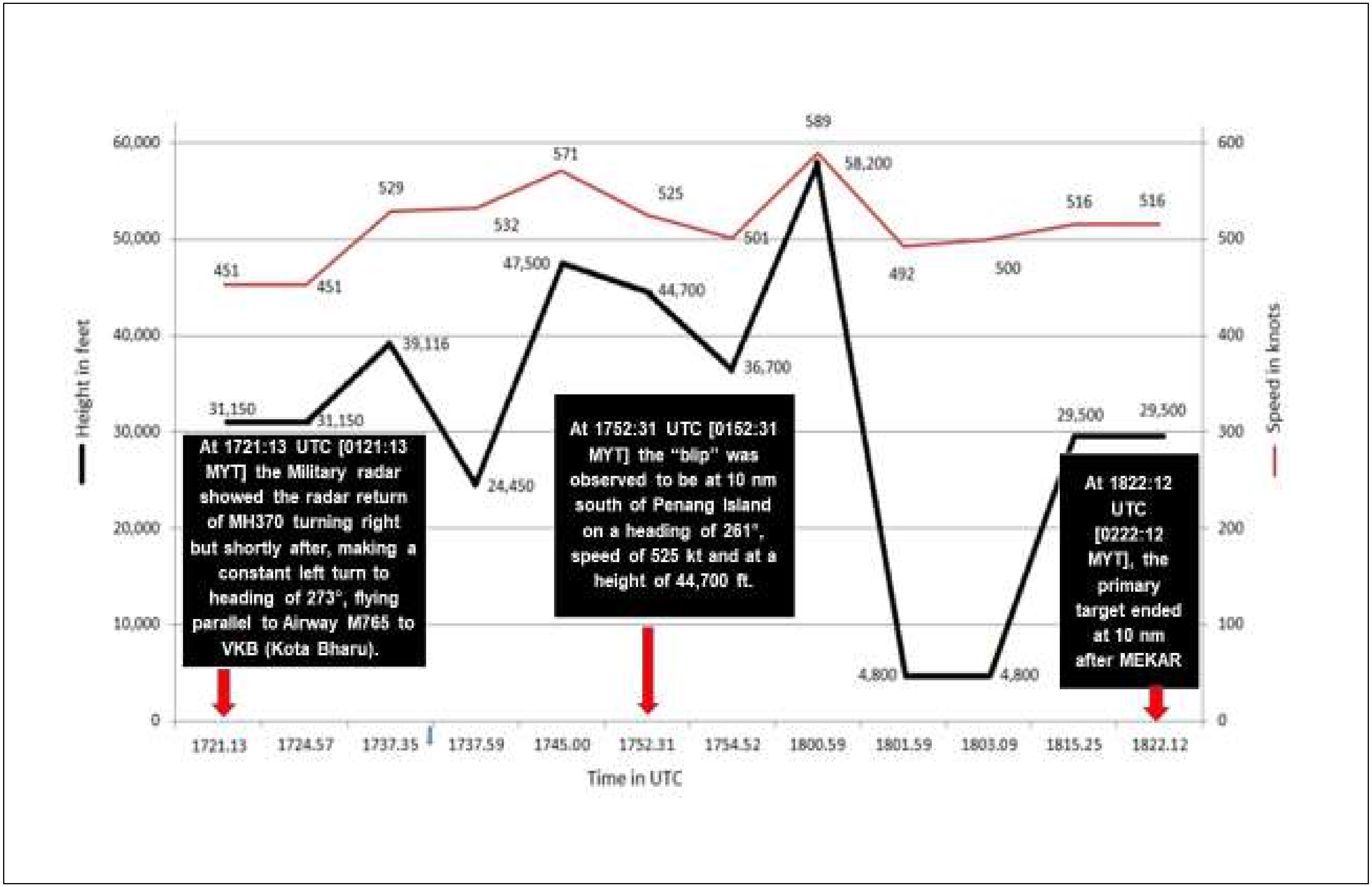


Figure 1.1B - Profile Chart of Data from Malaysian Military Radar (not to scale).

1	P3362: Appeared at 1730:37 UTC [0130:37 MYT]
2	P3362: Coasted at 1737:12 UTC [0137:12 MYT] Dropped at 1737:22 UTC [0137:22 MYT]
3	P3401: Appeared at 1738:56 UTC [0138:56 MYT]
4	P3401: Coasted at 1744:42 UTC [0144:42 MYT] Dropped at 1744:52 UTC [0144:52 MYT]
5	P3415: Appeared at 1747:02 UTC [0147:02 MYT]
6	P3415: Coasted at 1748:29 UTC [0148:29 MYT] Dropped at 1748:39 UTC [0148:39 MYT]
7	P3426: Appeared at 1751:45 UTC [0151:45 MYT]
8	P3426: Coasted at 1752:25 UTC [0152:25 MYT] Dropped at 1752:35 UTC [0152:35 MYT] P3426 last seen on radar display Approximately 6 nm south of Penang
9	The primary target (military radar) appeared to track west-northwest direction joining RNAV Route N571 at waypoint VAMPI thence to 10 nm north MEKAR *Source: RMAF*
10	The primary target ended at 10 nm after MEKAR at 1822:12 UTC [0222:12 MYT] *Source: RMAF*

(red dashed line)	Filed Flight Plan Route
(dotted line)	Diversion route
(red)	Radar target appearance
(blue)	Radar target coasted/dropped off

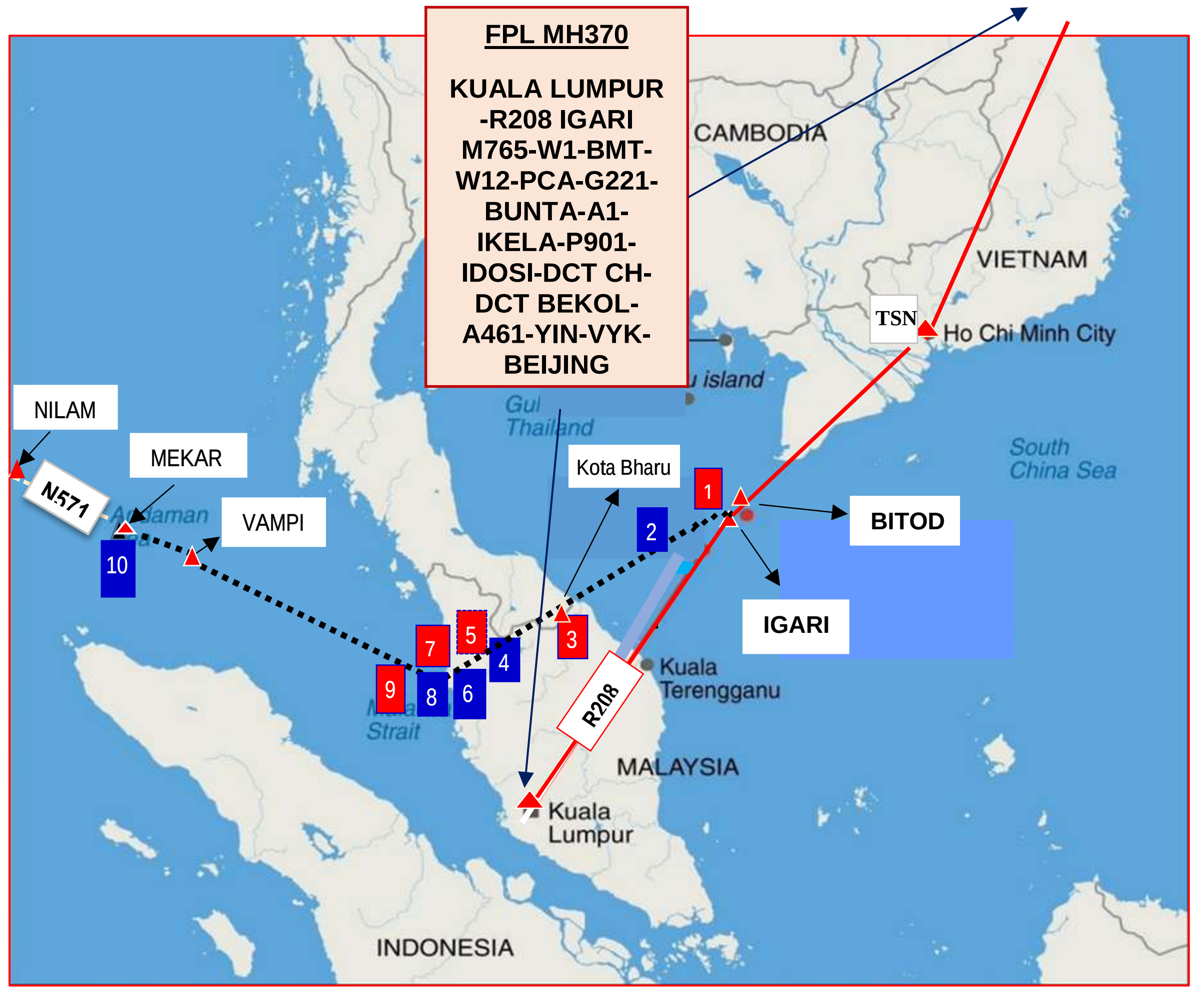


Figure 1.1C - Diversion from Filed Flight Plan Route - Civilian Radar (in pictorial form and not to scale)

Figure 1.1D (below) shows the suitable airports for emergency en-route diversion.

Figure 1.1D - Airports for Emergency Landing along the Flightpath of MH370 (chart not to scale)

Figure 1.1E (below) shows the *Filed Flight Plan message of MH370*.

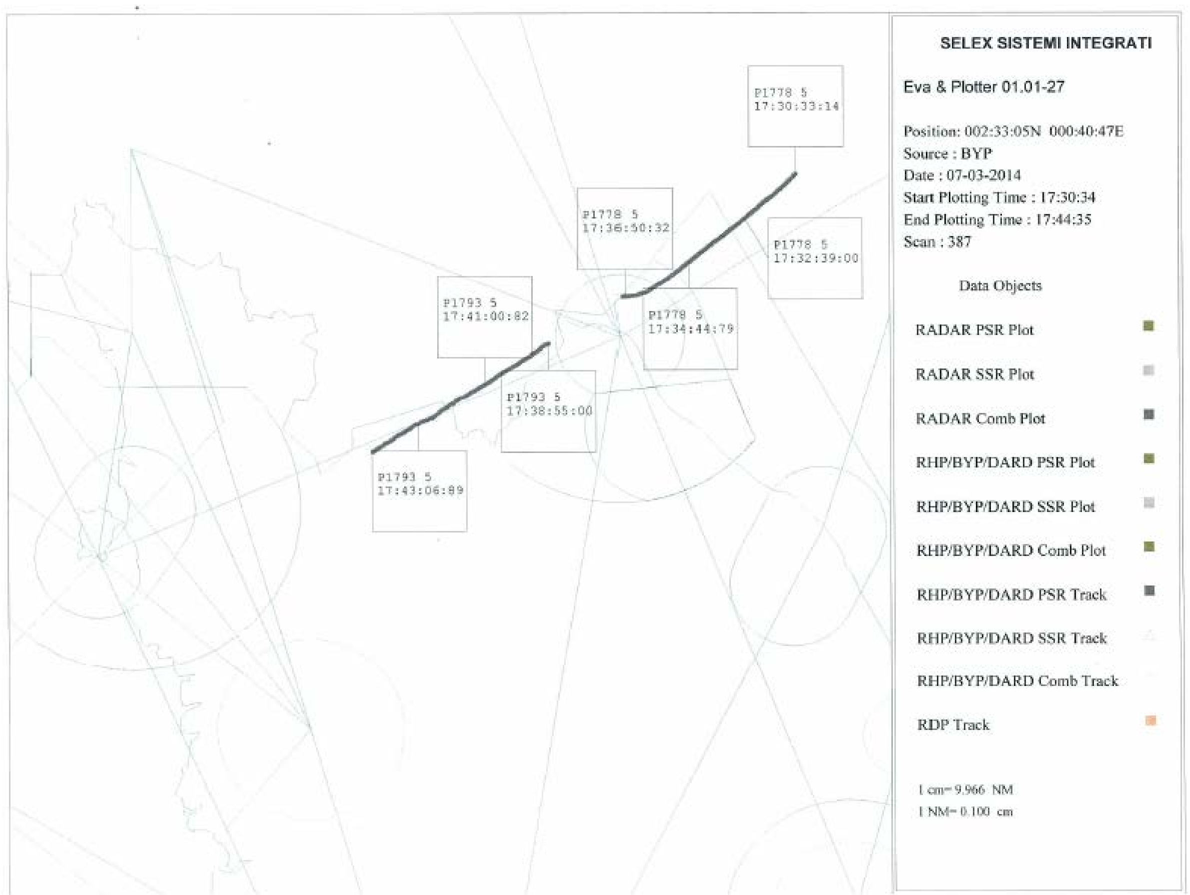
```
KLA297 070444
FF WMKKZQZX WMKKZRZX
070441 WMKKYOYX
(FPL-MAS370-IS
-B772/H-SDFGHIJ3J5M1RWXY/LB1D1
-WMKK1635
-N0470F290 DCT PIBOS R208 IKUKO/M081F330 R208 IGARI M765
 BITOD/N0480F330 L637 TSN/N0480F350 W1 BMT W12 PCA G221
 BUNTA/N0480F370 A1 IKELA/N0480F370 P901 IDOSI/N0480F390 DCT CH
 DCT BEKOL/K0900S1160 A461 YIN/K0890S1130 A461 VYK
-ZBAA0534 ZBTJ ZBSJ
-PBN/A1B1C1D1L1O1S2 DOF/140307 REG/9MMRO EET/WSJC0032 VVTS0042

ZJSA0210 VHHK0233 ZGZU0304 ZHWH0356 ZPE0450 SEL/QRC RMK/ACASII
EQUIPPED)
```

Source: DCA Malaysia

Figure 1.1E - Filed Flight Plan message of MH370.

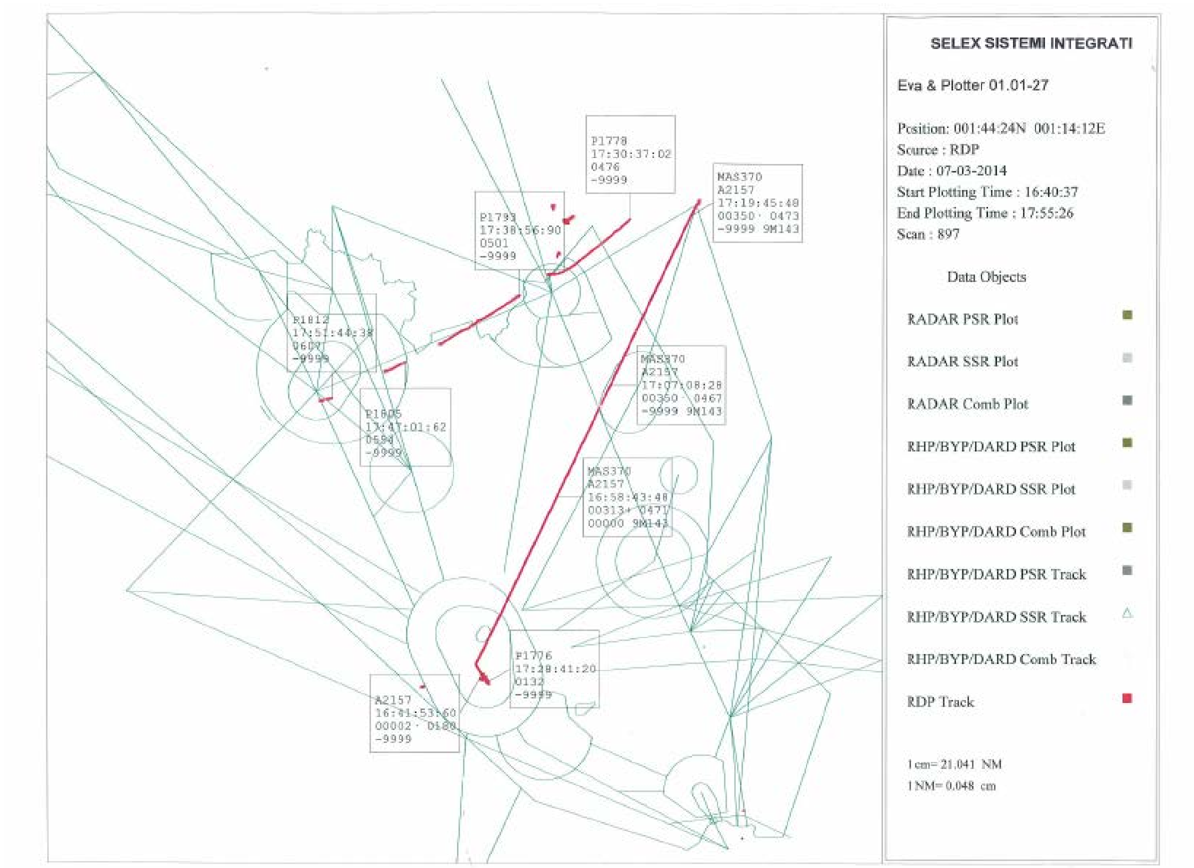
Figure 1.1F (below) shows Radar Data Plots (RDP) Tracks from the 60 nm Terminal Primary Approach Radar co-mounted with 200 nm monopulse SSR located to the south of Kota Bharu - Sultan Ismail Petra Airport runway after Diversion and *Figure 1.1G* (below) shows RDP Tracks from Kuala Lumpur after take-off.

All the primary aircraft targets that were recorded by the DCA radar are consistent with those of the military data that were made available to the Investigation Team.



Source: Advanced Air Traffic Systems (M) Sdn. Bhd. (AAT)

Figure 1.1F - Radar Data Plots (RDP) Tracks from the 60 nm Terminal Primary Approach Radar co-mounted with 200 nm monopulse SSR located to the south of Kota Bharu - Sultan Ismail Petra Airport runway after Diversion.



Source: Advanced Air Traffic Systems (M) Sdn. Bhd. (AAT)

Figure 1.1G - Radar Data Plots (RDP) Tracks from Kuala Lumpur after take-off

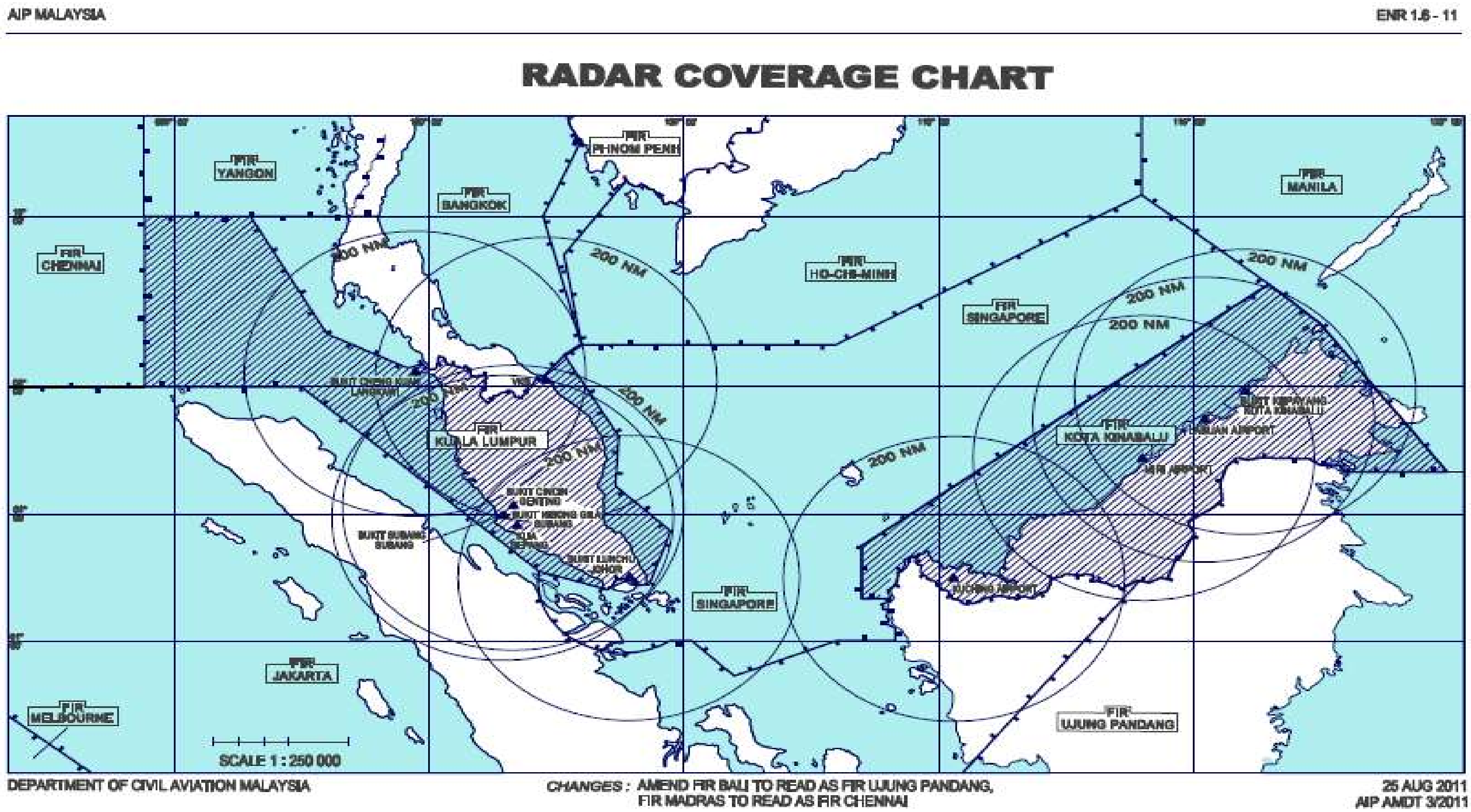
Reference:

The Malaysia Aeronautical Information Publication [AIP] ENR 1.6 dated 05 June 2008, AIP AMDT 2/2008 on the Provision of Radar Services and Procedures states that, in paragraph 1.1.4:

"*In the Kuala Lumpur and Kota Kinabalu FIRs, radar services are provided using the following civil/military ATC Radars:*

g) A 60 nm Terminal Primary Approach Radar co-mounted with 200 nm monopulse SSR located to the south of Kota Bharu - Sultan Ismail Petra Airport runway.".

Figure 1.1H (below) shows the Radar Coverage Chart of Kuala Lumpur and Kota Kinabalu FIRs.



Source: DCA Malaysia

Figure 1.1H - Radar Coverage Chart of Kuala Lumpur and Kota Kinabalu Flight Information Regions

3) Ho Chi Minh Air Traffic Services

The tracking of MH370 was captured by HCM ACC Secondary Radar at Tan Son Nhut and at Camau Province, and Automatic Dependent Surveillance- Broadcast (ADS-B) located at Conson Island/range 270 nm) at 1711:59 UTC [0111:59 MYT] as it was heading for waypoint IGARI.

At 1720:59 UTC [0120:45 MYT] the “blip” from MH370 from both SSR and ADS-B radar position symbols disappeared from the radar display.

A visit was made to the office of the Vietnamese Civil Aviation Authority (CAAV) in Ho Chi Minh City on 10 September 2014. In interviews, the Duty HCM Duty ACC Controller who was handling MH370 on that night could not explain why he did not initiate any call to MH370 within the standard 5 minutes as specified in the Letter of Agreement (LOA) between Department of Civil Aviation Malaysia and Viet Nam Air Traffic Management dated 07 July 2001 and effective on 01 November 2001 (Refer *Appendix 1.1A - Letter of Agreement between DCA Malaysia and Viet Nam*). It was noted that he had only initiated an enquiry on the whereabouts of MH370 at 1739:03 UTC [0139:03 MYT] after a lapse of 12 minutes.

The Duty Controller however had stated that he had initiated calls to other aircraft on the existing frequency and on the emergency frequency of 121.5 MHz. This was neither supported nor collaborated by any documents.

The landline recorded transcripts between KL ACC and HCM ACC suggested that there were confusions on the position of MH370. This was evident when HCM ACC requested KL ACC for information on MH370 at 1739:06 UTC [0139:06 MYT]. This conversation took place:

KL ACC: *“MH370 already transferred to you rite?”*

HCM ACC: *“Yeah…yeah…I know at time two zero but we have no just about in contact up to BITOD…we have radar lost with him…the one we have to track identified via radar*.”

When pointed out that neither HCM ACC SSR nor ADS-B showed any presence of a “blip” of MH370, the Duty Controller could not explain why he mentioned BITOD.

MH370 was operating within the Singapore FIR, in that portion of the airspace which has been delegated to Malaysia (Refer to *Figure 2.2K - Singapore Airspace delegated to Malaysia)* for the provision of air traffic services when the last air-ground radio contact was made at 1719 UTC [0119 MYT]. As such, KL ACC should be responsible for the alerting service which would mean that KL ACC would have to declare the Distress Phase at 1827 UTC [0227 MYT] when HCM ACC informed that there had been no two-way radio communications with MH37O.

The *DETRESFA* was only declared at 2232 UTC [0632 MYT]. Refer to para. 2.2.7 Table 2.2C, No. 26-28 - Chronology of ATC Events following the Disappearance of MH370; and to para. 2.2.8 1) o) - Activation of Aeronautical Rescue Coordination Centre, for details.

<u>Reference</u>:

Manual of Air Traffic Services, Part 9 - Emergencies, para. 9-6-5, Para, 6.7.2 dated 15/3/2009 states:

> *If alerting service is required for an aircraft that is flight planned to operate through more than one FIR including the airspace delegate to the Kuala Lumpur and Kota Kinabalu ATSCs and the position of the aircraft is in doubt, the responsibility for co-ordinating such service shall normally rest with the ATSC of the respective FIRs:*
>
> - *within which the aircraft was flying at the time of last air-ground radio contact;*
> - *that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;*
> - *within which the aircraft's intermediate stop or final destination point is located:*
>
>   *1) if the aircraft was not equipped with suitable two-way radio communication, or*
>
>   *2) was not under obligations to transmit position reports.*

and

ICAO Doc 4444 ATM/501 Procedures for Air Navigation - Air Traffic Management (PANS-ATM), page 9-6, para 9.2.2.2, dated 22/11/07 states*:*

> *When alerting services is required in respect of a flight operated through more than one FIR or control area, and when the position of the aircraft is in doubt, responsibility for coordinating such service*

shall rest with the ATS unit of the FIR or control area within which the aircraft was flying at the time of last air-ground radio contact:

a) that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;

b) within which the aircraft's intermediate stop or final destination point is located:

1) if the aircraft was not equipped with suitable two-way radio communication, or

2) was not under obligations to transmit position reports.

Based on interviews, HCM ACC had stated that it did not initiate any emergency actions as it did not receive any change of the transfer of control time of IGARI, MH370 did not contact the Centre at the stated time, and it was unable to establish radio communication with MH370.

MH370 was also operating in the airspace delegated to KL ACC and the last air-ground radio contact was with KL ACC. Hence the provision of alerting service for MH370 rests with KL ACC.

These uncertainties were further compounded by the Duty Despatcher, based on MAS Flight Following System (FFS), who mentioned that the aircraft was over the Cambodian airspace when in fact the filed flight plan routing did not include flying over the Cambodian airspace.

Added to these confusions, for reasons best known to him, the MAS Captain from the Technical and Development Department, Flight Operations spoke to KL ACC saying that the aircraft did not leave the Malaysian airspace. When interviewed, the Captain insisted that he was asking a question rather than making a statement. This conversation was recorded at 0521.23 MYT:

KL ACC: *"…had never leave Lumpur airspace?"*

MAS Captain: *"…yea he has not left Lumpur airspace because he has failed to call Ho Chi Minh."*

4) Kuala Lumpur ACC Radar

KL ACC Radar captured the disappearance of MH370 at 1721:13 UTC [0121:13 MYT]. In interviews with the Duty KL ACC Radar Controller, he stated that he did not notice the "blip" disappearance as MH370 was out of radar coverage and would be in contact with HCM ACC after the transfer of responsibility was effected.

From 1730:37 UTC [0130:37 MYT] to 1752:35 UTC [0152:35 MYT], what appeared to be MH370 was captured on KL ACC primary radar, coded as P3362, P3401, P1415, P3415 and P3426 (P signifies Primary Radar). *Figure 1.1C - Diversion from Filed Flight Plan Route.*

The appearance of a “blip” coded as P3362 was recorded at 1730:37 UTC [0130:37 MYT)] but disappeared abruptly at 1737:22 UTC [0137:22 MYT].

At 1738:56 UTC [0138:56 MYT], a “blip” identified as P3401 was tracked by KL ACC but disappeared at 1744:52 UTC [0144:52 MYT].

Shortly after, another “blip” coded as P3451 appeared at 1747.02 UTC [0147:02 MYT] but disappeared at 1748:39 UTC [0148:39 MYT].

At 1751:45 UTC [0151:45 MYT], a “blip” coded as P3426 appeared south of Penang Island but disappeared at 1752:35 UTC [0152:35 MYT].

5) Medan Air Traffic Control Radar

The Medan ATC Radar has a range of 240 nm, but for unknown reasons, did not pick up any radar return bearing the SSR transponder code A2157 of MH370.

The Indonesian Military however stated that they picked up MH370 earlier as it was heading towards waypoint IGARI.

No other information was made available.

6) Bangkok Air Traffic Control Radar

The radar position symbol with SSR transponder code A2157 was detected on the Aeronautical Radio of Thailand Limited (AEROTHAI) radar display at 1711 UTC [0111 MYT] as the aircraft was tracking for waypoint IGARI.

Thailand DCA is a government agency whereas AEROTHAI is a state enterprise under the Ministry of Transport and Communications. AEROTHAI is the air navigation service provider responsible for the provision of Air Traffic Services within the Bangkok Flight Information Region (FIR).

As the flight plan of MH370 did not fall under the purview of Thailand's FIR, Bangkok ACC did not pay attention to this flight. On playback of the radar recording it was noted that the radar position symbol of A2157 disappeared at 1721:13 UTC [0121:13 MYT].

7) Singapore Air Traffic Services

The Team visited Singapore to conduct interviews with officers from Civil Aviation Authority of Singapore (CAAS) and the Air Traffic Controllers on duty on 07 March 2014. The following were noted:

i) Singapore ACC did not have radar coverage over the South China Sea. (*ADS and CPDLC services are available to suitably equipped aircraft operating outside radar cover over the South China Sea …);*

Reference:

AIP Singapore page 94 GEN 3.4-2, 10 MAR 11, para 3.2.2 d.

ii) At 2104:00 UTC [0504:00 MYT], Singapore ACC received a call from Hong Kong ACC enquiring any knowledge of a missing Malaysian aircraft MH370. Hong Kong ACC then requested assistance from Singapore ACC to contact Lumpur ACC for detailed information. It was evident that Singapore ACC was not aware of the problem until this call was received. Hong Kong ACC however had the knowledge of the missing Aircraft earlier after receiving unconfirmed information from HCM ACC;

iii) At 2109:13 UTC [0509:13 MYT], Singapore ACC contacted Lumpur ACC to relay the query from Hong Kong ACC.

Reference

Radiotelephony transcripts between Sin*gapore ACC and KL ACC Sector 3+5 Planner - Appendix 1.18G* on *Direct Line Coordination Communication,* pages 109 to 114*.*

1.1.4 Role of Malaysian Military

On the day of the disappearance of MH370, the Military radar system recognised the 'blip' that appeared west after the left turn over IGARI was that of MH370. Even with the loss of SSR data, the Military long range air defence radar with Primary Surveillance Radar (PSR) capabilities affirmed that it was MH370 based on its track behaviour, characteristics and constant/

continuous track pattern/trend. Therefore, the Military did not pursue to intercept the aircraft since it was 'friendly' and did not pose any threat to national airspace security, integrity and sovereignty.

1.1.5 Detection of Hand Phone Signal

A Telco service provider in an interview with the RMP confirmed a signal "hit" occurred at 0152:27 MYT on 08 March 2014, coming from the mobile phone tower (LBS Location Base station) at Bandar Baru Farlim Penang. The signal "hit" however did not record any communication except to confirm that it was in the ON mode signal related to the "hit". The phone number *xxxxxxx* was later traced to that registered under the FO. This was supported by the RMP's report.

To ascertain the probability of making calls inside an aircraft from different altitudes, a reconstructed flight using a King Air 350 over the said area and during the same time when the signal "hit" happened was carried out shortly after the disappearance of MH370. The flight was conducted from an altitude of 24,000 ft with step descents every 4,000 ft until 8,000 ft. The next descent was to 5,000 ft but at 1,000 ft interval. An expert from a Telco service provider conducted the test using three different brands of phone and related equipment that were carried on board the King Air 350. Test call will be automatically answered by the server in the event of connectivity.

In summary, during the tests, it was found that it was difficult to maintain successful call connectivity above 8,000 ft. However, one brand of phone was able to make a call at 20,000 ft. Only one cell phone service provider recorded the highest call attempts using their 3G network above 8,000 ft. Two service providers could only provide connection below 8,000 ft.

The Telco service provider expert cautioned the Team that the tests would be difficult to conclude and use as scientific/theoretical assumptions for the case of MH370, as the measurement results were only valid for that specific time, flight path, speed, altitude, devices used, and environment during the tests.

1.1.6 Search for Aircraft

Extensive work done by the MH370 Search Strategy Group, coordinated by the Australian Transport Safety Bureau (ATSB), by analysing signals transmitted by the aircraft's satellite communications terminal to Inmarsat's Indian Ocean Region satellite indicated that the aircraft continued to fly for

several hours after loss of contact. The analysis showed the aircraft changed course shortly after it passed the northern tip of Sumatra (Indonesia) and travelled in a southerly direction until it ran out of fuel in the southern Indian Ocean west of Australia. Details of this work can be found in the ATSB's report: AE-2014-054 dated 26 June 2014, and in subsequent updates, available at ATSB's website:
http://www.atsb.gov.au/publications/investigation_reports/2014/aair/ae-2014-054/

On 03 October 2017, the ATSB published a report detailing the history of the search and made conclusions and recommendations relating to the search activities. This is contained in the report titled "***The Operational Search for MH370".*** The report and relevant attachments are available at ATSB's website:
https://www.atsb.gov.au/newsroom/news-items/2017/chapter-closes-on-mh370/

The search for Malaysia Airlines flight MH370 commenced on 8 March 2014 and continued for 1,046 days until 17 January 2017 when it was suspended in accordance with a decision made by the Governments of Malaysia, Australia and the People's Republic of China. This involved surface searches in the South China Sea, Straits of Malacca and the southern Indian Ocean. The 52 days of the surface search involving aircraft and surface vessels covered an area of several million square kilometres. A sub surface search for the aircraft's underwater locator beacons was also conducted during the surface search. The underwater search started with a bathymetry survey which mapped a total of 710,000 square kilometres of Indian Ocean seafloor and continued with a high-resolution sonar search which covered an area in excess of 120,000 square kilometres. The last search vessel left the underwater search area on 17 January 2017 without locating the missing aircraft. Although combined scientific studies continued to refine areas of probability, there was no new information at that date to determine the specific location of the aircraft.

On 10 January 2018, the Malaysian Government entered into an agreement with the US company, Ocean Infinity, to conduct a 90-day underwater search in an area that was considered the most likely location for the wreckage. This search which commenced in the identified search area on 22 January 2018 was completed on 29 May 2018 without locating the missing aircraft. The search utilising the most advance underwater search technology currently available covered an area in excess of 112,000 square kilometres.

Details on the whole search effort for the aircraft have been documented elsewhere, in particular in the Australian Transport Safety Bureau report, "The Operational Search for MH370", in relation to the search in the southern Indian Ocean and the weekly updates provided by the MH370 Response Team in relation to the re-activated search by Ocean Infinity, and are separate and distinct from this Safety Investigation Report.

SECTION 1 – FACTUAL INFORMATION

1.2 INJURIES TO PERSONS

While injuries to persons on the flight could not be established as no survivors or bodies were found to date, the fact remains that there are 239 persons still missing.

SECTION 1 – FACTUAL INFORMATION

1.3 DAMAGE TO AIRCRAFT

Several pieces of debris were found washed ashore the south eastern coasts of Africa (South Africa, Mozambique and Tanzania), the Islands of Madagascar, Mauritius and Réunion, suggesting that the aircraft had suffered damage.

Refer to *Section 1.12 - Wreckage and Impact Information* for the list of significant debris possibly/confirmed belonging to MH370, recovered and examined to date.

SECTION 1 – FACTUAL INFORMATION

1.4 OTHER DAMAGES

Other damages could not be established as the main wreckage of the aircraft had not been found. There was no reported ground impact or damage to any ground facilities or properties.

SECTION 1 – FACTUAL INFORMATION

1.5 PERSONNEL INFORMATION

1.5.1 Introduction

This investigation emphasised on the Pilot-in-Command (PIC), First Officer (FO) and the 10 cabin crew but did not include the passengers on board Flight MH370. The factual information of the crew was gathered from the following sources:

1) **Personal records/files of the Pilot-in-Command, First Officer and the Cabin Crew from Malaysia Airlines**

   These documents included the log book, certificates, licences, medical records and any disciplinary/administrative actions;

2) **Investigation details from the Polis Di Raja Malaysia (Royal Malaysia Police)**

   These were statements obtained from the next-of-kin and relatives, doctors/ care givers, co-workers, friends and acquaintances; financial records of the flight crew; Closed Circuit Television (CCTV) recordings at KLIA; and analysis of the radio transmission made between MH370 and ground air traffic control;

3) **Medical records from private health care facilities and from the Malaysia Airlines Medical Centre; and**

4) **Interviews with Malaysia Airlines staff and several of the next-of-kin of the crew**

The facts obtained were in relation to the demographic and employment history, financial background and insurance cover, significant past medical and medication history, psychological, social and behavioural pattern of the crew.

1.5.2 Malaysia Airlines Training and Check Records

As professional pilots, the two Malaysia Airlines (MAS) flight crew were subjected to periodic checks when flying on the type of aircraft at least on a bi-annual basis to revalidate the currency of their licences. These performance checks were conducted in approved flight simulators and in addition, further checks are conducted on route flying duties on normal commercial flights on a yearly basis.

1.5.3 Pilot-in-Command

The PIC was born in the Island of Penang. He completed his Malaysian Certificate of Education (MCE) - the equivalent of the United Kingdom Ordinary (UK 'O') Level - at the Penang Free School, where he sat for his MCE Examination in 1978. In 1981 he was accepted as a Cadet Pilot with MAS under the sponsorship of Majlis Amanah Rakyat (MARA), a People's Trust Council of the Malaysian Government.

1) Personal Profile of Pilot-in-Command

Sex	Male
Age	53 years
Marital Status	Married with 3 children
Date of joining MAS	15 June 1981
Licence country of issues	Malaysia
Licence type	Air Transport Pilot Licence (ATPL)
Licence number	A751
Validity Period of Licence	14 May 2014
Ratings	Boeing B777
Medical Certificate	First Class (valid until 30 June 2014)
Aeronautical experience	18423:40 hours
Experience on type	8659:40 hours
Last 24 hours	0:00:00 hours
Last 72 hours	07:00:00 hours
Last 07 days	20:39:00 hours
Last 28 days	91:04:00 hours
Last 90 days	303:09:00 hours
Last line check	08 April 2013
Instrument rating check	15 November 2013
Last proficiency	15 November 2013
Last promotion	B777 Captain (22 September 1998)

The PIC was sent to Manila in the Philippines to be provided ab-initio pilot training and graduated 2 years later with a Commercial Pilot Licence & Instrument Rating (CPL & IR). He joined MAS as a Second Officer in 1983 and was posted on the F27 where he obtained his initial airline flying experience. He was then posted to the B737-200 in 1985, thereafter the A300B4, and stayed on as First Officer (FO) until March 1990. In July 1990 he was promoted to captain and took his first command on the F50 aircraft.

By the end of 1991 he was promoted to Captain on the B737-400 until December 1996. His next promotion was to the A330-300 and stayed on the fleet until September 1998 when he was promoted to the B777-200ER fleet until the day of the event. By virtue of his good track record and seniority he was made a Type Rating Instructor (TRI) and Type Rating Examiner (TRE) on this present fleet effective November 2007.

The PIC's flying record for the last 72 hours and preceding 28 days' cycle were well within the Company's specified limits. His last flight as an operating PIC was to Denpasar, Bali, in the Republic of Indonesia on 03 March 2014. This was a daily return flight with a sector time of approximately 3 hours. On the day of the event, he was conducting training for the FO who was functionally checked out.

2) Royal Malaysia Police's Report on Flight Simulator of PIC

The Royal Malaysia Police (RMP) seized the PIC's home flight simulator from the residence of the PIC on 15 March 2014.

The RMP Forensic Report dated 19 May 2014 documented more than 2,700 coordinates retrieved from separate file fragments and most of them are default game coordinates.

It was also discovered that there were seven 'manually programmed' waypoint[4] coordinates (*Figure 1.5A* [below), that when connected together, will create a flight path from KLIA to an area south of the Indian Ocean through the Andaman Sea. These coordinates were stored in the Volume Shadow Information (VSI) file dated 03 February 2014. The function of this file was to save information when a computer is left idle for more than 15 minutes. Hence, the RMP Forensic Report could not determine if the waypoints came from one or more files.

The RMP Forensic Report on the simulator also did not find any data that showed the aircraft was performing climb, attitude or heading manoeuvres, nor did they find any data that showed a similar route flown by MH370.

The RMP Forensic Report concluded that there were no unusual activities other than game-related flight simulations.

[4] 'Manually programmed waypoints' - Manually programmed waypoints are waypoints that are not published in Airway Charts

Figure 1.5A - Snapshot of Seven Manually Programmed 'Waypoints'

Source: Royal Malaysia Police

1.5.4 First Officer

The FO was born in the State of Kelantan and had his basic primary education in Segamat, Johor. He completed his secondary Education in Maktab Rendah Sains MARA (MRSM) or MARA Junior Science College, in Taiping, Perak, where he left in 2004 with the Sijil Pelajaran Malaysia (SPM) or Malaysia Certificate of Education, which is equivalent to the UK 'O' Level. He was accepted as a MAS Cadet Pilot and completed his flying training at the Langkawi Aerospace Training Centre, Langkawi in 2008.

His first fleet posting was on the B737-400 as a Second Officer until May 2010 He was promoted to FO in May 2010 and was on the fleet until August 2012. Between the end of 2012 to November 2013, he was promoted to the A330-300 and the B777-200.

On the day of the flight, he was operating his last training flight before he was scheduled to be checked out on his next scheduled flight. His flying record for the last 72 hours and preceding 28 days cycle were well within the Company's specified limits. His previous flight as a functional FO under Line Training, was to Frankfurt, Germany, on 01 March 2014 and he returned to Malaysia on 02 March 2014. All his required licences and certificates were valid when he was assigned to operate this flight to Beijing.

1) Personal Profile of First Officer

Sex	Male
Age	27 years
Marital Status	Single
Date of joining MAS	23 July 2007
Licence type	Air Transport Pilot Licence (ATPL)
Licence number	A3550
Validity Period of Licence	26 July 2014
Ratings	Boeing B777
Medical Certificate	First Class (valid until 31 October 2014)
Aeronautical experience	2813:42 hours
Experience on type	39:11 hours
Last 24 hours	0:00:00 hours
Last 72 hours	0:00:00 hours
Last 07 days	28:47:00 hours
Last 28 days	51:17:00 hours
Last 90 days	158:46:00 hours
Last line check*	22 July 2013 (A330)
Instrument rating check*	04 December 2012 (A330)
Last proficiency	26 January 2014
Last promotion	B777 FO (04 November 2013)

* *No record on B777*

1.5.5 Summary of Work Schedule for Flight Crew of MH370

A summary of the work schedule for the PIC and the FO, three months prior to the eventful flight, is available in *Table* 1.5A (below).

Rank	24	72	7	28	90	SEP Validity
	Hours		Days			
Pilot-in-Command	0:00:00	07:00:00	20:39:00	91:04:00	303:09:00	14 May 2014
First Officer	0:00:00	0:00:00	28:47:00	51:17:00	158:46:00	26 July 2014

Table 1.5A - 3 Months Work Schedule of PIC and FO

1.5.6 Cabin Crew and Personal Profiles

The cabin crews' flying experiences spread from 13 years for the most junior member to 35 years for the most senior member. A review of their records in MAS reveals that all certificates, which include Safety Emergency Procedures (SEP) training, Crew Resource Management (CRM), Safety Awareness Programme (SAP), are valid as per the requirement stated in the Company's document. CRM & SAP incorporate Human Factors as part of the training modules. The flying records which were monitored by the Scheduling Office indicated that all the cabin crew were well-rested before operating the flight.

1) In-flight Supervisor (IFS)

Sex	Male
Age	55 years
Marital status	Married with 4 children
Date of Joining MAS	19 November 1979
Aircraft Ratings	A330/B777/B747
Crew Performance Appraisal	Rating: 4
Validity period of licence	28 April 2014
Aeronautical experience	35 years
Medical History	43 days medical leave including 6 days hospitalisation in 2013
Last 24 hours	0:00:00 hours
Last 72 hours	8:00:00 hours
Last 07 days	19:44:00 hours
Last 28days	82:43:00 hours
Last 90 days	305:06:00 hours
Last promotion	IFS (27 March 2000)

2) Chief Steward (CS)

Sex	Male
Age	49 years
Marital status	Married with 2 children
Date of Joining MAS	13 November 1989
Aircraft Ratings	A330/B777/A380
Crew Performance Appraisal	Rating 4
Validity period of licence	26 June 2014
Aeronautical experience	25 years
Last 24 hours	0:00:00 hours
Last 72 hours	0:00:00 hours
Last 07 days	30:56:00 hours
Last 28 days	124:35:00 hours
Last 90 days	408:32:00 hours
Last promotion	CS (06 March 2000)

3) Chief Stewardess (CSS)

Sex	Female
Age	49 years
Marital status	Married with a child
Date of Joining MAS	02 January 1990
Aircraft Ratings	A330/B777/A380
Crew Performance Appraisal	Rating 5
Validity period of licence	23 October 2014
Aeronautical experience	24 years
Last 24 hours	0:00:00 hours
Last 72 hours	0:00:00 hours
Last 7 days	30:55:00 hours
Last 28 days	118:02:00 hours
Last 90 days	355:23:00 hours
Last promotion	CSS (22 October 2003)

4) Leading Steward (LS)

Sex	Male
Age	42 years
Marital status	Married with 4 children
Date of Joining MAS	05 October 1995
Aircraft Ratings	B737/B777/A380
Crew Performance Appraisal	Rating 4
Validity period of licence	22 August 2014
Aeronautical experience	19 years
Last 24 hours	00:00:00 hours
Last 72 hours	10:47:00 hours
Last 7 days	38:38:00 hours
Last 28 days	106:10:00 hours
Last 90 days	365:51:00 hours
Last promotion	LS (28 May 2005)

5) Leading Stewardess (LSS)

Sex	Female
Age	42 Years
Marital status	Married with 2 children
Date of Joining MAS	18 August 1992
Aircraft Ratings	B737/B777/A380
Crew Performance Appraisal	Rating 5
Validity period of licence	01 November2014
Aeronautical experience	22 years
Last 24 hours	0:00:00 hours
Last 72 hours	11:36:00 hours
Last 7 days	41:27:00 hours
Last 28 days	140:11:00 hours
Last 90 days	443:23:00 hours
Last promotion	LSS (09 May 2004)

6) Flight Stewardess (FSS) 1

Sex	Female
Age	42 years
Marital status	Married with 2 children
Date of Joining MAS	18 January 1992
Aircraft Ratings	A330/B777/A380
Crew Performance Appraisal	Rating 4
Validity period of licence	27 June 2014
Aeronautical experience	22 years
Last 24 hours	0:00:00 hours
Last 72 hours	9:39:00 hours
Last 7 days	34:22:00 hours
Last 28 days	93:50:00 hours
Last 90 days	327:18:00 hours
Last promotion	FSS wide-body aircraft (18 January 1993)

7) Flight Stewardess (FSS) 2

Sex	Female
Age	39 years
Marital status	Married with 2 children
Date of Joining MAS	16 April 1996
Aircraft Ratings	A330/B777/A380
Crew Performance Appraisal	Rating 4
Validity period of licence	11 May 2014
Aeronautical experience	18 years
Last 24 hours	0:00:00 hours
Last 72 hours	0:00:00 hours
Last 7 days	16:12:00 hours
Last 28 days	112:11:00 hours
Last 90 days	323:55:00 hours
Last promotion	FSS Wide-body aircraft (01 October 2001)

8) Flight Steward (FS) 1

Sex	Male
Age	46 years
Marital status	Married with 3 children
Date of Joining MAS	16 April 1996
Aircraft Ratings	B737/B777/A380
Crew Performance Appraisal	Rating 5
Validity period of licence	24 October 2014
Aeronautical experience	18 years
Last 24 hours	0:00:00 hours
Last 72 hours	11:02:00 hours
Last 7 days	30:58:00 hours
Last 28 days	119:27:00 hours
Last 90 days	429:15:00 hours
Last promotion	FS Wide-body aircraft (03 December 2001)

9) Flight Steward (FS) 2

Sex	Male
Age	41 years
Marital status	Married with 2 children
Date of Joining MAS	13 February 1997
Aircraft Ratings	B737/B777/A380
Crew Performance Appraisal	Rating 5
Validity period of licence	03 November 2014
Aeronautical experience	17 years
Last 24 hours	0:00:00 hours
Last 72 hours	0:00:00 hours
Last 7 days	30:36:00 hours
Last 28 days	122:22:00 hours
Last 90 days	391:20:00 hours
Last promotion	FS Wide-body aircraft (15 February 2002)

10) Flight Steward (FS) 3

Sex	Male
Age	34 years
Marital status	Married with 2 children
Date of Joining MAS	27 September 2001
Aircraft Ratings	B737/B777/A380
Crew Performance Appraisal	Rating 5
Validity period of licence	06 February 2015
Aeronautical experience	13 years
Last 24 hours	0:00:00 hours
Last 72 hours	10:47:00 hours
Last 7 days	26:24:00 hours
Last 28 days	125:01:00 hours
Last 90 days	435:43:00 hours

1.5.7 Disciplinary/Administrative Actions

There were no major disciplinary records on any of the flight and cabin crew. However, there were minor disciplinary issues among the cabin crew, where cautionary administrative letters were issued.

1.5.8 Financial Background and Insurance Cover

The PIC held bank accounts, two savings accounts, one current account, two national trust funds (ASB and ASN) and a joint account with his wife. He had a credit card. He was contributing to the Employees Provident Fund (EPF). There is no record of him having secured a life insurance policy. He had 2 houses, one in Shah Alam and the other in Subang Jaya. He had taken a bank loan on one of his houses and had a mortgage insurance policy on this loan. He also had 3 vehicles. His gross monthly income and out-of-pocket expenses indicated nothing unusual.

The PIC also had a trading account with an investment bank. The Central Depository System (CDS) and Trading accounts were opened since 13 February 1998 and 19 March 1998 respectively. The CDS account was inactive whereas the last transaction of the trading account was noted on 03 February 2000.

The FO had two saving accounts and a national trust fund (ASB) account. He contributed to the EPF. He owned two cars and spent money on the upkeep of his cars. He did not have much savings in his bank account. He had a life insurance policy and a mortgage insurance policy for a loan he took for his car.

The cabin crew had bank accounts and loans. However, the gross monthly income and out-of-pocket expenses indicated nothing unusual. There is also no evidence of recent or imminent significant financial transactions carried out.

1.5.9 Significant Past Medical and Medication History

The PIC had received treatment for minor medical ailments and was diagnosed as having osteoarthritis on 05 May 2007. He had a spinal injury on 28 January 2007 in a paragliding event. He sustained a fracture of the 2nd lumbar vertebra and underwent surgery on 30 January 2007 in a private health care facility. He was discharged on 05 February 2007 and went for a follow-up as advised. He was certified fit to fly in mid-2007 and went regularly for his six-monthly medical examinations for his continued licensure as a pilot. For his pain he was noted to have taken analgesics on an irregular basis. Based on available information, he was not on any regular long-term medication for any chronic medical illness.

There was no significant health-related issue for the FO. He went regularly for his yearly medical examinations for his continued licensure to fly.

Based on the medical records from MAS, there were no unusual health-related issues for the cabin crew, except for the in-flight supervisor who had a history of first onset of seizures on 09 June 2013. He was admitted on the same day in a private health care facility and was treated by a Consultant Neurologist. He was discharged on 14 June 2013 and went for a follow-up as advised. He had not experienced any further seizures since his discharge. He was certified fit to fly on 06 August 2013.

1.5.10 Psychological and Social Events

The PIC's ability to handle stress at work and home was reported to be good. There was no known history of apathy, anxiety, or irritability. There were no significant changes in his lifestyle, interpersonal conflict or family stresses.

Similarly, the FO's ability and professional approach to work was reported to be good. This was evident with the rapid fleet promotion within 3 years as a professional pilot. There were no reports on recent changes in his behaviour or lifestyle.

1.5.11 Behavioural Events

There were no behavioural signs of social isolation, change in habits or interest, self-neglect, drug or alcohol abuse of the PIC, FO and the cabin crew.

The CCTV recordings at KLIA on 07 March 2014 were evaluated to assess the behavioural pattern of the PIC, and the FO from the time of arrival at KLIA until boarding time.

Three previous CCTV recordings of the movements of the PIC in KLIA were also viewed to see the behavioural pattern and were compared with the CCTV recordings on 07 March 2014.

The PIC's movement was captured on CCTV at KLIA on the following days:

- 07 March 2014 - To Beijing

- 03 March 2014 - To Denpasar
- 26 February 2014 - To Melbourne
- 21 February 2014 - To Beijing

On studying the PIC's behavioural pattern on the CCTV recordings on the day of the flight and prior 3 flights there were no significant behavioural changes observed. On all the CCTV recordings the appearance was similar, i.e. well-groomed and attired. The gait, posture, facial expressions and mannerism were his normal characteristics.

The FO's movement captured on CCTV at KLIA on 07 March 2014 was observed. The FO's behavioural pattern on CCTV recordings on the day of the flight showed no significant behavioural changes.

1.5.12 Voice Recognition of the Radio Transmissions between MH370 and Air Traffic Control

The radio transmissions made between MH370 and the air traffic control were studied. The Team used pilot friends, family members, and an expert report of objective analysis of the radio transmissions in the voice recognition of the transmissions made between MH370 and air traffic control.

Five sets of audio recordings were analysed starting from Airway Clearance Delivery at 1625:52 UTC [0025:52 MYT] till the last utterance from Lumpur Radar at 1719:30 UTC [0119:30 MYT]. There was a total of 23 utterances as follows:

No.	Audio Recordings	Frequency (MHz)	Utterances	
1.	Airway Clearance Delivery (ACD)	126.0	→	4
2.	Lumpur Ground (LG)	122.27	→	6
3.	Lumpur Tower (LT)	118.8	→	4
4.	Approach Radar (AR)	121.25	→	3
5.	Lumpur Radar (LR)	132.5	→	6

From the information available, the first 3 sets of audio recordings (ACD, LG, LT), the speech segments are those of the FO before take-off, and the 4^{th} & 5^{th} (AR & LR) sets of the audio recordings originated from the PIC after take-off.

SECTION 1 – FACTUAL INFORMATION

1.6 AIRCRAFT INFORMATION

1.6.1 Airframe

Manufacturer	Boeing Company
Model	777-2H6ER
Serial Number	28420
Manufacturer's Line No.	404
Variable No.	WB175
Registration	9M-MRO
Date of manufacture	29 May 2002
Date of delivery to MAS	Delivered new on 31 May 2002
Certificate of Airworthiness	M.0938 valid to 02 June 2014
Certificate of registration	M.1124 issued 23 August 2006. Replacement of Certificate issued on 17 June 2002
Last Maintenance check	A1 Check on 23 February 2014 at 53,301:17 hours and 7,494 cycles
Total airframe hours/cycles	53,471.6 hours/7,526 cycles (as of 07 March 2014)

1.6.2 Engine

Manufacturer	Rolls-Royce
Model	RB211 Trent 892B-17
Engine 1 (Left)	
Serial Number	51463
Date of Construction	November 2004
Date Installed	08 May 2013
Last Shop Visit	06 September 2010 to 21 November 2010
Time in Service	40,779 hours, 5,574 cycles (as of 07 March 2014)
Engine 2 (Right)	
Serial Number	51462
Date of Construction	October 2004
Date Installed	15 June 2010
Last Shop Visit	05 February 2010 to 14 April 2010
Time in Service	40,046 hours, 5,508 cycles (as of 07 March 2014)

1.6.3 Auxiliary Power Unit

Manufacturer	Allied Signal
Model	GTCP 331-500B
Serial Number	P1196
APU Hours	22,093 (as of 07 March 2014)

1.6.4 Airworthiness and Maintenance

The aircraft, Serial Number 28420, was issued with a Federal Aviation Administration (FAA) Export Certificate of Airworthiness No: E370249 on 29 May 2002 and placed on the Malaysian aircraft register as 9M-MRO on 03 June 2002. Ownership of the aircraft, as stated on the Certification of Registration (C of R), was Malaysian Airline System Berhad. The ownership was subsequently changed to Aircraft Business Malaysia Sdn. Bhd., as the lessor, and leased and operated by MAS. A new C of R to reflect the new owner was issued on 17 June 2002.

A Certificate of Airworthiness (C of A) in the 'PRIVATE' category was initially issued on 03 June 2002. The aircraft was then flown to Kuala Lumpur, Malaysia where a C of A in 'TRANSPORT PASSENGER' category was issued by the DCA Malaysia on 12 June 2002 after the pre-service modifications were accomplished.

The C of A was subjected to annual renewal by DCA Malaysia and its renewal was subjected to compliance to the DCA Malaysia Airworthiness Notice No. 2 - Certificate of Airworthiness Renewal Procedure. The operator was required to declare the aircraft, engine, APU and equipment maintenance status as per the approved Maintenance Schedule, and that they complied with all the mandatory inspections and modifications originating from the State of Manufacture and State of Registry. The Quality Assurance Department of MAS was required to submit an 'Aircraft Physical Inspection for the Purpose of C of A Issue/Renewal' prior to the expiry of the C of A. An 'Aircraft Survey Report for Certificate of Airworthiness' will be issued by the DCA Inspector after a satisfactory physical inspection on the aircraft has been carried out. At times, the physical aircraft inspection has to coincide with the aircraft scheduled check at base or line maintenance.

The last C of A document review by DCA Inspector was carried out on 15 May 2013 for the C of A renewal and the aircraft physical inspection was carried out by MAS Quality Assurance Engineer (QAE) on 12 April 2013. The only inspection defect noted was a torn left hand flaperon inboard seal which was subsequently replaced. The aircraft C of A was renewed with no airworthiness issues identified.

1) Aircraft Maintenance Schedule

Brief description of the sections follows:

a) Section 1

The definition and introduction of the routine check types. Check intervals and limitations at which the maintenance tasks are to be carried out.

b) Section 2

Task Maintenance Requirements relating to on-wing tasks or tasks to be performed on parts after removal from the aircraft, their intervals and control in the routine maintenance check or independently.

c) Section 3

Component Maintenance Requirements on tasks to be performed on components, their intervals and controlled independently.

d) Section 4

Registers all the applicable job cards which are tied up to the maintenance Checks or Phases of inspections or tasks. The job cards/task cards cover the system, power plants, structural and zonal tasks.

The Master document of the approved Maintenance Schedule is stored in the Engineering Maintenance System (EMS) computer system bank and subject to regular revisions.

In addition to the Maintenance Schedule, a Supplementary Maintenance Schedule covered MAS' own generated tasks, non-mandatory manufacturer/vendor recommended tasks and non-airworthiness items.

The Maintenance check cycles are translated into the routine Transit Check, Stayover Check, Equalised 'A' Check, 'C' Check, 'C Extended' Check and 'D' Check. *Table 1.6A* (below) summarises the maintenance check intervals.

Transit	Stay-over	A Check	C Check	CX (Extended) Check	D Check
Whenever aircraft is on transit	6 hours planned or 12 hours unplanned	In 4 parts A1 thru A4 • A1 to A2 = 550 hours • A2 to A3 = 550 hours • A3 to A4 = 550 hours • A4 to A1 = 550 hours	In 2 parts C1 and C2 • C1 to C2 = 13 months • C2 to C1 = 13 months	52 months	8 years

Table 1.6A - Maintenance Check Intervals

No.	Type of Aircraft Checks	Date of aircraft Checks	Airframe Hours	Landing Cycles
1.	A1	23 February 2014	53,301:17	7,494
2.	A4	14 - 16 January 2014	52,785:37	7,422
3.	A3	13 December 2013	52,323:00	7,359
4.	A2	04 November 2013	51,766:29	7,282
5.	C1 and A1	29 August-26 September 2013	51,270:15	7,208
6.	A4	24 - 25 July 2013	50,810:19	7,132
7.	A3	19 June 2013	50,372:07	7,069
8.	A2	14 May 2013	49,840:28	6,994
9.	A1	04 April 2013	49,331:52	6,910
10.	A4	19 - 20 February 2013	48,836:23	6,840
11.	A3	10 January 2013	48,291:37	6,766
12.	A2	03 December 2012	47,749:39	6,693
13.	A1	25 October 2012	47,214:27	6,617
14.	A1, A4 and C2	06 - 22 July 2012	46,727:16	6,552
15.	A4, C2, CX and D	25 May - 26 June 2010	37,014:15	5,304

Table 1.6B - Recent Aircraft Checks

A review of the maintenance records for 9M-MRO revealed the following sequence of recent checks (*Table 1.6B* [above]) carried out by MAS prior to the disappearance of the aircraft on the 08 March 2014. No significant defects were noted during the checks including the turn-around transit checks.

The Maintenance Schedule incorporated the Structural Inspection Programme based on the B777 Maintenance Review Board Report and B777 Maintenance Planning Document, which are categorised as Structural Inspection Items, Corrosion Prevention and Control Items and Fatigue Related Inspection Items. Inspection findings would be evaluated by the MAS Reliability Section of the Technical Services Department and the department would recommend any follow-up actions as necessary and report to Boeing Company of all significant structural discrepancies.

The Maintenance Schedule also included compliance procedures for Airworthiness Directives[5], Airworthiness Limitations (AWL)[6] and Structural Inspections with Provisions for Damage Tolerance Rating. It also included Certification Maintenance Requirement Compliance to the Extended Twin Engine Operations (ETOPS)[7] operational approval, which was obtained from DCA Malaysia. The MAS B777 ETOPS Maintenance Manual specified the maintenance policies, procedures and requirements for ETOPS operations. A policy to prevent the same personnel to perform or certify certain tasks on multiple similar systems at the same downtime is stipulated. ETOPS task intervals cannot be exceeded. If a concession is given for a check that contains ETOPS task or for individual ETOPS task, the aircraft must be downgraded to non-ETOPS status. 9M-MRO was approved and had no limitations for ETOPS operations at the time of departure from Kuala Lumpur to Beijing. It was not on an ETOPS flight plan. MAS and its fleet of B777 were approved for Reduced Vertical Separation Minimum (RVSM) operation.

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[5] An AD is a notification to owners and operators of certified aircraft that a known safety deficiency with a particular model of aircraft, engine, avionics or other system exists and must be corrected. It is mandatory in nature.

[6] AWLs are items that the Certificate process has defined as critical from a fatigue or damage tolerance assessment.

[7] ETOPS is an aviation rule that allows twin-engine airliners to fly long distance routes that were previously off-limits to twin-engine aircraft.

2) Major Repair

There was an entry in the Aircraft Log Book on 09 August 2012 that the aircraft right wing tip was damaged during taxiing at Pudong, Shanghai Airport. The aircraft collided with a China Eastern Airlines A340-600, registered B-6050. The right wing tip of 9M-MRO ran into the left horizontal stabilizer of B-6050. Part of the aircraft wing tip was ruptured and stuck at the left elevator of the B-6050. *Figures 1.6A* and *1.6B* (below) show the wing tip damages.

Figure 1.6A - Right Wing Tip Damage

Figure 1.6B - Damaged Wing Tip

Boeing produced an Aircraft Survey Report reference WB175/W8134/LN404 on 15 August 2012 and the repair was carried out by Boeing Aircraft-On-Ground (AOG) Team at Pudong, Boeing Shanghai facility from 22 September to 03 October 2012. The Boeing repair scheme was approved under DCA Malaysia's Statement of Compliance (SOC) Reference Number SC/2012/081 issued on 03 September 2012. At the time of the incident, the recorded airframe hours were at 46,975:43 and landing cycles at 6,585.

There was a requirement for damage tolerance[8] information to be incorporated in the aircraft maintenance programme within 24 months from 02 October 2012 as stated in the FAA Form - Organization Designation Authorization (ODA). This damage tolerance information was not yet included in the maintenance programme for the aircraft at the time of the occurrence.

3) Cabin Configuration Change

The fleet of B777 of MAS went through a cabin interior retrofit programme which converted the configuration from 12 First Class seats/33 Business Class seats/233 Economy Class seats to 35 Business Class and 247 Economy Class seats. On 9M-MRO, this re-configuration started on 17 August 2006 and was completed on 08 September 2006. The modification was approved under FAA Supplemental Type Certificate (STC) No. STO1493SE dated 24 January 2005 and DCA's SOC No. SC2004/98.

4) Mandatory Occurrence Reports

A review of the Mandatory Occurrence Reports (MORs) for the B777 fleet raised by the Engineering & Maintenance Quality Assurance Department of MAS revealed that only one was raised for 9M-MRO, and this was related to the right wing tip damage stated above. A total of 77 MORs were raised for the MAS fleet of 17 B777 aircraft. MORs raised by the Quality Assurance department are primarily related to technical issues with the fleet. The average age of the B777 fleet as of 01 March 2014 was 14.35 years. 9M-MRO was 11.75 years old.

[8] Damage tolerance means that the structure has been evaluated to ensure that should serious fatigue, corrosion or accidental damage occurs within the operational life of the aircraft, the remaining structure can withstand reasonable loads without failure or excessive structural deformation until the damage is detected.

5) Airworthiness Directives

Maintenance and Inspection records provided by MAS indicated that at the time the aircraft 9M-MRO went missing, the aircraft and engines were fully compliant with all applicable Airworthiness Directives (AD).

The most recent AD, which was accomplished on 17 January 2014, was FAA AD 2012-13-05 which made mandatory the accomplishment of Boeing Service Bulletin 777-35A0027 which requires replacement of low pressure oxygen hoses in the cockpit. The changes provided in the service bulletin are to prevent damage to the low pressure oxygen hoses that may be subjected to electrical current. An electrical current condition in the low pressure oxygen hose can cause the low pressure oxygen hose to melt or burn. This could result in smoke and/or fire in the flight compartment. An operator (not MAS) reported that a fire originated near the first officer's area which caused extensive damage to the cockpit. One scenario of the causes being considered is that an electrical fault or short circuit resulted in electrical heating of the low pressure oxygen hoses in the flight crew oxygen system. This service bulletin is to replace low pressure oxygen hoses with non-conductive low pressure oxygen hoses located in the cockpit. The replacement of the low pressure oxygen hoses will prevent electrical current from passing through the low pressure oxygen hose internal anti-collapse spring which can cause the low pressure oxygen hose to melt or burn.

An FAA AD 2014-05-03 was issued and became effective on 09 April 2014. This AD made mandatory the accomplishment of Boeing Service Bulletin 777-53A0068 which addresses a crack in the fuselage skin under the SATCOM antenna adapter. The Service Bulletin was issued on 12 June 2013. The AD was issued to detect and correct cracking and corrosion in the fuselage skin, which could lead to rapid decompression and loss of structural integrity of the aircraft. However, this AD was not applicable to 9M-MRO as the location and configuration of the antenna on the aircraft, as delivered by Boeing ex-production, were different and not affected by the issues highlighted in the Service Bulletin.

6) Technical Log

a) MR1 and MR2

The MAS Technical Log Book was divided into Maintenance Report 1 (MR1) and Maintenance Report 2 (MR2). The MR1 has provision for the flight crew to enter any aircraft defects for each flight phase. It can also be used to enter maintenance required and rectifications by the Licenced Aircraft Maintenance Engineers (LAME) or Approval Holders, or defer defects within the Minimum Equipment List (MEL) procedures to the Maintenance Report 2 (MR2) section.

A review of the Technical Log entries for 9M-MRO since the last D check in June 2010 did not reveal any significant defects or trend.

The most recent entries made in the Technical Log Book for 9M-MRO are listed in *Appendix 1.6A.*

b) Oxygen System Replenishment

A Technical Log entry of interest, made on 07 March 2014, is the replenishment of crew oxygen system. This replenishment was reviewed in detail together with information gathered from the interview of the LAME who performed the task. Replenishment (servicing) of the crew oxygen system is a routine procedure, carried out before the minimum pressure required for departure is reached, usually carried out during a Stayover check. The minimum pressure for despatch as per the MAS Minimum Equipment List (MEL) is 310 psi at 35°C for 2-man crew and with a 2-cylinder configuration (as installed on MAS B777 fleet).

It has been the practice of the airline to service the oxygen system whenever time permits, even if the pressure is above the minimum required for despatch.

During the Stayover check on 07 March 2014, the servicing on 9M-MRO was performed by the LAME with the assistance of a mechanic, as the pressure reading was 1120 psi. The servicing was normal and nothing unusual was noticed. There was no leak in the oxygen system and the decay in pressure from the nominal value of 1850 psi was not unusual. The system was topped up to 1800 psi. Before this servicing, maintenance records showed that the system was last serviced on 14 January 2014 during an A4 check.

A small amount of oxygen is normally expended during pre-departure checks of the oxygen masks by the flight crew. Oxygen pressure is also dissipated by a bleed valve in the system for a few seconds during engine start following the end of a flight.

7) Deferred Defects (Maintenance Report 2)

A review of the aircraft records from the MAS Maintenance Control Centre (MCC) showed that the following defects were outstanding on 9M-MRO and deferred to the Deferred Defect Log (*Table 1.6C,* [below]). The hole found on the right engine acoustic panel, mentioned below in item 7, was of dimension of approximately 1 inch by 1 inch and is allowed to be deferred by the B777 Maintenance Manual until permanent repair is carried out within 500 flight hours. This minor damage is considered normal wear and tear of the engine nacelles and does not pose any hazard to the engine.

No.	Deferred Date	Defect
1.	25 Sep 2013	To carry out installation test for aft water quantity gauge.
2.	31 Oct 2013	In-Flight Entertainment (IFE) Airshow does not show arrival time/time to destination logged time & problem still persists.
3.	07 Nov 2013	From Daily Engineering Operations Report (DEOR) - Right engine consumes average 1.5T more fuel per/hour compared to left engine
4.	21 Jan 2014	Toilet 3F-1L mirror light lens broken
5.	30 Jan 2014	Pre-departure F/O seat power adjustment (fwd/aft) found inoperative.
6.	05 Mar 2014	Please check alignment for left runway turn/off light.
7.	05 Mar 2014	Hole found at 6 o'clock position of the right engine acoustic panel.

Table 1.6C - Deferred Defects

8) Engine Health Monitoring

Engine Health Monitoring (EHM) was contracted out to Rolls Royce, the engine manufacturer. Engine data 'snapshot' reports were generated by the Aircraft Condition Monitoring System (ACMS) and transmitted via ACARS to MAS, who then submitted them to Rolls Royce for analysis on its behalf. The transmitted engine parameters primarily used to assess engine health are:

- Turbine Gas Temperature
- Shaft Speeds
- Shaft Vibration (Low Pressure, Intermediate Pressure and High Pressure)
- Oil Pressure
- Oil Temperature

The EHM system trend reports over the last 3 months which covered 'snapshot' data points gathered at take-off, climb and cruise received through the ACMS show no evidence of unusual engine behaviour for both engines. On the occurrence flight, 2 EHM reports were transmitted; the first was a Take-off report generated at 1641:58 UTC, 07 March 2014 [0041:58 MYT, 08 March 2014] and the second was a Climb report at 1652:21 UTC, 07 March 2014 [0052:21 MYT, 08 March 2014]. Reports are transmitted by ACARS at convenient times during the flight (not necessarily at the time of generation/data capture). Both reports did not show any unusual engine behaviour. The data transmitted on these reports are shown in *Appendix 1.6B - Engine Health Monitoring Decoded Data for Take-off and Climb Reports*. The ACMS will also generate other pre-defined engine reports including engine parameters' exceedance reports. However, no such EHM reports were received during the flight. Position reports are also transmitted, via ACARS, every 30 minutes. Refer to *Section 1.9.4* for further details.

9) Central Maintenance Computing System

The Central Maintenance Computing System (CMCS) collects and stores information from most of the aircraft systems. It can store fault histories as well as monitor and conduct tests on the various systems. The fault history contains details of warnings, cautions and maintenance messages.

At regular intervals, during flight, the CMCS transmits any recorded fault messages, via the ACARS, to the Maintenance Control Centre (MCC) of MAS. This helps in the planning and preparation for the rectification of any potential aircraft defects at the main base or line stations.

The traffic log of maintenance messages transmitted for the last 10 flights on 9M-MRO were reviewed. There were messages transmitted, indicating that the CMCS was functioning prior to the occurrence flight. However, no maintenance messages were transmitted during the occurrence flight. These messages are transmitted in real time that is, as the faults occur.

Maintenance messages are not displayed on the Engine Indicating and Crew Alerting System (EICAS) in the cockpit and they are not used to determine the airworthiness of the aircraft. They provide diagnostic information useful in troubleshooting or maintenance planning. Only maintenance messages which trigger EICAS Alert messages require maintenance action (including deferment, if allowable) prior to despatch.

1.6.5 Weight and Balance

The aircraft underwent a scheduled reweighing on 28 April 2009 at the MAS maintenance facility at KLIA. The next aircraft re-weighing was due on or before 27 April 2014. The aircraft Weight Schedule dated 12 June 2009 was reviewed with the following pertinent details (also refer to *Table 1.6D* [below]):

- Basic Empty Weight (BEW) of 138,918.7 kg
- Centre of Gravity (C of G) position of 1,248.8 Inches
- Index of 60.07 I.U.
- C of G of 26.7 % Mean Aerodynamic Chord (MAC) Dry Operating Weight (DOW) of 145,150 kg and Index 61.13

The maximum authorised take-off weight was 286,897 kg. On the occurrence flight, the aircraft departed with a calculated take-off weight of 223,469 kg. This take-off weight was broken down as follows:

	Actual (kg)	Maximum (kg)
Take-off Weight (TOW)	223,469	286,897
Zero Fuel Weight (ZFW)	174,369	195,044
Take-off Fuel	49,100	-
Landing Weight (LDW)	186,269	208,652
Trip Fuel	37,200	-
Total Traffic Load	31,086	-
Total Payload (Load in compartment)	14,296	-
Passenger & Luggage	16,790	-
Dry Operating Weight (DOW)	143,283	-

Table 1.6D - Aircraft Weight

The balance corresponding to the aircraft take-off weight and shown on the final loadsheet (after Last Minute Changes) was 33.78% of the Mean Aerodynamic Chord (MAC) which was within limits.

During take-off, the aircraft Basic Empty Weight (BEW) was 138,918.7 kg and the C of G position was 1,248.8 inches (C of G MAC was 26.7%). Total moment was 173,478,288.65 kg in. This indicates the planned weight and balance of the aircraft was within the allowable limits. The planned cargo weight (load in compartment) of 14,296 kg and distribution matched the recorded cargo weight and distribution.

Based on the available data, the aircraft weight and balance for the take-off from Kuala Lumpur was found to be normal and within the allowable limits.

1.6.6 Fuel

The aircraft used Jet A-1 fuel. Following the previous flight, as per records in the Transit Check and Fuel Log, the total remaining fuel before refuelling as per the cockpit indication was 8,200 kg (Left Tank was 3,700 kg and Right Tank was 4,500 kg). Total departure fuel after refuelling was 49,700 kg (Left Tank was 24,900 kg and Right Tank was 24,800 kg) as indicated in the cockpit.

The fuel weight on board corresponded to a planned trip-fuel of 37,200 kg. Based on MH370 ATC flight plan dated 07 March 2014, the take-off fuel recorded was 49,100 kg. This figure differed slightly from the take-off fuel figure of 49,200 kg generated by the Aircraft Condition Monitoring System (ACMS) and transmitted by Aircraft Communications Addressing and Reporting System (ACARS). The difference was due to the actual time the fuel figure was taken from the aircraft fuel quantity indication system, by Operations for the load sheet, and by the ACMS for the ACARS report, considering fluctuations in the fuel quantity indication. The investigation estimated that the aircraft would have had 41,500 kg fuel remaining after 41 minutes flying from KLIA to IGARI.

The last position report transmitted via ACARS at 1707:29 UTC, 07 March 2014 [0107:29 MYT, 08 March 2014] recorded remaining fuel of 43,800 kg at 35,004 ft altitude.

ATC flight plan forecast recorded remaining fuel of 11,900 kg at landing, including 7,700 kg of diversion fuel. The first alternate airport, Jinan Yaoqiang International Airport (China), was estimated to be 46 minutes from the diversion point with 4,800 kg fuel required and the second alternate airport, Hangzhou Xiaoshan International Airport (China) was estimated to be 1 hour 45 minutes with 10,700 kg fuel required.

The fuel carried on board for the flight met the regulatory requirements on the minimum required, taking into account the use of possible diversion airports. There was also no evidence that more than the reasonable amount required was carried.

1.6.7 Emergency Locator Transmitter

An emergency locator transmitter (ELT) is a radio beacon that when activated will transmit digital distress signals. These signals can be tracked in order to aid the detection and localisation of an aircraft in distress.

The Fixed and Portable ELT radio beacons interface worldwide with the international Cospas-Sarsat satellite system for Search and Rescue (SAR). When activated and under satellite coverage, such beacons send out a distress signal which can be detected by satellites. The satellite receivers send this information to ground stations. This signal is transmitted to Mission Control Centres (MCC) located in six regions worldwide. The MCC covering the Indian Ocean is managed by the Australian Maritime Safety Authority based in Canberra, Australia.

ELTs are mandatory safety items carried on board the aircraft. The cabin and the technical crew attend compulsory safety emergency procedure (SEP) training and have to remain current by attending refresher SEP courses. Operation and functioning of the ELT is part of the SEP training module.

The specifications for the ELT are contained in FAA Technical Standard Orders TSO-C126 and TSO-C91A.

The ELT is a radio beacon; like all other radio equipment installed on-board, its usage is approved by the Malaysian Communications and Multimedia Commission through the Aircraft Radio Licence.
Appendix 1.6C - Copy of the Radio Licence issued for 9M-MRO.

9M-MRO had four ELTs installed. They were located as follows:

- **One FIXED ELT** located above ceiling of the aft passenger cabin at STA 1880.

  The aircraft was delivered without a fixed ELT; this component was added by MAS later (between December 2004 and July 2005). This unit is mounted to aircraft structure at the aft passenger cabin at STA 1880.

  A control switch installed in the cockpit (flight deck) aft overhead panel provides the command signal. This switch is guarded in the ARMED position. If required, the flight crew can select the ELT to ON by moving the guarded switch from ARMED to ON.

  The fixed ELT is manufactured by ELTA FRANCE and is of the 406 series, part number is 01N65900. The unit is connected to an Omni-directional, triple frequency blade antenna located at the rear fuselage forward of the vertical stabilizer at station 1881. The ELT will activate upon a sudden deceleration force per the Technical Standard Order.

  This ELT has the provision to operate on the satellite frequency of 406 MHz when activated. The transmission includes the ELT identifier, aircraft nationality and registration markings. It will also transmit on 121.5 MHz and 243 MHz when activated and these signals may be detected by air, sea or ground receivers. Transmissions on VHF frequency (121.5/243 MHz) are line of sight and effective only in close proximity (about 20 km radius).

  The battery expiry date for the FIXED ELT was November 2014.

  One PORTABLE ELT located in the forward cabin right hand coat closet.

  This closet is used by the cabin crew.

  This unit is bracket-mounted to the inside of the coat closet door. A label fixed on the coat closet door identifies the ELT. The installation allows quick removal. The Portable ELT is manufactured by ELTA FRANCE and is of the 406 series. It is identical to the fixed ELT except that this unit has its own foldable antenna. The operations and function are the same. The manufacturer part number is 01N65910.

The portable ELT has a control switch on the front face. It is normally in the OFF position. When needed, the switch can be selected to the ON position to activate the ELT transmission.

The battery expiry date for the PORTABLE ELT was November 2014.

- **Two SLIDE RAFT** mounted ELTs located at Door 1 Left and Door 4 Right (packed within the slide raft assembly).

The slide raft mounted ELT will only be available when the slide rafts at doors 1 Left or 4 Right are deployed. The ELT transmission is not satellite enabled. The transmission signal is on 121.5 MHz and 243 MHz which may be monitored with air, sea and ground-based receivers. The slide raft ELT is automatically armed when the slide raft is deployed and inflated. Once armed the ELT is automatically activated by a water sensor coming in contact with water. This ELT is not activated by deceleration. The slide raft ELTs (Part No.: P3-03-0029-10) are manufactured by DME Corporation and the battery expiry dates are as follows:

- Door 1 Left - August 2016
- Door 4 Right - May 2017

No relevant ELT beacon signals from the aircraft were reported from the responsible Search and Rescue agencies or any other aircraft.

1) Review of Effectiveness of Emergency Locator Transmitters

In general, Emergency Locator Transmitters (ELT) are intended for use on land or on the surface of water, and neither portable nor fixed ELT signals are detectable when the ELT is submerged in deep water. Portable ELT is equipped with a floatation device and can be activated by immersion in water. For effective signal transmission, the antenna of the ELT must remain above water. Damage to an ELT or its associated wiring and antenna, or shielding by aircraft wreckage or terrain, may also prevent or degrade transmission. If the portable ELT is activated within a closed aircraft the shielding effect of the aircraft structure may degrade the transmission.

a) A review of ICAO accident records over the last 30 years indicates that of the 114 accidents in which the status of ELTs was known, only 39 cases recorded effective ELT activation. This implies that of the total accidents in which ELTs were carried, only about 34% of the ELTs operated effectively (*Appendix 1.6D*).

b) The Cospas-Sarsat system has been helpful for search and rescue teams in numerous aircraft accidents on a world-wide basis. Despite these successes, the detection of ELT signals after an aircraft crash remains problematic. Several reports have identified malfunctions of the beacon triggering system, disconnection of the beacon from its antenna or destruction of the beacon as a result of accidents where aircraft was destroyed or substantially damaged. Even when the beacon and its antenna are functioning properly, signals may not be adequately transmitted to the Cospas-Sarsat satellites because of physical blockage from aircraft debris obstructing the beacon antenna or when the antenna is under water.

Source: Global Aeronautical Distress and Safety System (GADSS document)

Note:

In the aftermath of the disappearance of MH370, following a multi-disciplinary meeting in May 2014, ICAO formed an Ad-hoc Working Group on Flight Tracking with the mandate to develop a Concept of Operation on the sequence of events before and after the occurrence of an accident which should include all identified phases of such a sequence including detection of an abnormal situation, alert phase, distress phase, and search and rescue activities. This Concept of Operation is GADSS.

c) ELT can be activated automatically by shock typically encountered during aircraft crashes or manually. It is possible for Flight Crew to manually activate the ELT; however existing flight operating procedures do not call for activation of the ELT until the incident has occurred.

d) The Cospas-Sarsat system does not provide a complete coverage of the earth at all times. As a consequence, beacons located outside the areas covered by these satellites at a given moment cannot be immediately detected and must continue to transmit until a satellite passes overhead.

e) The global distress beacon detection system, Cospas-Sarsat, no longer detects 121.5 MHz distress signals. Only 406 MHz digital distress beacons are now capable of detection by satellite. Analogue beacon signals may be received by other aircraft within VHF range but there may not be such aircraft within range at the time of beacon transmission and monitoring 121.5 MHz.

1.6.8 Aircraft Systems Description

Most of the electronic equipment on the aircraft are mounted on equipment racks in the various equipment centres.

The Main Equipment Centre (MEC) contains most of the electronics equipment on the aircraft. The MEC is below the passenger cabin, rear of the nose wheel well and forward of the forward cargo compartment. Access to the MEC is possible on ground or in flight. The equipment in the MEC includes electronics for these functions:

- Information Management
- Generator Control
- Transformer Rectifier
- Flight control and autopilot
- Environmental control
- Recording
- Navigation
- Communication
- Cabin Management
- Weight and balance
- Air data
- Inertial data
- Warning
- Proximity sensing
- Engine control
- Electrical Load Management.

The Forward Equipment Centre is forward of the nose wheel well and contains the two weather radar receiver/transmitters. Access to the

Forward Equipment Centre is through the access door forward of the nose landing gear or through the MEC.

The passenger compartment above the Door 3 cross-aisle at station 1530 on the left of the aircraft centre line contains the satellite communication equipment.

A rack in the passenger compartment above the rear galley at station 2100 on the right side of the aircraft contains the flight recorders.

There are also equipment racks adjacent to the forward, aft and bulk cargo doors. The forward cargo racks contain the primary flight control, actuator control, radio altitude, fuel quantity and cargo handling electronics. The aft cargo racks contain the HF communication, brake and tire and main gear steering electronics. The bulk cargo racks contain the APU battery and charger.

1) Air Conditioning and Pressurisation

The aircraft has two air conditioning systems divided into left pack and right pack. Engine bleed air provides the pneumatic source for air conditioning and pressurisation.

There are two electronic Controllers, each of which can provide both pack and zone control. Each Controller has two channels that alternate command cycle. Cockpit and cabin temperature selection is monitored, and the Air cycle machine and temperature control valves will be commanded to deliver temperature conditioned air to the various cabin zones.

Conditioned air is also used for electronic equipment cooling. This is supplied through a series of pneumatic valves with supply and exhaust fans. Exhaust air from the equipment cooling flow is routed to the forward cargo and used for forward cargo compartment heating.

Two cabin pressure Controllers regulate the aircraft pressurisation and command the pneumatic system. System operation is automatic and works in conjunction with the forward and aft outflow valves that are used for pressurisation. The outflow valves can also be manually operated from the cockpit by switches on the overhead panel.

Loss of cabin pressure will be indicated to the flight crew by a Cabin Altitude warning message on the Engine Indicating and Crew Alerting System (EICAS) display together with the associated aural warning.

2) Autopilot Flight Director System

The autopilot is engaged by operation of either of two A/P pushbutton switches on the Mode Control Panel (MCP) located on the glareshield panel (*Figure 1.6C* [below]). Once engaged the autopilot can control the aircraft in various modes selected on the MCP. Normal autopilot disengagement is through either control wheel autopilot disengage switch. The autopilot can disengage if the flight crew override an

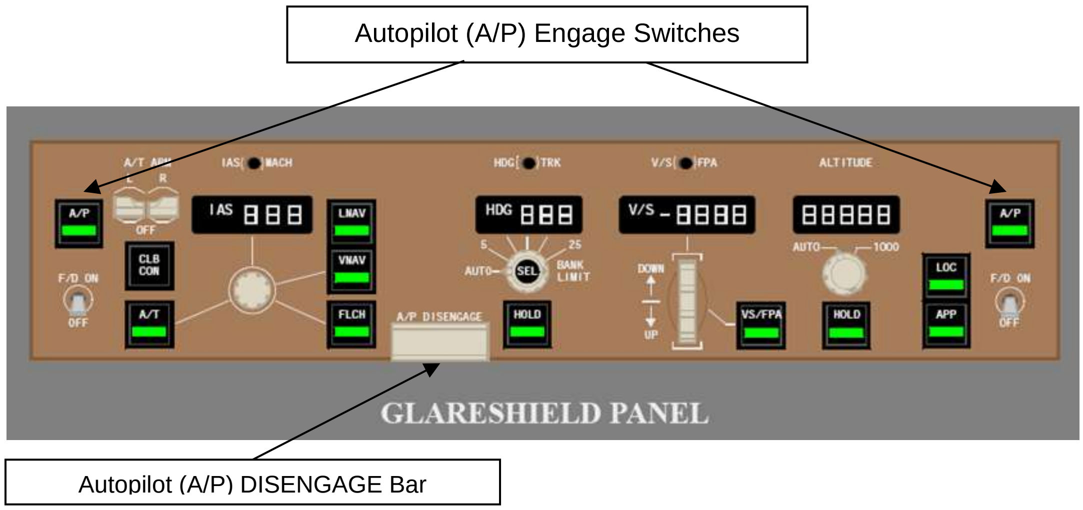

Figure 1.6C - Autopilot Mode Control Panel

autopilot command through the use of the control column, control wheel or rudder pedals (when the yaw axis is engaged for approach).

The autopilot can also be disengaged by pulling down on the A/P Disengage Bar on the MCP. The autopilot will also disengage automatically for failures of systems on which it relies upon for specific operations. The Autopilot Flight Director System (AFDS) consists of three Autopilot Flight Director Computers (AFDCs), one MCP, and six backdrive actuators (one each for the Captain's and First Officer's control column, control wheel, and rudder pedals). The left and right 28V DC buses power the left and right AFDCs, respectively and the MCP while the 28V DC battery bus powers the centre AFDC.

Emergency power from the Ram Air Turbine (RAT) generator does not power these busses and as a result the autopilot will not function with RAT electrical power.

a) Take-off Mode

The Take-off (TO/GA) mode controls roll and pitch during take-off. Also, the Thrust Management Computing Function (TMCF) controls thrust during take-off. Turning a flight director on while the aircraft is on the ground, or activating either TO/GA switch while on the ground, will engage Take-off mode.

b) Roll Modes

The following AFDS roll modes are available during climb, cruise and descent (*Figure 1.6D* [below]*):*

i) Lateral Navigation

Pushing the Lateral Navigation (LNAV) switch arms or disarms the LNAV mode. The commands come from the active Flight Management Computing Function (FMCF) when there is a valid navigation data base and an active flight plan.

ii) Heading Hold/Track Hold

Pushing the Heading Hold (HDG HOLD)/Track hold (TRK HOLD) switch selects Heading or Track hold. In this mode, the aircraft holds either heading (HDG) or track (TRK). If the HDG/TRK display on the MCP shows TRK, the aircraft holds track. If the HDG/TRK display on the MCP shows HDG, the aircraft holds heading.

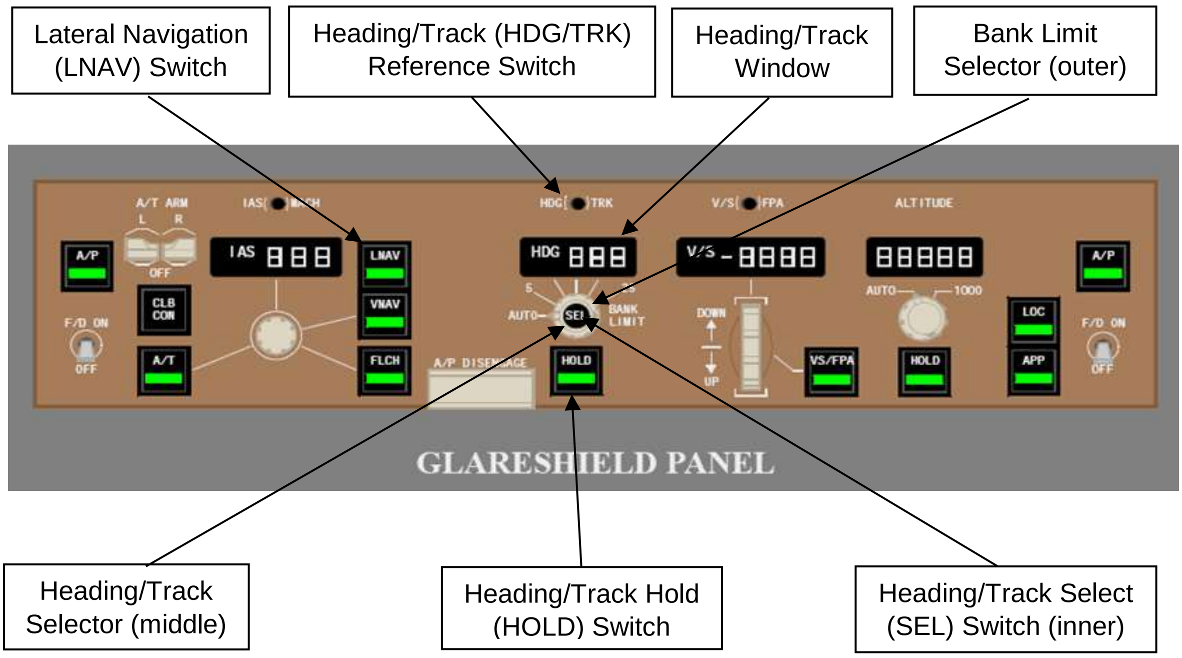

Figure 1.6D - Lateral Mode Switches and Indicators

iii) Heading Select/Track Select

Pushing the Heading Select (HDG SEL)/Track Select (TRK SEL) switch (inner) selects Heading Select or Track Select modes. In this mode, the aircraft turns to the heading or track that shows in the heading/track window. Pushing the Heading/Track (HDG/TRK) Reference switch alternately changes the heading/track reference between heading and track. Rotating the Heading/Track selector (middle) sets the heading or track in the heading/track window. If the HDG/TRK display shows HDG, the aircraft goes to and holds the heading that shows in the heading/track window. If the HDG/TRK display shows TRK, the aircraft goes to and holds the track that shows in the heading/track window. Rotating the Bank Limit selector (outer) sets the bank limit when in the Heading Select or Track Select modes. In the AUTO position, the limit varies between 15 - 25°, depending on True Airspeed. When the other detented positions are selected, the value is the maximum, regardless of airspeed.

iv) Roll Attitude Hold

The Roll Attitude Hold mode is used to hold the roll attitude that exists at the time the flight director is first turned on, or the autopilot is first engaged. The Roll Attitude Hold mode is activated, and ATT annunciated, if the bank angle is greater than 5 degrees when either:

- A flight director is turned on with the autopilot not engaged; or
- The autopilot is initially engaged with no flight director on.

c) Pitch Modes

The following AFDS pitch modes are available during climb, cruise and descent (*Figure 1.6E* [below]):

i) Vertical Navigation

Pushing the vertical navigation (VNAV) switch arms or disarms the VNAV mode. In this mode, the AFDS uses vertical steering commands provided by the Flight Management Computer Function (FMCF). The FMCF vertical steering commands come from the active FMCF based on the navigation data and the active flight plan.

ii) Vertical Speed/Flight Path Angle

Pushing the Vertical Speed/Flight Path Angle (V/S-FPA) switch selects the V/S or FPA mode. Rotating the V/S-FPA selector Up or Down sets the vertical speed or flight path angle in the vertical speed/flight path angle window. Pushing the V/S-FPA Reference switch alternately changes vertical speed/flight path angle window references between vertical speed and flight path angle. The vertical speed or flight path angle command is an elevator command. The pilot uses this mode to change flight levels. The pilot must set the engine thrust necessary to hold the vertical speed or flight path angle command. When the V/S/FPA display shows V/S, the aircraft goes to and holds the vertical speed that shows on the vertical speed/flight path angle window.

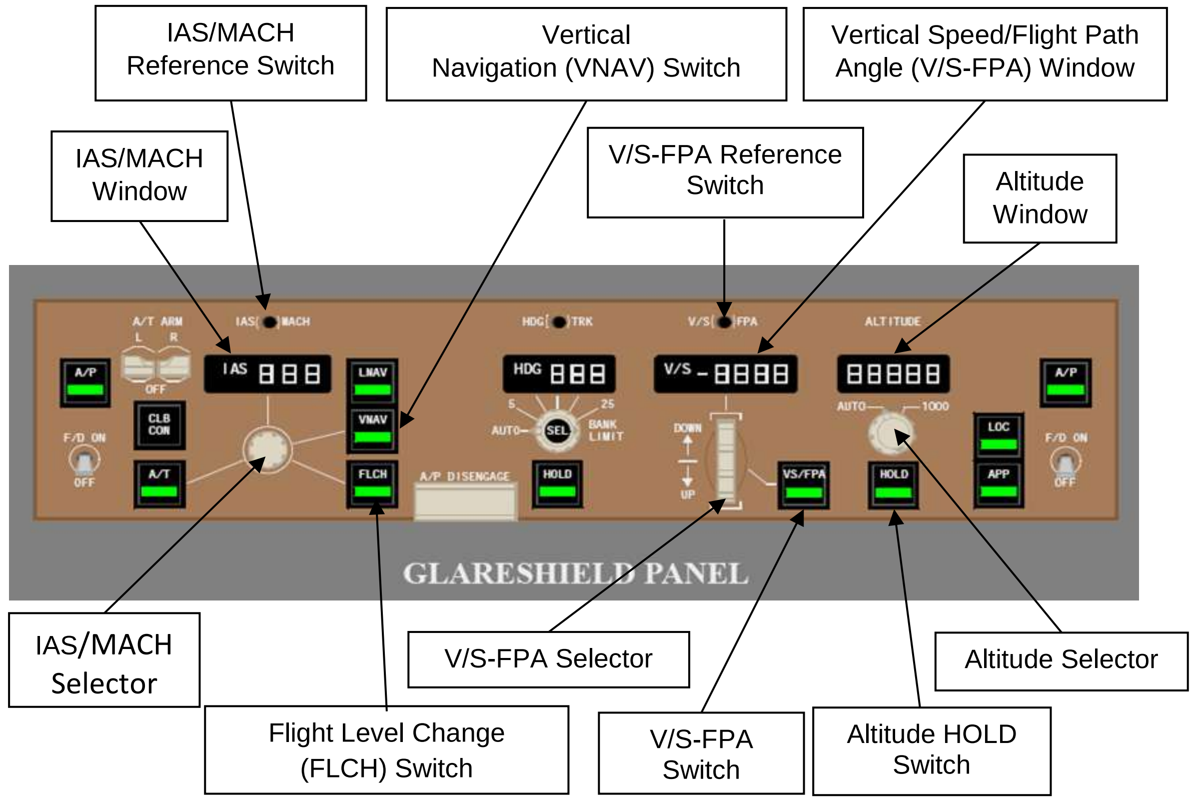

Figure 1.6E - Vertical Mode Switches and Indicators

iii) Flight Level Change

Pushing the Flight Level Change (FLCH) switch selects the FLCH mode. In this mode, the AFDS will control to the speed target in the IAS/MACH window, providing climb and descent guidance and control. FLCH mode may be used with autothrottles, or with manual throttle control. When the IAS/MACH display shows IAS, the elevator command holds the speed that shows on the IAS/MACH window. When the IAS/MACH display shows MACH, the elevator command holds the MACH that shows on the IAS/MACH window. Rotating the IAS/MACH selector sets the speed in the IAS/MACH window. Pushing the IAS/MACH Reference switch alternately changes the IAS/MACH window between IAS and MACH. The Thrust Management Computing Function (TMCF) supplies the engine thrust commands.

iv) Altitude Hold

Pushing the Altitude Hold (ALT) switch selects the Altitude hold mode. In this mode, the aircraft holds the barometric altitude present when the pilot pushes the altitude HOLD switch. Altitude Capture and Hold can also be engaged from a climb or descent as the aircraft approaches the altitude that is selected and displayed in the altitude window.

d) Landing Modes

The following AFDS functions are available for landing:

i) Localizer

The Localizer (LOC) mode captures and holds the aircraft to a localizer flight path.

ii) Glideslope

The Glideslope (G/S) mode captures and holds the aircraft to a vertical descent flight path.

iii) Flare

The flare (FLARE) mode controls the aircraft to a smooth touchdown at a point past the glideslope antenna. This is a computed command and is not part of the glideslope mode.

iv) Runway Alignment

In crosswind conditions, the runway alignment mode supplies roll and yaw control to decrease the aircraft crab angle for touchdown. The runway alignment mode also includes roll and yaw control for an engine failure in approach during autoland.

v) Rollout

After touchdown, the rollout **(**ROLLOUT) mode controls the aircraft to the runway centre line. Aircraft deviation from the localizer centre line supplies rudder and nose wheel steering signals.

vi) Go-Around

The go-around (TO/GA) mode controls roll and pitch after an aborted approach. Also, the TMCF controls thrust during go-around.

Pushing the LOC switch arms or disarms the localizer as roll mode. Pushing the Approach (APP) switch arms or disarms the localizer as roll mode and G/S as pitch mode (*Figure 1.6F* [below]*).*

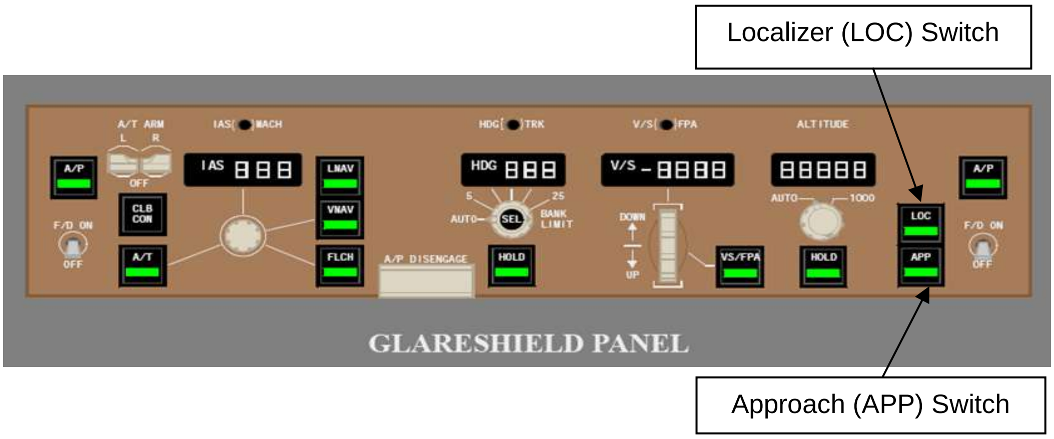

Figure 1.6F - Approach Mode Switches

e) Autothrottle (Thrust Management Computing Function)

The autothrottle (A/T) commands the thrust levers to achieve an engine thrust setting, or a selected airspeed. The A/T is armed by raising one or both A/T Arm switches, and is engaged by a pushbutton switch on the MCP (*Figure 1.6G* [below]).

During normal flight operations, the flight crew uses the Thrust Management Computing Function (TMCF) to perform several routine or normal operations and tasks. These operations or tasks relate to autothrottle modes. The A/T modes operate in these flight phases:

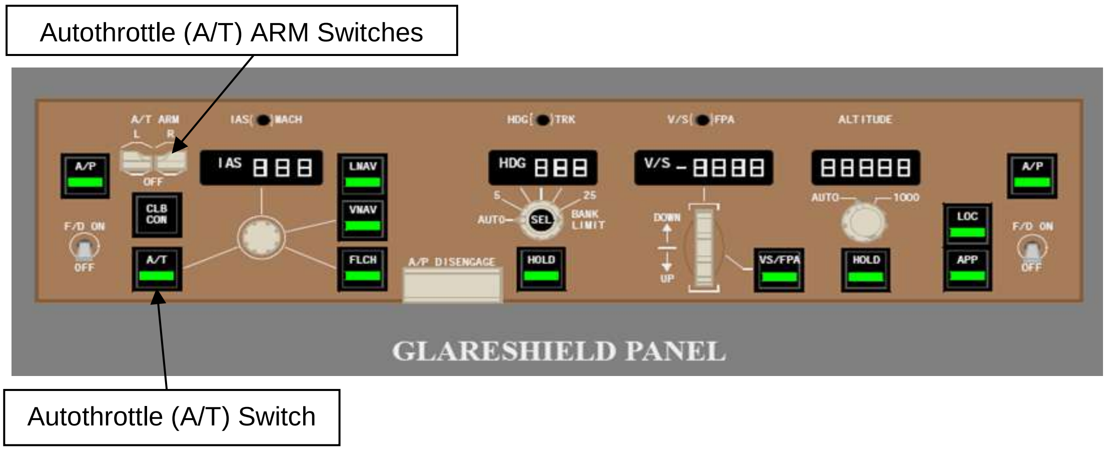

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Figure 1.6G - Autothrottle Switches

- Take-off (TO)
- Climb (CLB)
- Cruise (CRZ)
- Descent (DES)
- Approach (APP)
- Go-around (GA)

Autothrottle thrust mode annunciations relate to pitch mode annunciations on the Primary Flight Display (PFD).

f) Autothrottle Modes

i) Take-off

In take-off (TO), the autothrottle controls thrust to the TO thrust limit. The autothrottle mode annunciation on the PFD is thrust reference (THR REF). At a threshold air speed, the autothrottle mode annunciation on the PFD changes to HOLD.

ii) Climb

These are the three autothrottle mode selections in climb (CLB):

- Vertical navigation (VNAV)
- Flight level change (FLCH)

- Autothrottle (MCP) speed mode or thrust mode.

These are the autothrottle mode annunciations for these modes:

- THR REF when VNAV engages
- THR when FLCH engages
- SPD or THR REF when autothrottle mode engages.

The autothrottle speed mode only engages when VNAV, FLCH, and TO/GA are not active, and the aircraft is in the air.

iii) Cruise

In cruise, the pitch mode could be VNAV PTH, VNAV ALT or MCP ALT; the corresponding A/T mode is SPD.

iv) Descent

These are the three autothrottle modes in descent (DES):

- VNAV
- FLCH
- Autothrottle speed mode

These are the autothrottle mode annunciations in descent:

- IDLE, THR, SPD or HOLD shows for VNAV
- THR, or HOLD shows for FLCH
- SPD shows for V/S, FPA or no AFDS mode

v) Approach

SPD is normal mode in approach with glideslope active or in a manual approach (APP).

- **Go-Around**

  A go-around (GA) mode request causes the autothrottle mode to change to THR. A second GA request causes the autothrottle mode to change to THR REF. The TO/GA switch must be pushed to request GA.

- **Flare Retard**

  Flare retard occurs when a specified altitude threshold has been achieved when in SPD mode, or during an Autoland approach with a command from the autopilot flight director system (AFDS). The autothrottle mode changes to IDLE during a flare retard.

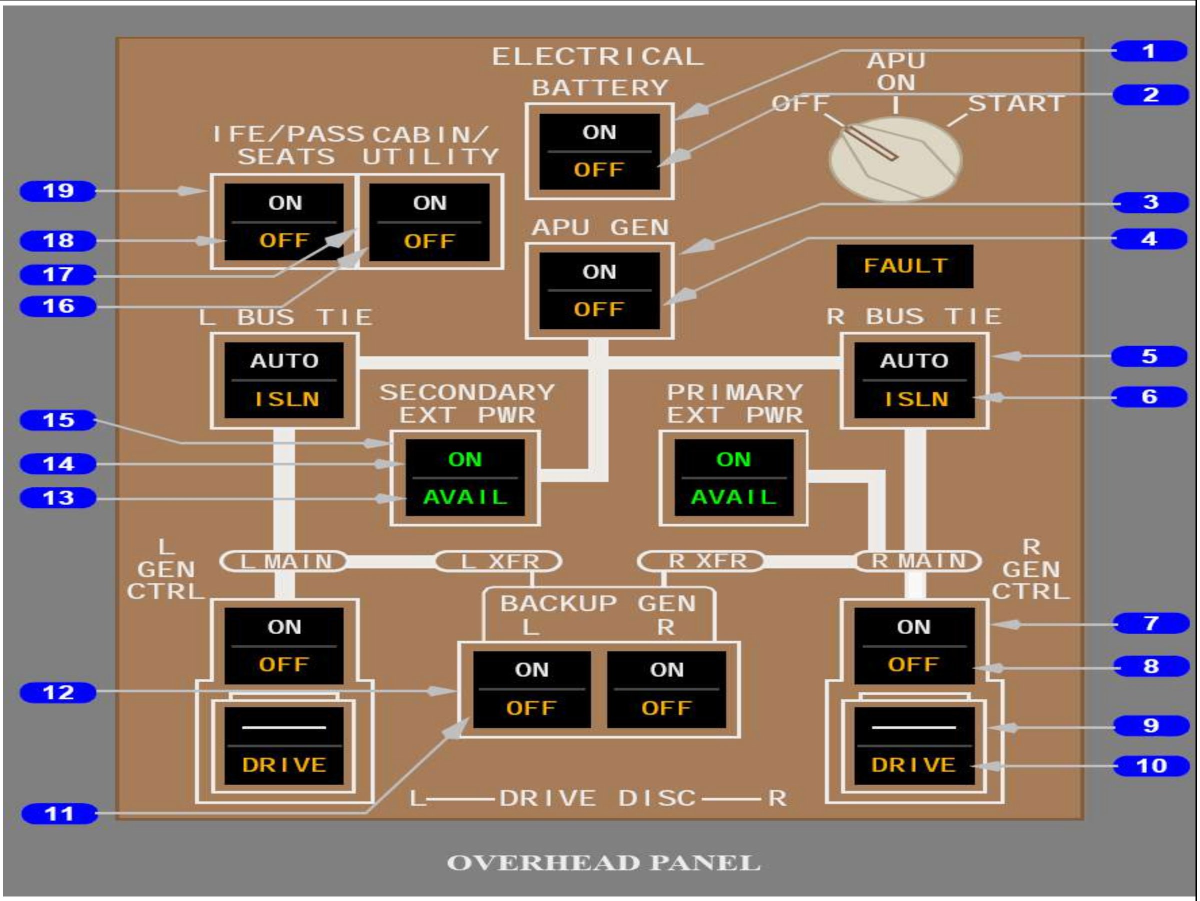
vi) Autothrottle Disconnect

The autothrottle disconnects when there is a manual autothrottle disconnect or when there is thrust reverser application. This occurs after initial touchdown during rollout. The autothrottle will disconnect automatically for certain system faults.

3) Electrical Power

The electrical system generates and distributes AC and DC power to other aircraft systems, and is comprised of: main AC power, backup power, DC power, standby power, and flight controls power. System operation is automatic. Electrical faults are automatically detected and isolated. The AC electrical system is the main source for aircraft electrical power. *Figure 1.6H* (below) shows the cockpit electrical panel where electrical switching can be made. It also shows the associated lights.

As the various aircraft systems rely on electrical power, failure of the electrical buses will affect the systems operation which will in turn trigger the corresponding fault messages. These messages are collected by the CMCS which will transmit the messages, via the ACARS, to the Maintenance Control Centre (MCC).



Electrical Power Panel Switches/Lights			
1.	Battery Switch	11.	Backup Generator OFF Lights
2.	Battery OFF Light	12.	Backup Generator (BACKUP GEN) Switches
3.	APU Generator (APU GEN) Switch	13.	External Power AVAIL Lights
4.	APU Generator OFF Light	14.	External Power ON Lights
5.	BUS TIE Switches	15.	External Power (EXT PWR) Switches
6.	BUS Isolation (ISLN) Lights	16.	CABIN/UTILITY Power OFF Light
7.	Generator Control (GEN CTRL) Switches	17.	Cabin/Utility (CABIN/UTILITY) Power Switch
8.	Generator OFF Lights	18.	IFE/PASS SEATS OFF Light
9.	Drive Disconnect Switches	19.	In Flight Entertainment System/ Passenger Seats (IFE/PASS SEATS) Power Switch
10.	Generator DRIVE Lights		

Figure 1.6H - Electrical Power Panel Switches/Lights

a) Electrical Load Management System

The Electrical Load Management System (ELMS) provides load management and protection to ensure power is available to critical and essential equipment. If the electrical loads exceed the power available (aircraft or external), ELMS automatically shed AC loads by priority until the loads are within the capacity of the aircraft or ground power generators. The load shedding is non-essential equipment first, then utility busses. Utility busses are followed by individual equipment items powered by the main AC busses. When an additional power source becomes available or the loads decrease, ELMS restores power to shed systems (in the reverse order). The message LOAD SHED displays on the electrical synoptic when load shed conditions exist.

b) Alternating Current Electrical System Power Sources

The entire aircraft alternating current (AC) electrical load can be supplied by any two main AC power sources. The main AC electrical power sources are:

- left and right engine integrated drive generators (IDGs)
- APU generator
- primary and secondary external power

The power sources normally operate isolated from one another. During power source transfers on the ground (such as switching from the APU generator to an engine generator) operating sources are momentarily paralleled to prevent power interruption.

c) Integrated Drive Generators

Each engine has an Integrated Drive Generator (IDG). Each IDG has automatic control and system protection functions. When an engine starts, with the GENERATOR CONTROL switch selected ON, the IDG automatically powers the respective main bus. The previous power source is disconnected from that bus.

The IDG can be electrically disconnected from the busses by pushing the GENERATOR CONTROL switch to OFF. The IDG can also be electrically disconnected from its respective bus by selecting an available external power source prior to engine shutdown. The DRIVE light illuminates and the EICAS message ELEC GEN DRIVE L or R displays when low oil pressure is detected in an IDG. The IDG drive can be disconnected from the engine by pushing the respective DRIVE DISCONNECT switch. The IDG cannot be reconnected by the flight crew. High drive temperature causes the IDG to disconnect automatically.

d) Auxiliary Power Unit Generator

The Auxiliary Power Unit (APU) generator is electrically identical to the IDG generators. The APU generator can power either or both main busses and may be used in flight as a replacement to an IDG source. If no other power source is available when the APU generator becomes available, the APU generator automatically connects to both main AC busses. If the primary external source is powering both main busses, the APU powers the left main bus, and the primary external source continues to power the right main bus. If the primary external source is powering the right main bus, and the secondary external source is powering the left main bus, the APU then powers the left main bus and the primary external source continues to power the right main bus. If the secondary external source is powering both main busses, the APU then powers both main busses.

The APU generator OFF light illuminates when the APU is operating and the APU generator breaker is open because of a fault or the APU GENERATOR switch is selected OFF. When the APU GENERATOR switch is ON and a fault is detected, the APU generator cannot connect to the busses.

In flight, when both transfer busses are unpowered, the APU starts automatically, regardless of APU selector position.

e) Alternating Current Electrical Power Distribution

The AC power is distributed through the left and right main busses and the ground service bus. The right IDG normally powers the right main bus and the left IDG normally powers the left main bus. The APU normally powers both main busses when they are not powered by any other source.

Bus tie relays, controlled by BUS TIE switches, isolate or parallel the right and left main busses. When both BUS TIE switches are set to AUTO, the bus tie system operates automatically to maintain power to both main busses.

Power transfers are made without interruption when the aircraft is on the ground, except when switching between primary and secondary external power sources. The source order for powering left and right main busses in flight is the:

- respective IDG
- APU generator
- opposite IDG

f) Autoland

During autoland, the busses isolate to allow three independent sources to power the three autopilots:

- the left IDG powers the left AC transfer bus, the left main DC bus, and the captain's flight instrument bus;
- the right IDG powers the battery bus and AC standby bus through the main battery charger; and
- the back-up system powers the right AC transfer bus, the right DC bus, and the first officer's flight instrument bus.

g) Backup Alternating Current Electrical System

The electrical system is highly reconfigurable to accommodate multiple failures. The electrical system is designed to automatically provide power to selected aircraft systems. The electrical system automatically powers one or both transfer busses when:

- only one main AC generator (includes APU) is available;
- power to one or both of the main AC busses is lost;
- approach (APP) mode is selected for autoland; and
- the system is automatically tested after engine starts

The system automatically transfers power without interruption.

h) Backup Generators

Backup power is provided by one variable speed, variable frequency generator mounted on each engine. A frequency converter converts the generator frequency to a constant 400 Hz. Only one backup generator can power the converter at a time.

Each backup generator contains two permanent magnet generators (PMGs) that supply power to the flight control DC electrical system (refer to DC Electrical System). If both IDGs and the APU generator are inoperative, a backup generator powers essential aircraft equipment. To reduce electrical loading on the backup generator, the following systems are inoperative:

- TCAS
- SATCOM
- Right HF radio

i) Direct Current Electrical System

The direct current (DC) electrical system includes the main DC electrical system and the flight control DC electrical system. The main DC electrical system uses four transformer-rectifier units (TRUs) to produce DC power. The TRUs are powered by the AC transfer busses.

TRU DC electrical power is distributed to various DC busses as follows:

(1) The left TRU powers the left main DC bus, which provides a second DC power source for:

- left flight control power supply assembly (PSA)
- right main DC bus.

(2) The right TRU powers the right main DC bus, which provides a second DC power source for:

- right flight control PSA
- left main DC bus.

(3) The C1 TRU powers the captain's flight instrument bus and the battery bus. The captain's flight instrument bus provides a second DC power source for:

- centre flight control PSA
- first officer's flight instrument bus

The C2 TRU powers the first officer's flight instrument bus, which provides a second DC power source for the captain's instrument bus.

j) **Batteries**

The main battery is connected directly to the hot battery bus and provides standby power to other busses. The main battery charger normally powers the hot battery bus and maintains the main battery fully charged.

The APU battery is connected directly to the APU battery bus and provides dedicated power to the APU electric starter, which is used when sufficient bleed air duct pressure is unavailable for the APU air turbine starter. The APU battery charger normally powers the APU battery bus and maintains the APU battery fully charged.

k) **Flight Control Direct Current Electrical System**

The flight control DC electrical system is a dedicated power source for the primary flight control system. Primary power for the flight control DC electrical system comes from permanent magnet generators (PMGs) housed within each backup generator. Variable frequency PMG AC power is used by individual power supply assemblies (PSAs) to provide DC power to the three flight control DC busses. To ensure a high level of system reliability, each PSA also has multiple DC power sources. If primary PMG AC power is not available, secondary power for the left and right PSAs is provided by the related main DC bus. Secondary power for the centre PSA is provided by the captain's flight instrument bus. The hot battery bus provides additional backup power for the left and centre PSAs only. Each PSA also uses a dedicated battery to prevent power interruptions to the related flight control DC bus. The batteries have limited capacity and are incorporated to supply power for brief periods during PSA power source transfers.

l) **Standby Electrical System**

The standby electrical system can supply AC and DC power to selected flight instruments, communications and navigation systems, and the flight control system, if there are primary electrical power system failures. The standby electrical system consists of:

- the main battery
- the standby inverter
- the RAT generator and its associated generator control unit
- the C1 and C2 TRUs

(1) Main Battery

The main battery provides standby power to the:

- hot battery bus
- battery bus
- captain's flight instrument bus
- left and centre flight control PSAs
- standby inverter.

Note:

The main battery can power the standby system for a minimum of 10 minutes.

(2) Standby Inverter

The standby inverter converts DC power to AC power. The inverter powers the AC standby bus if the left transfer bus is not powered.

(3) Ram Air Turbine Generator

The ram air turbine (RAT) generator provides standby power to the C1 and C2 TRUs. The RAT can supply electrical and hydraulic power simultaneously. If the RAT is unable to maintain RPM, the RAT generator electrical load is shed until RPM is satisfactory. Power for standby electrical loads is provided by the main battery during deployment of the RAT and when RAT generator loads are shed. The RAT is deployed automatically if both AC transfer busses lose power in flight. The RAT can be manually deployed by using the RAM AIR TURBINE switch on the overhead panel.

(4) Cabin Systems and Utility Power

Electrical power to some cabin and utility systems are controlled from the cockpit. The IFE/PASS SEATS Power switch controls power to the IFE and passenger seats. The CABIN/UTILITY Power switch controls power to cabin and utility systems.

4) Cabin and Cargo Compartments

The aircraft, 9M-MRO was configured to 35 business class and 247 economy class seats. The business class and economy class seats were procured from BE Aerospace. An approved Lay Out of Passenger Accommodation (LOPA) determines the cabin interior configuration. Safety and emergency equipment are fitted and positioned throughout the cabin.

There is one crew rest area in the forward cabin behind the cockpit. There is a cabin crew rest area in the aft cabin lower lobe. Access is through a compartment door adjacent to Door 3R.

The cockpit door provides selective entry to the cockpit and is resistant to ballistic penetration. When closed, the door locks when electrical power is available and unlocks when electrical power is removed. A viewing lens in the door allows observation of the cabin. The door can be manually opened from the cockpit by turning the door handle.

An emergency access code is used to gain access to the cockpit in case of pilot incapacitation. Access is provided by the use of a Keypad Access System which consists of a numeric keypad outside the cockpit area and a chime module and electric strike that is not accessible from outside the cockpit. The chime module provides an audible alert to the pilots that the correct code has been entered into the keypad. There is also an indicator light in the cockpit and a Light Emitting Diode (LED) on the keypad that indicates that the correct code has been entered.

The pilots have a 3-position switch by which they can open the door lock, close the door lock, or permanently lock the door for a specified amount of time to prevent access by anyone regardless if the correct code is entered into the keypad.

The door has blowout panels that will open in the event of a rapid decompression of the passenger compartment. A pressure sensor controls an electric strike and allows the door to open inward in the event of a rapid decompression in the cockpit. These features serve to equalise the pressure between the passenger compartment and the cockpit in case of decompression either side of the door.

The aircraft is also fitted with a Flight Deck Entry Video Surveillance System (FDEVSS) which provides the pilots surveillance capability of the cockpit doorway and the forward galley areas. This allows the pilots to see the person who wants to access the cockpit before they allow entry.

There are four Type A passenger and service doors on each side of the aircraft. Each door has a window. The passenger compartment has windows along both sides of the passenger compartment. Each exit is fitted with a slide raft system for emergency use.

The overhead passenger cabin is fitted with Passenger Service Units (PSU) above each seat row. They are hinged and secured by a magnetic latch that is electrically controlled. In the event of cabin depressurisation, the PSU magnetic latch will be electrically released and allow the oxygen masks to drop for passenger use.

The aircraft cabin lighting system comprises of ceiling lights, sidewall lights, entry lights and emergency lights. The cabin management system (CMS) controls the passenger cabin lighting.

The lower section of the fuselage houses forward, aft and bulk cargo compartments. A cargo handling system is fitted for the forward and aft cargo to command power drive units (PDU) to move cargo containers laterally and longitudinally.

Cargo compartment sidewalls, ceilings and walkways are constructed of fire resistant materials. There is a smoke detection warning system and fire extinguishing system installed to contain any smoke or fire eventualities.

5) Flight Controls

The flight control system is an electronic fly by wire system. It is divided into two separate systems to control the aircraft in flight.

Primary Flight control system (PFCS) is a modern three axis, fly by wire system. It controls the roll, yaw and pitch commands using the ailerons, flaperons, spoilers, elevators, rudder and horizontal stabilizer. The high lift control system (HLCS) comprises of inboard and outboard trailing edge flaps, leading edge flaps and Kruger flaps. It supplies increased lift at lower speeds for take-off and landing.

The PFCS and HLCS use 3 dedicated ARINC 629[9] Flight Control digital busses to transmit data signals to command the flight controls. Mechanical control is available to two spoilers and horizontal stabilizers.

The PFCS has three operational modes of command - Normal mode, Secondary mode and Direct mode. The PFCS command signals are computed by three redundant Primary Flight Computers (PFCs) in Normal and Secondary modes and directed through four Actuator Control Electronic (ACE) units. In Direct mode, the control surface command signals are computed by the ACEs without reliance on the PFCs.

The PFC also receives airspeed, altitude and inertial reference data from Airplane Information Management System (AIMS), Air Data Inertial Reference Unit (ADIRU) and Secondary Attitude and Air Data Reference unit (SAARU). The PFCs calculate the flight control commands based on control laws, augmentation and envelop protections. The digital command signals from the PFCs go to the ACEs that will change the digital signal to analogue format and send to the power control units (PCU) that will command the control surface movement.

The HLCS operates in three modes, primary, secondary and alternate. Command signals are transmitted from the flap lever to two Flap Slat Electronic Units (FSEU).

The FSEU process the flap command and control the sequence of flaps and slats operation. It also commands auto slat, load relief and asymmetry protection.

Two spoilers and the horizontal stabilizer receive mechanical control signals from pilots input.

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[9] *Aeronautical Radio, Incorporated (ARINC) 629 is an aeronautical standard which specifies multi-transmitter data bus protocol where up to 128 units can share the same bus.*

6) Fuel System

The fuel system has three fuel tanks, two integral wing tanks and one centre tank. The tanks are part of the wing structure and have many fuel system components located inside the tanks and on the rear spar. The fuel tanks are vented through channels in the wing to allow near ambient pressure during all phases of flight.

An integrated refuel panel (IRP) on the lower left wing and two refuel receptacles on each wing allows rapid pressure refueling of the aircraft. The refueling operation is automatic with fuel load selection on the IRP. Fuel quantity indicating system (FQIS) processor unit controls all fueling operations and measuring of fuel quantity.

Several enhanced features were incorporated in the design to include the following:

- Ultrasonic Fuel Quantity Indicating system
- Automatic centre tank scavenge system
- Ultrasonic water detection system
- Densitometers
- Jettison system

Fuel quantity is displayed on the fuel synoptic page and the upper EICAS fuel block.

a) Engine Fuel Feed System

There are two boost pumps for each main tank and two override/ jettison pumps in the center tank to supply fuel to the engines. The fuel flows through the crossfeed manifold to the engines. Redundant crossfeed valves isolate the left and right sides of the manifold.

At the start of a flight, when all the tanks are full, the normal procedure is to turn on all the fuel pumps. The override/jettison pumps supply center tank fuel to both engines. This occurs because the override/jettison pumps have a higher output pressure than the main tank boost pumps. When the override/jettison pump output pressure decreases because of low fuel quantity in the center tank, the boost pumps automatically supply fuel to both engines from the main tanks.

b) **Auxiliary Power Unit Fuel Feed System**

The Auxiliary Power Unit (APU) can receive fuel from any tank. A DC pump supplies fuel from the left main tank if no AC power is available. APU fuel is supplied from the left fuel manifold. APU fuel can be provided by any AC fuel pump supplying fuel to the left fuel manifold or by the left main tank DC fuel pump. On the ground, with the APU switch ON and no AC power available, the DC pump runs automatically. With AC power available, the left forward AC fuel pump operates automatically, regardless of fuel pump switch position, and the DC fuel pump turns off. In flight, the DC fuel pump operates automatically for quick left engine relight with the loss of both engines and all AC power. *Figure 1.6I* (below) shows the Engine and APU Fuel Feed System.

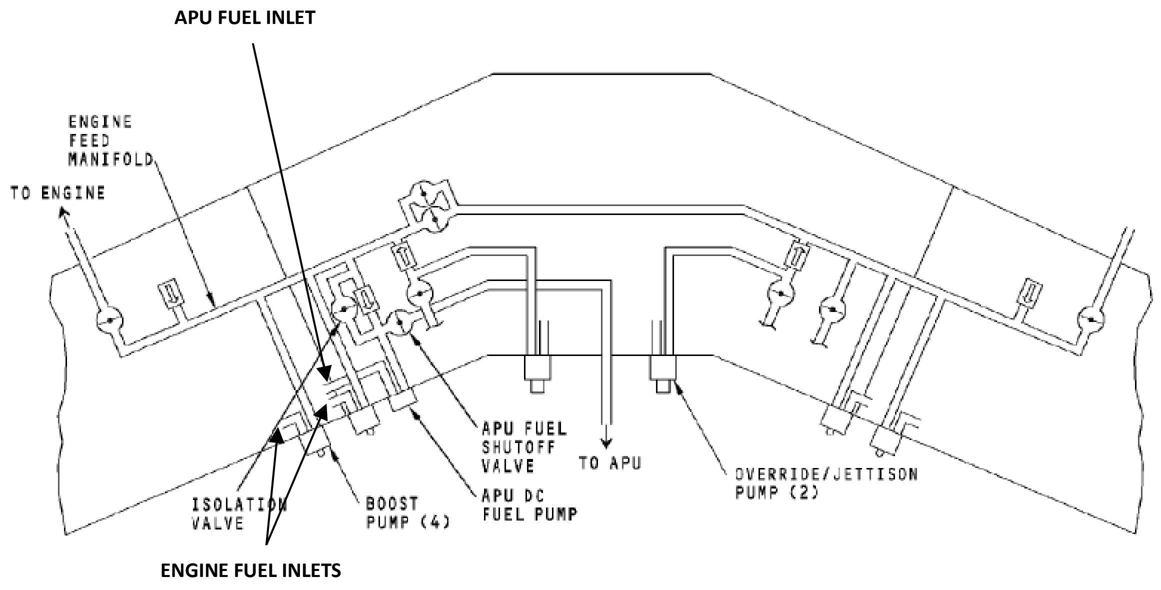


Figure 1.6I - Engine and APU Fuel Feed

c) **Fuel Inlets**

The fuel intake inlet for the APU (in the left main tank) is located lower than that for the engine. As the fuel level drops below the engine fuel intake level the engine will be starved of fuel, however fuel will still be available for the APU as its fuel intake is lower. This difference in level between the engine and APU fuel intakes, accounts for approximately 30 pounds of fuel in a standard flight attitude (1° pitch). The APU is estimated to consume (when electrically loaded) approximately 2 pounds of fuel in 55 seconds which will amount to a maximum APU run time of 13 minutes and 45 seconds. The pitch attitude and in-flight accelerations can affect the actual amount available for the APU.

7) Hydraulics

There are three independent hydraulic systems using electrical, pneumatics or engine driven power source. They are identified as Left, Centre and Right. Each hydraulic system can independently operate the flight controls for safe flight and landing.

Each hydraulic system uses a Hydraulic Interface Module Electronics Card (HYDIM) for automatic control and indications. The three systems operate independently at 3000 psi nominal pressure.

The left system is powered by an engine driven pump (EDP) and an electric motor pump (ACMP). The right system is also powered by an EDP and ACMP. The centre system has two ACMP and two air driven pumps (ADP) and a ram air turbine (RAT) pump.

Hydraulic pumps control and indication are on the P5 overhead panel. During normal operation the flight crew will select the switches to the auto position before flight. The pressure and quantity indication is provided on the hydraulic synoptic page and the status page.

The primary pumps are the EDPs in the left and right system and the ACMPs for the centre system. These pumps operate continuously. The demand pumps are the ACMPs for the left and right systems and the ADPs for the centre system. These pumps normally operate only during heavy system demands. The operation logic is controlled and monitored by the HYDIM cards.

The RAT deploys automatically during flight when both engines are shutdown or for loss of all three hydraulic power. The RAT hydraulic pump supplies hydraulic power to some of the center hydraulic system flight controls. When the aircraft is operating on RAT power only, the flap drive hydraulic motor is isolated from the center hydraulic system and as a result the flaps will not respond to the cockpit flap handle inputs.

8) Instrumentation

The flight instruments and displays supply information to the flight crew on six flat panel liquid crystal display units:

- Captain and First Officer Primary Flight Display (PFD)
- Captain and First Officer Navigation Display (ND)
- Engine Indication and Crew Alerting System (EICAS)
- the Multifunction Display (MFD)

Standby Flight Instruments provide information on separate indicators. Clocks display Airplane Information Management System (AIMS) generated UTC time and date, or manually set time and date.

a) Primary Flight Display

The Primary Flight Display (PFD) presents a dynamic color display of all the parameters necessary for flight path control. The PFDs provide the following information:

- flight mode annunciation
- airspeed
- altitude
- vertical speed
- attitude
- steering information
- radio altitude
- instrument landing system display
- approach minimums
- heading/track indications, engine fail, Ground Proximity Warning System (GPWS), and Predictive Windshear (PWS) alerts.

Failure flags are displayed for aircraft system failures. Displayed information is removed or replaced by dashes if no valid information is available to the display system (because of out-of-range or malfunctioning navigation aids). Displays are removed when a source fails or when no system source information is available.

b) Navigation Display

The navigation displays (ND) provide a mode-selectable color flight progress display. The modes are:

- MAP
- VOR
- APP (approach)
- PLN (plan)

The MAP, VOR, and APP modes can be switched between an expanded mode with a partial compass rose and a centered mode with a full compass rose.

c) Engine Indication and Crew Alerting System

The Engine Indication and Crew Alerting System (EICAS) consolidates engine and aircraft system indications and is the primary means of displaying system indications and alerts to the flight crew. The most important indications are displayed on EICAS which is normally displayed on the upper centre display.

i) System Alert Level Definitions

(1) Time Critical Warnings

Time critical warnings alert the crew of a non-normal operational condition requiring immediate crew awareness and corrective action to maintain safe flight. Master warning lights, voice alerts, and ADI indications or stick shakers announce time critical conditions.

(2) Warnings

Warnings alert the crew to a non-normal operational or system condition requiring immediate crew awareness and corrective action.

(3) Cautions

Cautions alert the crew to a non-normal operational or system condition requiring immediate crew awareness. Corrective action may be required.

(4) Advisories

Advisories alert the crew to a non-normal operational or system condition requiring routine crew awareness. Corrective action may be required.

(5) Engine Indication and Crew Alerting System Messages

Systems conditions and configuration information are provided to the crew by four types of EICAS messages:

- EICAS alert messages are the primary method to alert the crew to non-normal conditions.
- EICAS communication messages direct the crew to normal communication conditions and messages.
- EICAS memo messages are crew reminders of certain flight crew selected normal conditions.
- EICAS status messages indicate equipment faults which may affect aircraft capability.

An EICAS alert, communications, or memo message is no longer displayed when the respective condition no longer exists.

d) Multifunction Display

The electronic checklist (ECL) system shows normal and non-normal checklists on a multifunction display (MFD). The electronic checklist system is not required for, and a paper checklist or other approved backup checklist must be available in the cockpit.

The checklist display switch on the display select panel opens the electronic checklist. The flight crew operates the checklist with the cursor control devices (CCDs).

The MFD has also communications functions which are used to control data link features. Data link messages not processed by the Flight Management Computer (FMC) are received, accepted, rejected, reviewed, composed, sent, and printed using communications functions on the MFD. ACARS and data link radio management functions are provided through communications management menus. The COMM display switch, located on the display select panel, displays the communications main menu on the selected MFD.

Communications functions are selected using the cursor control device. Message text entry is accomplished by entering data into the Control Display Unit (CDU) scratchpad and transferring it to the appropriate area. Messages can be printed on the cockpit printer. Incoming message traffic is annunciated by EICAS communications messages.

e) Standby Flight Instruments

The standby flight instruments include:

- standby attitude indicator
- standby airspeed indicator
- standby altimeter
- standby magnetic compass

An external Power Supply Assembly supplies power to the standby attitude and airspeed indicators and the standby altimeter. The standby magnetic compass does not require any electrical power except for its lighting.

(1) Standby Attitude Indicator

The Standby Attitude Indicator displays Secondary Attitude Air Data Reference Unit (SAARU) attitude. A bank indicator and pitch scale are provided.

(2) Standby Airspeed Indicator

The Standby Airspeed Indicator displays airspeed calculated from two standby air data modules (one pitot and one static). It provides current airspeed in knots as a digital readout box with an airspeed pointer.

(3) Standby Altimeter

The standby altimeter displays altitude from the standby (static) air data module. Current altitude is displayed digitally. A pointer indicates altitude in hundreds of feet. The pointer makes one complete revolution at appropriate intervals.

(4) Standby Magnetic Compass

A standard liquid–damped magnetic standby compass is provided. A card located near the compass provides heading correction factors.

f) Clock

A clock is located on each forward panel. Each clock displays Airplane Information Management System (AIMS) generated UTC time and date, or manually set time and date. The AIMS UTC time comes from the global positioning system (GPS). In addition to time, the clocks also provide alternating day-month and year, elapsed time, and chronograph functions.

9) Airplane Information Management System

The Airplane Information Management System (AIMS) collects and calculates large quantities of data. The AIMS manages this data for several integrated avionics systems. These systems are the:

- Primary display system (PDS)
- Central maintenance computing system (CMCS)
- Airplane condition monitoring system (ACMS)
- Flight data recorder system (FDRS)
- Data communication management system (DCMS) - including ACARS datalink
- Flight management computing system (FMCS)
- Thrust management computing system (TMCS)

The AIMS has software functions that do the calculation for each of these avionics systems. The AIMS supplies one other software function that many aircraft systems use. It is the data conversion gateway function (DCGF).

The AIMS has two cabinets, for redundancy, which do the calculations for other avionic systems. The Left cabinet is located in the forward rack of the Main Equipment Centre (MEC) while the Right cabinet is located in rear rack of the MEC. To do these calculations, each AIMS cabinet has the following:

- A cabinet chassis
- Four Input/output modules (IOM)

- Four Core processor modules (CPM)

The IOMs and CPMs are considered Line Replaceable Modules (LRM). The IOM transfers data between the software functions in the AIMS CPMs and external signal sources. The CPMs supply the software and hardware to do the calculations for several avionic systems. The software is called functions. To keep a necessary separation between the functions, each function is partitioned. The partitions permit multiple functions to use the same hardware and be in the same CPM.

The Left AIMS cabinet gets electrical power from the 28V DC Capt Flight Instrument bus and the 28V DC F/O Flight Instrument bus. The Right AIMS cabinet gets electrical power from the 28V DC Left bus and the 28V DC Right bus. Each cabinet receives the power from four 28V DC circuit breakers in the overhead circuit breaker panel. The four 28V DC bus inputs are known as power 1 through power 4. Power 1 and power 2 enter the cabinet through a connector on the left side of the cabinet and therefore they are considered as left power. Power 3 and power 4 enter the cabinet through a connector on the right side of the cabinet and are considered as right power.

Each LRM receives power from four sources, two for main power and two for monitor power. The main circuitry uses the main power. Special circuits that monitor the condition of the power supply in the LRM use the monitor power. The two main and two monitor sources of power for each LRM come from different power sources.

Each AIMS cabinet also receives power through one hot battery bus circuit breaker in the standby power management panel. The connection to the hot battery bus keeps the LRMs internal memories active. The hot battery bus also makes the AIMS cabinet less likely to have faults due to power transients.

10) Navigation Systems

The Navigation systems of interest include Global Positioning System (GPS), Air Data Inertial Reference System (ADIRS) and the Flight Management System (FMS).

a) Global Positioning System

The Left and right GPS receivers are independent and use navigation satellites to supply very accurate position data to the

FMC. One is powered by the 115V AC Standby bus and the other by the 115V AC Transfer bus. They pass data to aircraft systems including the ADIRS via the AIMS. GPS tuning is automatic. If the Air Data Inertial Reference Unit (ADIRU) becomes inoperative during flight, the EICAS displays the message NAV ADIRU INERTIAL and the FMC uses only GPS data to navigate.

b) Inertial System

The ADIRS calculates aircraft altitude, airspeed, attitude, heading, and position data for the displays, flight management system, flight controls, engine controls, and other systems. The major components of ADIRS are the ADIRU, Secondary Attitude and Air Data Reference Unit (SAARU), and air data modules. The ADIRU supplies primary flight data, inertial reference, and air data. The ADIRU is fault-tolerant and fully redundant. The SAARU is a secondary source of critical flight data for displays, flight control systems, and other systems. If the ADIRU fails, the SAARU automatically supplies attitude, heading, and air data. SAARU heading must be manually set to the standby compass magnetic heading periodically. The ADIRU and SAARU receive air data from the same three sources. The ADIRU and SAARU validate the air data before it may be used for navigation. The three air data sources are the left, centre, and right pitot and static systems.

c) Flight Management System

The FMS aids the flight crew with navigation, in-flight performance optimisation, automatic fuel monitoring, and cockpit displays. Automatic flight functions manage the aircraft lateral flight path (LNAV) and vertical flight path (VNAV). The displays include a map for aircraft orientation and command markers on the airspeed, altitude, and thrust indicators to help in flying efficient profiles. The flight crew enters the applicable route and flight data into the CDUs. The FMS then uses the navigation database, aircraft position, and supporting system data to calculate commands for manual and automatic flight path control. The FMS tunes the navigation radios and sets courses. The FMS navigation database supplies the necessary data to fly routes, SIDs, STARs, holding patterns, and procedure turns. Cruise altitudes and crossing altitude restrictions are used to calculate VNAV commands. Lateral offsets from the programmed route can be calculated and commanded.

The basis of the flight management system is the flight management computer function. Under normal conditions, one Flight Management Computer (FMC) accomplishes the flight management tasks while the other FMC monitors. The second FMC is ready to replace the first FMC if system faults occur. The FMC uses flight crew-entered flight plan data, aircraft systems data, and data from the FMC navigation database to calculate aircraft present position and pitch, roll, and thrust commands necessary to fly an optimum flight profile. The FMC sends these commands to the autothrottle, autopilot, and flight director. Map and route data are sent to the NDs. The EFIS control panels select the necessary data for the ND. The mode control panel selects the autothrottle, autopilot, and flight director operating modes.

Crew Procedure on the operations and programming of the Flight Management System safeguards and protects against incorrect execution of erroneous Information for the Navigation and Performance Data Input. Different levels of verification and cross checking between the Captain and Co-Pilot ensure that any error would be captured and corrected during the crew preparation.

In addition, system logics will also prevent the crew against selection of the wrong co-ordinates from the stored Navigation Database if a particular waypoint code happens to be used by many different places worldwide.

11) Oxygen Systems

a) Flight Crew Oxygen System

The flight crew oxygen system provides oxygen to the flight crew for emergencies and other procedures which make its use necessary. The oxygen is supplied by two cylinders located in the left side of the main equipment centre. Each cylinder is made of composite material and holds 115 cubic feet (3,256 litres) of oxygen at 1,850 psi. The oxygen is supplied, through regulators, to four oxygen masks in the cockpit, one each for the Captain, the First Officer, the First Observer and the Second Observer. The mask has a dilution control which is normally set at ‘Normal’ position. In this position the oxygen is diluted with ambient air according to the pressure altitude in the cockpit. It can also be selected to '100%', in which case 100% oxygen will be supplied. *Table 1.6E* (below) shows the expected duration of oxygen supply from the two cylinders with the dilution control in 'Normal' position.

AIRCRAFT ALTITUDE: 36,000 ft			
Cabin Altitude: 8,000 ft.		**Cabin Altitude: 36,000 ft.**	
No. of Crew Members	**Expected Duration (hour)**	**No. of Crew Members**	**Expected Duration (hour)**
1	42	1	27
2	21	2	13
3	14	3	9
4	10.5	4	6.5

Table 1.6E - Expected Duration of Crew Oxygen

Aircraft altitude is assumed to be 36,000 ft. A cabin altitude of 8,000 ft. would indicate a normally pressurised cabin and a cabin altitude of 36,000 ft. would indicate an unpressurised cabin. At this cabin altitude of 36,000 ft, 100% oxygen will be supplied even with the dilution control in the 'Normal' position.

b) Passenger Oxygen System

The passenger oxygen system is supplied by separate and individual chemical oxygen generators. The oxygen system provides oxygen to:

- passenger seats
- attendant stations
- lower crew rest compartment
- lavatory service units

The passenger oxygen masks and chemical oxygen generators are located in passenger service units (PSUs). A door with an electrically operated latch keeps the masks in a box until the oxygen deployment circuit operates. The deployment circuit operates, and the masks automatically drop from the PSUs if cabin altitude exceeds approximately 13,500 feet. The passenger masks can be manually deployed from the cockpit by pushing the overhead panel PASSENGER OXYGEN switch to the ON position. Oxygen flows from a PSU generator when any mask hanging from that PSU is pulled. Oxygen is available for approximately 22 minutes. The electrical power to the latch is supplied through a circuit breaker located in the Main Equipment Centre. It is not possible to deactivate automatic deployment of the masks from the cockpit.

c) Portable Oxygen

Portable oxygen cylinder lets the flight attendants move in the aircraft when oxygen is in use. It is also a gaseous oxygen supply for medical emergencies. The bottle is fitted with disposable mask. 15 cylinders are located throughout the passenger cabin. Each cylinder is of 11 cubic ft (310 litres) capacity. The flow of oxygen can be controlled by an 'Off-On' knob which can be rotated to control the flow from 0 to 20 litres per minute. Therefore, the minimum time for the portable oxygen supply from full is 15.5 minutes.

12) Central Maintenance Computing System

The Central Maintenance Computing System (CMCS) collects and stores information from most of the aircraft systems. It can store fault histories as well as monitor and conduct tests on the various systems. The fault history contains details of warnings, cautions and maintenance messages.

At regular intervals, during flight, the CMCS transmits any recorded fault messages, via the Aircraft Communications Addressing and Reporting System (ACARS), to the Maintenance Control Centre (MCC) of Malaysia Airlines. This helps in the planning and preparation for the rectification of any potential aircraft defects at the main base or line stations. Refer also to *Section 1.6.4 para. 9)*.

13) Engines

The aircraft is fitted with two engines (Model: RB211 TRENT 892B-17) manufactured by Rolls-Royce. The RB211 TRENT 892B-17 engine is a high bypass turbofan (bypass ratio of 6.4:1 at a typical cruise thrust) axial flow, three-rotor with a single low pressure fan driven by a five-stage, low-pressure turbine.

The engine has an eight-stage intermediate pressure compressor driven by a single-stage turbine and a six-stage high pressure compressor driven by a single-stage turbine.

The engine take-off thrust is 92,800 lb and weighing approximately 15,700 lb (7,136 kg). The engines are certified in accordance with the US FAA Type Certificate E00050EN.

The FAA Type Certificate Data Sheet certifies that the engines meet the smoke and gaseous emission requirements of the US FAR 34. The engine is certified under FAR Part 36 Stage 3 Noise regulation.

The engine is fitted with a digital Electronic Engine Fuel Control System and it interfaces with many systems and components in the form of primary analogue or ARINC 629 buses.

The following analogue engine fuel and control system interfaces and correlates with the other systems for supply and feedback:

- Engine ignition - ignition unit power
- Engine air - actuator and valves
- Engine controls - resolver excitation and position
- Engine indicating - engine parameter data
- Engine exhaust - thrust reverser operations
- Engine oil - oil cooling and indications
- Engine starting - auto-start and manual start
- Electrical power - aircraft power from the Electrical Load Management System (ELMS)

The following ARINC 629 engine fuel and control system interfaces and correlates with other systems for supply, control and indication data:

- AIMS - indication, air data and flight management control
- Cockpit controls - switch position and indication
- Flap Slat Electronic Unit (FSEU) - Flap indication
- Proximity Switch Electronic Unit (PSEU) - Landing gear lever position
- Air Supply Cabin Pressure Controller (ASCPC) - Pneumatic system demand

The RB211 TRENT 892B-17 engine Electronic Engine Control (EEC) serves as the primary component of the engine fuel control system and uses data from the engine sensors and aircraft systems to control the engine operations. The EEC controls most of the engine components and receives feedback from them. These digital data go to the Engine Data Interface Unit (EDIU) and send the signal to the AIMS. The AIMS transmits and receives a large amount of data to and from the EEC. These include:

- Engine bleed status - EEC thrust limit calculations
- Air data - EEC thrust limit calculations
- Engine data – system requirements
- Autothrottle Engine Pressure Ratio (EPR) trim - thrust balancing
- Condition monitoring - performance tracking
- Maintenance data - trouble shooting
- Primary display system data - indication.

14) Auxiliary Power Unit

The aircraft is fitted with an Auxiliary Power Unit (APU) - Model: GTCP 331-500 - manufactured by Allied Signal. The Allied Signal GTCP 331-500 gas turbine APU is a two-stage centrifugal flow compressor, a reverse flow annular combustion chamber and a three-stage axial flow turbine. It supplies the auxiliary power system for the aircraft pneumatic and electrical power. This permits independent operations from the ground external power sources or the main engines.

The APU generator supplies 120 KVA electrical power at any altitude. The APU can start at all altitudes up to the service ceiling of the aircraft (43,100 ft/13,100 m). Electrical power is available up to the service ceiling and pneumatic power is available up to 22,000 ft (6,700 m).

The ELMS contains the APU autostart logic and sends signal to the APU Controller (APUC).

The APU Controller serves to control the APU functions for:

- Starting and ignition
- Fuel metering
- Surge control
- Inlet guide vane (IGV) control
- Data storage
- Protective shutdown
- BITE/Fault reporting

- APU indication

The APU is designed to automatically start when certain logic conditions are met when the aircraft is in the air or electrical power removed from left and right transfer buses from respective No. 1 and No. 2 engine generators.

15) Communications

For Communications Systems description, refer to *Section 1.9*.

1.6.9 Aircraft Performance

The detailed Boeing Performance analysis of the aircraft is provided in *Appendix 1.6E.* This section summarises the aircraft performance and range capability of MH370.

The following data were available to help analyse the possible flight paths of the aircraft: ACARS data, radar data, and satellite data. Wind data were incorporated along the paths to determine the true airspeed which was incorporated into the performance fuel burn and range analysis.

The ACARS data provided the quantity of fuel on board after approximately 25 minutes of flight following take-off from KUL.

The radar data provided information about the flight path and ground speed after the last ACARS transmission and captured the left turn off of the scheduled route until the data ended over the Straits of Malacca. The analysis of the radar data allowed for an estimation of the fuel burn during that portion of the flight. However, that estimation was built on many assumptions, including flying at constant altitude and constant airspeed during each flight segment.

The satellite data provided evidence that the satellite was in communication with the aircraft until the last transmission at time 0019:29.42 UTC, approximately 7 hours and 37 minutes after take-off from KUL. Refer to *Section 1.9.5*.

The performance range capability of the aircraft, along with the satellite data, allowed for the creation of multiple flight path profiles that demonstrate that the aircraft had the range capability to reach the 7th Arc[10].

[10] Arcs - Lines created along the earth representing a set of possible aircraft positions at the time of satellite communication based on Burst Timing Offset (BTO). Refer to *Appendix 1.6E* for further details.

Many assumptions were also made during the flight path profile creation, including but not limited to, constant altitude and constant speed from Arc 1 to Arc 7, with the restriction that there were no course changes between the arcs. Additional analyses were conducted in Boeing and MAS simulators that continued the analysis after fuel exhaustion and assumed no intervention in the cockpit.

The results of the simulator session showed that the aircraft would roll gently to the left due to residual rudder deflection commanded by the Thrust Asymmetry Compensation (TAC) with the end of flight occurring within a 100 nm^2 box that extended 10 nm beyond fuel exhaustion and 10 nm to the left of the flight path. The maximum range after dual engine flame-out would have been achieved through driftdown, with manual control keeping the aircraft in wings level flight, and would extend the range of the aircraft by approximately 120 nm beyond the location of the dual engine flame-out.

1.6.10 Boeing Patent on Remote Control Take-over of Aircraft

There have been speculations that MH370 could have been taken over control remotely in order to foil a hijack attempt. Some of these speculations have mentioned a US patent that Boeing filed for in February 2003 and received (US 7,142,971 B2) in November 2006 for a system that, once activated, would remove all controls from pilots and automatically fly and land the aircraft at a predetermined location.

According to the patent, existing preventative measures such as bullet-proof doors and the carriage of air marshals on board may have vulnerabilities. The flight crew could decide to open a lockable bullet-proof cockpit door [refer to *Section 1.6.8, para. 4*)] and air marshals, if used, might be over-powered. In light of the potential that unauthorised persons might be able to access the flight controls of an aircraft, the inventors conceived of a technique to avoid this risk by removing any form of human decision process that may be influenced by the circumstances of the situation, including threats or violence on-board.

The ‘uninterruptible’ autopilot envisioned by the patent could be activated, either by pilots, on-board sensors or remotely via radio or satellite links by the airline or government agencies if there were attempts to forcibly gain control of the cockpit. This system once activated would disallow pilot inputs and prevent anyone on-board from interrupting the automatic take-over. Thus, the personnel on-board could not be forced into carrying out the demands of any unauthorised person(s). To make it fully independent, the system described in the patent would have its own power supply, inaccessible in-flight, so that it could not be disengaged by tripping circuit breakers accessible on-board the aircraft. The aircraft would remain in automatic mode until after landing when ground crew working in conjunction with authorised personnel would be called to disengage the system.

Boeing has confirmed that it has not implemented the patented system or any other technology to remotely pilot a commercial aircraft and is not aware of any Boeing commercial aircraft that has incorporated such technology. The technology was never installed on an aircraft.

It should also be noted that the aircraft 9M-MRO was delivered in May 2002 to MAS before the patent was issued in 2006. The aircraft was under the control of MAS for the entire time after delivery except for a short duration at Pudong, Shanghai Airport, China in August 2012, when it underwent wing tip repair by Boeing [refer to *Section 1.6.4, para. 2*)]. Even then the repair was under the oversight of MAS engineers. Aircraft modification installation data do not indicate that any systems like that described in the patent were installed on the aircraft post delivery and during in-service. Airworthiness protocols require that all modifications are approved for installation and a record kept of each modification incorporated. There is no reason to believe any systems like that described in the patent either were or could have been incorporated without the knowledge of MAS.

From the foregoing, there is no evidence to support the belief that control of the aircraft 9M-MRO (operating as MH370) could have been or was taken over remotely as the technology was not implemented on commercial aircraft.

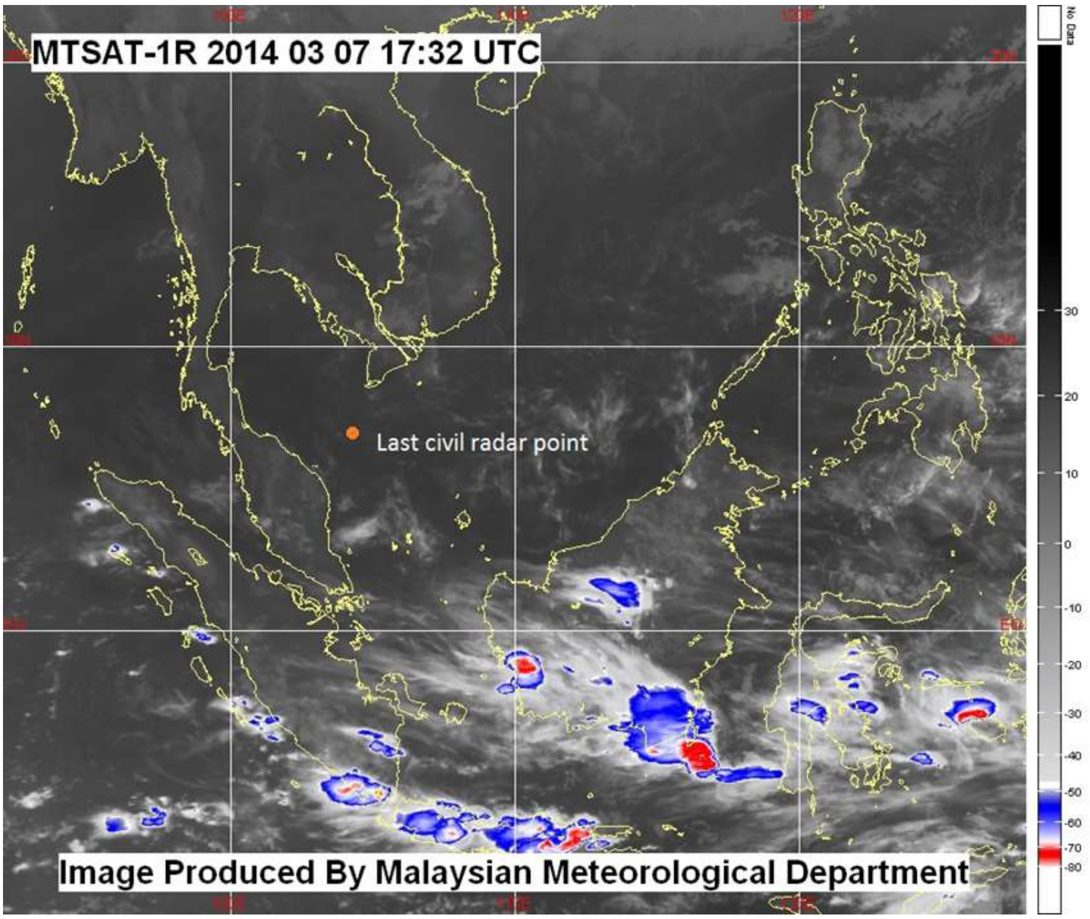
SECTION 1 – FACTUAL INFORMATION

1.7 METEOROLOGICAL INFORMATION

1.7.1 Meteorological Situation

Climatologically for the month of March, the position of the sub-tropical high is located over the Gulf of Thailand. The weather is generally dry with very little clouds. The winds are generally light from the surface to the height of 40,000 ft above sea level.

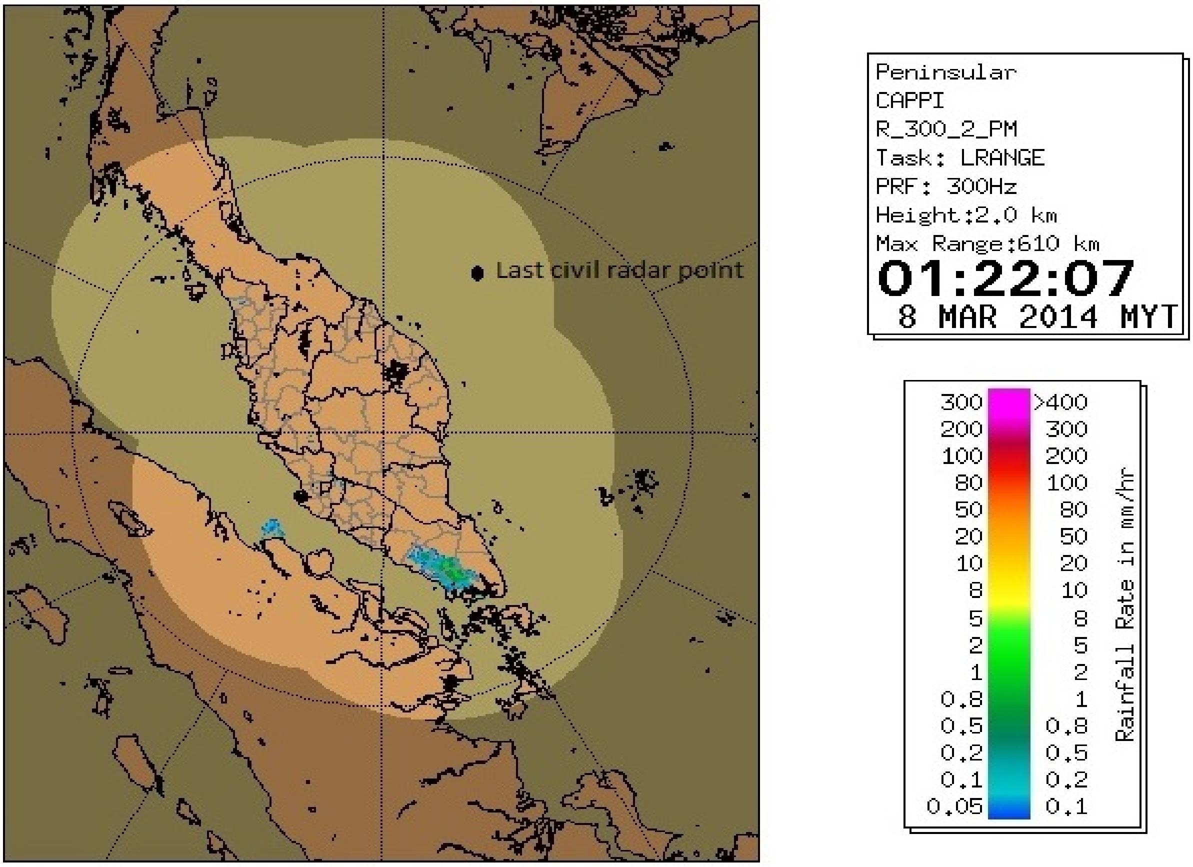
The infra-red image taken by the geostationary satellite Multifunctional Transport Satellites (MTSAT) 1R of Japan Meteorological Agency (JMA) at 1732 UTC 07 March 2014 [0132 MYT 08 March 2014] *(Figure 1.7A* [below]*)* showed that there were no significant clouds at the last civil radar point at 1722 UTC, 07 March 2014 [0122 MYT, 08 March 2014].



Source: Malaysian Meteorological Department

Figure 1.7A - Infrared Satellite image taken by MTSAT at 1732 UTC 07 March 2014 [0132 MYT, 08 March2014]

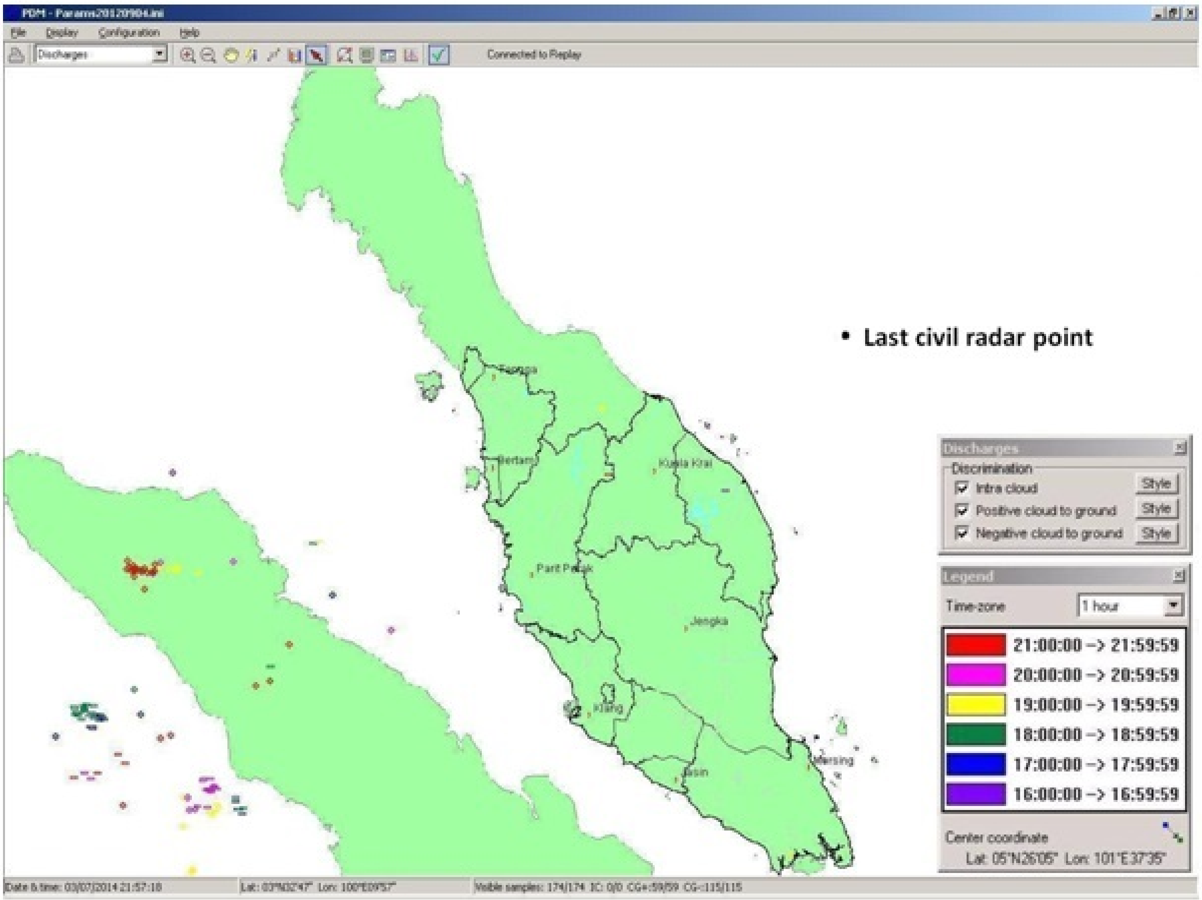
The meteorological radar image taken at 1722 UTC, 07 March 2014 [0122 MYT, 08 March 2014] (*Figure 1.7B* [below]) showed that no rain occurred at the last civil radar point.



Source: Malaysian Meteorological Department

Figure 1.7B - Meteorological Radar Image at 1722 UTC 07 March 2014 [0122 MYT, 08 March 2014]

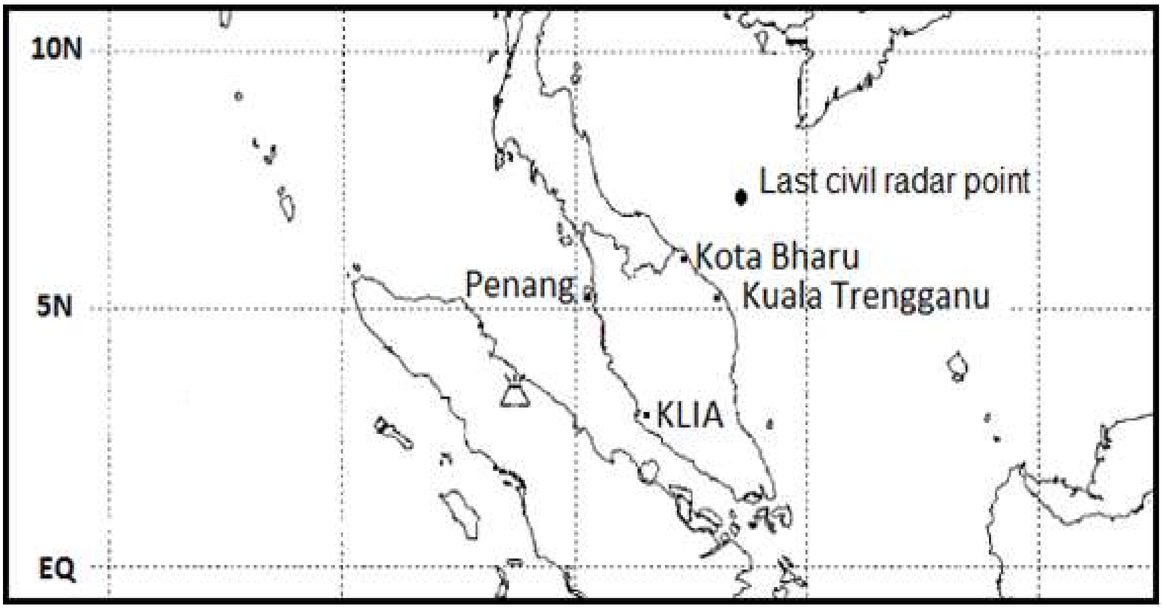
No lightning discharges were detected by the Lightning Detection System of the Malaysia Meteorological Department at the vicinity of last civil radar point from 1600 to 2159 UTC, 07 March 2014 [0000 to 0559 MYT, 08 March 2014]. *Figure 1.7C* (below) *Blue symbol* shows the lightning detected 1700 UTC to 1800 UTC, 07 March 2014 [0100 to 0200 MYT, 08 March 2014].



Source: Malaysian Meteorological Department

Figure 1.7C - Lightning Detection Map from 1600 to 2159 UTC 07 March 2014 [0000 to 0559, 08 March 2014]

The Meteorological Aerodrome Report (METAR) issued at 1600, 1700 and 1800 UTC [0000, 0100 and 0200 MYT, 08 March 2014] from Kota Bharu Sultan Ismail Petra Airport (WMKC), Kuala Terengganu Airport (WMKN), Penang International Airport (WMKP) and KLIA (WMKK) (*Figure 1.7D* [below]) did not report any significant weather phenomena.



Source: Malaysian Meteorological Department

Figure 1.7D - Locations of METAR Reports

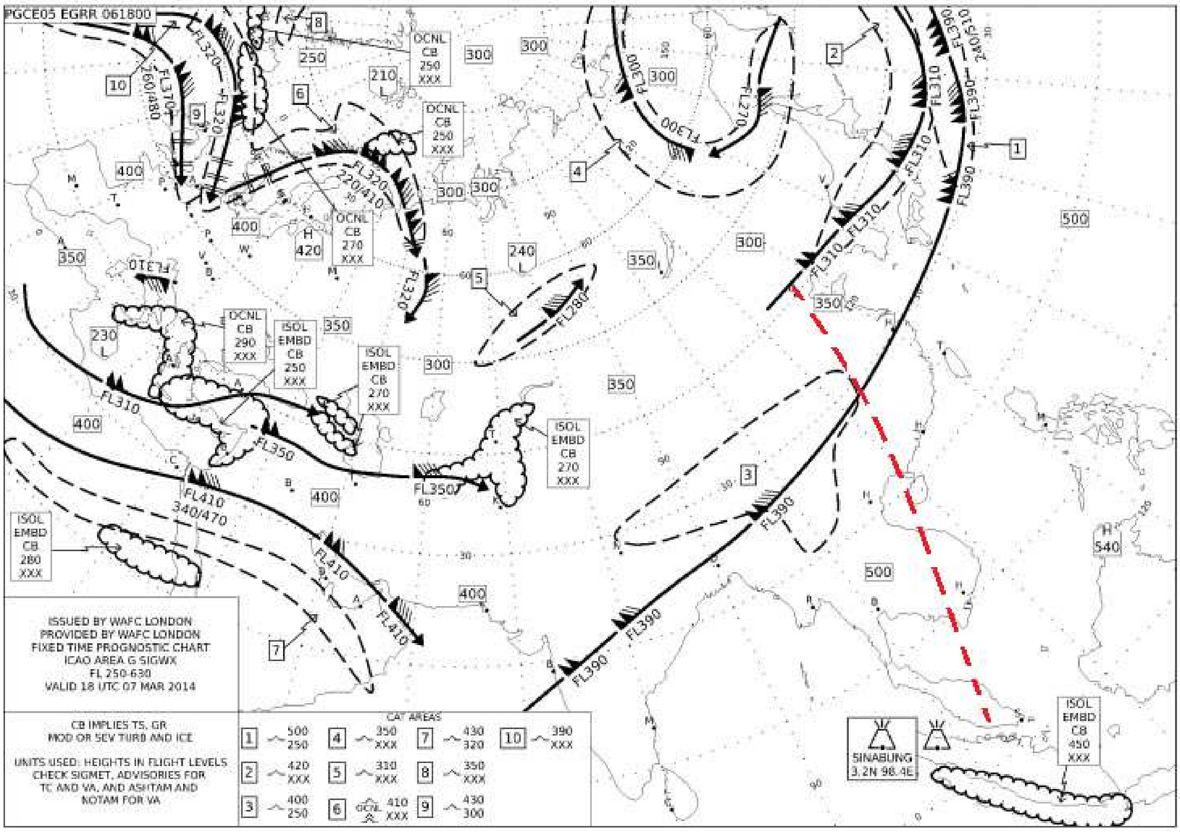
There was no direct observation of the wind conditions at the last civil radar point, the closest upper air observation was at the Kota Bharu Meteorological Station, taken at 1200 UTC, 07 March 2014 and at 0000 UTC, 08 March 2014 [2000 MYT, 07 March 2014 and 0800 MYT, 08 March 2014] respectively, both reported a temperature of -40ºC and wind from the north-east at 15 kt or less at 36,000 ft above sea level.

1.7.2 Comments on the Information Available

1) Forecast Charts

a) Significant Weather Chart

The Significant Weather Chart (SIGWX) *PGCE05 EGRR 061800* issued by World Area Forecast Centre (WAFC) London Fixed Time Prognostic Chart ICAO Area G SIGWX for FL250-630 (25,000 ft to 63,000 ft above standard sea-level pressure) valid 1800 UTC, 07 March 2014 [0200 MYT, 08 March 2014] showed that the filed flight plan route (red dotted line - *Figure. 1.7E* [below]) passed through a westerly jet stream with wind speed of up to 150 kt at latitude 30°N at FL390. Another westerly jet stream with wind speed of up to 100 kt at FL310 at the destination. Light clear air turbulence (CAT) might be expected from 25°N onwards to the destination. However, no significant adverse weather phenomenon was expected for the whole planned flight route.



Source: WAFC London

Figure 1.7E - Significant Weather Chart PGCE05 Issued by WAFC London Fixed Time ICAO Area G Prognostic Chart SIGWX FL250-630 valid 1800 UTC, 07 March 2014 [0200 MYT, 08 March 2014

b) Wind and Temperature Forecast Chart

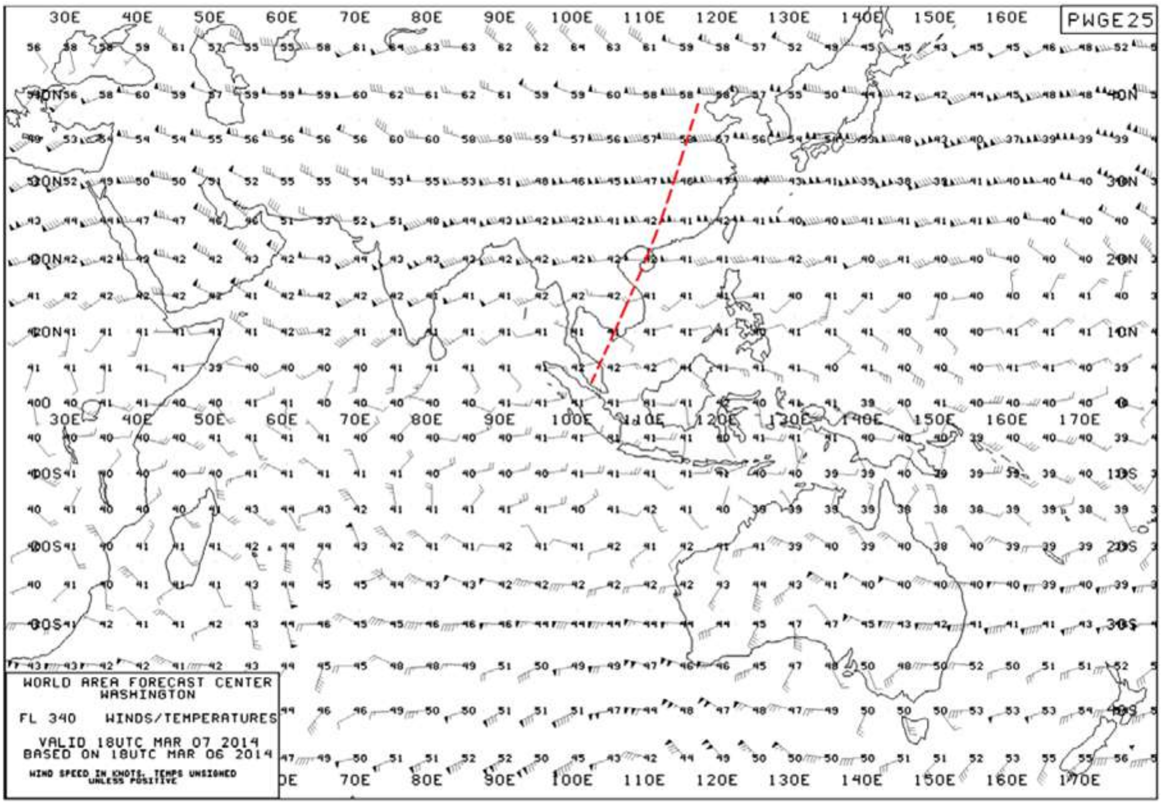
The wind and temperature forecast chart PWGE25 for FL340 valid 1800 UTC, 07 March 2014 issued by WAFC Washington showed the jet stream as in the significant weather chart above. The forecast winds at the last civil radar point and last air defence radar point were below 20 kt *(Figure 1.7F* [below]).

2) Significant Meteorological Information

Significant Meteorological Information (SIGMET) 3 was issued for the GUANGZHOU FIR valid from 12:45 to 16:45 UTC, 07 March 2014 [0200 MYT, 08 March 2014] indicated a thunderstorm forecast north of latitude 27°N and moving eastwards at 50 km/h in the layer with cloud tops at FL260.

3) Volcanic Ash Advisory

Volcanic ash advisories issued by Darwin Volcanic Ash Advisory Centre (VAAC) on 07 March 2014 at 06:27 and 18:37 UTC [2045 MYT, 07 March 2014 and 0045 MYT, 08 March 2014] for Sinabung (Sumatra, Indonesia) highlighted volcanic eruption located at 3.10°N 98.23°E (*Figure 1.7E* [above]*)* and volcanic ash plume observed up to FL120 and the plume was extending toward the west.



Source: WAFC Washington

Figure 1.7F - The wind and temperature forecast chart PWGE25 issued by WAFC Washington for FL340 valid 1800 UTC 07 March 2014 [0200 MYT, 08 March 2014]

1.7.3 Availability of Meteorological Information

The necessary meteorological information was made available to the crew.

SECTION 1 – FACTUAL INFORMATION

1.8 AIDS TO NAVIGATION

Not applicable.

SECTION 1 – FACTUAL INFORMATION

1.9 COMMUNICATIONS

1.9.1 High Frequency System

This aircraft was installed with Collins HFS-900 High Frequency (HF) System. The HF communication system on this aircraft uses two HF systems with a common HF antenna to transmit and receive radio frequency (RF) signals in the HF range.

The HF transceiver operates within the frequency range of 2,000 MHz to 29,999 MHz and one KHz channel spacing.

The Left Transfer bus sends 115V AC three-phase power to the Left HF communication system. The Left HF communication transceiver supplies 115V AC single phase to the Left HF antenna coupler for operational power. It also supplies 28V DC for the key interlock function. The Right HF communication system is the same as the Left, except that it uses power from the Right AC Sec 2 bus.

1.9.2 Very High Frequency System

This aircraft was installed with Collins VHF-900B VHF System. The very high frequency (VHF) communication system permits voice and data communication over line-of-sight distances. It permits communication between aircraft or between ground stations and aircraft. The VHF system operates in the VHF aeronautical frequency range of 118.000 MHz to 136.992 MHz.

The VHF communication system on this aircraft uses three VHF systems. Each VHF system has a VHF antenna and a VHF communication transceiver.

The VHF communication system connects with Selective Calling Equipment (SELCAL) decoder that starts an alert when a call comes in for that aircraft.

The captain's flight instrument bus sends 28V DC to the Left VHF communication transceiver and the Left Radio Tuning Panel (RTP). The Left Main DC bus sends 28V DC to the centre VHF communication transceiver and the centre RTP.

The Right Main DC bus sends 28V DC to the right VHF communication transceiver and the right RTP.

1.9.3 Air Traffic Control/Mode S Transponder System

This aircraft was installed with a Bendix/King TRA-67A Mode S transponder. The Air Traffic Control (ATC) ground stations interrogate the airborne ATC/Mode S transponder system as shown in *Figure 1.9A* (below).

The ATC/Mode S transponder replies to the interrogations in the form of coded information that the ground station uses. The ground station uses a Primary Surveillance Radar (PSR) to get radar returns from aircraft within the radar range. To make a communication link with the aircraft in the radar range, the ground station uses a Secondary Surveillance Radar (SSR) to interrogate the ATC/Mode S transponder. The ground station transmits a side lobe suppression signal to inhibit close ATC replies that come from a SSR side lobe transmission.

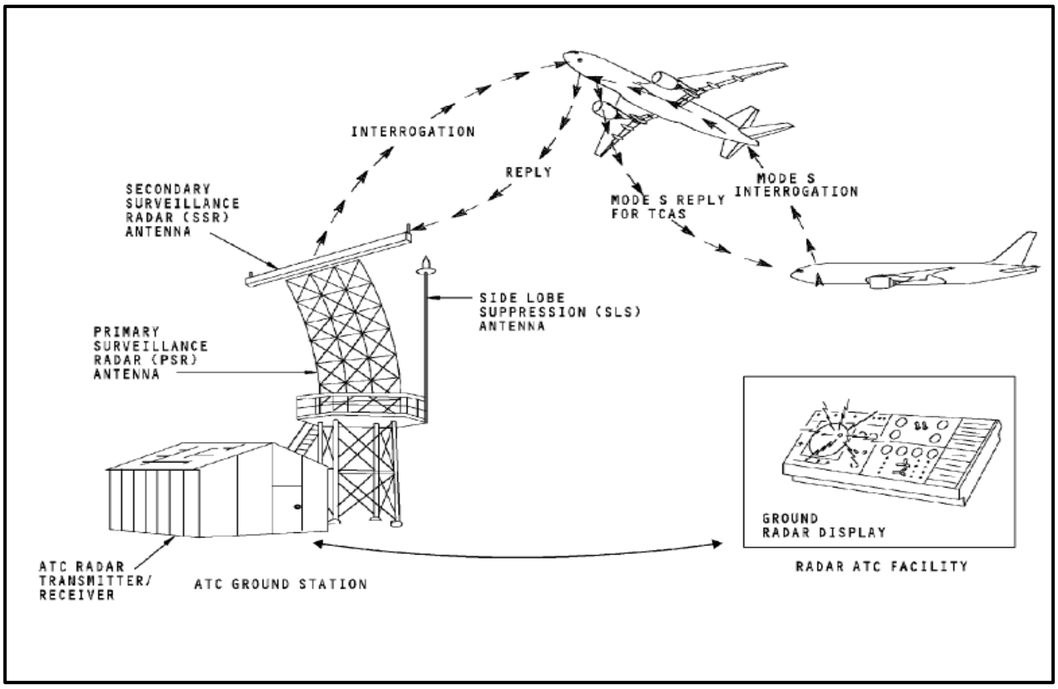


Figure 1.9A - Air Traffic Control/Mode S Transponder System

On the ground radar display, the Air Traffic Controller (ATC) sees the radar returns, altitude, and a four digit aircraft identifier. The ATC also sees aircraft derived Enhanced Surveillance downlink data on the ground station radar display, such as Magnetic Heading, Air Speed (Indicated Air Speed and Mach number), Ground Speed, Roll Angle, Selected Altitude, True Track Angle, and Vertical Rate.

The ATC/Mode S transponder also replies to mode S interrogations from the Traffic Alert and Collision Avoidance Systems (TCAS) of other aircraft. ATC/Mode S transponders with Extended Squitter function provide broadcast of Global Position System (GPS) position and velocity data.

Two transponders are installed on the aircraft. A Transponder selector switch on the Transponder panel in the cockpit allows selection of either the left or the right transponder. During normal operations the crew procedure is to leave the left transponder selected on the panel. There is no automatic switching between the transponders if one fails. It must be done manually by the pilots. Failure of either of the transponders will be annunciated in the cockpit. The Left ATC/Mode S transponder gets 115V AC power from the AC Standby bus. The Right ATC/Mode S transponder gets 115V AC power from the Right AC Transfer bus. The dual transponder panel gets 115V AC power from the AC Standby bus. The two transponders are powered by highly reconfigurable AC buses; the left one can be powered by the battery if the left AC bus is unavailable (the AC Standby bus can be powered by the left Transfer bus or the battery), and the AC Transfer busses also have their alternate sources.

This system can be deactivated (turned OFF) by pulling the circuit breakers located at the P11 overhead circuit breaker panel or by selecting the Transponder Mode Selector (Transponder Panel) to “STBY” position. The transponder on the occurrence flight was operating satisfactorily up to the time it was lost on the ATC radar screen at 1721.13 UTC, 07 March 2014 [0121:13 MYT, 08 March 2014]. There was no message received from the aircraft to report a system failure.

1.9.4 Aircraft Communications Addressing and Reporting System

The Aircraft Communications Addressing and Reporting System (ACARS) is a digital data-link system that manages flight plan and maintenance data between the aircraft and the Ground Service Provider (GSP) by using radio i.e. VHF or satellite communications (SATCOM) as shown in *Figure 1.9B* (below).

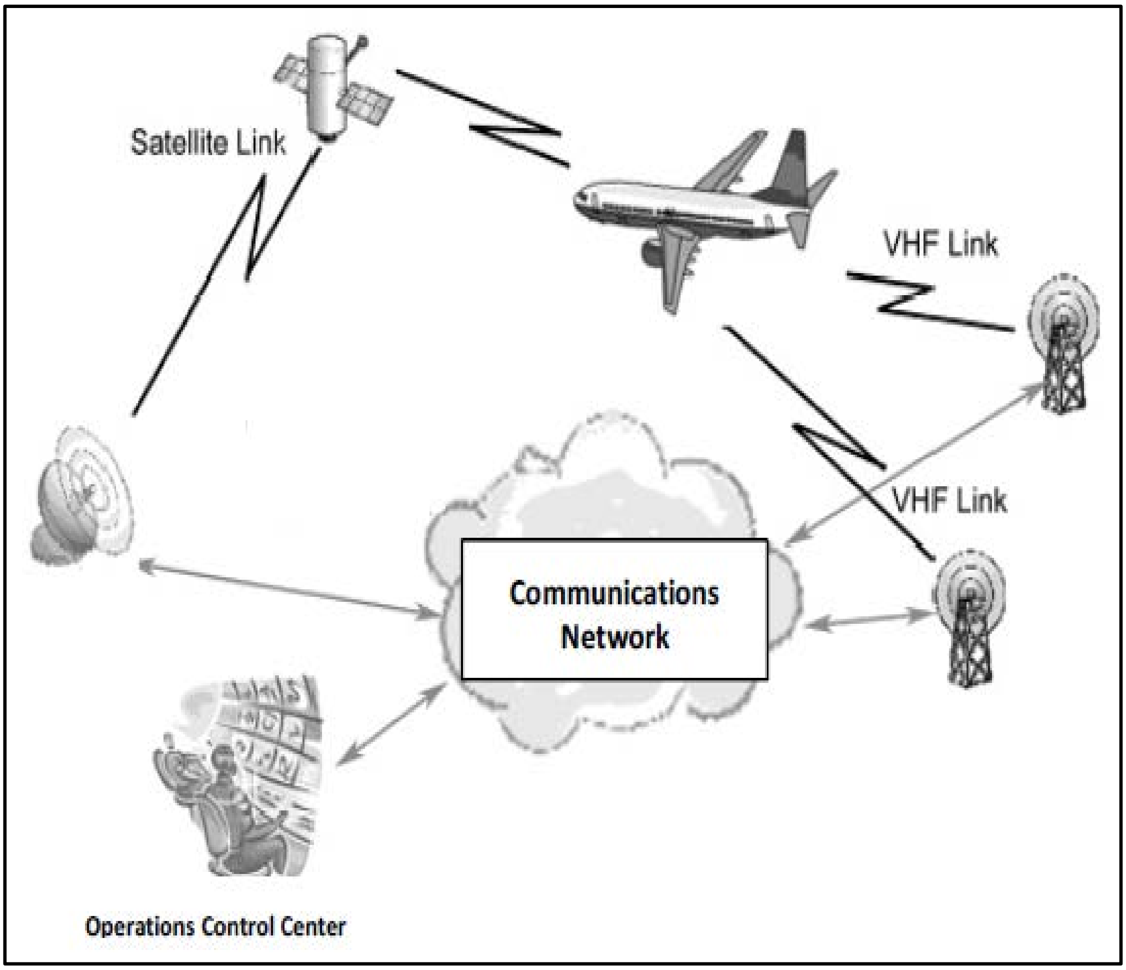


Figure 1.9B - ACARS System

ACARS provides message communication between aircraft and its base (ground). The following messages are transmitted:

- **O**ut of the gate, **O**ff the ground, **O**n the ground, and **I**nto the gate (OOOI) events:
  - **O**ut of the gate event: Departure from the gate with all doors closed and parking brake released;
  - **O**ff the ground event: Take-off with the nose gear squat switch extended;
  - **O**n the ground event: Touch down with the nose gear squat switch compressed; and
  - **I**nto the gate event**:** Parked at the gate with the parking brake set and the door open.

- Flight plans: ACARS interfaces with Flight Management Systems (FMS) acting as the communication system for flight plans to be sent from the ground to the FMS. This enables the aircraft to update the FMS while in flight and allows the flight crew to evaluate the alternative flight plans including the status of connecting flights.

- Weather information: ACARS interfaces with FMS, acting as the communication system for weather information to be sent from the ground to the FMS. This enables the aircraft to update the FMS while in flight and allows the flight crew to evaluate new weather conditions.

- Equipment health: ACARS is used to send information from the aircraft to ground stations about the conditions of various aircraft systems and sensors in real-time. Maintenance faults and abnormal events are also transmitted to ground stations along with detailed messages, which are used by MAS for monitoring equipment health, and to better plan the repair and maintenance activities.

- Aircraft positions which provide latitude and longitude, altitude, speed, total air temperature, total remaining fuel, wind direction and speed and heading.

- Engine performance data which provide engine data during take-off, climb, cruise and approach.

ACARS interfaces with the Multifunction Display (MFD) in the cockpit, which flight crew can use to send and receive technical messages and reports to or from ground stations, such as a request for weather information or clearances or the status of connecting flights. The response from the ground station is received on the aircraft via ACARS as well. The ACARS Manager page in the Communications main menu on the selected Multifunction Display (MFD) is used for this purpose. The COMM display switch, located on the display select panel, displays the communications main menu on the selected MFD. The ACARS Manager page allows the flight crew to independently select/deselect VHF or SATCOM transmission of data.

The ACARS communicates through either the VHF or the SATCOM systems. The ACARS datalink connects to the Satellite Data Unit (SDU) of the SATCOM system and the Center and Right VHF Communication Transceivers of the VHF systems. The Center VHF exchanges data with the ACARS modem in the Communications Core Processor Module (CPM/Comm) of the Left AIMS cabinet. The right VHF exchanges data with the ACARS modem in the CPM/Comm of the Right AIMS cabinet. The ACARS does not interface with the Left VHF Transceiver.

For the ACARS operation the Data Communication Management Function (DCMF) of the AIMS uses the voice/data select to set the VHF Communication Transceiver to the data signal mode. At power-up, the DCMF sets the Center VHF Communication Transceiver to the data signal mode. If the Center VHF Communication Transceiver fails, or voice is selected manually by the flight crew, the DCMF selects SATCOM for data transmissions. If SATCOM fails, the DCMF selects the Right VHF Communication Transceiver for data transmissions. The Left VHF Communication Transceiver is voice only. On the event flight, as instructed by Ground Operations via text message shown on the MFD (shown as 'Switch VHF3 to Voice'), the flight crew would have selected voice on the Center VHF resulting in SATCOM being used for the data transmissions. Refer to page 1 of *Appendix 1.9A – ACARS Traffic Log*. The use of SATCOM for the ACARS transmissions is evident in the SATCOM Ground Station Logs [refer to *Section 1.9.5*, *para. 4*)]. This switching from VHF to SATCOM for the data transmissions is normal practice in MAS for commercial reasons.

In the event that the aircraft ACARS unit has been silent for longer than a pre-set time interval, the ground station can ping the aircraft (directly or via satellite). A ping response indicates a healthy ACARS communication. This ping is different from the Satellite ping or handshake.

Pre-set time interval for MAS B777 is 30 minutes. When the aircraft ACARS is silent for more than 30 minutes, MAS Operation Control Centre (OCC) is required to send a text message via ACARS to the cockpit or to call the cockpit via SATCOM.

1) Aircraft Communications Addressing & Reporting System Traffic Log

ACARS traffic log messages sent/received to/from 9M-MRO between 1554:41 UTC, 07 March 2014 [2354:41 MYT, 07 March 2014] until 1815:25 UTC, 07 March 2014 [0215:25 MYT, 08 March 2014] is shown in *Appendix 1.9A*. Some key events are extracted and explained below.

At 1554:41 UTC, 07 March 2014, ACARS data link was fully established on SATCOM transmission and at 1556:08 UTC the flight information (FI) MH0370 and Aircraft Number (AN) 9M-MRO were keyed in by the crew as per *Figure 1.9C* (below).

Figure 1.9C - ACARS data link established SATCOM transmission

Notice to Crew (NOTOC) was sent at 1606:15 UTC on 07 March 2014 [0006:15 MYT, 08 March 2014] direct to the aircraft printer and to be printed out by the crew.

NOTOC from the ground station to the cockpit stated the special loads of total 4,566 kg of mangosteens were carried on board. Details of the mangosteens were:

- 1,128 kg at station 41L,
- 1,152 kg at station 41R,
- 1,148 kg at station 43L, and
- 1,138 kg at 44L respectively.

(Refer to *Section 1.18.2* for details of cargo carried).

Declaration of *"there is no evidence that any damaged or leaking packages containing dangerous goods have been loaded on the aircraft at this station"* was also written in the NOTOC message. *Figure 1.9D* (below) shows the snapshot of the ACARS NOTOC message.

Aircraft final loadsheet was sent via ACARS at 1606:32 UTC, 07 March 2014 [0006:32 MYT, 08 March 2014] direct to the aircraft printer and to be printed out by the crew. Details of aircraft weight as stated in the final loadsheet are discussed in *Section 1.6.5*.

16:06:15	46818160	Outgoing Uplink	9M-MRO	MH0370	MHKULKJACM001	071606	AGM	RELAY
Uplink Sent		AGM NOTOC Uplink B777 -- AGM NOTOC Uplink B77 QXSXMXS						

```
QU QXSXMXS
.DPCCAMH 071606
□AGM
AN 9M-MRO/FI MH0370/MA 989I
-
NOTOC MESSAGE
SPECIAL LOAD NOTOC

FLIGHT   DATE       EDNO
MH 0370 /08  08MAR14  01
FROM/TO  AC/REG
KULPEK   9M-MRO

OTHER SPECIAL LOAD

TO  POS PCS QTY/TI IMP
DESCRIPTION
PEK 41L 001 1128KG PER
MANGOSTEEN

PEK 41R 001 1152KG PER
MANGOSTEEN

PEK 43L 001 1148KG PER
MANGOSTEEN

PEK 44L 001 1138KG PER
MANGOSTEEN

THERE IS NO EVIDENCE
THAT ANY DAMAGED OR
LEAKING PACKAGES
CONTAINING DANGEROUS
GOODS HAVE BEEN LOADED
ON THE AIRCRAFT AT THIS
STATION.

END ACARS NOTOC
```

Figure 1.9D - Snapshot of ACARS NOTOC message

Figure 1.9E (below) shows the snapshot of the final loadsheet of this aircraft.

16:06:32	381598235	Outgoing Uplink	9M-MRO	MH0370	MHKULKJACM001	071606	AGM	RELAY
Uplink Sent		Loadsheet FINAL <9M-MR> -- LOADSHEET - AGM(Pi QXSXMXS						

```
QU QXSXMXS
.DPCCAMH 071606
□AGM
AN 9M-MRO/FI MH0370/MA 990I
-
X LOADSHEET FINAL  1606 01
MH0370/ 07MAR14
KUL PEK   9M-MRO   2/10
ZFW 174369 MAX 195044 L
TOF  49100
TOW 223469 MAX 286897
TIF  37200
LAW 186269 MAX 208652
UNDLD  20675
PAX/10/215       TTL 227
TTL 222/3/2
TTL COMPARTMENTS 014296
 1/2500 2/4530 3/804 4/5
885 5/577    0/0
SEATING
0A/10 0B/127 0C/88

DOI        59.07


LIZFW      67.05
MACZFW     31.65
LITOW      70.05
MACTOW     33.78

DLI        57.29
STAB TO    03.9 MID
SI:
NOTOC YES
TTL PAYLOAD 014296
DOW 143283

WBC K8-45
EXP 20SEP14
NOTOC - YES




-------------------------

PAX/10/215       TTL 227
TTL 222/3/2


0A/10 0B/127 0C/88


*--------------------------------------------*
* PLSE ACK WITH                              *
```

Final Loadsheet transmitted to aircraft Cockpit and directed to aircraft printer

Figure 1.9E - Final Loadsheet

Pilot acknowledgement and confirmation of the final loadsheet is shown in the ACARS snapshot in *Figure 1.9F* (below).

```
16:09:29   46818215   Outgoing Downlink   9M-MRO   MH0370   IOR2   MHKULKJACM001   071609   EMAILCNX
Ground Sent           B777 Final Loadsheet Acknowledgement -- B777 LS   mtb01mh@malaysiaairlines.com

***FINAL LOADSHEET ACKNOWLEDGEMENT from PILOT*****
AIRCRAFT REGISTRATION       : 9M-MRO
Flight No                   : MH0370
Date                        : 07-03-2014
Time                        : 16:09 UTC
Departure Station           : KUL(WMKK)
Acknowledgement From Pilot  : LS FINAL OK

PIC License No              :
751 KUL


****************END of MESSAGE******************
```

Confirmation from pilot that he has received the Loadsheet in human readable structure

Figure 1.9F - Final Loadsheet Acknowledgement

Data on aircraft APU is shown in *Figure 1.9G* (below). APU report generated by ACMS sent via ACARS at 1629:33 UTC stated the total APU cycles and hours were 15,699 cycles and 22,093 hours. APU hours for the previous flight was 4 hours.

```
16:29:33   46818489   Incoming Downlink   9M-MRO   MH0370   IOR2   MHKULKJACM001   071629   DFD   RELAY
Normal                B777 APU Report                       QXSXMXS

QU DPCCAMH
.QXSXMXS 071629
□DFD
FI MH0370/AN 9M-MRO
DT QXT IOR2 071629 D00A
-  MAS002A0          B777 APU OPS REPORT            332

ACID    FLT  FM FLCT   DATE      GMT    DPT  DST
MRO     S370 PO  318 07/03/14 16:29:12 WMKK ZBAA

     SWID          SFC
316A-BSM-710-02 17911

APU CYC    APU TOT HRS   APU PREV FLT HRS
 15699        22093              4
```

Figure 1.9G - APU Report

Engine take-off and climb reports transmitted via ACARS are explained in *Section 1.6.4 para. 8*). Engine parameter reports were transmitted to MAS and then to Rolls Royce for Engine Health Monitoring (EHM). *Appendix 1.9A* shows these data in coded form. The decoded data are shown in *Appendix 1.6B*.

The first (which was also the last) position report was transmitted via ACARS at 1707:29 UTC, 07 March 2014 [0107:29 MYT, 08 March 2014]. This was a collation of 6 reports generated at 5-minute intervals by the system at 1641:43 UTC, 1646:43 UTC, 1651:43 UTC, 1656:43 UTC, 1701:43 UTC and 1706:43 UTC, 07 March 2014. Parameters transmitted are as per *Table 1.9A* (below). The actual traffic log on the position report is reproduced in *Figure 1.9H* (below). Position reports were programmed to be transmitted every 30 minutes.

<u>Note</u>:

Aircraft position information is also included in the EHM take-off and climb reports.

Greenwich Mean Time (GMT) - UTC	**1641:43**	**1646:43**	**1651:43**	**1656:43**	**1701:43**	**1706:43**
Altitude (ALT) – Feet	103	10,582	21,193	28,938	34,998	35,004
Calibrated Airspeed (CAS) - Knots.	168.4	261.8	301.1	303.1	278.0	278.4
MACH	0.255	0.478	0.669	0.783	0.819	0.821
Total Air Temperature (TAT) - °C	31.1	23.4	11.6	2.5	-13.4	-13.1
Static Air Temperature (SAT) - °C	27.3	10.4	-11.8	-27.4	-43.9	-43.8
Latitude (LAT)	2.667	3.074	3.553	4.109	4.708	5.299
Longitude (LONG)	101.715	101.760	01.988	102.251	102.434	102.713
Gross Weight (GWT) – lb	492,520	489,200	486,240	483,840	481,880	480,600
Total Remaining Fuel Weight (TOTFW) - kg	49,200	47,800	46,500	45,400	44,500	43,800
Wind Direction (WINDIR)	140.3	107.6	1.8	58.4	69.6	70.0
Wind Speed (WINDSP)	1.25	9.38	19.50	10.63	17.38	17.13
True Heading (THDG)	-33.5	27.7	27.8	26.0	26.8	26.7

Table 1.9A - ACARS Position Report

```
17:07:29   46818992   Incoming Downlink        9M-MRO    MH0370    IOR2      MHKULKJACM001        071707      DFD      RELAY
Normal                DFD B777 Position Report (NEW)               QXSXMXS

QU DPCCAMH
.QXSXMXS 071707
□DFD
FI MH0370/AN 9M-MRO
DT QXT IOR2 071707 D03A
-  MAS001A0         B777 POSITION REPORT           565

ACID   FLT  FM FLCT   DATE    DPT  DST
MRO    S370 TR  318 07/03/14 WMKK ZBAA

     SWID        SFC
316A-BSM-710-02 18661

 GMT    ALT    CAS  MACH  TAT   SAT     LAT     LONG
164143    103 168.4 .255  31.1   27.3   2.767  101.715
164643  10582 261.8 .478  23.4   10.4   3.074  101.760
165143  21193 301.1 .669  11.6  -11.8   3.553  101.988
165643  28938 303.1 .783   2.6  -27.4   4.109  102.251
170143  34998 278.0 .819 -13.4  -43.9   4.708  102.534
170643  35004 278.4 .821 -13.1  -43.8   5.299  102.813

 GWT   TOTFW  WINDIR WINDSP  THDG
492520  49200  140.3   1.25  -33.5
489200  47800  107.6   9.38   27.3
486240  46500   91.8  19.50   27.8
483840  45400   58.4  10.63   26.0
481880  44500   69.6  17.38   26.8
480600  43800   70.0  17.13   26.7

18:03:23   46819784   Outgoing Uplink          9M-MRO    MH0370              MHKULKJACM001        071803      AGM      RELAY
```

Figure 1.9H - Position Report

The first message sent to the aircraft cockpit printer from the MAS ODC was at 1803:23 UTC. The ACARS message requested the crew to contact the HCM ACC immediately. The incoming downlink message at 1803:24 UTC showed the message failed to reach the aircraft. Messages are auto transmitted every 2 minutes and the message was retransmitted until 1843:33 UTC but all messages failed to get a response. Automated downlink message by ACARS showed ‘failed’. Message sent to the aircraft cockpit printer and the Automated Downlink messages are shown in *Figures 1.9I* and *1.9J* (below), respectively.

```
18:03:23   46819784   Outgoing Uplink   9M-MRO   MH0370   MHKULKJACM001   071803   AGM   RELAY
Uplink Sent           B777 Cockpit Printer Uplink for ODC -- B777 Cockpit QXSXMXS

QU QXSXMXS
.DPCCAMH 071803
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

THEY COMPLAIN CANNOT TRACK YOU ON THEIR RADAR

I RECEIVED CALL FROM SUBANG CENTRE

PLS ACK THESE MSG

REGARDS
```

Figure 1.9I - Message from MH ODC

```
18:06:25   46819784   Incoming Downlink   9M-MRO   MH0370   MHKULKJACM001   071806   MAS   RELAY
Normal                MAS-F (failed)                QXSXMXS
```

Figure 1.9J - Automated Downlink Message

1.9.5 Satellite Communications

1) Satellite Communications System Description

Satellite Communications (SATCOM) is an acronym of, and generic term for, satellite communications. SATCOM operates by using satellites to relay radio signals between the sender and receiver. It can cover far more distance and wider areas than other radios. SATCOM can be used to transmit words, pictures and other forms of information.

The aircraft, 9M-MRO, was equipped with a SATCOM terminal that used the Inmarsat Classic Aero system. The Inmarsat system utilises a constellation of satellites to provide nearly global coverage, the exception being polar areas. The aircraft SATCOM system, also referred to as an Airborne Earth Station (AES) operates on L Band, transmits at 1.6 GHz and receives at 1.5 GHz. For this aircraft, the

SATCOM system provided a total of five voice channels and one data channel. The satellite link provides the following functions:

- Audio and text communication;
- ACARS data; and
- In-flight Entertainment (IFE) Equipment connectivity.

The Earth or Ground Station uses C Band, transmits at 6 GHz and receives at 4 GHz. Inmarsat uses a network of Ground Earth Stations (GES) to communicate with the satellites and connect the SATCOM signal to other terrestrial data networks such as telephone systems, internet, etc.

When the SATCOM AES is first powered on, it sends a log-on request to the GES to initiate service.

There are a number of channels available for messages to be sent between the Satellite and Earth Station. One of the channels is called the 'common access channel', which aircraft will constantly listen to when able to do so.

If the GES has not heard from an aircraft for an hour after the last communication, it automatically transmits a 'log on interrogation' ("ping") message on the common access frequency using the aircraft's unique identifier. If the aircraft receives its 'unique identifier', it returns a short message that it is still logged onto the network. Both the initial log-on request and the hourly ping have been termed as a 'handshake'.

The SATCOM AES consists of the following equipment: Radio frequency unit (RFU), Radio frequency attenuator (RF ATTN), Radio frequency splitter (RFS), Class C high power amplifier (HPA), Class A high power amplifier (HPA), High power relay (HPR), three low noise amplifier/diplexers (LNA/DIPs), Low gain antenna (LGA), two beam steering units (BSUs), two high gain antennas (HGAs), Radio frequency combiner (RFC) and Satellite data unit (SDU).

The SATCOM avionics are located on the E11 rack, which is in the crown area aft of doors 3 left/right. The High Gain antennas are mounted above door 3 left and door 3 right. The Low Gain antenna is mounted on the fuselage centreline. The SATCOM Circuit Breakers (CB) are located in the Main Equipment Center (MEC).

The Satellite Data Unit (SDU) receives 115V AC from the Left Main bus. In flight, this bus can be powered by engine mounted generators or the APU generator. Neither the aircraft battery nor the ram air turbine will power the SATCOM system.

The diagram in *Figure 1.9K* (below) shows the complete set of SATCOM units, including avionics, High Gain Antenna Subsystem and Low Gain Antenna Subsystem. It also shows interfaces to the aircraft cockpit and cabin systems and functions. The following notes are intended to be read in conjunction with *Figure 1.9K* (below)*:*

a) CDU (3) are the three Control Display Units, otherwise known as Multi-function Control Display Units (MCDUs).

b) CPMU is Cabin Passenger Management Unit, which provides an interface between the Panasonic IFE and the SDU, for any Data-3 SMS/e-mail messages.

c) AMU is the Audio Management Unit, which feeds cockpit audio to and from the SDU.

d) CTU is the Cabin Telecommunications Unit, which provides an interface between the in-seat handsets and the SDU, for cabin telephony calls, were that functions available. In the case of 9M-MRO, the in-seat phones can only be used for seat-to-seat calling.

e) AIMS Cabinet is one of two Airplane Information Management System cabinets, which route numerous information to and from the SDU, including ACARS data, Navigational data, AES ID and Flight ID.

f) SATCOM Maintenance Switch is not relevant to this document, as no maintenance activity is possible in flight.

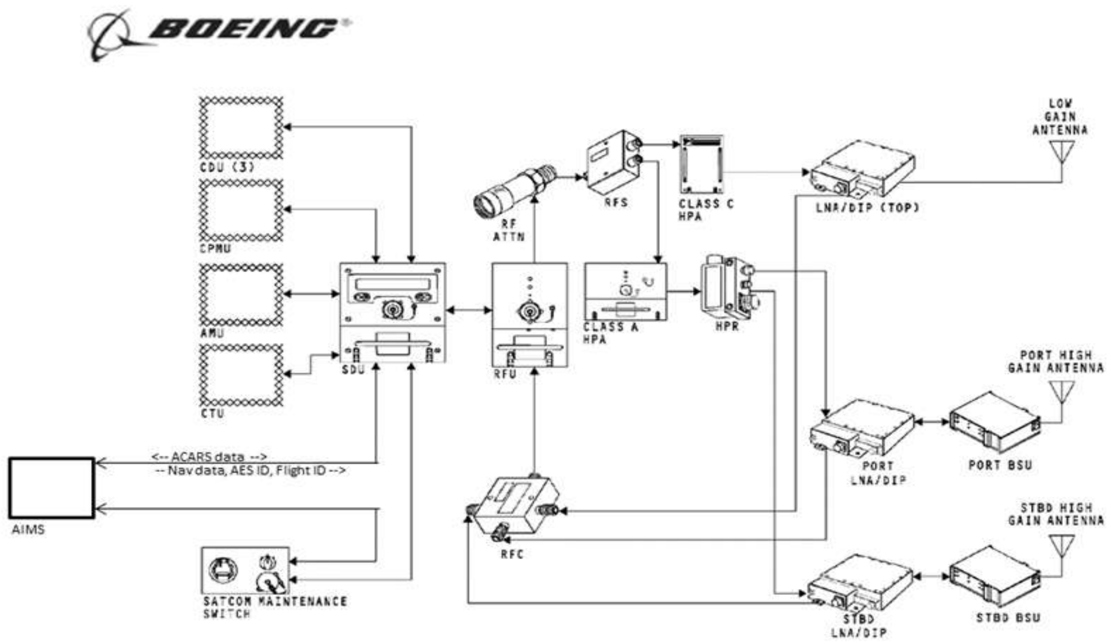


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Figure 1.9K - SATCOM System

The photo in *Figure 1.9L* (below) shows the Honeywell/Racal (Honeywell/Thales) MCS-6000 SATCOM Units - RFU (left), SDU (centre) and HPA (right).

Figure 1.9L - RFU (left), SDU (centre) and HPA (right)

2) Satellite Communications Ground Station Logs of the Event - Introduction

Throughout the flight of MH370, the aircraft communicated through the Inmarsat Indian Ocean Region (IOR) I-3 Satellite and the GES in Perth, Australia.

Figure 1.9M (below) shows the Inmarsat I-3 IOR Satellite Coverage Map. The blue lines represent the elevation angle to the IOR satellite for a SATCOM unit on the ground or in the air. Due to the satellite inclination, the elevation angles are approximate.

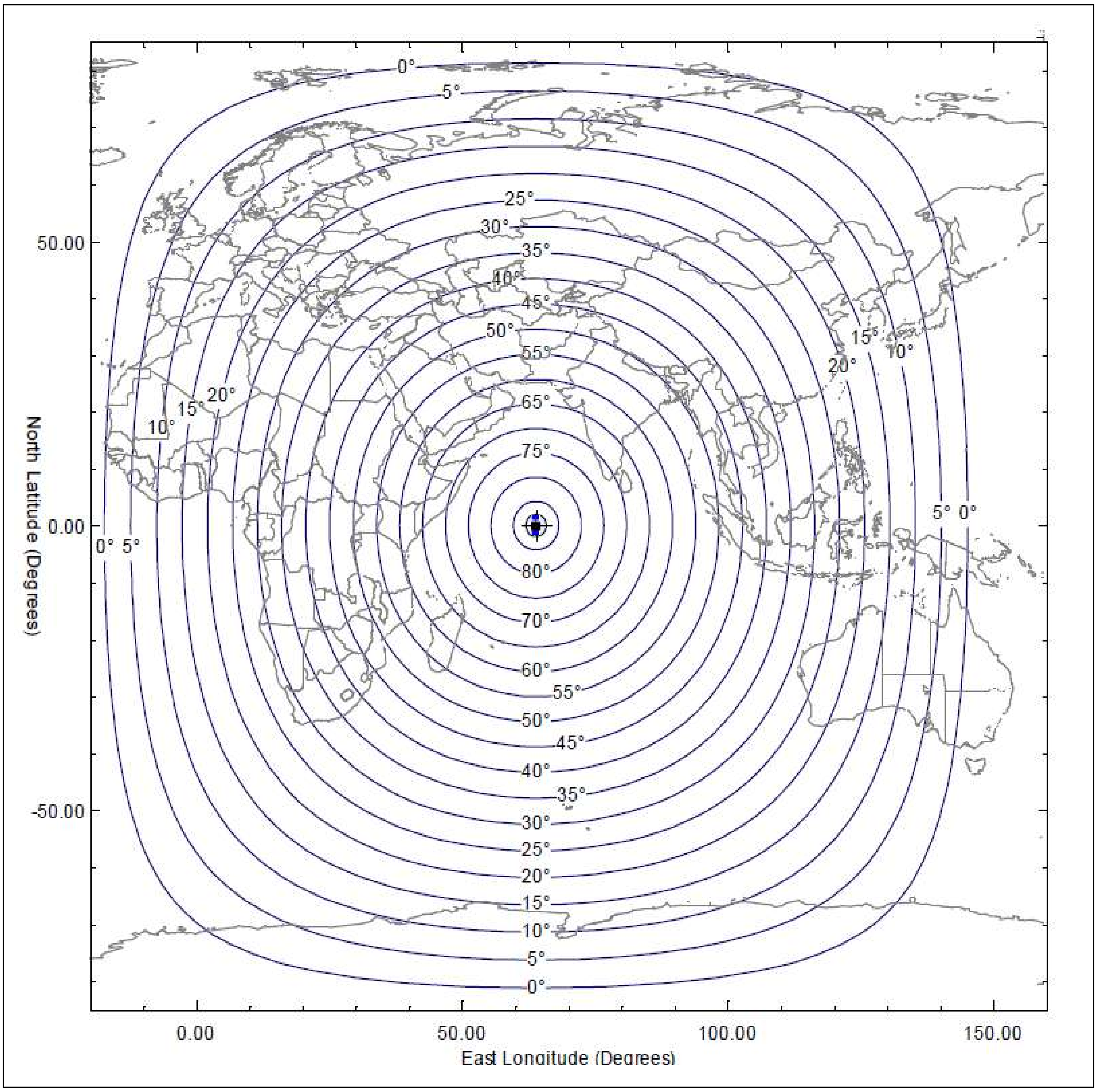


Figure 1.9M - Inmarsat I-3 IOR Satellite Coverage Map

MH370 departed KLIA at 1642 UTC [0042 MYT, 08 March 2014]. At 1707 UTC, the SATCOM system was used to send a standard ACARS report, normally sent every 30 minutes. The message also indicated the remaining fuel on-board.

The ACARS reports expected at 1737 UTC and 1807 UTC were not received. The next SATCOM communication was a log-on request from the aircraft at 1825 UTC. From that point until 0011 UTC, SATCOM transmissions indicate that the link was available, although not used for any voice, ACARS or other data services apart from two unanswered ground-to-air telephone calls. At 0019 UTC, the AES initiated another log-on request. The log-on acknowledge was the last transmission from the SATCOM.

The SATCOM link was available for most of the flight, excluding a period of between 22 and 78 minutes leading up to 1825 UTC, 07 March and a period of less than 8 minutes leading up to 0019 UTC, 08 March 2014. The absence of any aircraft-initiated handshakes, and on-going success of ground-initiated handshakes, indicates that power to the SATCOM was maintained other than the two periods stated above.

Data from the last seven 'handshakes' were used to help establish the most probable location of the aircraft. Initially only the first six of these 'handshakes' were considered to be complete. The seventh and last 'handshake' that was automatically initiated by the aircraft, was originally assessed as a partial 'handshake'. Subsequent analysis confirmed the 7th handshake could be used to help determine the most probable flight path. Two unanswered ground-to-air telephone calls had the effect of resetting the activity log and hence increased the period between the ground initiated 'handshakes'. The significant times used to identify the most probable final location of the aircraft are tabulated in *Table 1.9B* below. Details of the event's SATCOM ground station logs are provided in *Section 1.9.5 para. 3) and 4)* (below).

SATCOM TRANSMISSIONS		TIME	
		UTC	MYT*
1.	Aircraft departed KLIA	1642	0042
2.	Last ACARS transmission	1707	0107
3.	1st handshake - log-on initiated by the aircraft	1825	0225
4.	Unanswered ground-to-air telephone call	1839	0239
5.	2nd handshake initiated by ground station	1941	0341
6.	3rd handshake initiated by ground station	2041	0441
7.	4th handshake initiated by ground station	2141	0541
8.	5th handshake initiated by ground station	2241	0641
9.	Unanswered ground-to-air telephone call	2313	0713
10.	6th handshake initiated by ground station	0011*	0811
11.	7th handshake - log-on initiated by the aircraft	0019*	0819
12.	Aircraft did not respond to 'handshake' from Satellite Earth Ground Station	0115*	0915
* 08 March 2014			

Table 1.9B - SATCOM 'Handshakes'

3) Satellite Communications Ground Station Logs of the Event - Summary

The SATCOM utilised the Inmarsat Indian Ocean Region (IOR) I-3 satellite and the associated Perth Ground Earth Station (GES) throughout the flight. Inmarsat has confirmed that during the flight, no SATCOM signalling or traffic was routed via any other satellites (including MTSAT) to any other GESs (including MTSAT[11] GESs).

The SATCOM provides the Satellite link for the following functions:

- Cockpit Voice - Call control via the Multi-function Control and Display Units (MCDUs) and audio via the cockpit Audio Management Unit (AMU) and associated headsets;
- Cockpit Packet Data (Data-2) - Interface via the ACARS Management Unit (MU); and

[11] MTSAT - A series of Japanese weather and aviation satellites and GESs. MTSAT-1R and MTSAT-2 satellites are interoperable with Inmarsat satellites.

- Cabin Packet Data (Data-3) - Interface via the Panasonic System 3000i IFE equipment:
  - SMS/e-Mail
  - BITE-offload

The GES logs contain the following key information for each transmission to and from the aircraft:

- Time tag, Satellite and GES (Note: the timestamp accuracy does vary between the different logs, but should always be <1 second, and usually to a few milliseconds);

- Channel Type, Channel Number (frequency), Received Carrier/Noise Density Ratio (C/No), channel Bit-Error-Rate (BER), Burst Frequency Offset (BFO) and Burst Timing Offset (BTO, or round trip delay); and

- All payload data (excluding voice frames) contained within the transmission - these are known as the Signal Unit contents.

The events are summarised below. All times are in UTC. In the summary below, times are truncated to the nearest minute (the format is Hours Minutes) and in *Section 1.9.5 para. 4)*, times are truncated to the nearest second (the format is Hours Minutes:Seconds).

No.	Summary of SATCOM Ground Station Logs
1.	Prior to take-off, the SATCOM Logged On (normally) a number of times, the last time being at 1600, when it sent a valid Flight ID to the GES. The SATCOM link was available for both voice and data (known as Log-On Class 3).
2.	After take-off, the IFE SMS email application sent a normal beginning-of-flight message at 1642 (containing the correct Airborne Earth Station [AES ID], Flight ID "MAS370", origin airport "WMKK", and destination airport "ZBAA"), indicating that the IFE was receiving the valid Flight ID, origin airport and destination airport from AIMS and the ICAO (AES) ID from the Satellite Data Unit (SDU) at this time.
3.	The SATCOM link was available for most of the flight, excluding periods leading up to 1825 UTC, 07 March and 0019 UTC, 08 March 2014.

cont…

No.	Summary of SATCOM Ground Station Logs
4.	When the SATCOM link was re-established at the above times, no Flight ID was present
5.	During each of the two in-flight Log Ons at 1825 UTC and 0019 UTC, the GES recorded abnormal frequency offsets for the burst transmission from the SATCOM.
6.	There is no indication of the SATCOM link being manually Logged Off from the cockpit (via an MCDU). Such activity would have been captured in the GES logs, but it was not.
7.	No Data - 2 ACARS traffic was observed after 1707 UTC 07 March 2014.
8.	The IFE equipment set up two ground connections over SATCOM [for the SMS e-mail application and Built-In Test Equipment (BITE) application] after the SATCOM re-established the link at 1825 UTC, 07 March 2014 (normal), but not after the SATCOM re-established the link at 0019 UTC, 08 March (abnormal). At no time during the flight was any user data sent over the link by means of the SMS/e-Mail application.
9.	Two Ground-to-Air Telephone Calls were placed to the cockpit from MAS Operations Centre (MOC) at Airline Operational Communications (AOC) Q10 priority level at 1839 UTC and at 2313 UTC, 07 March 2014. Neither of the calls was answered.
10.	The SATCOM responded normally to a series of roughly hourly Log-On Interrogations from the Perth GES, up to and including a Log-On Interrogation at 0011 UTC, 08 March 2014. The two unanswered ground to air calls at 1839 UTC and 2313 UTC reset the Perth GES inactivity timer and hence the Log-On Interrogations were not always hourly.
11.	The last transmission received from the SATCOM occurred at 0019 UTC, 08 March 2014 and the SATCOM failed to respond to a series of three Log-On interrogations starting at 0115 UTC, 08 March 2014.

4) Satellite Communications Ground Station Logs – Key Observations (in chronological order) *(Table 1.9C* [below]*)*

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
1.	1250:19	Prior to take-off, the SATCOM initiates a normal Log-On as Class 1 (data only capable) via the Pacific Ocean Region (POR) I-3 satellite, using the Low Gain Antenna (LGA) subsystem, suggesting that ADIRU (Air Data Inertial Reference Unit) navigation data was not available to the SDU at this time. No flight ID is sent to the GES at this time. This is the first SATCOM activity recorded at the GES since 0802:27, suggesting that the SATCOM was not powered for a period of several hours, whilst the aircraft was on ground. This is quite normal.
2.	1555:57	The SATCOM initiates a normal Log On Renewal as Class 1 (data only capable) via the POR I-3 satellite, using the LGA subsystem, this time with a valid Flight ID.
3.	1557:49	The SATCOM initiates a normal Log-On as Class 3 (voice and data capable) via the POR I-3 satellite, using the High Gain Antenna (HGA) subsystem, with a valid Flight ID. This suggests that the ADIRU derived navigation data has become available at this time.
4.	1559:57	The SATCOM initiates a Log-On handover as Class 3 (voice and data capable) to the IOR I-3 satellite, using the HGA subsystem, with a valid Flight ID. This suggests that the IOR is now considered to be the best available satellite. This is probably because either the line of sight to the IOR satellite is now clearer than that to the POR satellite, or the antenna gain in the direction of the IOR satellite has become higher than the antenna gain in the direction of the POR satellite.
5.	1642:04	After take-off, the IFE SMS e-mail application sends a normal beginning-of-flight message. a. The message contained the correct AES ID, Flight ID "MAS370", origin airport "WMKK", and destination airport "ZBAA". b. This indicates that the IFE was receiving the Flight ID, origin airport and destination airport from AIMS and the ICAO (AES) ID from the SDU at this time.

Table 1.9C - Chronology of Satellite Communications Ground Station Logs

cont…

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
6.	1707:48	Last DATA-2 ACARS Message received at the GES. No further SATCOM Data-2 ACARS messages or acknowledgements were received at the GES for the remainder of the flight. This is abnormal and suggests that the on-board ACARS equipment either failed, or was disabled or powered down at some time between 1707:48 and around 1825:00.
7.	1803:41	GES initiates a DATA-2 ACARS transmission (uplink), but receives no acknowledgement from the SATCOM. a. Therefore, the SATCOM Link was lost at sometime between 1707:48 and 1803:41. b. There is no evidence of a cockpit-initiated manual Log-Off of the SATCOM. c. Note that even if the on-board ACARs equipment was failed, disabled or powered down at this time, it would not prevent the SATCOM from acknowledging the ACARS-related P-Channel transmissions from the GES.
8.	1805:11	GES initiates a DATA-2 ACARS transmission, but receives no acknowledgement from the SATCOM, indicating that there is still no SATCOM link at this time.
9.	1825:27	SATCOM Log-On, initiated from the aircraft terminal. a. This is the first 'handshake'. b. This marks the end of the link lost period that began at sometime between 1707:48 and 1803:41. c. This log-on request suggests that whatever caused the SATCOM link loss to occur between 1707:48 and 1803:41 had been reversed.
10.	1825:34	SATCOM Log-On, successfully completed. a. The SATCOM link becomes available (for both voice and data - Class 3) once more and normal SATCOM operation resumes (except that there is no Data-2 ACARS traffic). b. No Flight ID was sent to the GES during the Log-On. This implies that the SDU stopped receiving a valid Flight ID from the AIMS at sometime between 1642:04 and 1825:00. *cont…*

Table 1.9C - Chronology of Satellite Communications Ground Station Logs

cont…

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
10. *cont…*	1825:34	c. The possible reasons for the link loss and the subsequent Log-On that took place at 1825:00 have been investigated and are detailed in *Table 2.5A*. There are many quite complicated scenarios that could have caused the 1825:00 Log-On. However, the most likely reason is a power interrupt to the SATCOM avionics, of a duration greater than 22 minutes (the time between events 7 and 9) and less than 78 minutes (the time between events 6 and 9). d. The GES recorded an abnormal BFO for the SATCOM Log-On Acknowledge transmissions (*Sections 1.9.5 para.* 5) and *2.5.3*). • 1825:00 Log-On Acknowledge - Most likely due to the power-on drift of the Oven Controlled Crystal Oscillator (OCXO), thus endorsing the belief that the 1825:00 Log-On was preceded by a lengthy power interrupt. An OCXO provides a stable reference frequency for the SDU Radio Frequency (RF) transmit and receive circuits and also for SDU modem timing. Within the OCXO, a regulated oven keeps the crystal at an almost constant temperature if the ambient temperature in the crown area is between the ranges -55ºC up to above +70ºC. The oven also contains extra electrical regulation and isolation to ensure frequency accuracy and stability. The OCXO includes an oven ready flag, which triggers the Log-On initiation when the OCXO reaches its operating temperature. Extensive laboratory testing has revealed that during warm up, the OCXO frequency may vary non-linearly with time, but then settles with almost negligible variation. At power-on, the OCXO can exhibit either a rising or falling frequency gradient, before decaying over time to its normal steady state value. The testing has indicated that reasonable stability (within 2Hz/minute) is typically reached by around five minutes after an initial peak or overshoot. The testing has also shown that there can still be a significant frequency offset at the time that the oven ready flag initiates the Log-On process, so the Log-On request, Log-On Acknowledge and subsequent data bursts can all exhibit significant frequency offsets.

Table 1.9C - Chronology of Satellite Communications Ground Station Logs

cont…

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
11.	1827:03	The IFE sets up a Data-3 ground connection (X.25 circuit) over SATCOM for an SMS/e-mail application after the SATCOM link is re-established.
12.	1828:05	The IFE sets up a Data-3 ground connection (X.25 circuit) over SATCOM for a BITE application after the SATCOM link is re-established.
13.	1839:52	Ground-to-air telephony call placed from a number with country code 60 (Malaysia) a. Q10 Airline Operational Communications (AOC) Priority Level b. The Perth GES logs indicate that a good link is likely to have existed at this time. c. This call would have been routed to the cockpit and should have resulted in a chime and an incoming visual annunciation on the Audio Control Panels (ACPs), and, if the appropriate SATCOM page was selected, then also on one or more MCDU. d. The GES logs show zero duration, indicating that the call went unanswered. Note that there are two methods for the answering of an incoming call: Either by pressing the relevant Line Select Key on an MCDU, or by keying a microphone.
14.	1840:56	The GES logs show that the unanswered Ground-to-Air telephony call was cleared by the calling party.
15.	1941:00	Log-On Interrogation by the Perth GES, with a response from the SATCOM a. This is the second ‘handshake’, whereby the GES inactivity timer has expired and the GES has sent a message to interrogate the status of the SATCOM. b. The SATCOM responded normally and the SATCOM link was therefore available at this time.
16.	2041:02	Log-On Interrogation by the Perth GES, with a response from the SATCOM a. This is the third ‘handshake’. b. The SATCOM responded normally and the SATCOM link was therefore available at this time.

Table 1.9C - Chronology of Satellite Communications Ground Station Logs

cont…

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
17.	2141:24	Log-On Interrogation by the Perth GES, with a response from the SATCOM a. This is the fourth 'handshake'. b. The SATCOM responded normally and the SATCOM link was therefore available at this time.
18.	2241:19	Log-On Interrogation by the Perth GES, with a response from the SATCOM a. This is the fifth 'handshake'. b. The SATCOM responded normally and the SATCOM link was therefore available at this time.
19.	2313:58	Ground-to-air telephony call placed from a number with country code 60 (Malaysia) a. Q10 AOC Priority Level. b. The Perth GES logs indicate that a good link is likely to have existed at this time. c. This call would have been routed to the cockpit and should have resulted in a chime and an incoming visual annunciation on the Audio Control Panels, and, if the appropriate SATCOM page was selected, then also on one or more MCDU. d. The GES logs show zero duration, indicating that the call went unanswered. Note that there are two methods for the answering of an incoming call: Either by pressing the relevant Line Select Key on an MCDU, or by keying a microphone.
20.	2315:02	The GES logs show that the unanswered Ground to Air telephony call was cleared by the calling party.
21.	0010:58	Log-On Interrogation by the Perth GES, with a response from the SATCOM a. This is the sixth 'handshake'. b. The SATCOM responded normally and the SATCOM link was therefore available at this time.

Table 1.9C - Chronology of Satellite Communications Ground Station Log

cont…

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
22.	0019:29	SATCOM Log-On, initiated from the aircraft terminal. This is the seventh 'handshake'. a. For there to have been a Log-On at this time, there must have been a prior loss of the SATCOM link. This link loss must have occurred at some time after 0010:58, when the SATCOM responded to a Log-On interrogation. b. This Log-On request suggests that whatever caused the SATCOM link loss to occur had been reversed.
23.	0019:37	SATCOM Log-On, successfully completed a. The SATCOM link becomes available (for voice and data – Class 3) once more and normal SATCOM operation resumes. b. No Flight ID was sent to the GES during the Log-On. This infers that the SDU was still not receiving the Flight ID from AIMS. c. The possible reasons for the link loss and the subsequent Log-On that took place at 0019:00 have been investigated and are detailed in Section 2.5.2. There are many quite complicated scenarios that could have caused the 0019:00 Log-On with no Flight ID. However, the most likely reason is a power interrupt to the SATCOM avionics, of a duration less than 8 minutes. d. The GES recorded an abnormal frequency offset for the SATCOM Log-On Request and Acknowledge transmissions (see *Sections 1.9.5 para. 5) and 2.5.3*). The abnormal BFOs for the 0019 Log-On Request and Log-On Acknowledge are more likely due to a combination of uncompensated vertical velocity (descent) and OCXO warm up drift. e) The IFE did not subsequently establish the two Data-3 X.25 connections over the SATCOM, which it normally does if it is functional. It can be inferred that the IFE was either not operating at this time (powered off, not being powered whilst the SATCOM was being powered by the APU, failed, or still resetting after a power cycle), or the SATCOM and/or the IFE became inoperative before the IFE was able to establish the Data-3 connection <u>Note:</u> This is the last transmission received from the aircraft terminal.

Table 1.9C - Chronology of Satellite Communications Ground Station Logs

cont…

No.	Time (UTC)	Key Observations - Satellite Ground Station Logs
24.	0115:56	Log-On Interrogation by the Perth GES, with no response from the SATCOM a. The SATCOM Link was lost at sometime between 0019:37 and 0115:56. b. There is no evidence of a cockpit-initiated manual Log-Off of the SATCOM. c. The loss of SATCOM link was due to one of the following: i. The SATCOM stopped receiving the P-Channel transmission from the satellite ii. SATCOM input power (115VAC 400Hz) was removed iii. The SATCOM experienced a BITE failure.
25.	0116:06	Log-On Interrogation by the Perth GES, with no response from the SATCOM.
26.	0116:15	Log-On Interrogation by the Perth GES, with no response from the SATCOM.

Table 1.9C - Chronology of Satellite Communications Ground Station Logs

5) Frequencies of Log-On Bursts

During each of the two in-flight Log-Ons that occurred at 1825 and 0019, the GES recorded abnormal frequency offsets for the SATCOM transmissions. This is in contrast with the ‘normal’ Log-On behaviour.

Table 1.9D (below) shows the frequencies of these Log-On bursts, as measured at the GES, plus differences from assumed reference frequencies (closest stable values in time, where the aircraft is assumed to be in level flight). The table also shows the very high delta frequencies between the respective Log-On Request and Log-On Acknowledge bursts.

Log-On Time	**1825**	**0019**
BFO used as a reference (closest stable value, assume level flight)	144Hz @ 1828:05	252Hz @ 0010:59
Log-On Request BFO	142Hz @ 1825:27	182Hz @ 0019:29
Log-On Request C/No recorded at GES	30.28	40.59
Log-On Request Channel BER recorded at GES	5	0
Log-On Request Difference Frequency (from BFO reference)	-2Hz @ 1825:27	-70Hz @ 0019:29
Log-On Acknowledge BFO	273Hz @ 1825:34	-2Hz @ 0019:37
Log-On Acknowledge C/No recorded at GES	42.55	43.38
Log-On Acknowledge Channel BER recorded at GES	0	0
Log-On Acknowledge Difference Frequency (from BFO reference)	+129Hz @ 1825:34	-254Hz @ 0019:37
Delta frequency between the Log-On Request and the Log-On Acknowledge bursts, plus time period	+131Hz over 7 seconds	-184Hz over 8 seconds

Table 1.9D - Log-On Bursts

SECTION 1 – FACTUAL INFORMATION

1.10 AERODROME INFORMATION

Not applicable.

SECTION 1 – FACTUAL INFORMATION

1.11 FLIGHT RECORDERS

The aircraft was equipped with two crash-protected recorders:

- Solid State Flight Data Recorder (SSFDR)
- Solid State Cockpit Voice Recorder (SSCVR)

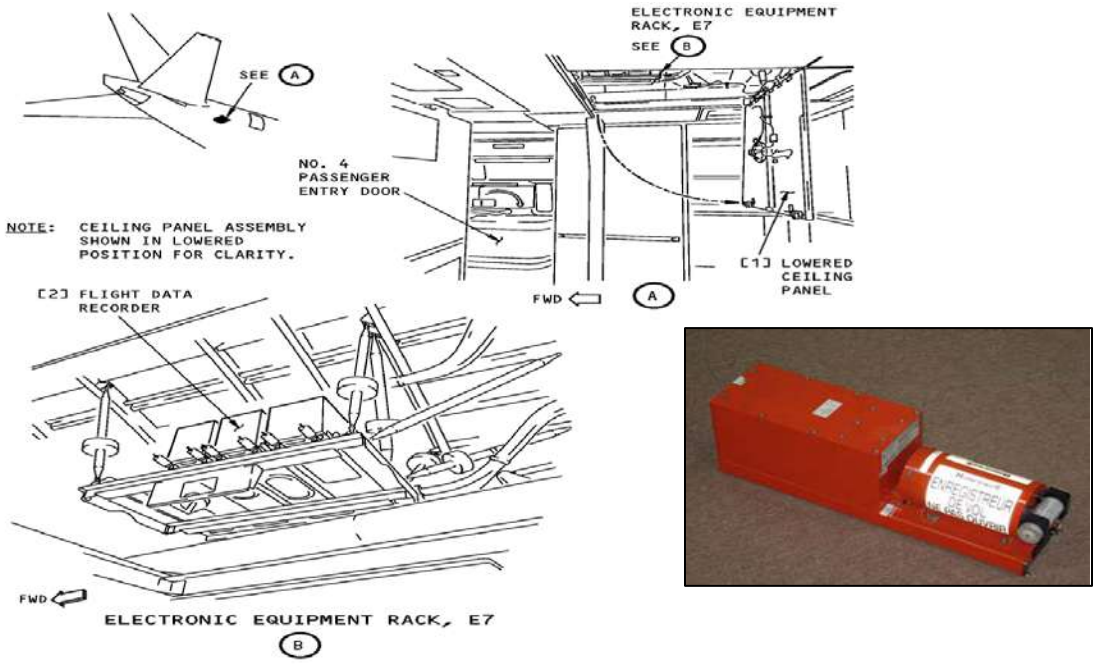


Figure 1.11A - Location of Solid State Flight Data Recorder

1.11.1 Solid State Flight Data Recorder

The solid state flight data recorder (SSFDR) is located in the Electronic Equipment rack, E7, which is in the aft cabin above the ceiling (*Figure. 1.11A* [above]).

The SSFDR receives and stores selected aircraft parameters from various aircraft systems and sensors in a crash-protected solid state memory.

The flight data recorder system (FDRS) operates during any engine start, while any engine is running, during test or when the aircraft is in the air. The SSFDR is powered from the right AC transfer bus which is powered by the engine generators or the APU generator. If none of these generators are functioning due to non-operation of the engines and APU then the bus will not be powered and the SSFDR will not operate in the air.

This is a solid state flight data recorder (SSFDR) with a recording capacity of at least twenty-five hours.

The SSFDR records the most recent 25 hours of flight and records more than 1300 parameters. The SSFDR is a 256 word per second (wps) data rate recorder. The most recent flight data recorder download for this aircraft was in September 2013 and this was carried out for the annual readout. The annual readout extracts 151 parameters for evaluation. Details of the SSFDR installed and specifications are as follows:

- Manufacturer: Honeywell
- Model: SSFDR Model 4700
- Part Number (P/N): 980-4700-042
- Serial Number (S/N): SSFDR-08636
- Date last installed on aircraft: 26 August 2012
- Weight: 6.8 kg
- Electricity Consumption: 15 W, 115 VAC 400 Hz
- Impact Shock: 3400 G for 6.5 ms
- Fire Temperature: Max 1100°C (30 min)
- Deep Sea Pressure and Sea Water Immersion: 20,000 ft.

1.11.2 Solid State Cockpit Voice Recorder

The solid state cockpit voice recorder (SSCVR) is in the Electronic Equipment Rack, E7, in the aft cabin above the ceiling and located adjacent to the SSFDR (*Figure 1-11B* [below]).

The SSCVR has a recording capacity of at least two hours in standard quality and thirty minutes in high quality.

The voice recorder system receives cockpit sounds and flight crew communications. It keeps this audio in a solid state memory.

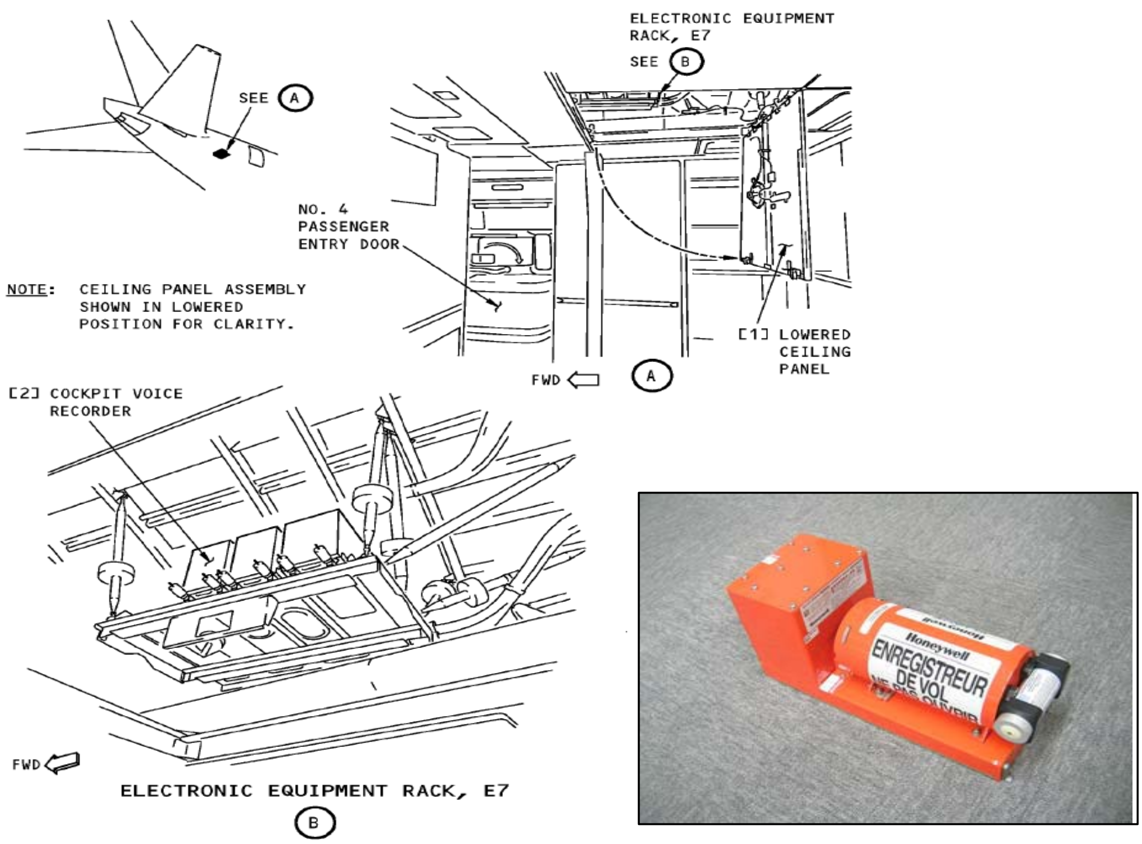


Figure 1.11B - Location of Solid State Cockpit Voice Recorder

Four audio channels go to the SSCVR. Channel 1, 2, and 3 audio is from the audio management unit (AMU). Each channel carries audio from one crew member's flight interphone audio. The audio on each channel is the sum of these signals:

- Hot mic audio (microphone audio when there is no press-to-talk [PTT])
- Received audio as selected on the crew member's audio control panel (ACP)
- Side tone audio to the crew member

Channel 4 audio is from the Cockpit Area Microphone (CAM). The CAM sends cockpit area audio to the SSCVR. The SSCVR operates any time power is available on the Left AC transfer bus. This bus is not powered from batteries or the Ram Air Turbine (RAT).

Details of the SSCVR installed and the specifications are as follows:

- Manufacturer: Honeywell
- Model: SSCVR Model 6022
- Part Number (P/N): 980-6022-001
- Serial Number (S/N): 2677
- Date last installed on aircraft: 26 August 2012
- Weight: 5.9 kg Electricity Consumption: 8 W, 115 VAC 400 Hz
- Impact Shock: 3400 G for 6.5 ms
- Fire Temperature: Max 1100°C (30 min)
- Deep Sea Pressure and Sea Water Immersion: 20,000 ft.

1.11.3 Underwater Locator Beacons

Both crash-protected recorders were equipped as provided by the regulations with underwater locator beacons (ULB) whose transmission time is at least 30 days, on the 37.5 kHz frequency, operating depth up to 20,000 ft (6096 m) and activated with fresh or salt water immersion. Detail specifications are as per below:

- Manufacturer: Dukane
- Model: DK-100 / DK-120
- Operating Frequency: 37.5 kHz ± 1 kHz
- Operating Depth: Surface to 20,000 ft. (6,096 meters)
- Pulse Length: 10 milliseconds + 10%
- Pulse Repetition Rate: Not less than 0.9 Pulse/Sec
- Operating Life: 30 days (minimum)
- Battery Life In Beacon: 6 Years
- Acoustic Output, Initial: 1060 dynes/cm^2 rms pressure at 1 meter (160.5 dB)
- Acoustic Output After 30 Days: 700 dynes/cm^2 rms pressure at 1 meter (157.0 dB)
- Operating Temperature Range: +28°F (-2.2°C) to +100°F (+37.8°C)
- Actuation: Fresh or salt water
- Radiation Pattern: Rated output over 80 percent of sphere
- Size: 1.30 inches (3.30 cm) diameter x 3.92 inches (9.95 cm) long (less mount)
- Weight, Beacon: 6.7 ounces (190 grams)
- Storage Temperature Range: -65°F (-54°C) to 160°F (71°C)

The SSFDR was attached with a ULB as below:

- S/N: SC26210
- ULB Expiry Date: December 2012

The SSCVR was attached with ULB as below:

- S/N: Not Recorded
- ULB Expiry Date: June 2014

1) Solid State Flight Data Recorder Underwater Locator Beacon Battery Expiry

According to maintenance records, the solid state flight data recorder (SSFDR) Underwater Locator Beacon's (ULB) battery expired in December 2012. There is no evidence to suggest that the SSFDR ULB battery had been replaced before the expiry date. The SSCVR ULB battery however was replaced, as scheduled, with the next expiry in June 2014.

Technical Log records showed that the SSFDR (together with the ULB) was replaced on the aircraft on 29 February 2008. Component installation records for the ULB showed that at the time the SSFDR was replaced on aircraft the expiry date for the battery was December 2012.

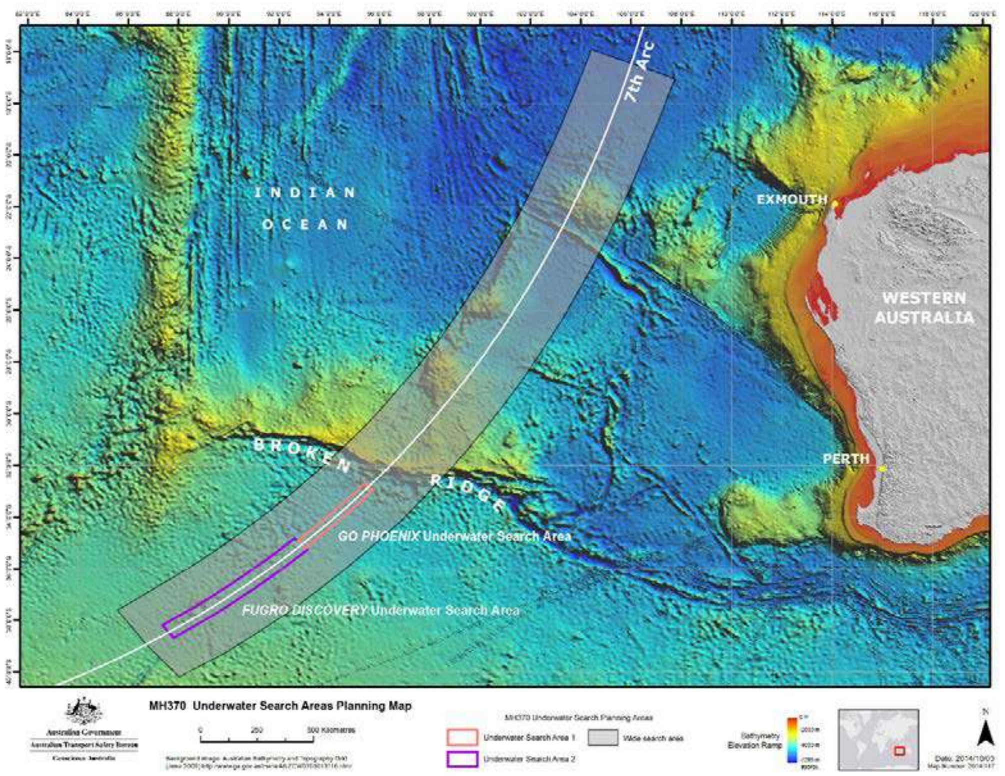
SECTION 1 – FACTUAL INFORMATION

1.12 WRECKAGE AND IMPACT INFORMATION

1.12.1 Introduction

Extensive work by the the MH370 Search Strategy Group, coordinated by the ATSB, by analysing signals transmitted by the aircraft's satellite communications terminal to Inmarsat's Indian Ocean Region satellite indicated that the aircraft ended its flight in the Southern Indian Ocean.

The ATSB led the underwater search for MH370 in the southern Indian Ocean. The search area, as shown (below) in *Figure 1.12A*, covered in excess of 120,000 sq. km at the 7th Arc.



Source: ATSB

Figure 1.12A - MH370 Search Area

Further search was carried out by the US company, Ocean Infinity, which covered an area of more than 112,000 sq. km towards the north of the area covered by ATSB on the 7th arc.

No wreckage of the aircraft has been found after the completion of the search. However, several floating components and debris confirmed/possibly from MH370 have been found as far as the south eastern coast of Africa. Refer to *Figure 1.12B* (below).

1.12.2 Location of Where the Debris were Found

After a number of assessments, more than 20 items were considered for further examination. These items were found in the north west corner of the Indian Ocean, namely in Réunion Island, Mozambique, Tanzania,

MOZAMBIQUE

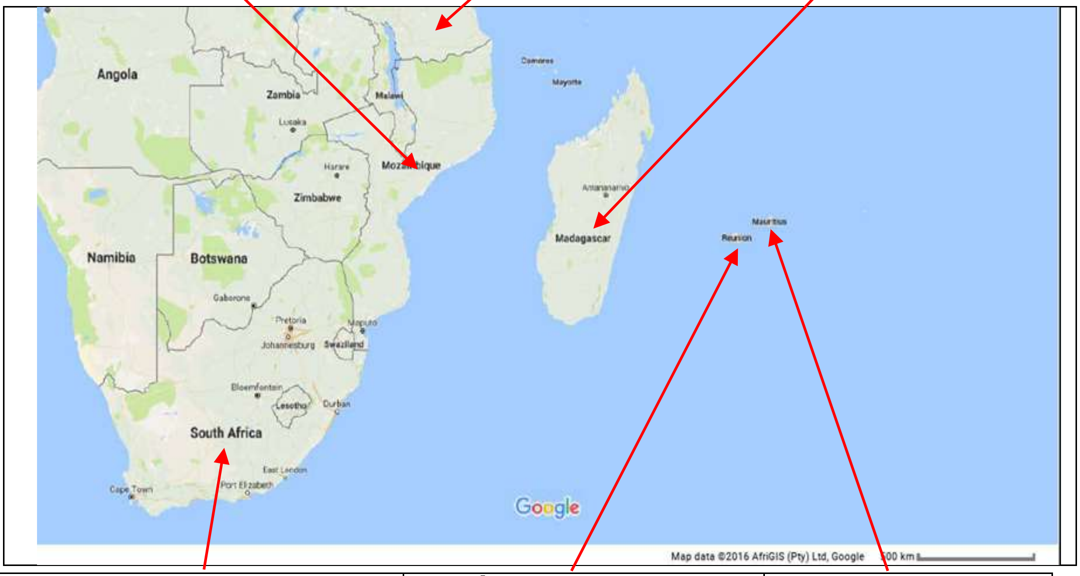
Item					
2	3	6	7	9	22

TANZANIA

Item
19

MADAGASCAR

Item					
11	12	13	14	15	16
17	18	23	24	25	-



SOUTH AFRICA

Item				
4	20	21	26	27

RÉUNION ISLAND

Item
1

MAURITIUS

Item		
5	8	10

Keys	Item	Status	Total
	1, 10 & 19	*Confirmed*	3
	2,3,4,5,6,16 & 22	*Almost Certain*	7
	8, 9, 11, 15, 18, 20 26 & 27	*Highly Likely*	8
	7 & 12	*Likely*	2
	13, 14, 17, 21, 23, 24 & 25	*Not Identifiable*	7
	Total		27

Figure 1.12B - Locations and Status of Identification of the Debris

South Africa, Madagascar and Mauritius. *Figure 1.12B* (above) shows the distribution of the debris found in the above respective areas. *Table 1.12A* (below) provides a summary of the items of debris examined.

Ref.	Date Found	Debris	Location	Remarks
Item 1	29 July 2015	 Right Flaperon	 Saint-Denis, Réunion Island	• *Confirmed* by French Judicial Authority belonging to MH370 on 03 September 2015 • Refer to *Appendix 1.12A-1* and *Appendix 1.12A-2*
Item 2	27 December 2015	 Right Wing No. 7 Flap Support Fairing	 Daghatane Beach, Mozambique	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12B*

Table 1.12A - Items of Debris

cont…

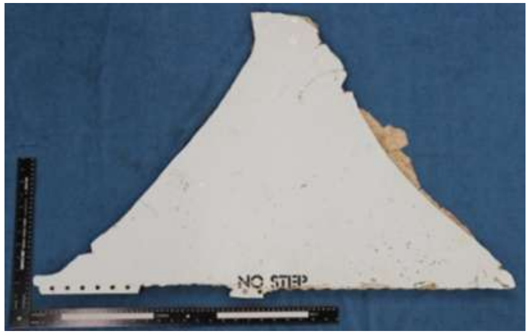
Ref.	Date Found	Debris	Location	Remarks
Item 3	27 February 2016	 Right Horizontal Stabiliser Panel	 Valankulo, Paluma Sandbank, Mozambique	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12B*
Item 4	22 March 2016	 Engine Nose Cowl	 Mossel Bay, South Africa	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12C*

Table 1.12A - Items of Debris

cont…

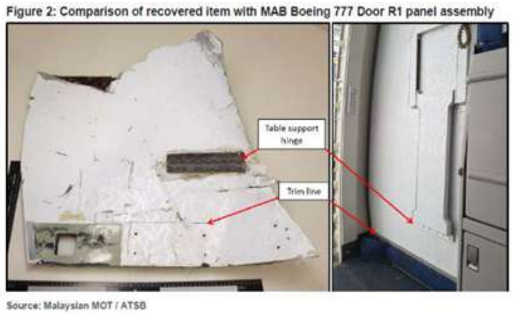
Ref.	Date Found	Debris	Location	Remarks
Item 5	30 March 2016	 Door R1 Stowage Closet	 Rodrigues, Mauritius	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12C*
Item 6	24 April 2016	 Right Hand Engine Fan Cowling	 South of Chidenguele, Mozambique	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12D*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 7	30 April 2016	 Wing to Body Fairing	 Anvil Bay, Chemucane, Mozambique	• Examination showed that part is *likely* from MH370 • Refer to *Appendix 1.12E*
Item 8	24 May 2016	 No. 1 Flap Support Fairing Tail Cone	 Gris Gris Beach, Mauritius	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12F*

Table 1.12A - Items of Debris

cont...

Ref.	Date Found	Debris	Location	Remarks
Item 9	22 May 2016	 Left Wing Trailing Edge Panel	 Macenta Peninsular, Mozambique	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12G*
Item 10	10 May 2016	 Left Outboard Flap	 Ilot Bernache, Mauritius	• This part is *confirmed* from MH370 • Refer to *Appendix 1.12H*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 11	06 June 2016	 Seat Back Trim Panel encasing IFE Monitor	 Riake beach, Nosy Boraha Island, Madagascar	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12I*
Item 12	06 June 2016	 Bottom panel on the Wing or Horizontal Stabilizer	 Riake beach, Nosy Boraha Island, Madagascar	• Examination showed that part is *likely* from MH370 • Refer to *Appendix 1.12J*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 13	12 June 2016	 Unidentified part	 Riake beach, Nosy Boraha Island, Madagascar	• Not identifiable • Refer to *Appendix 1.12K*
Item 14	12 June 2016	 Unidentified part	 Riake beach, Nosy Boraha Island, Madagascar	• Not identifiable • Refer to *Appendix 1.12L*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 15	06 June 2016	 Right Wing Trailing Edge Panel	 Riake beach, Nosy Boraha Island, Madagascar	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12G*
Item 16	12 June 2016	 Cabin Interior Panel	 Antsiraka beach, Madagascar	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12M*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 17	12 June 2016	 Unidentified part	 Antsiraka beach, Madagascar	• Not identifiable • Refer to *Appendix 1.12M*
Item 18	12 June 2016	 Right Forward Nose Landing Gear Door	 Antsiraka beach, Madagascar	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12N*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 19	20 June 2016	 Right Outboard Flap	 Pemba Island, East of Tanzania	• The part is *confirmed* from MH370 • Refer to *Appendix 1.12O*
Item 20	21 June 2016	 Right Aft Wing to Body Fairing	 Kosi Bay Mouth, Kwa Zulu Natal, South Africa	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12P*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 21	18 July 2016	 Unidentified Part	 Northern Kwa Zulu Natal, South Africa	• Not identifiable • Refer to *Appendix 1.12Q*
Item 22	26 August 2016	 Right Vertical Stabilizer Panel	 Linga Linga beach Mozambique	• Examination showed that part is *almost certain* from MH370 • Refer to *Appendix 1.12R*

Table 1.12A - Items of Debris

cont...

Ref.	Date Found	Debris	Location	Remarks
Item 23	October 2016	 Unidentified Part	 Riake beach, Nosy Boraha Island, Madagascar	• Not identifiable • Refer to *Appendix 1.12S*
Item 24	February 2016	 Unidentified Part	 Saint Luce, Madagascar	• Not Identifiable • Refer to *Appendix 1.12T*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 25	July 2016	 Unidentified Part	 Riake beach, Nosy Boraha Island, Madagascar	• Not identifiable • Refer to *Appendix 1.12U*
Item 26	23 December 2016	 Right Aileron	 Nautilus Bay, South Africa	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12V*

Table 1.12A - Items of Debris

cont…

Ref.	Date Found	Debris	Location	Remarks
Item 27	27 January 2017	 Right Wing No. 7 Flap Support Fairing	 Mpame Beach, South Africa	• Examination showed that part is *highly likely* from MH370 • Refer to *Appendix 1.12W*

Table 1.12A - Items of Debris

1.12.3 Details of the Debris

The debris are briefly described in the following paragraphs. The details of the parts will be found in the *Appendix 1.12A* to *Appendix 1.12W* of this report.

1) Item 1 - Right Flaperon

Item No. 1 was found on 29 July 2015 in Saint-Denis, Réunion Island. Réunion Island is a French territory in the Indian Ocean.

This item was one of the biggest and complete part of an aircraft found washed ashore. The item was retrieved by the local French authorities and shipped to General Delegate of Armament Aeronautical Technique (DGA/TA) facility in Toulouse for detailed examination. Because of a court case pending in Paris, the part was taken custody by the French Investigative Judge, as evidence for a criminal investigation.

The part identification, detailed examination and analysis were carried out at DGA/TA in Toulouse under the directive and jurisdiction of the French Investigative judge. Although the name plate was missing, which could have provided immediate traceability to the aircraft (9M-MRO), the part was *confirmed* to be a right flaperon of the aircraft 9M-MRO, by tracing the identification numbers of the internal parts of the flaperon to their manufacturing records at EADS CASA, Spain. Refer to *Appendix 1.12A-1.*

The examination of the flaperon at DGA/TA revealed the following damages:

a) the inboard and outboard hinge fittings were fractured in two places; at the level of the leading edge and on the lower surface of the flaperon;

b) the fracture surfaces on the hinge fittings were highly corroded;

c) the ribs at the edge of the flaperon showed, in their metallic area, holes due to corrosion;

d) the leading edge showed dents and cracks;

e) the trailing edge was generally broken;

f) the lower and upper surface panels showed localised dents and the upper surface had a large crack; and

g) the mounting attachment zones on each side of the flaperon were damaged or broken off.

In addition, the flaperon was covered with a colony of barnacles. Most of them were on the upper surface (extrados).

Refer to *Appendix 1.12A-2* for details.

2) Item 2 - Right Wing No. 7 Flap Support Fairing

Item No. 2 was found on 27 December 2015 in Daghatane Beach, Mozambique.

The item was brought to ATSB Laboratory in Canberra for detailed examination and analysis. The part was identified from a number stencilled on the part (676EB), as a segment from a Boeing 777 flap track (support) fairing (Fairing No. 7) from the right wing. All measurable dimensions, materials, construction and other identifiable features conformed to the applicable Boeing drawings for the identified fairing. It was concluded that the item is *almost certain* from MAS B777 aircraft, registered 9M-MRO.

Refer to *Appendix 1.12B* for details.

3) Item 3 - Right Horizontal Stabilizer Panel Piece

Item No. 3 was found on 27 February 2016 in Valankulo, Paluma Sandbank, Mozambique.

The item was brought to ATSB Laboratory in Canberra for detailed examination and analysis. The part was primarily identified from images showing the materials, construction and “NO STEP” stencil, as a segment of a Boeing 777 right horizontal stabilizer panel. All measurable dimensions, materials, construction and other identifiable features conformed to the Boeing drawings for the stabiliser panel. It was concluded that the item is *almost certain* from MAS B777 aircraft, registered 9M-MRO.

Refer to *Appendix 1.12B* for details.

4) Item 4 - Engine Nose Cowl

Item No. 4 was found on 22 March 2016 in Mossel Bay, South Africa.

The item was brought to ATSB Laboratory in Canberra for detailed examination and analysis. The part was identified from the partial Rolls-Royce stencil as a segment from an aircraft engine cowling. The panel thickness, materials and construction conformed to the applicable drawings for Boeing 777 engine cowlings. There were no identifiers on the engine cowling segment that were unique to 9M-MRO, however the Rolls-Royce stencil font and detail did not match the original from manufacture. The stencil was consistent with that developed and used by MAS and closely matched exemplar stencils on other MAS B777 aircraft. There were no significant differentiators on the cowling segment to assist in determining whether the item of debris was from the left or right side of the aircraft, or the inboard or outboard side of the cowling. It was concluded that the item is *almost certain* from MAS B777 aircraft, registered 9M-MRO.

Refer to *Appendix 1.12C* for details.

5) Item 5 - Door R1 Stowage Closet

Item No. 5 was found on 30 March 2016 in Rodrigues Island of Mauritius.

The item was brought to ATSB Laboratory in Canberra for detailed examination and analysis. The part was identified by the decorative laminate as an interior panel from the main cabin. The location of a piano hinge on the part surface was consistent with a work-table support leg, utilised on the exterior of the MAS Door R1 (forward, right hand) closet panel. The part materials, dimensions, construction and fasteners were all consistent with the drawing for the panel assembly and matched that installed on other MAS Boeing 777 aircraft at the Door R1 location.

There were no identifiers on the panel segment that were unique to 9M-MRO, however the pattern, colour and texture of the laminate was only specified by MAS for use on Boeing 747 and 777 aircraft. There is no record of the laminate being used by any other Boeing 777 customers.

It was concluded that the item is *almost certain* from MAS B777 aircraft, registered 9M-MRO.

Refer to *Appendix 1.12C* for details.

6) Item 6 - Right Hand Engine Fan Cowling

Item No. 6 was found on 24 April 2016, south of Chidenguele, Mozambique. The item was brought back to Malaysia for identification and further examination by the Team. The possible location of the debris on a MAS B777 aircraft was determined. The hinge bracket, number of fasteners and fasteners' pitch on the part were consistent with those on the right engine fan cowl on the aircraft. The mount found on the part was also consistent with the mount of the fan cowl "Hold-Open Stay Rod" in regards to its location, shape and size of the mounting bracket. The words "HOIST POINT" were still visible and in the correct location. The fonts used for the words on the part matched those on the fan cowl of the aircraft. The part was brought near to the right fan cowl and was found to physically resemble it in terms of shape, size, colour and features.

It has been concluded that the debris is part of the Right Fan Cowl of a B777. As the right fan cowls on both the engines are similar, there is no conclusive evidence to determine whether it belongs to the left (No. 1) or right (No. 2) engine. Based on the other features on the recovered part it has also been determined that the part is *almost certain* from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12D* for details.

7) Item 7 - Unidentified Part

Item No. 7 was found on 30 April 2016 on Anvil Bay, Chemucane, Mozambique. The item was brought back to Malaysia for identification and further examination by the Team.

The exact location of the debris on a MAS B777 aircraft could not be identified since it did not have any markings or numbers and there were no peculiar features which could match it on the aircraft except for one edge of the part which had a distinct radius, which suggested that the joining part would be at an angle.

While the construction was similar to a B777 part, there was no conclusive evidence to determine the origin of this part with respect to the aircraft. After review of the B777 Illustrated Parts Catalogue (IPC), the most possible location of the part was determined to be the wing to fuselage body fairing.

There is no conclusive evidence to determine the origin of this part with respect to the aircraft however it is likely to be a part of a panel of the wing to body fairing on a B777 and it is *likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12E* for details.

8) Item 8 - Flap Support Fairing Tail Cone

Item No. 8 was found on 24 May 2016 on Gris Gris Beach, Mauritius. The item was brought back to Malaysia for identification and further examination by the Team.

Initial assessment indicated that this could be a flap support fairing tail cone of a B777. The part was identified from the legible numbers that were observed on the inner surface. The following part number 113W9154-401 and serial number 407 were visible on one side. The profile of the part resembled the wing flap support fairing tail cone.

The part number was cross referenced to the Boeing component maintenance manual and drawings. This identified it as a component of the wing flap fairing assembly and the fit closely matched that of the No. 1 flap support fairing. As the records of where these fairing tail cones are fitted are not normally kept by airlines, the serial number 407 could not be tracked to any particular aircraft.

Based on the legible numbers and the fit, it is confirmed that it is the tail cone of the No. 1 flap support fairing of B777 and *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12F* for details.

9) Item 9 - Left Wing Trailing Edge Panel

The item was found on 22 May 2016 in Macenta Peninsular, Mozambique. The item was brought back to Malaysia for identification and further examination by the Team.

The item matched the left part (outboard section) of the Upper Fixed Panel forward of the flaperon on the left wing. It was observed that the outboard side was fractured and on the inboard side the fastener holes were still visible with a pitch of 1 in. This fastener pitch matched that on the inboard side of the panel of the aircraft. The fasteners' pitch on the outboard side is 2 in. The raised portion of the core of the section of the panel of length 18 in. also matched with that on the aircraft panel.

The item is confirmed to be the outboard section of the "Upper Fixed Panel forward of the flaperon" on the left wing. The debris is *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12G* for details.

10) Item 10 - Left Outboard Flap

Item No. 10 was found on 08 May 2016 at Ilot Bernache, Mauritius. A part number was identified on a section of the debris, identifying it as a trailing edge splice strap, incorporated into the rear spar assembly of a Boeing 777 left outboard flap. This was consistent with the appearance and construction of the debris.

Adjacent to the part number was a second part identifier. The flap manufacturer supplied records indicating that this identifier was a unique work order number and that the referred part was incorporated into the outboard flap shipset line number 404 which corresponded to the Boeing 777 aircraft line number 404, registered 9M-MRO and operating as MH370.

Refer to *Appendix 1.12H* for details.

11) Item 11 - Seat Back Trim Panel Encasing IFE Monitor

Item No. 11 was found on 06 June 2016 on Riake beach, Nosy Boraha Island, Madagascar.

The item was brought back to Malaysia for the identification and further examination by the Team.

The part was identified as the seat back trim panel which encases the In-Flight Entertainment (IFE) monitor. There was a small fragment of fabric around the coat hanger on the debris, which was greenish in colour. This colour matched the seat fabric used on the MAS B777 on the centre seats. The location of the coat hanger on the left conforms to the Right Hand, Triple Seat Assembly column in the Economy (EY) class.

This part is confirmed to be the seat back trim panel for encasing the IFE monitor and is *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12I* for details.

12) Item 12 - Bottom Panel on Wing or Horizontal Stabilizer

Item No. 12 was found on 06 June 2016 on Riake beach, Nosy Boraha Island, Madagascar.

The item was brought back to Malaysia for identification and further examination by the Team. The letters “FB” were clearly visible on the part which indicates that it is a bottom panel on the wing or horizontal stabilizer. An attempt was made to match the part to all the wing and horizontal stabilizer panels with the identification marks ending with “FB”. The thickness and profile of the part did not match any of those panels on the aircraft. However, it could be confirmed that it is very likely to be a part from a Boeing aircraft and *likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12J* for details.

13) Item 13 - Unidentified Part

Item No. 13 was found on 06 June 2016 on Riake beach, Nosy Boraha Island, Madagascar.

The item was brought back to Malaysia for the further examination and identification by the Team. The part could not be matched exactly to any part on a MAS B777 aircraft. There were also no identification numbers on the part.

Refer to *Appendix 1.12K* for details.

14) Item 14 - Unidentified Part

Item No. 14 was found on 06 June 2016 in Riake beach, Nosy Boraha Island, Madagascar.

The item was brought back to Malaysia for identification and further examination by the Team. The part did not have any distinguishing features to match any on a MAS B777 aircraft. It did not have any identification numbers. The part resembled a cabin interior piece based on the decorative finish, however there was insufficient evidence to positively identify the part to be from an aircraft.

Refer to *Appendix 1.12L* for details.

15) Item 15 - Right Wing Trailing Edge Panel

Item No. 15 was found on 06 June 2016 in Riake beach, Nosy Boraha Island, Madagascar.

The item was brought back to Malaysia for identification and further examination by the Team.

It was identified to be the outboard section of the “Upper Fixed Panel forward of the flaperon” on the right wing of a MAS B777 aircraft. The pitch of the fasteners’ holes on the right side (outboard) of the panel was measured to be 2 in. and that matched that on the debris. The debris is *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12G* for details.

16)Item 16 - Cabin Interior Panel

Item No. 16 was found on 12 June 2016 on Antsiraka beach, Madagascar.

The piece was small and did not have any evidence of part number printed on it. The vinyl cover showed a unique pattern of interior decorative panel on one side and white vinyl on the other side of the piece. The pattern was similar to the one used on MAS 777 cabin interior panels. There were also 'insert' holes visible on one of the sides. The part has been determined to be *almost certain* from MH370.

The detailed examination was conducted by the Team in collaboration with Science & Technology Research Institute for Defence (STRIDE).

Refer to *Appendix 1.12M* for details.

17)Item 17 - Unidentified Part

Item No. 17 was found on 12 June 2016 on Antsiraka beach, Madagascar.

This item is a sandwich structure panel with Nomex Honeycomb core of typical aircraft composite structure. No markings were found on this item. Further analysis on this item is difficult due to lack of features to indicate that it could be a B777 part.

Refer to *Appendix 1.12M* for details.

18)Item 18 - Right Forward Nose Landing Gear Door

Item No. 18 was found on 12 June 2016 in Antsiraka beach, Madagascar.

The item was brought back to Malaysia for the identification and further examination by the Team.

The part did not have any identification numbers on it. However, the features on the part resembled the Right Nose Gear Forward Door of a MAS B777 aircraft. The oval depressions on the inner skin and the orientation of a diagonal, raised bar matched that on the Right Nose Gear Forward Door on the aircraft.

The part is positively identified as the Right Hand Nose Gear Forward Door of a B777. It is *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12N* for details.

19)Item 19 - Right Outboard Flap

Item No. 19 was found on 21 June 2016 in Pemba Island, East of Tanzania. This is the largest piece found after the flaperon and has been determined to be part of the inboard section of the right outboard flap of a B777. The Italian part manufacturer build records for the numbers located on the part *confirm* that all of the numbers relate to the same serial number outboard flap that was shipped to Boeing as line number 404. Aircraft line number 404 was delivered to MAS and registered as 9M-MRO.

Refer to *Appendix 1.12O* for details

A fibreglass and aluminium seal pan located at the inboard end of this outboard flap was found damaged. Two adjacent aluminium stiffeners within this inboard seal pan area also exhibited damage which was due to impact.

Refer to *Appendix 2.5C* for details.

20)Item 20 - Right Aft Wing to Body Fairing

Item No. 20 was found on 21 June 2016 on Kosi Bay Mouth, Kwa Zulu Natal, South Africa.

The item was brought back to Malaysia for identification and further examination by the Team. Part of the identification number was visible on the debris indicating that it is part of the right aft wing to body fairing panel, 196 MR. Part of the part number, 149W5232-1, was visible with the letter ‘R’ below it, indicating it is a panel on the right side of the aircraft.

This item is confirmed to be part of the right aft wing to body fairing panel from a B777 aircraft. It is *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12P* for details.

21) Item 21 - Unidentified Part

Item No. 21 was found on 18 July 2016 in Northern Kwa Zulu Natal, South Africa.

The item was brought back to Malaysia for identification and further examination by the Team. Based on the structure construction, this part could be a small section of a panel from an aircraft. There were no identification numbers on the part and it could not be positively determined from which aircraft and which section it could have come from. It could not be positively determined whether the debris could be from a B777 aircraft.

Refer to *Appendix 1.12Q* for details.

22) Item 22 - Vertical Stabilizer Panel

Item No. 22 was found on 26 August 2016 on Linga Linga beach Mozambique.

The item was brought back to Malaysia for the identification and further examination by the Team.

On the interior side of the part, there was still a decal with part identification numbers. The Assembly (Assy) Number 177W3103-8 was visible. When referred to the Boeing 777 Illustrated Parts Catalog (IPC) this part was confirmed to be the right vertical stabilizer panel between the auxiliary and front spar. The red/white paint on the panel and the paint configuration appeared to match that of the MAS 'kite' logo on the right side of the vertical stabilizer.

The debris is confirmed to be part of the right vertical stabilizer panel of a B777. Based on the red/white livery on the panel it is determined to be *almost certain* from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12R* for details.

23)Item 23 - Unidentified Part

This item was recovered from Riake Beach, Nosy Bohara Island, Madagascar in October 2016.

The item was brought back to Malaysia for the identification and further examination by the Team.

The part structure construction characteristics showed that it was not part of the aircraft structure. It appeared more likely to be from the aircraft interior based on the vinyl and edge sealant which was on the part. The vinyl and sealant colour on the part matched that of the parts generally used in aircraft galleys. Although it appeared to be part of an aircraft interior there is no conclusive evidence to indicate whether the part could have actually originated from an aircraft.

Refer to *Appendix 1.12S* for details.

24)Item 24 - Unidentified Part

Two items of fibreglass-honeycomb composite debris were recovered near Sainte Luce on the south-east coast of Madagascar, having reportedly washed ashore in February 2016.

They were hand-delivered to the ATSB on 12 September 2016. The items were initially reported in the media as being burnt.

No manufacturing identifiers, such as a part numbers or serial numbers were present on either item that may have provided direct clues as to their origin. Despite no evidence of overall gross heat damage, two small (<10mm) marks on one side of the larger item and one on the reverse side were identified as damage resulting from localised heating. A burnt odour emanating from the large item was isolated to these discrete areas. The origin and age of these marks was not apparent. However, it was considered that burning odours would generally dissipate after an extended period of environmental exposure, including salt water immersion, as expected for items originating from 9M-MRO.

Refer to *Appendix 1.12T* for details.

25) Item 25 - Unidentified Part

This item was recovered from Riake beach, Nosy Boraha Island, Madagascar in July 2016.

The item was brought back to Malaysia for examination and identification by the Team. There were no identification numbers on the part and with the available features it could not be matched to any part on a MAS B777 aircraft.

Refer to *Appendix 1.12U* for details.

26) Item 26 - Right Aileron

This item was recovered from Nautilus bay, South Africa on 23 December 2016.

The item was brought back to Malaysia for identification and further examination by the Team. The debris closely matched the inboard section of the Right Aileron on a MAS B777 aircraft.

The numbers on the head of the fasteners on the debris were compared with those on the inboard section of the right aileron on the aircraft. These numbers matched. Additionally, the spacing of the fasteners on the aileron also matched those on the debris. The core and its dimensions also matched those on the inboard section of the right aileron. These confirmed that the debris is part of the inboard section of the right aileron of a B777 aircraft.

Based on the dimensions and fit on the aircraft and the visible fasteners it could be confirmed that the debris is part of the inboard section of the right aileron of a B777 aircraft. It was also determined to be *highly likely* from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12V* for details.

27)Item 27 - Right Wing No. 7 Flap Support Fairing

This item was recovered from Mpame beach, South Africa on 27 January 2017.

The item was brought back to Malaysia for identification and further examination by the Team. The possible location of the part on a MAS B777 aircraft was determined.

It was easily matched to the fixed, forward portion of the No. 7 flap support fairing. Item No. 2, found on 27 December 2015 at Daghatane Beach, Mozambique, is also part of the same fairing; however, it is part of the rear, moveable section.

The debris was thoroughly cleaned to reveal any identification numbers. After cleaning, the numbers 113W9211-402, S/N: 406 were found on the inside surface of the debris. The part number 113W9211-402 indicated that the debris was indeed a part of the No. 7 flap support fairing of a B777 aircraft. The serial number, 406 could not be used to link it to any particular aircraft as there were no records available to confirm this.

Based on the legible part number and the match of the part on the aircraft it is confirmed that the debris is part of the fixed, forward No. 7 flap support fairing of a B777 aircraft, and also determined to be *highly likely* to be from MH370 (aircraft registered as 9M-MRO).

Refer to *Appendix 1.12W* for details.

1.12.4 Process for Recovery of Debris

At the time of writing of this report, the possibility exists that more debris might be found washed ashore, especially at the coasts of south east Africa. Arrangements have been made with the Civil Aviation Authorities there to retrieve and secure the debris and to be delivered to the Team for examination.

SECTION 1 – FACTUAL INFORMATION

1.13 MEDICAL AND PATHOLOGICAL INFORMATION

Medical information relating to the crew is under *Section 1.5.*

Loss of aircraft cabin pressure, or depressurisation, is a potentially serious emergency in an aircraft flying at normal cruising altitude. Depressurisation, also known as decompression, is the reduction of atmospheric pressure inside a contained space such as the cabin of a pressurised aircraft. The cabins of modern passenger aircraft are pressurised in order to create an environment which is physiologically suitable for humans. The higher the aircraft flies, the higher the pressure differential that needs to be maintained and the higher the stress on the aircraft structure. Without a fully functional pressurised cabin, passengers and crew need to use oxygen systems during cruise. The composition of atmospheric air remains constant as air pressure reduces with increasing altitude. Since the partial pressure of oxygen also reduces, the absolute amount of oxygen also reduces. The reduction in air pressure reduces the flow of oxygen across lung tissue and into the human bloodstream. A significant reduction in the normal concentration of oxygen in the bloodstream is called hypoxia.

Hypoxia is a condition in which the body or a region of the body is deprived of adequate oxygen supply at the tissue level. The major symptoms and signs of hypoxia include light headedness or dizziness, blurred or tunnel vision, headache or nausea, diminished hearing and tingling or numbness of finger tips. The effects of hypoxia become more significant when exposed to an altitude above 10,000 ft.

Time of useful consciousness or also known as effective performance time is the amount of time crew and passengers can continue to conduct duties and activities in an environment with inadequate oxygen. It is measured from the time when the occupants of the aircraft are exposed to a low-pressure environment to the time when the occupants have lost the capability to take corrective and protective actions, such as self-administration of oxygen. The time of useful consciousness is dependent on the pressure altitude inside the cabin following depressurisation (Refer to *Table 1.13A* below). Hypoxia symptoms can be worse and time of useful consciousness shorter for people with respiratory or heart conditions, who are smokers and unfit, or have been drinking alcohol.

There was no evidence that physiological factors or incapacitation affected the performance of flight crew members on MH370.

Cabin Pressure Altitude (ft)	*Time of Useful Consciousness (TUC)*
15,000	More than 30 min
18,000	20 – 30 min
22,000	10 min
25,000	3 – 5 min
28,000	2.5 – 3 min
30,000	1 – 2 min
35,000	30 sec – 1 min
40,000	15 – 20 sec
Source: Reinhart, R.O. 1996. Basic Flight Pathology. 2nd Edition. McGraw-Hill: New York.	

Table 1.13A: Time of Useful Consciousness

SECTION 1 – FACTUAL INFORMATION

1.14 FIRE

Aircraft fire could not be established as there was no reported air or ground fire.

SECTION 1 – FACTUAL INFORMATION

1.15 SURVIVABILITY

Survivability of persons on board could not be established as the aircraft has not been found.

SECTION 1 – FACTUAL INFORMATION

1.16 TESTS AND RESEARCH

Not applicable.

SECTION 1 – FACTUAL INFORMATION

1.17 ORGANISATIONAL AND MANAGEMENT INFORMATION

1.17.1 Department of Civil Aviation Malaysia

1) Introduction

The Department of Civil Aviation **(**DCA) is an agency under the purview of the Ministry of Transport (MOT) with the authority to regulate and oversee all technical-operational aspects of the civil aviation industry in Malaysia.

As a Contracting State of the International Civil Aviation Organization (ICAO) since 1958 Malaysia through DCA is responsible to ensure that the safety and security of flights are consistently maintained at the highest level possible, and at the same time, to ensure the safety of the Malaysian airspace for aircraft operations in conformity to the requirements of ICAO in all aspect of polices, regulations and Standards and Recommended Practices (SARPs).

Malaysia's civil aviation system is based on the Federal Constitution as the supreme law. The legal framework in place consists of the following legislations enacted by Parliament:

- Civil Aviation Act 1969 (Act 3), last amended 01 June 2003
- Aviation Offences Act 1984 (Act 307);
- Airport and Aviation Services (Operating Company) Act 1991 (Act 467); and
- Carriage by Air Act 1974 (Act 148).

Specifically, Section 3 of the *Civil Aviation Act 1969* empowers the Minister of Transport *"to give effect to the Chicago Convention and regulate civil aviation.''* Under the authority conferred by the same provision, the Minister of Transport also enacted the *Civil Aviation Regulations 1996 (CAR) [P.U. (A) 139/96].*

CAR 201 stipulates the use of '*ipso facto*' to address ICAO Annexes 1 to 19, including the application of not only ICAO Standards, but also the recommended practices, provided that a regulation has not already been established in CAR and that a difference has not been notified to ICAO. In particular, DCA relies completely on CAR 201 for the implementation of Annexes 3, 4, 5 and 12.

The *Civil Aviation Act 1969* or Act 3 also empowers the Minister of Transport to make rules providing for *"the investigation in such manner as may be prescribed, including by means of a tribunal established for the purpose, of any accident either occurring in Malaysia or occurring to Malaysian aircraft."* In addition, this Act provides the Minister of Transport, the Chief Inspector of Air Accidents Investigation Bureau (AAIB) with the proper authority and legal tools to conduct investigations effectively, and in compliance with Annex 13.

CAR defines which accidents and incidents shall be reported and empowers the Minister of Transport to appoint a Chief Inspector of Air Accidents and Incidents. CAR provides for the Chief Inspector to *"determine whether or not an investigation shall be carried out in respect of any accident to which these regulations apply and the form of the investigation"*. The Chief Inspector may carry out, or may cause another Inspector to carry out, an investigation of any such accident. CAR also makes provision for the mandatory submission of a report to the Director-General of Civil Aviation (DGCA) in respect of any reportable occurrence. No provision is however made for a voluntary non-punitive reporting system.

2) Functions and Responsibilities of Department of Civil Aviation

The functions and responsibilities of DCA are, as follows:

- To exercise regulatory functions in respect of civil aviation and airport and aviation services including the establishment of standards and their enforcement;
- To represent the Government in respect of civil aviation matters and to do all things necessary for this purpose;
- To ensure the safe and orderly growth of civil aviation throughout Malaysia;
- To encourage the development of airways, airport and air navigation facilities for civil aviation;

- To promote the provision of efficient airport and aviation services by the licensed Company; and

- To promote the interests of users of airport and aviation services in Malaysia in respect of the prices charged for, and the quality and variety of, services provided by the licensed Company.

3) Sectors and Divisions of Department of Civil Aviation

<table>
<tr><th colspan="2">Sectors and Divisions of DCA</th></tr>
<tr><td>1. Flight Operations Sector</td><td rowspan="3">Grouped under a broader unit called Engineering and Flight Operations</td></tr>
<tr><td>2. Airworthiness Sector</td></tr>
<tr><td>3. Flight Calibration Division</td></tr>
<tr><td colspan="2">4. Air Traffic Management Sector</td></tr>
<tr><td colspan="2">5. Air Traffic Management Inspectorate Division</td></tr>
<tr><td colspan="2">6. Aviation Security Division</td></tr>
<tr><td colspan="2">7. Airport Standards Division</td></tr>
<tr><td colspan="2">8. Malaysian Aviation Academy Division</td></tr>
</table>

4) Areas of Focus

Section 1.17.1 will focus on three Sectors of DCA, as below:

a) Air Traffic Management Sector,

b) Airworthiness Sector, and

c) Flight Operations Sector.

5) Air Traffic Management Sector

The Director of the Air Traffic Management (ATM) Sector is responsible to the DGCA for the planning, implementation and operation of the air traffic services systems in the two Malaysian Flight Information Regions (FIRs), i.e. Kuala Lumpur and Kota Kinabalu FIRs respectively, in accordance with the ICAO Standards and Recommended Practices (SARPs).

The function of the ATM Sector is responsible for the provision of air traffic service for the safe and efficient conduct of flight within Malaysian airspace pursuant to the Chicago Convention 1944.

The Malaysian airspace is divided into the Kuala Lumpur and Kota Kinabalu FIRs, where operations are associated with air traffic control units. There are two Air Traffic Control Centres; in Kuala Lumpur and Kota Kinabalu, a sub-centre in Kuching as well as 12 Control Towers in Peninsular Malaysia, 4 in Sabah and 8 in Sarawak.

The Director of ATM Sector is supported by Regional Director I (Peninsular Malaysia), Regional Director II (Sabah), Regional Director III (Sarawak), Director KLIA and Director of KL ATSC in the functionality of the Sector.

Supporting the Regional Directors/Directors are ATSC Chiefs, Supervisors, DCA Managers, Unit Chiefs, Operational Controllers and support staff. Other entities, including Aeronautical Information Service (AIS), Procedures for Air Navigation Services and Operations (PANS-OPS), Cartography and SAR are under the direct responsibility of the Director of ATM Sector. The ICAO SARPs associated with the responsibility of ATM Sector are those contained in:

- Annex 1 - Personnel licensing;
- Annex 2 - Rules of the Air;
- Annex 3 - Meteorological Service for International Air Navigation;
- Annex 4 - Aeronautical Charts;
- Annex 5 - Units of Measurement to be used in Air and Ground Operations
- Annex 10 - Aeronautical Telecommunications Volume I & II;
- Annex 11 - Air Traffic Services;
- Annex 12 - Search and Rescue;
- Annex 14 - Aerodromes; and
- Annex 15 - Aeronautical Information Services.

Other relevant documents are:

- DOC 4444 - Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM);
- DOC 9859 - Safety Management System Manual;
- CIR 314 - Threat and Error Management (TEM);
- DOC 9910 - Normal Operations Survey (NOSS);
- DOC 9426 - Air Traffic Services Planning Manual; and
- DOC 9683 - Human Factors Training Manual.

a) Air Traffic Inspectorate Division

The Air Traffic Inspectorate (ATI) Division is the regulatory body that oversees the provision of Air Navigation Services (ANS) by the ANS providers to ensure compliance with the national legislations, namely the Civil Aviation Act 1969 and the Civil Aviation Regulations 1996, and ANS-related ICAO Annexes to the Chicago Convention.

The ATI Division develops and establishes the ANS safety standards and performs safety oversight and surveillance activities with the sole aim of regulating the ANS providers. The regulatory Manual of ANS Inspectorate contains the requirements and procedures pertaining to the provision of the ANS, based on the SARPs of ICAO Annexes to the Chicago Convention, other ICAO documents and best practices, as may be determined by the ATI Division which develops and establishes the ANS safety standards and performs safety oversight to be applicable in Malaysia. From time to time the ATI Division develops and establishes the ANS safety standards and performs safety oversight and may supplement these ANS safety standards in the form of safety publications such as Air Traffic Inspectorate Directives (ATIDS) or Aeronautical Information Circulars (AIC). Where appropriate, these safety publications will be incorporated into the Manual by amendments.

i) Audits/Inspections

The audits/inspections utilise protocols questions and compliance checklists to evaluate the level of adherence to stipulated national legislations, and ANS-related ICAO Annexes to the Chicago Convention and ICAO documents, including best practices. The ATI Division also conducts oversight of the ANS provider's safety management system (SMS) to ensure its formal and systematic implementation by all ATSUs, including compliance with stipulated requirements. Currently, the ANS providers that are regulated by the ATI Division include Air Traffic Management Sector of DCA, Malaysian Meteorology Department, Royal Malaysian Air Force (RMAF) and the Malaysian Army.

ii) Personnel Licensing

Personnel Licensing for ATCOs provisions was promulgated in the Malaysia Civil Aviation Regulations (MCAR) 1996. The ATI Division is the authority for issuance, renewal, endorsement and validation of an ATC Licence and an ATC Trainee Licence (implemented since 01 April 2011), in accordance with ICAO Annex 1 to the Chicago Convention.

(1) Air Traffic Control Examination activities include all ATC courses at ATC organisations that are approved by the DGCA and operational ATC examinations at ATS units that control civil air traffic. However, some functions are delegated to designated ATC Check Officers who are appointed on a two-year basis by the DGCA.

(2) Air Traffic Control Licensing provisions were promulgated in the MCAR 1996. The ATI Division is the authority for issuance, renewal, endorsement and validation of an ATC Licence and an ATC Trainee Licence in accordance with ICAO Annex 1 to the Chicago Convention, as follows:

(3) Class 3 Medical Assessment for ATCOs, as part of the pre-requisite for an ATC Licence and an ATC Trainee Licence,

shall only be issued by a Designated Aviation Medical Examiner (DAME). The ATI Division develops and establishes the ANS safety standards and performs safety oversight and maintains a comprehensive database of licensing information for all licensed holders, and

(4) English Language Proficiency (ELP) Assessment is required for ATCOs and aeronautical station operators, and they must meet the minimum required proficiency level for radiotelephony communications i.e. Level 4 in accordance with ICAO Annex 1 to the Chicago Convention.

iii) Certification and Audit of ATC Approved Training Organisation

The Certification and Audit of ATC Approved Training Organisation (ATC-ATO) is responsible for the training of ATCOs. It provides ATC training by holding ATC-ATO approval certificate that is issued by the DGCA. The ATI Division conducts a regular oversight programme on the approved ATC-ATO to ensure continuing compliance with the approval requirements.

iv) Air Traffic Control Incident Investigations

Air Traffic Control Incident Investigations are carried out for ATC safety-related occurrences to evaluate the effectiveness of the ATC system and its components, as well as recommending mitigation actions towards enhancements. The investigative process includes the Incident Review Panel (IRP), The Board of Inquiry (BOI) and the Safety Review Boards (SRB).

In addition to the licensing and validation of ATCOs, the ATI Division develops and establishes the ANS safety standards and performs safety oversight and is responsible for regulating the checks and standards units at various ATS facilities. It also conducts safety oversight of military ATCOs who are charged with the responsibility of providing air traffic services to civil flights in selected portions of the airspace.

The ATI Division develops and establishes the ANS safety standards and performs safety oversight and has also developed appropriate processes and procedures to enable the division to carry out its safety oversight functions in accordance with established requirements and in a standardised manner. The Division has the necessary facilities and equipment to enable the personnel to carry out their safety oversight functions in an effective manner. All necessary procedures, including guidance material, have been developed.

v) Search and Rescue

With respect to Search and Rescue (SAR), no legislation specifically addresses the provision of assistance to aircraft in distress. However, in Malaysia, aeronautical SAR (A-SAR) is provided in accordance with Annex 12 to the Convention of ICAO and International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual Vol. I to IV.

As a signatory to the Chicago Convention, Malaysia is obligated to provide A-SAR services on a 24-hour basis, within the Malaysian Aeronautical Search and Rescue Regions (SRR), (defined within the Kuala Lumpur and Kota Kinabalu FIRs).

With the implementation of National Security Council (NSC) Directive No. 20 effective 11 May 1977, A-SAR Operational procedures have been amended to harmonise with inter-agency actions during an aeronautical incident.

vi) Primary Aeronautical and Maritime Search and Rescue Agencies

(1) National Security Council

The National Security Council (NSC) is the body responsible for establishing, developing and maintaining Aeronautical and Maritime SAR Organisation in Malaysia. The Cabinet, through the Secretary of the National Security Council, directs the NSC on policy, international agreements, conventions and operational matter. The

NSC is responsible to the Cabinet on all matters pertaining to Aeronautical and Maritime SAR.

Note:

The National Security Council Act 2016 was enacted by the Parliament of Malaysia and published in the *Gazette* on 07 June 2016.

(2) Department of Civil Aviation

DCA is the SAR Authority for aeronautical incidents and shall be responsible for the provision of Aeronautical SAR service within Malaysia's Aeronautical Search and Rescue Regions (SRRs). As such DCA shall co-ordinate, liaise, train, equip, staff, maintain, develop procedures and operations and conduct exercises for A-SAR. DCA shall also assist the Maritime SAR Authority, when requested.

(3) Malaysian Maritime Enforcement Agency

The Malaysia Maritime Enforcement Agency (MMEA) is the SAR Authority for maritime incidents and shall be responsible for the provision of Maritime SAR service within Malaysia's Maritime SRRs. As such MMEA shall co-ordinate, liaise, train, equip, staff, maintain, develop procedures and operations and conduct exercises for maritime SAR. MMEA shall also assist the Aeronautical SAR Authority, when required.

vii) Aeronautical Search and Rescue Plan of Operation

The purpose of this plan is to provide a set of specific Aeronautical SAR Operation Procedures in all SAR missions within the Malaysian SRRs, for which DCA is the SAR Authority for aeronautical incidents and, acts as Chairman to the Aeronautical SAR Working Group. However, this plan is, by no means, exhaustive in nature, and is to be used in conjunction with IAMSAR MANUAL VOLUMES I, II, and III and as well as other departmental documents issued from time to time. Operational Letters of Agreements have also been signed with neighbouring States/SAR Regions. The preparedness and training of all entities is ensured through regular exercise and training.

viii) International Search and Rescue Treaties, Conventions and Agreements

DCA Malaysia had participated in a number of international organisations such as ICAO, and in accordance with the Convention on international Civil Aviation has adopted search and rescue (SAR) standards and practices. Additionally, there are SAR bilateral agreements between Malaysia and the ASEAN countries (Indonesia, Singapore, Thailand, Brunei and the Philippines) SAR agencies to enhance coordination, cooperation and mutual support for operations along commons borders.

(1) Search and Rescue Agreements:

(a) Multilateral

As a member state of the Association of South East Asia Nations (ASEAN), and in line with the Declaration of ASEAN Concord for Cooperation between the member states of Indonesia, Philippines, Singapore and Thailand, Malaysia has formalised the following on aeronautical and maritime SAR:

ASEAN Agreements for the facilitations of search for aircraft in distress and rescue of survivors of aircraft accidents, signed in Singapore on 14 April 1972; and

ASEAN Agreements for the facilitations of search for ships in distress and rescue of survivors of accidents, signed in Kuala Lumpur on May 1975.

(b) Bilateral

Malaysia has also signed Bilateral Aeronautical SAR Agreements with the following countries:

1.	Singapore	11 August 1984
2.	Thailand	09 August 1985
3.	Indonesia	29 August 1985
4.	Philippines	09 December 1985
5.	Brunei Darussalam	16 December 1998

(c) Other Arrangements

Special operational procedures for border SAR Malaysia/Indonesia by the General Border Committee, resulting from the special arrangements between the Malaysia/Indonesia SAR Working Group of both countries.

Under the Operational Letter of Agreements between Singapore and Malaysia pertaining to aeronautical SAR service in the South China Sea Corridor Area[12], Kuala Lumpur ACC shall take alerting actions while Singapore RCC shall conduct the aeronautical SAR mission (AIP Malaysia Volume I ENR 2.2-3).

It is noted that the SAR responsibilities over the high seas/Malaysia Exclusive Economic Zone (EEZ) within the KL FIR/ASRR over Malaysia Maritime SAR Region (MSRR) shall be under the jurisdiction of Malaysia SAR authorities.

[12] South China Sea Corridor Area is defined as the area West of 105E at flight level 150 to Ground/Sea Level and East of 105E at flight level 200 to Ground/Sea Level, within the dimensions of 023600N 1044500E to 020000N 107000E and along 020000N till the Singapore/Kota Kinabalu FIR boundary - thence along 060000N till the Singapore/ Kuala Lumpur FIR Boundary - thence along this boundary to 023600N1044500E)

(d) Area of Responsibility

In accordance with ICAO agreements, the international boundaries for the provision of the search and rescue (SAR) services in Malaysia and adjacent ocean areas are divided into two search and rescue regions (SRRs) for aeronautical coordination.

(e) Search and Rescue Regions of Malaysia

As promulgated in the ICAO's Regional Air Navigation Plan, the Search and Rescue Regions of Malaysia are defined as the areas coincide with the boundaries of the Kuala Lumpur and Kota Kinabalu Flight Information Regions; airspace as delegated by Aeronautical SAR Region (ASRR) Appendix ICAO under Malaysia's jurisdiction. The Malaysia ASRR area of responsibility is, as *Figure 1.17A* (below).

(f) Maritime Search and Rescue Regions

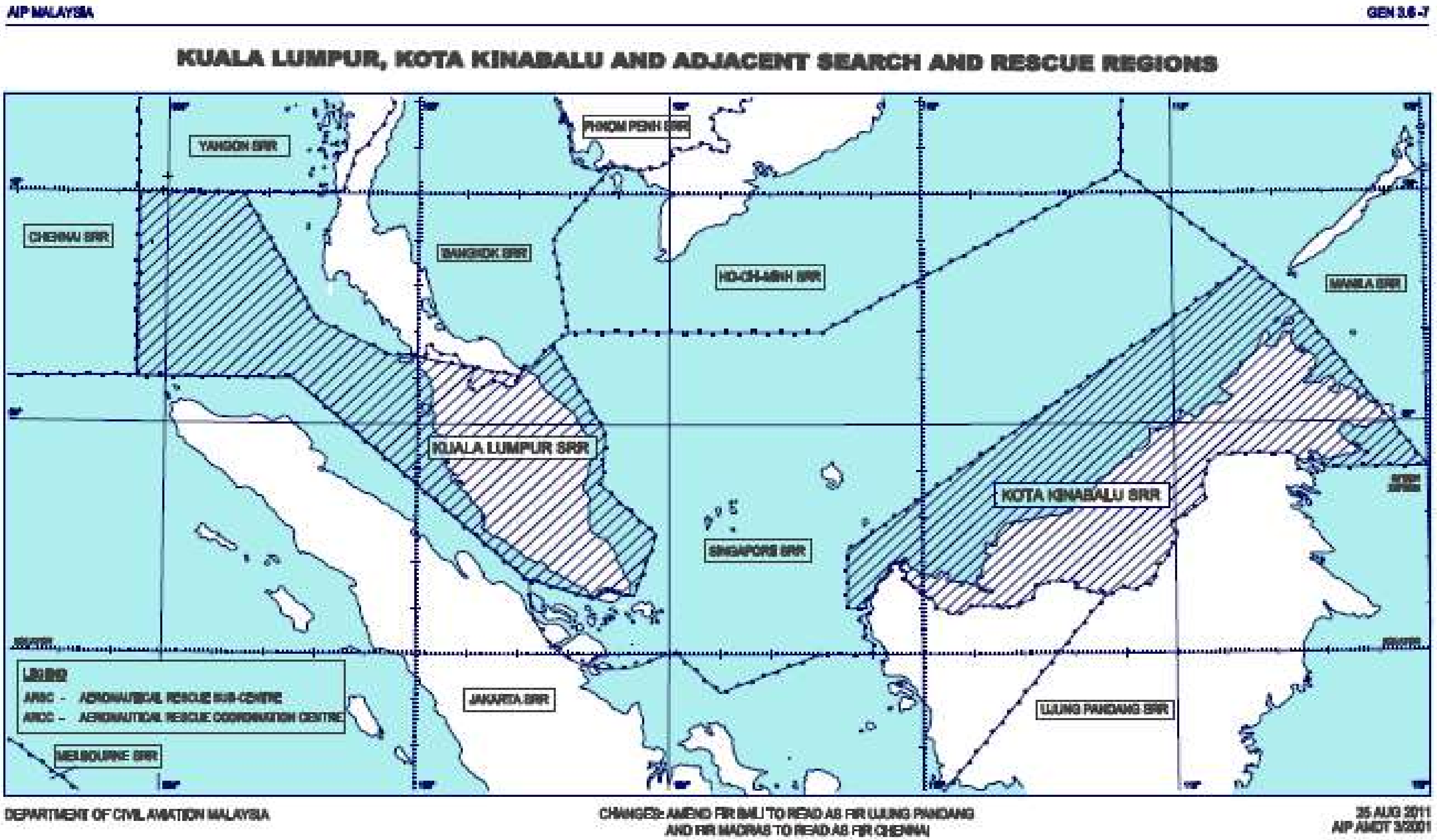
The Malaysia Maritime Search and Rescue Regions (MSSR) - *Figure 1.17B* (below), include the waters of Malaysia and the areas declared as the Continental Shelf Boundary and also the waters under the FIRs delegated to Malaysia. This information is published in IMO SAR Plan.

(g) Responsibilities of Department of Civil Aviation on Search and Rescue

The responsibilities of DCA on Search and Rescue are as follows:

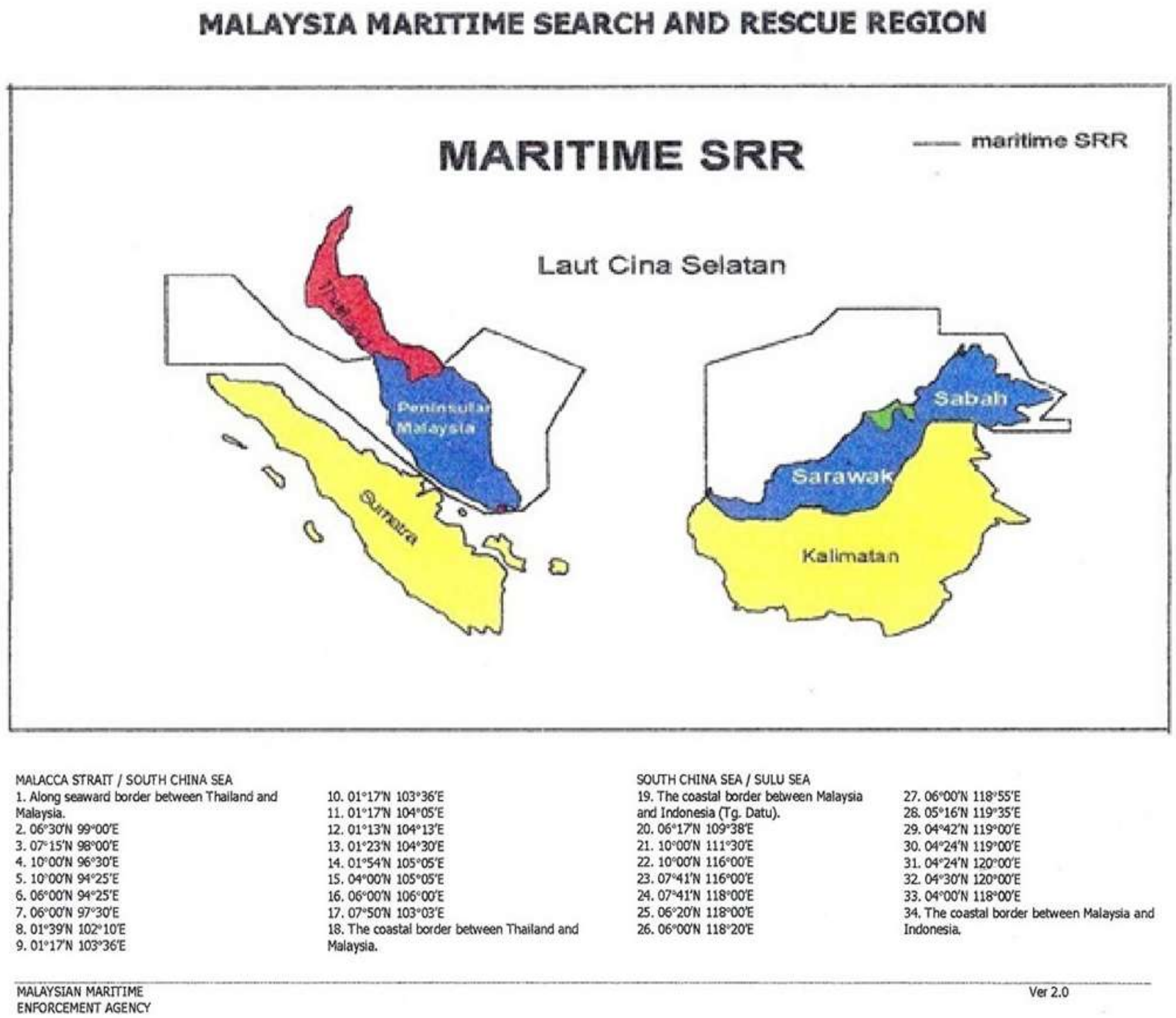
- Developing SAR policies;
- Developing A-SAR bilateral agreements with adjacent states;

- Establishing, staffing, equipment and managing the A-SAR system;
- Conduct training courses in search and rescue at the Civil Aviation Academy and refresher courses at the ARCC;
- Coordinate for SAR training and refresher courses;
- Establishing of ARCCs and ARSC;
- Arranging for SAR facilities; Conduct and coordinate all SAR missions involving civil aircraft within its areas of responsibility.
- Assist in the conduct of all SAR missions involving military aircraft, when requested by RMAF;
- Assist in the conduct of SAR missions involving vessel when requested by MRCC/MRSC;
- Provision and maintenance of the KL ARCC, KK ARCC and Kuching ARSC; and
- Tasking of SAR participating aircraft or vessel for search and rescue operations:
    - Provision of survival equipment; and
    - Periodically conduct national and international search and rescue exercises (SAREX).



Source: DCA Malaysia

Figure 1.17A - Malaysia Aeronautical Search and Rescue Region



Source: International Aeronautical and Maritime Search and Rescue Manual Volume

Figure 1.17B - Malaysia Maritime Search and Rescue Regions

h) Kuala Lumpur Air Traffic Service Centre

The Kuala Lumpur Air Traffic Service Centre (KL ATSC) is headed by a Director and supported by two deputies - Deputy Director for ATSC and Deputy Director for KL TMA - and 243 ATCOs of various grades. The total number of the ATCO posts approved by the Government was 353. As of March 2014, there were 110 vacant posts.

The KL ATSC's Controller Working Positions (CWPs):

(i) Approach Control Surveillance

- TMA Supervisor
- Aproach North
- Approach South
- Approach Low
- Approach Radar (Flow Control)

(ii) Area Control Surveilliance

- Sector 1 Area Control Surveilliance
- Sector 2 Area Control Surveilliance
- Sector 3 Area Control Surveillance
- Sector 4 Area Control Surveillance
- Sector 5 Area Control Surveillance
- Sector 6 Area Control Surveillance (Sector 1 Upper)
- Sector 7 Area Control Surveilliance

(iii) Area Control Procedural

- Sector 1 Area Control Procedural
- Sector 2 Area Control Procedural
- Sector 3 Area Control Procedural
- Sector 4 Area Control Procedural
- Sector 5 Area Control Procedural

(iv) Sector Flight Data Assistant/Clearance Delivery

- Sector 1 Flight Data Assistant
- Sector 2 Flight Data Assistant
- Sector 3 Flight Data Assistant
- Sector 4 Flight Data Assistant
- Sector 5 Flight Data Assistant
- Sector 6 Flight Data Assistant
- Flight Data Processing
- Clearance Delivery
- Assistant Clearance Delivery
- Assistant Flight Information Services

(v) Working Positions (No Rating required)

- Watch Manager
- Controller-Pilot Data Link Communications
- Flight Information Services
- High Frequency/Aeronautical Mobile Services Station (HF/AMSS) South East Asia (SEA)1 and HF/AMSS SEA 2 Aeronautical Fixed Telecommunications Networks (AFTN) 1 and AFTN 2

(vi) Butterworth Terminal Area

To enable the Military to meet its national operational requirements, a number of control zones, training areas and danger areas have been established. Operational control of these airspaces and responsibility for the provision of air traffic services within these airspaces have been delegated to the military. Coordination procedures between the civil and military authorities have also been established as follows:

Provision of approach control service within lateral limits of Butterworth Control Zone:

- Ground/Sea - 5,500 ft. altitude - FL245,
- Elsewhere 2,500 ft altitude - FL245 with Butterworth Terminal Area.

Air traffic to/from the civilian Penang International Airport (PIA), Alor Setar Airport and Langkawi International Airport is provided by military ATCOs who have been licensed by the ATI Division, which develops and establishes the ANS safety standards and performs safety oversight and to ensure the provision of services to civil traffic. The rationale for such an arrangement is based on the military activities at Butterworth Military Airport (BMA) which is in close proximity to PIA, and other military activities carried out over the high seas in danger areas WMD 412A and WMD 413A (permanently established). Furthermore, the final approach segments of both the PIA and the BMA intersect. No major incident has been recorded with the present arrangement/delegation of authority.

6) Airworthiness Sector

The Civil Aviation Act of 1969 empowered the DGCA to exercise its statutory powers to regulate the civil aviation and airport services including the establishment of standards and its enforcement.

The Civil Aviation Regulation (CAR) of 1996 was derived from the United Kingdom Air Navigation Order (ANO) of the mid-nineties and adopted with certain provisions for the Malaysian requirements. The CAR Fifth Schedule - Aircraft Equipment and Sixth Schedule - Radio and Radio Navigation Equipment to be carried in aircraft, and the DGCA issued Airworthiness Notices (ANs) specifically AN. No. 1 - Aircraft Certification, forms the basis for aircraft airworthiness and design standard for acceptance into Malaysian registry.

A comprehensive review of the MCAR 1996 by consultants was carried out in March 2013 and the submission of the final report was completed in January 2014. It was anticipated that the introduction of the CAR 2016 would streamline the DCA regulatory functions on similar approach to the European Aviation Safety Agency (EASA) requirements. This would include the introduction of CASR (Civil Aircraft Safety Requirements, AMC (Acceptable Means of Compliance) and GM (Guidance Materials) as part of the Malaysian regulatory framework, requirements and procedures.

The Director of Airworthiness Sector reports directly to the DGCA and is responsible for the operations of five divisions, namely: Continuing Airworthiness, Engineering, Maintenance Repair and Overhaul (MRO), Licensing and Standards.

The primary functions of the Airworthiness Sector include surveillance oversight of the aircraft maintenance activities on scheduled and non-scheduled air carriers, MROs, and the licensing of Aircraft Maintenance Engineers (AMEs). The sector is also responsible for the management of the aircraft register and joint technical audits with the Flight Operations Sector and Air Transport Sector for the issue or renewal of Air Operating Certificate.

With respect to aircraft accidents or incidents investigation, officers with specific trade and specialisation may be called upon, to assist the Air Accident Investigation Bureau, which is under the Ministry of Transport.

The Airworthiness Sector has established a minimum qualification of a university engineering degree or an Aircraft Maintenance Engineer's Licence (AMEL) for the posts of Airworthiness Engineers or

Airworthiness Inspectors respectively, and in addition, a minimum of five to seven years hands-on aviation industry experience. 37 of the 40 posts had been filled to support an 8% annual rate of growth of aircraft increment for the local air transport industry.

The Airworthiness Sector has developed a good working relationship with the local aviation organisations whereby, the newly recruited technical staff have been given the exposure to work closely with industry players. The DCA has made provisions in the AN. No. 1 Aircraft Certification, for the operator to bear the cost of training for DCA officers, specifically for the airworthiness engineers, inspectors and pilots for new aircraft type to be placed on the Malaysian register. This serves to keep them abreast with the latest development on the local airlines or operators fleet expansion programme.

The DCA Airworthiness Division Manual (ADM) provides guidance and procedures to airworthiness inspectors and airworthiness engineers to carry out their duties and function responsibilities.

The Sector emplaces a fairly comprehensive audit plan for the local and international organisations requiring DCA approvals. These approved organisations are subject to an annual audit. The audit includes local and international base maintenance and line stations. These audits may be scheduled on mutual arrangement with the organisation or be carried out on an opportunity basis when the DCA officers are in the vicinity of that organisation during the auditing period.

Any audit findings or deficiencies will be recorded in the NCRs (Non-Conformance Reports) and categorised into the respective levels of Level 1, Level 2 or Level 3. The Level 1 NCR requires urgent and mandatory compliance to a major deficiency in the audit findings. The Sector would review the corrective actions and reschedule an audit of the organisation before closing the finding as acceptable.

The ANs are published on a regular basis in the DCA website and would serve to notify any current changes on airworthiness policies or requirements for the Aircraft Maintenance Engineers and the aviation organisations to comply with as applicable. Some of the Airworthiness Notices issued by the Airworthiness Sector may originate from Original

Equipment Manufacturers' (OEMs) service bulletins or in-service difficulties arising from incident or accident reports which may affect aviation safety. The Airworthiness Notices form part of the Malaysian regulatory framework and the expedient means for the aviation industry to comply with at short notice.

The AN. No. 11 - Mandatory Occurrence Reporting, requires Air Operators and Maintenance Organisations to transmit information on faults, malfunctions, defects and other occurrences which cause or might cause adverse effects on the continuing airworthiness of the aircraft to the DCA.

With respect to ICAO Annex 19 - Safety Management, the Airworthiness Sector has implemented the requirement under AN No. 101 - Safety Management Systems (SMS) For Approved Maintenance Organisation (AMO) including Approved Training Organisations (ATOs) in March 2008. The SMS was made effective on 01 January 2009.

The Sector has been actively involved in the audits of 176 local and international Approved Maintenance Organisations (AMOs) that hold the DCA approvals; continuing airworthiness surveillance of 892 aircraft (of which 839 aircraft are active in operations), 12 Approved Training Organisations (ATOs) for Aircraft Maintenance Engineers and Technicians ab-initio training and also aircraft type training programme. There were 4,212 Licensed Aircraft Maintenance Engineers issued with DCA licence, but 2,374 licensed holders remain current. CAR 30 requires that inspection, overhaul, repair, replacement and modification works on a Malaysian-registered aircraft, including the engines, propellers and aircraft components, are carried out by an approved person or organisation, specifically, under the AMO maintenance organisation exposition procedures. The DCA requires the release of an aircraft 'Certificate of Release to Service' to be issued by an approved or authorised personnel, type-rated on the aircraft type under a DCA approved AMO procedures. The introduction of the new CARs would also address the training requirements and certification responsibilities of both Aircraft Maintenance Engineers in Category B and Aircraft Maintenance Technicians in Category A in their respective trades. The DCA Malaysia Part 66 engineers and technicians licensing system is based on the EASA Part 66 syllabus and training requirements.

7) Flight Operations Sector

The Director of Flight Operations reports directly to the DGCA and is responsible for the operations of five divisions, namely:

- Flight Crew Licensing,
- Air Operator Regulatory,
- Flight Simulator,
- General Aviation, and
- Flight Calibration.

The primary functions of the Flight Operations Sector include surveillance oversight on scheduled and non-scheduled air carriers, flight test and simulator training of pilots, flight crew licensing on examinations standards, General Aviation activities, airfields and airways calibration and the conduct of a joint technical audit with the Airworthiness Sector and Air Transport Sector for the issue or renewal of Air Operating Certificate (AOC) for scheduled and non-scheduled air carriers. With respect to aircraft accidents or incidents investigation, pilots from this sector may be called upon, to assist the Air Accident Investigation Bureau, under the Ministry of Transport.

The Sector has established the procedures for Mandatory Occurrence Reporting (MOR) Scheme Guidelines in the Flight Operations Notice for the air operators to comply with in DCA Malaysia website.

With respect to ICAO Annex 19 - Safety Management, the Flight Operations Sector had implemented the requirement under the Aeronautical Information Circular (AIC) No: 06/2008. In conjunction with ICAO Annex 6 Part 1 Chapter 3 paragraphs 3.2.3 and 3.2.4 and Part III Chapter 1 paragraphs 1.2.3 and 1.2.4 with effect from 1 January 2009, it requires all Malaysian AOC Holders to implement an integrated Safety Management Systems (SMS).

To date, 8 of the AOC Scheduled Operators have complied with the SMS requirements and approved by the Sector. The implementation of the SMS for the 16 Non-Scheduled Operators is being incorporated in stages.

The following documents form part of the sector procedure manual in carrying out their surveillance responsibilities:

- Flight Operations Surveillance Inspector Handbook,
- Flight Crew Licensing Handbook,
- Flight Operations Policy, and
- Procedure Manual and Ramp Inspection Handbook.

As stated in the authorised Flight Examiner Handbook, each flight examiner is required to conduct at least six instrument flight checks and two type rating checks over the three-year period of their authorisation. In addition, they have to submit a quarterly activity report. In accordance with the Handbook, the authorised examiner has to pass an initial test upon appointment and a renewal test, to be conducted six months prior to the expiration of the authorisation. In between the tests, the examiner will also be the subject of one observation session to be conducted by the inspector.

The present activities of the Flight Operations Sector for surveillance oversight includes 8 Scheduled Operators, 21 Non-Scheduled Operators 8 Approved Flying Training Organisations, 16 new AOC applicants, 12 Flying Clubs, international flight en-route Inspections, domestic and international Station Facility Inspections and Ramp Inspections.

The frequency for Station Facility is once in every 2 years, the RAMP Inspection is 4 inspections at every originating en-route or destination stops, 4 inspections annually at every location but may depend on the safety performance of the operator while Base Inspection for Scheduled Operations and Non-Schedule Operations to be carried out on annual basis.

The Sector has a total establishment of 28 pilot posts to manage the various divisions, and of which only 16 posts had been filled. The need for experienced pilots to fill up the various posts had been an issue for most authority bodies worldwide, unless better incentives are offered.

1.17.2 Malaysia Airlines

1) Introduction

Malaysia Airlines (MAS) began in 1937, when the Straits Steamship Company and Imperial Airways formed Malayan Airways Limited (MAL) in Malaya. MAL evolved through many changes to Malaysia-Singapore Airlines (MSA) until Singapore gained its independence in 1965, where its Malaysian part became Malaysian Airline System (MAS) Berhad. In 1987 the Company took the commercial name of 'Malaysia Airlines' in line with the international promotion of the country.

MAS held an Air Service Licence (ASL) and Air Operators Certificate (AOC) for scheduled and non-scheduled operations. It was public-listed in 1985 with the Government holding a golden share. At its peak, MAS had an extensive network of operations with more than 100 destinations spanning over 5 continents around the world. The recession in 1994 affected the airline's business significantly when its operations were drastically scaled down.

The airline's performance for the past years had been a subject of great interest as it had suffered financial losses. Competition from emerging low-cost operators significantly contributed to the negative performance of the Company. MAS had in its fleet the A380, A330, B747-400, B777-200ER, B737-400 and B737-800. Its subsidiaries Firefly & MASWings operated the ATR-72 plying most of the domestic network in Peninsular and East Malaysia.

In spite of its scaled-down operations it was still a fairly large organisation (*Figure 1.17C* [below] shows the *Organisation Structure of MAS*), with a staff strength of more than 20,000 employees. It was headed by a Group Chief Executive Officer (CEO) who reported to the Board. Eight Directors reported to him, each heading a Division. The Divisions were, as follows:

- Group CEO Office
- Commercial
- Operations
- Corporate Services
- Customer Services

- Finance
- Human Resources
- MAS Aerospace Engineering (Engineering & Maintenance Division)

2) Engineering & Maintenance

a) Organisation Structure

The Engineering & Maintenance Department (EMD), also known as MAS Aerospace Engineering, was headed by a Chief Executive Officer (CEO), assisted by a Deputy CEO (Airlines Operations) and Senior Vice President (SVP) MRO Operations. The Finance, Engineering Materials, Business Support, Business Development, Legal and Warranty departments of the EMD reported direct to the CEO of the EMD. Heavy Maintenance, Engineering, Commercial, Training, Special Project, Engineering Facility and Workshop departments reported to the SVP (MRO Operations). The Technical Services, Maintenance Operations, Aircraft & Engine Maintenance Planning, Quality Assurance, Aircraft Project, Lease Planning, End-of-Lease (EOL)/Airline Engineering Group (AEG) Special Project and EOL Project Departments reported to the Deputy CEO (Airlines Operations). The organisation's management structure encompassed all the relevant areas befitting a maintenance management and maintenance organisation and was manned by suitable and experienced personnel. Key positions (post holders) as required for the Air Operators Certificate (AOC) holder and maintenance organisation were nominated by MAS and approved by DCA Malaysia. These key positions were further supported downstream by departmental managers and their executives.

b) Maintenance and Design Approval

The EMD was responsible to manage and carry out the maintenance of the MAS fleet of aircraft, which consisted of B747-400, B777-200ER, B737-400, B737-800, A330 and A380. The Maintenance and Management approval was issued by the DCA Malaysia in 1971. The approval was based on the approved quality

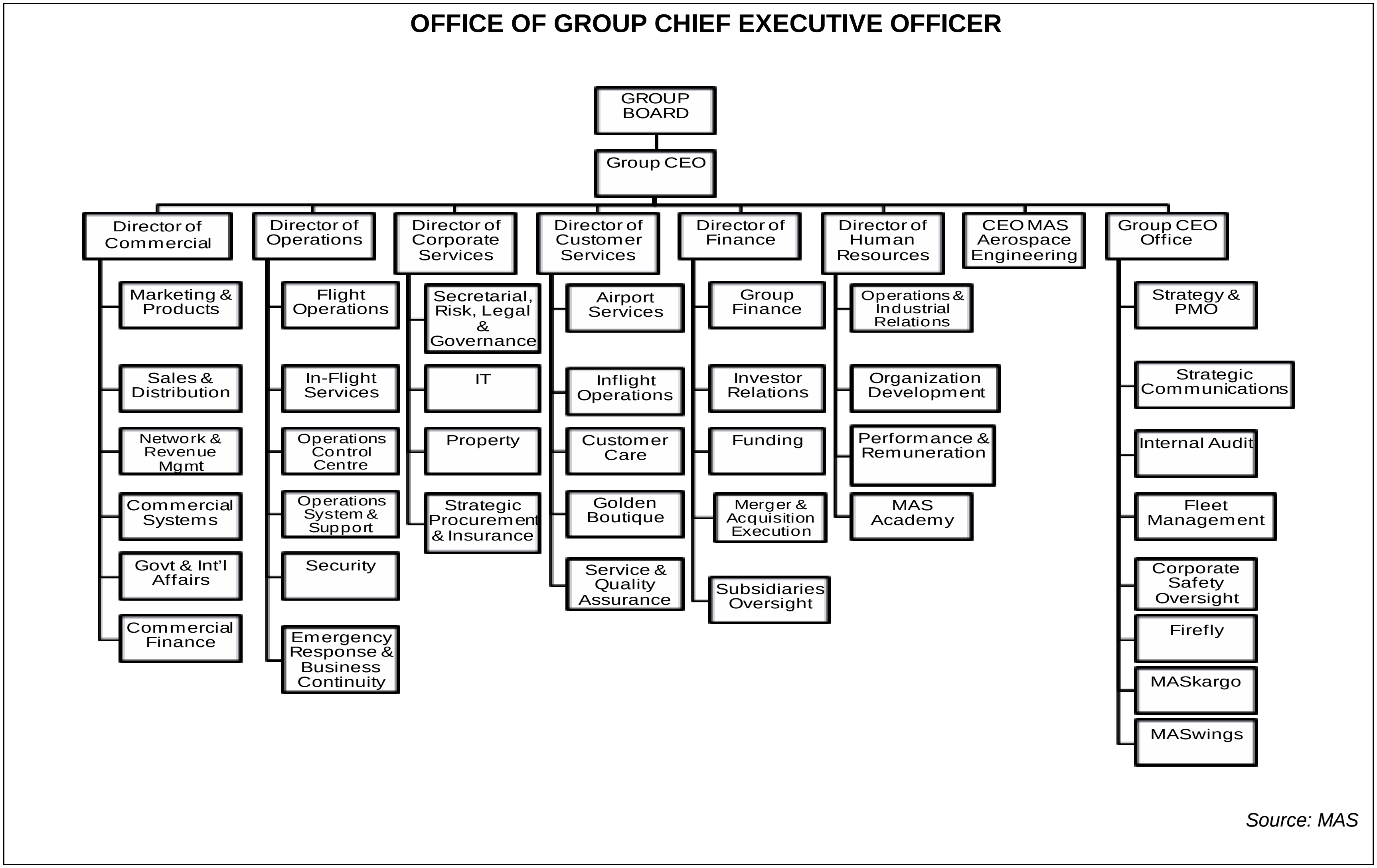


Figure 1.17C - Organisation structure of MAS

system laid out in the Maintenance Management Organisation Exposition (MMOE). The quality management system as detailed in the MMOE was under the responsibility of the Head of the Quality Assurance, who had direct access to the CEO of the EMD.

In the quest to undertake third party maintenance business the EMD also carried out maintenance of foreign registered aircraft under their respective National Aviation Maintenance Organisation Approvals. These approvals are from the European Aviation Safety Agency (EASA), the Federal Aviation Administration (FAA) of the United States of America (USA), the Civil Aviation and Safety Authority (CASA) of Australia and others. All these approvals had their independent approval process of initial approval, revalidation and surveillance.

The oversight of these maintenance activities was by regular audits and surveillance by the internal auditors of the Quality Assurance department and by DCA Malaysia, as well as the National Aviation Authorities of the various countries whose aircraft were maintained by MAS. In some cases, the audits were also carried out by the respective customers. There have not been any findings significant enough for any regulatory actions to be taken against the EMD for issues arising out of aircraft maintenance.

The EMD was also issued with Design Organisation Approval by DCA Malaysia. This allows the EMD to make minor design changes on the MAS fleet. To administer this, a team of engineers in the Technical Services Department of the EMD were qualified and approved in the various aviation disciplines such as Structures, Systems and Avionics.

c) Training

The EMD had its own Training school which provided ab-initio training to qualify selected candidates to obtain the DCA Malaysia Maintenance Engineers' licenses in the Mechanical or Avionics category. There were also training programmes for aircraft and workshop technicians as well as approval holders. The Training School also provided continuation training which was required for all staff working on aircraft and in workshops, and in addition, aircraft type training and training for external parties. The training requirements were laid down in the DCA Part 66, which is similar to the EASA Part 66 requirements.

d) Base Maintenance

The EMD had two main bases for base maintenance: KLIA in Sepang and Subang Airport (SZB) in Subang.

The Kota Kinabalu (BKI) base in Sabah was an extension of the KLIA base. These bases were equipped with the hangars and facilities as required in the scope of the approval. The SZB base had 4 hangars to accommodate all aircraft in the MAS fleet. The SZB facility also accommodated all the support workshops for the required maintenance. The KLIA base had 2 hangars, one of which could accommodate the A380-800. The KLIA base had some limited support workshops for maintenance activity under the scope of approval. The BKI, extension of KLIA, had one smaller hangar only capable to accommodate B737 series aircraft or its equivalent.

e) Line Maintenance

Other than the main bases, there were also line stations according to the regions around the world. These were, as follows:

- Peninsular Malaysia,
- Sabah and Sarawak,
- South East Asian,
- Far Eastern,
- America and Pacific,
- Australian and New Zealand,
- Indo-Pakistan/Mideast and African, and
- European.

Line maintenance of aircraft at international line stations was contracted out to the local maintenance organisations. These line maintenance organisations were approved by DCA Malaysia before they took over the task. The organisations were also subjected to regular audits by MAS and DCA Malaysia.

f) Maintenance Authorisation

The EMD had approximately 4000 staff; distributed among the SZB base, KLIA base and the BKI extension base. There were approximately 1240 certifying staff at both SZB and KLIA bases and 41 certifying staff in BKI. The certifying staff consisted of the following:

- Licenced Aircraft Maintenance Engineers,
- Workshop approval holders,
- Certifying mechanics,
- Stores Inspectors,
- Non Destructive Testing (NDT) approval holders,
- Welders.

Authorisation of certifying staff for aircraft and component maintenance was carried out by the EMD's Quality Assurance department. This was strictly in accordance with the requirements laid down in the MMOE. These requirements, which were in line with the EASA requirements, were approved by DCA Malaysia. This process of authorisation was subjected to internal audit by independent quality auditors within the organisation, as well as by the DCA and other National Aviation authorities.

The Head of Quality Assurance (QA) was responsible for the administration and control of the Certifying staff.

g) Safety Management System

The EMD had implemented the Safety Management System as documented in the Safety Management Manual and as required by DCA Malaysia Airworthiness Notice No. 101. This safety management was a part of the Company-wide Corporate Safety Management led by the Corporate Safety Oversight department which reports to the Group CEO's office. There was an internal reporting system in place for occurrences and hazards which encompassed provisions for confidential reporting. Regular safety meetings were conducted within the organisation as well as representing the division within the overall corporate system. Safety Management was supported by Occupational Safety, as required by the Occupational Safety and Health Act 1994. Safety actions were deliberated during these meetings and mitigating actions were discussed and followed up.

3) Operations

This division was headed by the Director of Operations and supported by Flight Operations, In-flight Services, Operations Control Centre, Operations System & Support, Security, and Director of Operations Office.

a) Flight Operations

The structure consisted of 6 Senior Managerial positions namely Quality Assurance & Regulatory Affairs, Training & Standards, Flight Safety & Human Factors, Technical & Development, Crew Planning & Deployment and Line Operations.

i) Flight Operations Management

The Flight Operations Management Structure *(Figure 1.17D* below*)* met the Air Operators Certificate (AOC) requirement as stipulated in the MCAR 1996. The key post holder positions in MAS were manned by captains who possessed outstanding credentials, senior in rank and had held several aircraft type rating in the airline's fleet. Their extensive exposure was therefore an asset to the airline's operations.

MAS Operations Manual A, Part 1.4.11 defined the guidelines for management pilots' office coverage and flying duties. As an example, the guideline stipulated that a Flight Operation

Manager (FOM) would be rostered 9 days flying duties (excluding weekend) and 13 days on office duties.

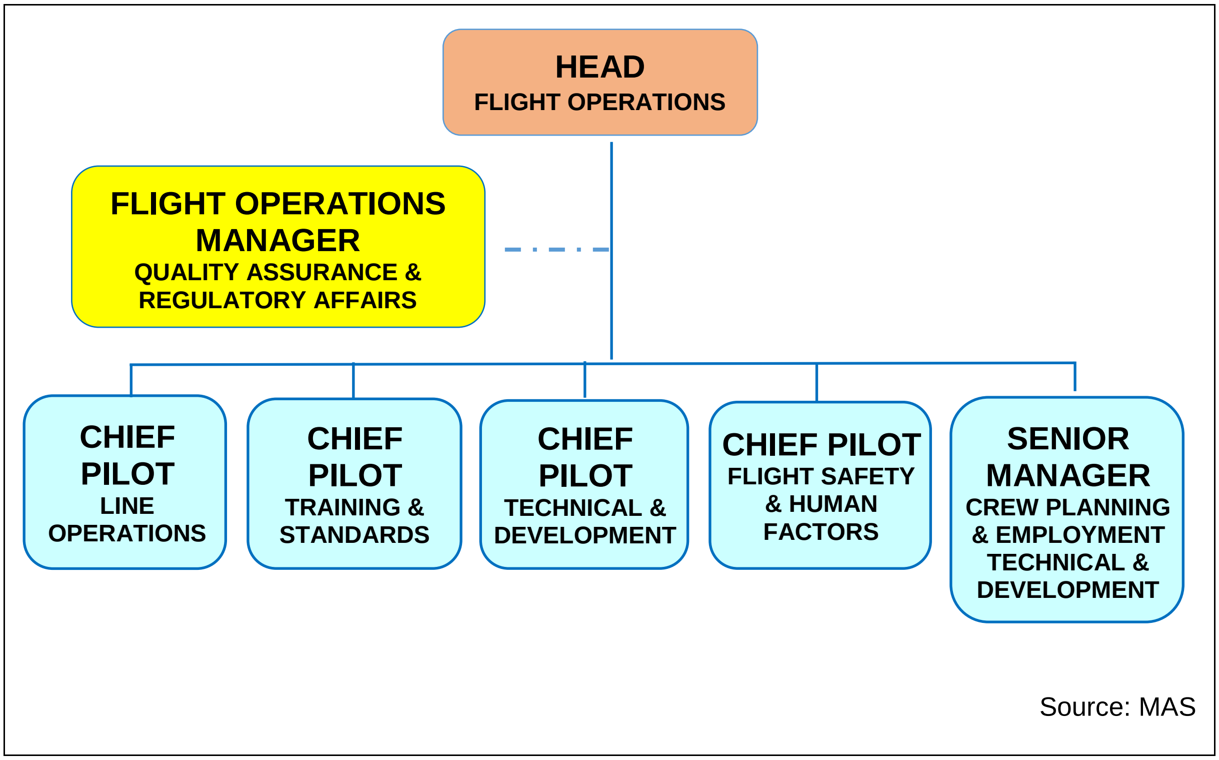
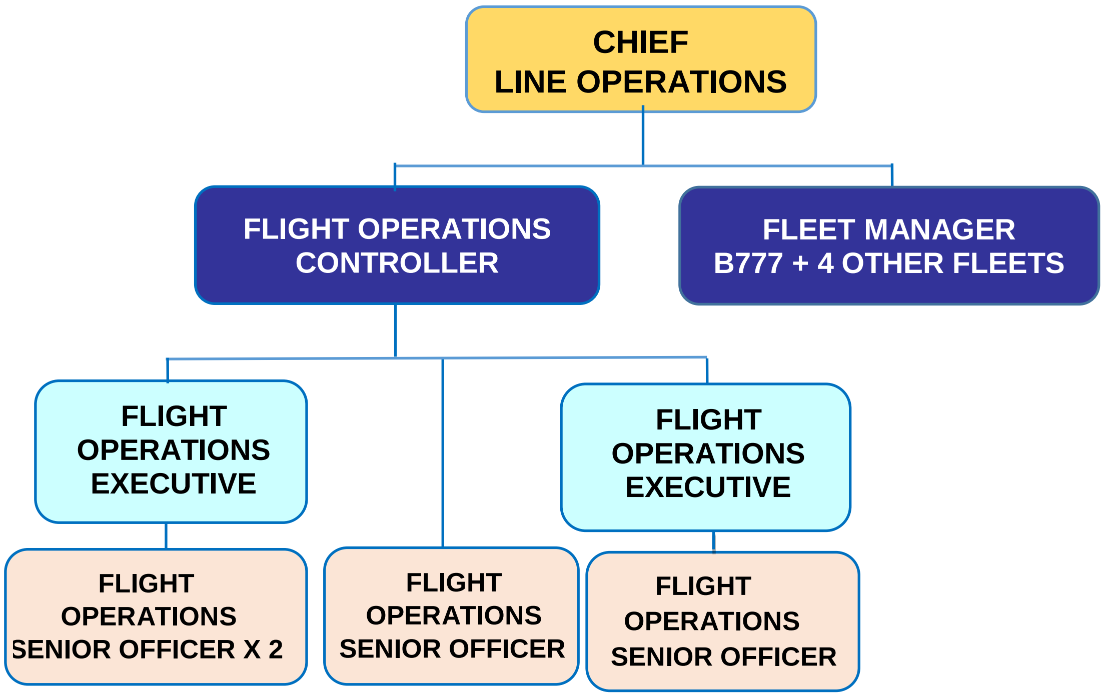


Figure 1.17D - Organisation of Flight Operations Management

ii) Organisation and Management related to B777 Operations

All the fleets in the Company were under the purview of Chief Pilot Line Operations. The fleet was headed by a Fleet Manager B777 who would report to the Chief Pilot Line Operations. The Fleet Manager B777 had been with the Company for the past 17 years and until March 2014 the fleet comprised of 17 aircraft. The Fleet Manager (with more than 10 years Command experience on the B777) was supported by non-flying staff in the day-to-day management of the fleet co-ordinated by Flight Operations Controllers (*Figure 1.17E* [below]).



Source: MAS

Figure 1.17E - Line Operations, Administration & Support (as of January 2014)

iii) Technical Crew

The airline technical crew were pioneered by pilots who crossed over to MAS when the then Malaysia-Singapore Airlines (MSA) split in 1972 to become MAS and SIA respectively. In the early days of MAS up to the mid-1980s a majority of MAS pilots came from MAS-sponsored cadets. These trainee pilots were normally sent to reputed Flying Colleges/Academies, mainly in Australia, Philippines, Scotland and Indonesia. These candidates were put through stringent pre-hire recruitment processes which included aptitude tests, psychomotor skills, as well as interviews by a panel comprising of Management Pilots and Human Resource Managers and/or Executives. In later years, the process became even more stringent with the inclusion of simulator evaluation and psychological tests.

After the mid-1980s, the emergence of local flying schools had resulted in most of the sponsored cadets undergoing their basic training in Malacca at the Malaysian Flying Academy (MFA). The MFA had also provided training for foreign students from Singapore, Indonesia, Bangladesh and India. This had benefited MAS in terms of costs and the ability to graduate ab initio qualified pilots in a shorter time compared to overseas flying schools.

In the last ten years, more flying colleges or academies were set up, such as in Kota Bahru and Langkawi. MAS-sponsored cadets were eventually trained at these places in tandem and then absorbed as trainee pilots into MAS, including a small number of self-sponsored students who made the grade. These cadets would pass out with a Frozen ATPL (Air Transport Pilot Licence) and by the time they had accumulated a total of 1,500 hours or more, the full authorisation of the licence would take effect giving the holder the privilege of its full coverage.

From the early days of operations, MAS started with domestic and regional services. Thus, the fleet of aircraft had always included small propeller aircraft to service remote towns that were equipped with short field aerodromes and short-haul twin engine jets. Generally, a career of a pilot in MAS began as a co-pilot on the smallest Turbo Props, or sometimes when the demand and the promotion was rapid, suitable candidates would be posted direct to the B737 upon entry into the airline. A co-pilot would need to serve for at least 5 to 7 years in the Company on the lower fleet before one could be considered for promotion to the B777. Before the arrival of the new generation aircraft, the career progression would start with the F27/50, then the 737 classics as their first jet aircraft experience, then to either A300B4 or the DC10/B747-200. After the introduction of the new generation aircraft, they were normally promoted from the B737/200/400/800 to the A330 or B777 fleet then the B747-400/A380 depending on the Company's individual fleet requirement.

The pilot promotion policy had since changed to include individual pilot's bidding for promotion to larger aircraft, which was not the case in the past.

The pre-hire test also applied to those joining the airline with previous flying experience from other flying organisations. A significant percentage of MAS pilots came from the Royal Malaysian Air Force (RMAF), mainly those who had served the Air Force as short-commissioned officers. After about seven to ten years of service in the RMAF, they were able to join MAS with recognised flying hours and experience to be accepted as First Officers in the lowest fleet. After accumulating sufficient airline flying hours, they would be ready for promotion to Captain on the lowest fleet, e.g. F27/50, or direct to the B737 jet. A small percentage of pilots came from a general aviation background and needed to go through the similar stringent pre-hire process before commencing their training to the appropriate fleet.

On the average it would take at least 15 years of flying in the Company before a pilot could be promoted to command the B777. Among the factors for career progression is eligibility in terms of total command hours, base check and line check competencies, seniority in the pilot ranking and the airlines expansion plan. In Malaysia Airlines, no young fresh ab-initio pilot would be posted direct to the big wide-body jet (i.e. B777) without the smaller twin jets experience. By the time a captain was ready for the B777, he would have at least flown F50, B737 or A330 or combination of all the 3 aircraft with at least a total of 5,500 hours, part of which had to be a minimum of 1,500 command hours and 2 years operational on the MAS B737.

By normal career progression, the Captain that was flying on this aircraft would have met the full pre-requisites to be on the elite fleet of the B747-400 or the A380. However, it was his choice that he preferred to remain on the B777 fleet as he did not bid for position on the two higher fleets.

iv) Technical Crew of MH370

The PIC of MH370 graduated in May 1981 from the Philippines Flying School under the MAS sponsorship programme during that era. He started his career with MAS upon graduation and served MAS until the day of the eventful flight.

The FO of MH370 graduated from the Langkawi Aerospace Training Centre (LATC) on the Island of Langkawi, Kedah, Malaysia in June 2007. LATC has been in existence for the last 12 years. MAS had sponsored at least ten batches of pilots at an average of 12 trainees per batch. These graduates had been flying with MAS upon graduation. Graduates from LATC generally met the standards set by MAS, proven by the numbers joining the airline as trainees and eventually becoming qualified First Officers. Since the last 5 or 6 years there were also pilots being sponsored and trained in the Asia Pacific Flight Training (APFT) Kota Bahru, one of the latest additions to the number of flying schools available locally.

The fleet carried sufficient numbers of Type Rating Examiners (TRE) and Type Rating Instructors (TRI) to fulfil the licensing requirements. TRE and TRI were Captains from within the airline, appointed with approval from the Licensing Section of the DCA. They were also tasked with monitoring the overall standards to be maintained by the fleet. This responsibility is under the jurisdiction of the Training and Standards Department, which is headed by a Chief Pilot. On the day of this eventful flight, the Captain was conducting the last phase of the Co-pilot's training as a B777 First Officer, in the capacity of a TRE.

v) Working Schedule/Roster Schedule and Management

The working schedule and rest requirement to manage crew fatigue was highly regulated and normally bounded by guidelines stipulated by the CAA UK CAP 371 and the Malaysian Civil Aviation Regulations (MCAR) 1996. The MCAR 1996 adapted the CAA CAP 371. With the formation of the Joint Aviation Requirements (JAR), DCA Malaysia had gradually migrated towards regulations stipulated in the JAR. Duty and Flight Time Limitation (FTL) was strictly guided by these published regulatory documents. In general, MAS has since its inception, adopted a more stringent and restrictive FTL based on the Memorandum of Understanding (MoU) between the Pilots Association and the adequately rested before they were scheduled to any assigned flight duties. The Pilots Association played an important role to ensure compliance to the limits were met.

In the case of MH370, the expected flight and duty time was less than 8 hours, with a single leg of one take-off and one landing. The Regulatory requirement and MAS Operations Manual A, Part 7.1.20 and MoU would only require one set of crew to man the flight. Standard Company's practice, in compliance with FTL, would call for the whole set of crew to be allocated a stop-over duration of 24 hours (more than the minimum rest period required) in Beijing before returning to Kuala Lumpur. Beijing was a destination that MAS operated with the same aircraft type on a daily basis.

The guidelines for Technical Crew complement requirements based on Maximum Schedule Block Time were as follows:

- Less than 8 hours: 2 crew (1 Captain and 1 Co-pilot);
- Between 8 to 12 hours: 3 crew (2 Captains and 1 Co-pilot); and
- More than 12 hours (3 Captains and 2 Co-pilots).

The Technical Crew were required to undergo medical check-up by approved aviation doctors for their license renewal. The medical certificate issued forms part of the validity of a pilot flying license.

A summary of the work schedule for the PIC and the FO, three months prior to the eventful flight, is available in *Table 1.17A* (below).

Rank	**24**	**72**	**7**	**28**	**90**	**SEP Validity**
	Hours		**Days**			
Pilot-in-Command	0:00:00	7:00:00	20:39:00	91:04:00	303:09:00	14 May 2014
First Officer	0:00:00	0:00:00	28:47:00	51:17:00	158:46:00	26 July 2014

Table 1.17A - 3 Months FTL Data

vi) Safety Management System

MAS Safety Management System (SMS) had been designed to comply with the framework as per ICAO in Annex 6, Appendix 7 (Currently Annex 19), Framework for Safety Management Systems and the expanded guidance found in the ICAO Doc.9859 Safety Management Manual (SMM) and IATA SMS Implementation Guide. In addition, this system was consistent with the requirements of the DCA Malaysia's Aeronautical Information Circular (AIC) document number 06-2008: SMS. MAS had established these requirements to ensure positive control and continuous improvement for safe and secure operations, including the operations of its subsidiaries, MASWings, Firefly, MAS Aerospace Engineering and MASkargo. This document had formed an integral part of the Corporate Safety Policy Manual.

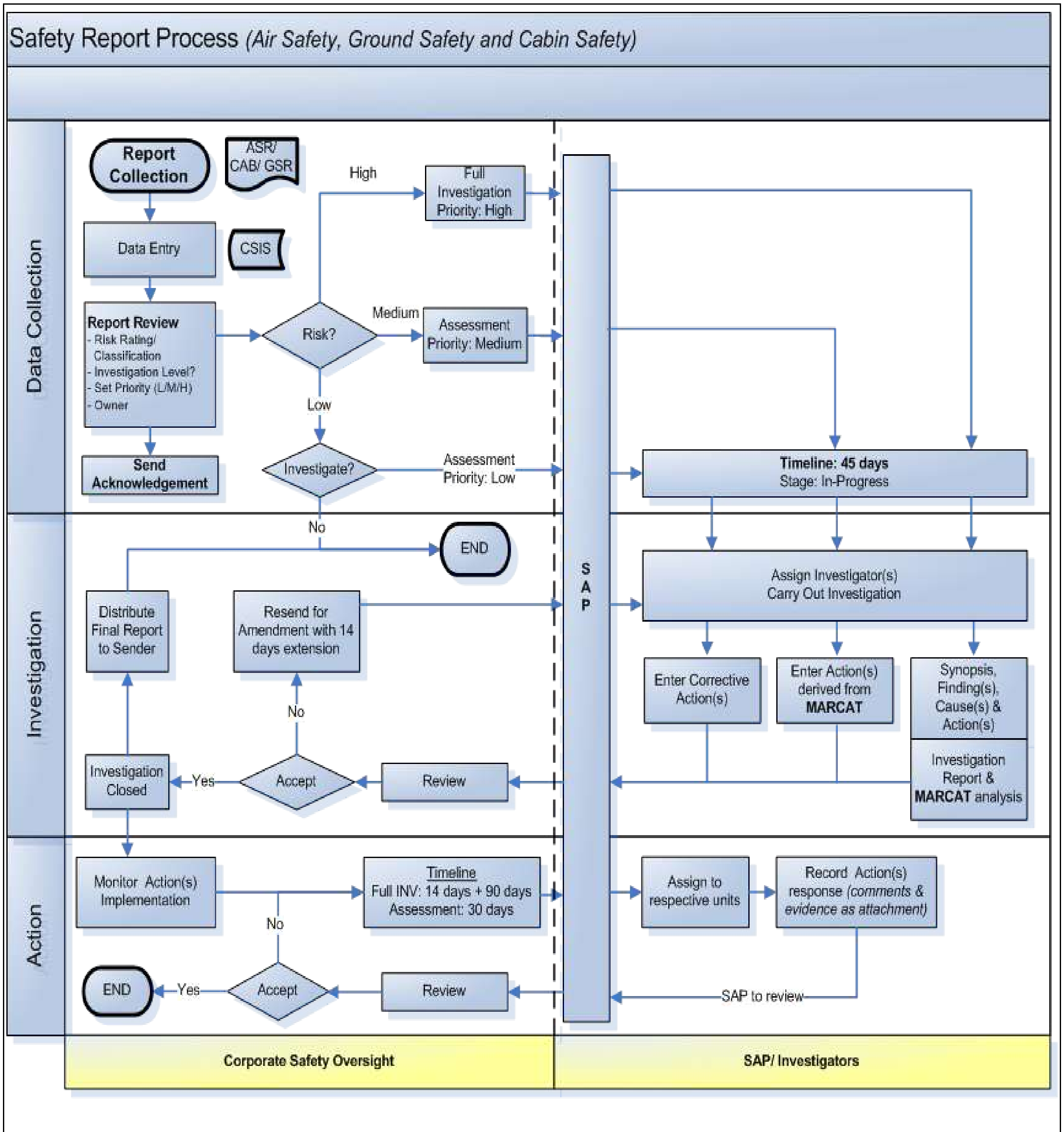
The SMS encouraged an open reporting policy or commonly referred by industry as non-punitive reporting system. This assured employees that reports of unpremeditated or inadvertent errors would not result in disciplinary or punitive action being taken against the reporter or other individuals involved. Employees were–assured that the identity, or information leading to the identity, of any employee who reported an error under this policy was never disclosed unless agreed to by the employee or required by law. The Open Reporting Policy encouraged individuals to report hazards and operational deficiencies to management. It also assured personnel that their candid input was highly desired and vital towards safe and secure operations.

The organisation had a proactive reporting system in place. Refer to *Figure 1.17F* (below):

- The SMS' guidelines resided in the Corporate Safety Manual. There were various reporting channels for the staff to transmit safety-related reports to account holders or their designates;
- The reporting channels were well-structured and covered all areas of operations:
  - Air Safety Report (ASR)
  - Cabin Safety Report (CSR)
  - Ground Safety Report (GSR)
  - Hazard report (Hazard/HZR)
  - Confidential Human Factors Incident Report Programme (CHIRPs); and
  - Flight Operations Quality Assurance (FOQA).

vii) Confidential Human Factors Incident Report

The flight crew and cabin crew were constantly being encouraged and reminded to utilise this reporting channel during their CRM and Safety classes (refer *SEP Manual; Part 7.15.2*). The Confidential Human Factors Incident Report (CHIRP), (refer to *Table 1.17B* [below]*)*, being a highly confidential report, had become the most appropriate tool for identifying potential human factor issues, especially on the behavioural patterns of flight and cabin crew.



Source: MAS

Figure 1.17F - Safety Report Process

	Year 2013				Year 2014		
	Sep	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
CHIRPS	**4**	**-**	**2**	**-**	**-**	**-**	**-**
10 September 2013	Communication issues between Tech Crew and Cabin Crew (1 report received)						
23 September 2013	Cabin Crew to be offloaded by Tech Crew (3 reports received)						
15 November 2013	Mis-communication between Technician and Cabin Crew during ground servicing (2 reports received)						

Table 1.17B - List of CHIRPs 2013 & 2014

viii) Flight Operations Quality Assurance

The airline had acknowledged the importance of safety as its utmost priority. Like most other airlines, with statistics showing Human Factor as the main contributor to air accidents, the Flight Operations Quality Assurance (FOQA) programme was introduced. This system had contributed tremendously even in non-eventful cases where impending trend towards an unsafe situation could be recorded. With this system in place investigations of events that could lead to an incident would be undertaken and remedial actions and recommendations put into place.

The FOQA programme was introduced in 2010. The objective of FOQA was to promote safety and accident prevention by identifying operational safety trends during normal line operations.

MAS considered FOQA as an important safety reporting culture where safety is enhanced in a non-punitive manner (reference: *MAS Operations Manual A, Part 2.2.4.2*). FOQA protocol, a written document under the custody of the Flight Safety and Human Factor Department (dated 07 July 2010) stipulated manners at which corrective and timely strategies were implemented following a risk or potential hazardous trend.

The statistics of FOQA events in the last 2-year period (April 2012-March 2014) is as in *Table 1.17C* (below).

ix) Line Operations Safety Audit

The Line Operations Safety Audit (LOSA) was first introduced in 2004 in collaboration with the University of Texas, USA. The results were fruitful, and recommendations were implemented via Safety Change Process (SCP). MAS conducted LOSA every 2 years but not later than 5 years. LOSA was conducted by taking random samplings of all aspects of operations including random audit of normal scheduled commercial flights.

The last LOSA (2nd LOSA) was carried out between March and August 2011. The objective of LOSA was for MAS to diagnose its level of resilience to systemic threats, operational risks, and front-line personnel errors, thus providing a data driven approach to prioritise and implement actions to primarily enhance safety. This was carried out system-wide with no emphasis on any specific fleet.

x) Crew Resources Management

MAS considered Crew Resources Management (CRM) as a critical component of flight safety during operations and introduced it more than 20 years ago. The training programme for the pilots included the Cabin crew & Dispatchers. For new recruits there was a 3-day programme for CRM. Recurrent training was conducted on a yearly basis. The Safety Awareness Programme (SAP) conducted on a yearly basis would include the recurrent for the CRM training/ refresher. This programme had been in the system ever since the release of ICAO Annex 6 Part 1.

It started off with the pilots only to improve the cockpit culture. It was considered essential then as the airline had

Flight Operation Quality Assurance (FOQA) data statistic 2 years before the incident date.

i. Number of Triggers
ii. Total numbers of flight.
iii. percentage of trigger

Rate per 10,000 flight cycles			2012									Year 2013												Year 2014		
			Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
1	Flight Cycles		798	780	789	811	813	785	817	852	799	836	672	809	779	842	837	826	812	659	684	792	811	837	772	831
2	UA	#	1	-	3	1	1	1	1	-	3	1	-	1	1	-	-	1	4	2	2	1	3	-	1	3
		Rate	12.53	-	38.02	12.33	12.3	12.74	12.24	-	37.55	11.96	-	12.36	12.84	-	-	12.11	49.26	30.35	29.24	12.63	36.99	-	12.95	36.1
3	Hard Landing	#	2	-	1	-	-	-	1	-	-	1	-	1	1	1	2	1	-	1	-	1	-	2	2	-
		Rate	25.06	-	12.67	-	-	-	12.24	-	-	11.96	-	12.36	12.84	11.88	23.89	12.11	-	15.17	-	12.63	-	23.89	25.91	-
4	Long Flare	#	9	19	11	8	10	7	13	9	10	7	10	9	11	17	15	17	10	9	10	11	8	10	7	7
		Rate	112.8	243.6	139.4	98.64	123	89.17	159.1	105.6	125.2	83.73	148.8	111.2	141.2	201.9	179.2	205.8	123.2	136.6	146.2	138.9	98.64	119.5	90.67	84.24
5	Late Land Flap	#	1	-	2	-	2	-	1	-	2	1	-	-	1	-	-	1	1	-	-	1	-	-	-	-
		Rate	12.53	-	25.35	-	24.6	-	12.24	-	25.03	11.96	-	-	12.84	-	-	12.11	12.32	-	-	12.63	-	-	-	-
6	Winshear	#	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
		Rate	-	-	-	-	-	-	-	-	-	-	14.88	-	-	-	-	-	-	-	-	-	-	-	-	-
7	TCAS	#	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1	2	2	-	-	1	2
		Rate	12.53	-	-	-	-	-	12.24	11.74	-	-	-	-	-	-	-	-	12.32	15.17	29.24	25.25	-	-	12.95	24.07

Source: MAS

Table 1.17C - Statistics of FOQA Events in the Last 2-Year Period (April 2012-March 2014) significant numbers of expatriate community serving MAS from a diverse culture. Later, the training programme also included Cabin crew & Despatchers. For new recruits there was a 3-day programme for the Initial CRM. Recurrent CRM training (1 day) also known as Safety Awareness Programme (SAP) was conducted regularly to cater for flight crew, cabin crew and flight despatchers. JAR-OPS Subpart N, JAR-OPS 1/3.965 stated that all major CRM topics should be covered every 3 years for technical crew, every 2 years for cabin crew and annually for flight despatchers.

xi) Training and Standards

MAS managed its entire training requirement in-house including the mandatory requirement for the flight crew. MAS had its own Training Centre for pilots as well as engineers. It was equipped with various Full Flight Simulators for all the fleet in the Company with most of the Flight training devices certified to FAA Level D, capable of zero flight time training. This Training Centre had been established for more than 40 years and had been certified by many countries as an approved Type Rating Training Organization (TRTO.)

Type Rating Instructors (TRI) & Type Rating Examiners (TRE) normally came from within the airline and they require stringent training and check before being approved by the DCA Licensing Division. Besides the availability as a TRTO, the Simulators were utilised by neighbouring airlines and smaller organisations within the region to fulfill their training and checking requirements.

Competency of pilots, as per regulatory requirements worldwide, is normally monitored every 6 months. MAS training policy required 2 Simulator sessions every 6 months. The two training sorties every 6 months consisted of 1 review and training followed by proficiency check session.

xii) MAS B777 Training and Standards

The training package for the B777 conversion training followed the Boeing Training Recommendations. During the introduction period, representatives from the Boeing Flight Training Department oversaw the operations. The first crew trained by Boeing comprised a project team of four pilots from the Company and one representative from DCA, the regulatory authority. The team members were then responsible for managing the introduction of the new aircraft into operation. Part of their responsibility was to ensure that the subsequent training and recurrent requirements were addressed according to the recommendations of the aircraft manufacturer, consistent with the mandatory requirements of the DCA Licensing Authority. When the B777 was introduced, the simulator was also procured, and it arrived at the MAS training premises before the first aircraft entered into commercial service. At the introduction phase of the B777 into MAS, the airline had sought assistance from the Boeing Flight Training Department to kick-start the training of new pilots locally.

In MAS, all aircraft purchased came with a package that included the respective simulator, except the B747-200/300 and Fokker F27. Like most other established airlines, MAS considered training as vital tool to maintain good pilot skills and standards.

The pilot's upgrade policy of having to serve on the smaller fleets at point of entry helped in preparing captains and co-pilots to handle larger machines, such as the B777. During the day of the event, the co-pilot was on his last training flight before he was due for a check flight on his next flight duty assignment. The Team had recorded that the FO was assigned to be the flying pilot for Kuala Lumpur/Beijing sector on the ill-fated flight.

Throughout a pilot's career, should the pilot's performance during Simulator and Line operational checks fell below the minimum standards, the Company would provide adequate retraining to ensure the required regulatory competency was maintained.

It is important to note that there were 3 phases of training when a pilot was undergoing conversion training to a new fleet in MAS. The FO's last fleet was the A330 and he was undergoing the final phase of training to be qualified as a co-pilot on the B777. The three training phases were:

- Ground School & Computer Base Training (CBT);
- Simulator Training; and
- Initial Operation Experience (IOE) Phase 1 and Phase 2.

The IOE was for the trainee to be trained during line operations on a passenger scheduled flight commanded by a TRE or TRI-qualified Captain.

During the initial part of the IOE, it was the Company's policy that the flight had to be accompanied by an additional experienced co-pilot or captain to support the flight in case the trainee needed any supervision and, most importantly, if the TRE or TRI was incapacitated. This policy guaranteed that in such an untoward incident, there would always be a qualified Pilot to take over command of the aircraft and proceed with the next safe course of action.

As the training progressed, and if the trainee's performance was above average, and deemed safe, the carriage of the third pilot would not be necessary beyond this stage of training, based on the recommendation of the earlier trainer (TRI/TRE) in accordance with the training policy.

In such a case, a trainee pilot under IOE would not need a third pilot to accompany the flight, even though he was effectively still in the training phase. This was the case on the day of the eventful flight.

On the B777 a pilot under training normally would require to operate a certain number of minimum sectors before he could be certified to be fully functional as a line operational pilot (end-of-training). Depending on the previous aircraft flown, the minimum and maximum number of required training sectors were, as follows:

- Last aircraft flown B737: Minimum 10 sectors, Maximum 14 sectors; and
- Last aircraft flown A330: Minimum 8 sectors, Maximum 14 sectors.

xiii) Multi-crew Operation MH370

During the day of the eventful flight, the FO was on his last training flight before he was due for a check flight on his next flight duty assignment. Record shows that he was assigned to be the flying pilot during that first leg from Kuala Lumpur to Beijing. The airline encouraged Captain to allow First Officer a fair share of flying and handling of the aircraft. Under normal practice, if the duty pattern involves more than 1 sectors, it is quite common that the additional sector will be flown by the First Officer. The decision of who to carry out the take-off and landing was solely at the discretion of the Captain. The assignment of duty regarding who was going to be the flying pilot for the first flight out normally decided during the pre-flight briefing at the despatch office.

If the decision was made that the First Officer was going to be the Pilot Flying, the MAS Flight Operations policy required that the Captain would start and taxi the aircraft up to the take-off point on the runway, after which control of the aircraft would be handed over to the co-pilot to perform the take-off and eventually the landing at the destination. Up to the take-off position at the beginning of the runway, radio communications with the ATC would be the responsibility of the co-pilot. It was a MAS' written procedure during this phase of the flight that the throttle would be handled by the Captain as PIC, a policy to ease and expedite the rejected take-off manoeuvre if so required. The First Officer would control the rudder and control column as the pilot flying.

As soon as control was handed over to the co-pilot at the take-off point, the ATC communication became the responsibility of the Captain. Evidence from the KL ATSC's voice recording indicated clearly (in interviews with the Captain's colleagues, friends and son), that the voice recorded was that of the Captain after the aircraft took off.

xiv) Safety and Emergency Procedures

Proficiency in Safety and Emergency Procedures (SEP) was also a part of the mandatory training requirement which was conducted every 12 months. It was based on the Aircraft Type that the pilot was rated on. This recurrent training required a minimum of 3 days which covered all aspects of emergencies including medical and first aid knowledge. This section of Training fell under the purview of Flight Safety and Human Factor.

(1) Operation Control Centre

The Operation Control Centre (OCC) was where the briefing of flight crew and cabin crew took place. A team of Licensed Aircraft Despatchers were stationed in this Department.

Besides the crew formalities required prior to departure, the flight crew would be working in tandem with the assigned despatcher to review all documentations related to the assigned flight which influenced the decision on the finalised routing and fuel ordered by the Captain of the flight.

(2) Flight-Following System

In MAS, the FFS was an integrated approach which enabled flight operations Controllers to easily monitor the status of flights and gain a better view of impending operational problems, and making the process of resolving them much more efficient. A 24-hour OCC maintained operational control of all fleets in MAS by providing support for the pilots before and during flights. The FFS played the foundational role in OCC. The system is a product from Sabre and utilises position input to update the aircraft's geographical position. Position updates come from two sources namely:

- ASDI (Aircraft Situation Display Information) sourced from the FAA for aircraft flying in the United States, and
- ACARS update from individual Company aircraft flying anywhere in the world.

The information was available on a monitor mounted in the ODC and was also available on all Despatchers' positions via selections to be displayed on individual monitors.

- Projected flight plan against hazardous weather and published prohibited or restricted areas en-route;
- Actual flight data; and
- Pertinent data related to the flight, and allows direct communications with aircraft via satellite phone or ACARS communications.

xv) Technical and Development

Technical data and aircraft performance were under the control of the Operations Engineering Department. This Department worked closely with the Technical Services Department of the Engineering Division and Aircraft Manufacturers on Performance Engineering matters. The Technical and Development Department participated in the evaluation of new Aircraft Type and Aircraft Equipment.

xvi) Fuel Policy

The fuel policy defined in the *MAS Operations Manual A (Part 8.1.7)* met the minimum required for aircraft despatch. A Captain has the privilege of carrying extra fuel if he feels that there is justification to do so, based on expected weather forecast enroute and at the destination. Extra Fuel carriage can also be due to aircraft performance penalty as required by MEL or specific ATC requirement at some destination airports.

xvii) Flight Plan Routing

The Company's policy required the despatcher to evaluate the flight routing for the best economy routes to Beijing based on the OCC Flight Management System. As there was no known enroute weather forecast that could pose a threat for MH370, the usual standard routing was chosen. This was normally done by the computer system to give the despatcher the recommended routing unless otherwise modified.

xviii) Hijack and Sabotage Security Procedures

The Hijack and Sabotage Security Procedures and Guidelines in MAS's SEP Manual (Part 4.3) were recommended by the world's aviation security authorities based on in-depth studies of actual hijack and sabotage incidents. These authorities included ICAO Annex 17, IATA, TSA, FAA, Malaysia Airlines Security Programme and the Aviation Offences Act 1984 (Act 307).

The procedures stipulated that security precautions against both hijack and sabotage cannot be maintained at maximum level at all times without disrupting operational functions and public goodwill.

b) In-flight Services

i) Cabin Crew Training

Cabin crew were required to be present on public transport flights to perform duties in the interest of passengers' safety. They must be well-informed about safety and Policies of the Company. Each cabin crew member shall:

- Be well-prepared and fit for the flight;
- Ensure adherence of "Fasten Seat Belt" and "No Smoking" signs;
- Ensure the comfort and safety of all passengers; and

- Ensure passengers safely escape in an emergency evacuation.

A cabin crew member is a person employed to facilitate the safety of passengers whose duties are detailed by the Company or the aircraft Commander. Cabin crew will not act as a member of the flight crew.

At the point of recruitment, the candidate would have to undergo through a thorough interview and medical check-up. Once selected, a comprehensive training of safety and service procedures would be provided by the airline for the duration of 3 months and he/she would graduate and leave the academy as a qualified cabin crew assigned to the selected fleet that he/she was trained for.

MAS had the policy of fleet grouping for cabin crew in the following order:

- Narrow Body - B737
- Wide Body - A330, B777 & B747/A380

Upon graduation, the cabin crew would be given a flight duty roster on a monthly basis. The roster was managed by the Crew Planning & Deployment Section.

Initially, a cabin crew was required to operate the domestic and the regional flights known as the Narrow Body Fleet for a minimum of 2 years. With sufficient experience gained on the narrow body fleet he/she might be eligible for promotion to the wide-body fleets. These new wide-body may include long-haul flights to international destinations. The selection of cabin crew for promotion normally depends on merit, track record and seniority.

A cabin crew would be provided with proper training on Safety and First Aid. He/she would be trained to handle:

- Safety and emergency evacuation
- Disruptive/Difficult passengers
- Medical emergency (Provide First Aid)

On a yearly basis, the cabin crew was required to go through a safety recurrent training on their Safety Emergency Procedures (SEP) at the academy in order to keep his/her licence and training validated by certified instructors. It was mandatory for the crew to achieve the required minimum safety and emergency procedures and knowledge which were assessed through examinations. This recurrent training included first aid training and examination, to get the certificate renewed. There were also “Safety Awareness Programme” and “Crew Resources Management” classes that were compulsory for the cabin crew to attend every 2 years. These two programmes were basically similar, and they were incorporated within the 3 days of training.

The cabin crew would be issued with a Safety Card endorsed by the Safety and Human Factors Department of MAS as well as a Crew Performance Card issued by the Cabin Crew Line Operation and Performance Department. The crew would be expected to carry these two documents at all times for flight duty.

Excellent service awards won by the Company’s cabin staff for several years stood as a testimony for the quality of the training and the service standards acquired. MAS’ reputation had attracted foreign established top-rated airlines for secondment of cabin crew.

ii) Crew Performance Appraisal

The Crew Performance Appraisal (CPA) was an established process in the organisation, monitoring crew performance and standards including safety knowledge. To maintain and achieve a high standard of service and safety, each and every cabin crew was required to have a CPA which was done twice a year. The assessment was carried out by the crew in charge on board during the flight.

Refer *Table 1.17D* (below) on Rating Score.

The cabin crew would be checked on aspects such as safety and service procedure, product knowledge, Customs, Immigration and Quarantine, station documents, grooming and leadership skills. The crew in charge would conduct the checking on the crew by Questions & Answers (Q & A) and how the individual performed as part of the operational crew member in his/her assigned capacity.

Ratings	Category	Range of Score
5	Amongst the Best	98% and above
4	Highly Effective	93%-97.90%
3	Fully Productive	87%-92.90%
2	Needs Improvement	80%-86.90%
1	Unacceptable	<80%

Table 1.17D - Crew Rating Score

iii) In-flight Operation

On board a Boeing 777-200ER aircraft the standard operating cabin crew of 11 was required. The normal cabin crew complement for the Boeing 777-200ER aircraft was as follows:

- 1 In-flight Supervisor
- 2 Chief Steward/Chief Stewardess
- 2 Leading Steward/Leading Stewardess
- 6 Flight Steward/Flight Stewardess

The 777-200ER fleet had a two-class cabin configuration, namely Golden Class Club (GCC) and Economy Class (EY). Four cabin crew would be designated to work in GCC and six in EY.

The In-flight Supervisor would be in charge of the whole cabin. Two Chief Stewards/Chief Stewardesses looked after the GCC assisted by two cabin crew. Six cabin crew were designated to work in EY class. The EY class was divided into two sections and each section was looked after by one Leading Steward/Leading Stewardess and assisted by two cabin crew.

The In-flight Supervisor was the person responsible to manage the cabin safety and report to the Commander of the aircraft.

He or she shall:

- have the overall responsibility to the aircraft commander for the conduct, coordination and performance of the cabin operations and the safety duties;
- verify that all the cabin crew members are fit for flight and with all relevant documents valid for flight duty; and
- coordinate and organise the functions and tasks of all cabin crew members:
    - Execute cabin crew briefing;
    - Nominate positions and working areas;
    - Nominate in-flight service duties;
    - Checking of emergency equipment, pre-flight safety briefing and reporting matters concerning safety (irregularities and malfunctions) to the Commander;
    - Debriefing the cabin crew members when required;
    - Ensuring efficient communication with crew members and ground personnel; and
    - Ensuring contact with the cockpit on a regular basis.

As per Civil Aviation Regulations 1996 the minimum requirement of the operating cabin crew for B777-200ER fleet is 8 based on the number of exit doors available on the aircraft.

Notwithstanding the above, many other airlines carry additional cabin crew above the minimum required in the interest of customer services.

iv) Flight and Duty Time Limitations Scheme for Cabin Crew

The prime objective of a flight time limitations scheme is to ensure that crew members are adequately rested at the beginning of each flying duty period, and whilst flying, be sufficiently free from fatigue so that they could operate to a satisfactory level of efficiency and safety in all normal and abnormal situations.

The maximum duty hours for cabin crew should not exceed:

- 60 hours in 7 consecutive days;
- 105 hours in any 14 consecutive days; and
- 210 hours in any 28 consecutive days.

Cabin crew would be notified in advance of a flying duty period so that sufficient and uninterrupted pre-flight rest can be assured in preparation for the flight. When away from base, opportunities and facilities for adequate pre-flight rest would be provided by the Company with suitable accommodation.

The minimum rest period which must be taken before undertaking a flying duty period shall be:

- At least as long as the preceding duty period, or
- 12 hours, whichever is the greater.

The minimum rest period would be the highest of pre-flight or post-flight rest. It was not cumulative of both rests.

The minimum rest period which must be provided before undertaking a flight, at home base would be:

Flight	Rest Period
Pre-flight	40 hours (inclusive 2-local nights)
Post-flight	72 hours (inclusive 3-local nights)

The minimum rest period which must be provided after performing a flight, out of base would be:

Flight	Rest Period
Post-flight	24 hours

MAS Employee Union (MASEU) was the recognised union certified by MAS to represent the cabin crew. Flight Time Limitation and working conditions were governed by the Collective Agreement (CA) signed between the union and MAS, in compliance with CAR or whichever was more limiting.

v) Safety Report

(1) Accident/Incident/Hazard Reports Form

MAS managed an in-house reporting system to identify many of these accidents/incidents/hazards by collecting and then analysing hazard and incident reports to audit incidents encountered during flight. The Incident reporting system was one of the most effective tools for pro-active hazard identification. Cabin crew were required to fill up this form and to submit it at the end of the flight within 24 hours.

(2) Confidential Human Factors Incident Reporting Programme

Confidential Human Factors Incident Reporting Programme (CHIRPs) applicable for the flight crew, cabin crew and engineering personnel only. It was a non-disclosure type of document where one could use and submit to the Company to report any complaints and issues. CHIRPs could only be used for human factor and safety issues, errors and unsafe practices and where some actions might potentially infringe regulatory practises. It was not to be used for mandatory incidents reporting, personality conflicts, industrial issues and employment problems. It would be reviewed by the members of the CHIRPs staff and action would be taken accordingly.

All these reports were managed by the Corporate Safety Oversight and Human Factors Department.

SECTION 1 – FACTUAL INFORMATION

1.18 ADDITIONAL INFORMATION

1.18.1 Provision of Air Traffic Services and Areas of Responsibilities

1) Introduction

For the provision of Air Traffic Services (ATS), the Kuala Lumpur FIR is divided into seven Sectors, namely Sector 1, Sector 2, Sector 3, Sector 4, Sector 5, Sector 6 and Sector 7.

Each Sector has a specified area of responsibility. Sectors 1 to 5 are manned by Sector Planning and Radar Controller jointly responsible for the safe, efficient and orderly provision of air traffic control service, flight information service and alerting service in their Sectors. Each Sector has an Assistant Flight Data (AFD) Controller.

Sector 6 is manned by a Radar Controller and supported by the Sector 1 Planning Controller and Sector 1 AFD Controller. Sector 7 is manned by a Radar Controller and supported by the Sector 2 Planning Controller and Sector 2 AFD Controller.

a) Responsibilities of Sector Radar Controller:

- Handle all radiotelephony functions;
- When necessary, coordinate to effect transfer of radar identity and control;
- Monitor the Sector Inbound List (SIL) to ensure appropriate action for orderly acceptance, control and transfer of aircraft; and
- Comply with instructions issued by FLOW control.

b) Responsibilities of Sector Planning Controller:

- Plan and coordinate as necessary for the management of all flights that will operate in their sectors; and
- Ensure that the information on the electronic flight strips (EFS) is updated.

The Radar and Planning Controllers will make available to each other information that is essential to enable them to carry out their responsibilities, e.g. change in cruising level/altitude or revision to transfer of control point estimates.

c) Responsibilities of Controllers at AFD Position:

- Assist the Planning Controller by ensuring that information displayed on the EFS is kept updated in a timely manner;
- Ensure that essential information found on the EFS is also available on the paper strips;
- Display the paper strips on the display board in the correct manner;
- Make paper strips available to the EXE Controller if requested;
- Wrap up all used strips, and place them at a common place for collection; and
- Clear wrong ADP Message Queues as follows:
  - AFD Sector 2 - wrong AFTN Message Queue
  - AFD Sector 5 - wrong METEO and AIS Message Queue
  - AFD Sectors 1 & 4 - wrong FDP Message Queue

2) Sector 3 Area of Responsibility

a) Sector 3 is responsible for the provision of air traffic services in controlled airspace and outside controlled airspace above FL145 within:

That airspace from VKL to PIBOS then to 033658N 1022253E then to 040051N 1034109E at the border of Peninsular Malaysia/Singapore International Boundary, thence southwards along the FIR boundary to 012652N 1034540E thence northwards to 021958N 1034235E (10 nm west of VMR) thence westwards to DAMAL thence northwards along the airway R325 to SAROX (but *excluding ATS Route R325) thence along the airway G334 to VKL but excluding the Kuantan TMA.*

b) Sector 3 is also responsible for the provision of FIS and Alerting Service in the South China Sea Corridor (SCSC). The lateral and vertical limits of the SCSC (Refer *Table 1.18A* [below]) are as follows:

Laterals Limits	Vertical Limits
From 023600N 1044500E to 020000N1070000E and along 020000N till the Singapore/Kota Kinabalu FIR Boundary, thence along this Boundary to 060000N 1132000E, thence along 060000N till the Singapore/Kuala Lumpur FIR Boundary, thence along this Boundary to 023600N 1044500E	West of 105E FL150 GND/SL East of 105E FL200 GND/SL

Table 1.18A - Lateral and Vertical Limits of South China Sea Corridor

c) Sector 3 encompasses the following ATS routes or route segments *(Table 1.18B* [below]*):*

Routes	Segments	Routes	Segments
A224	VMR - VJR	N884	VMR – LENDA
B338	VTK - VMR	N891	PU – MANIM
B469	VPK - PU	N892	KIBOL - VMR
G334	VKL - UKASA - VPT - KIBOL	R221	VMR - VPT
G582	Sector 1 boundary - VPK	R325	MATSU - SAROX (FL280 & below)
G584	VKL – VPK	W533	VKL - VKN - VKE
L629	VPK - BUVAL	W540	VPK - A/VKE (FL235 & below)
L635	VPK - DOVOL	Y331	PIBOS - TAXUL
L642	VMR - EGOLO	Y332	TAXUL - PADLI
M751	VPK - A/VKE (FL240 & above)	Y333	PADLI - BUVAL
M758	VPK - ISDEL	Y334	PADLI - DOVOL
M761	VPK - KETOD	Y335	PADLI - IDSEL
M763	VPK - TAXUL	Y336	ISTAN - PADLI - KETOD
M771	VMR - RAXIM	-	-

Table 1.18B - ATS routes or route segments of Sector 3

<u>Note</u>*:*

SAROX is not a waypoint on R325. It is a waypoint on G334 that intersects R325. It is used here for ease of reference.

d) Delegation of Airspace and Communication Watch

i) Delegation of Airspace from Kuala Lumpur ACC (Sector 3) to Singapore ACC

The contiguous airspace Areas A, C, E and H along eastern Johor/South China Sea and responsibility for provision of air traffic services in these areas remains delegated to Singapore.

ii) Communication Watch

To ease air traffic management, communications watch shall be maintained by Singapore HF, Lumpur Sector 3 and Lumpur HF within South China Sea Corridor (AIP Malaysia ENR 2.1-13 [below]*).*

AREAS WITHIN THE SINGAPORE FIR FOR WHICH LUMPUR ACC IS RESPONSIBLE FOR PROVIDING ATS.					
SOUTH CHINA SEA CORRIDOR Fm 023600N 1044500E to 020000N 1070000E and along 020000N till the Singapore / Kota Kinabalu FIR BDRY - thence along this BDRY to 060000N 1130000E, thence along 060000N till the Singapore/Kuala Lumpur FIR BDRY - thence along this BDRY to 023600N 1044500E.	W of 105E FL 150 GND / SEA E of 105E FL 200 GND / SEA	Lumpur ACC	Lumpur Control Lumpur Radio English H24	132.6 MHz HF 5655 KHz 8942 KHZ 11396 KHz	Lumpur ACC shall be responsible for the provision of air traffic services to flights operating within the South China Sea Corridor.

Extract from Malaysia AIP ENR 2.1-13

iii) Singapore will pass to Sector 3 Estimate for flights bound for the Natuna and Matak Islands. Sector 3 in turn, shall notify Aeronautical Mobile Service (AMS) High Frequency (HF) who shall provide additional communications watch in order to discharge its Flight Information Service (FIS)/Alerting Service functions.

3) Sector 5 Area of Responsibility

a) Sector 5 is responsible for the provision of air traffic services in controlled airspace and outside controlled airspace above FL145 within:

That airspace from VKL to PIBOS then to 033658N 1022253E then to 040051N 1034109E at the border of Peninsular Malaysia/Singapore International Boundary, thence northwards along the FIR boundary, thence westwards along the Peninsular Malaysia/Thailand International Boundary to 054342N 1010038E thence southwards to 044021N 1012704E, then to VKL but excluding the Kota Bharu TMA/Terengganu and Kerteh CTRs. Sectors 5 encompasses the following ATS routes or route segments *(Table 1.18C* [below]*)*:

Routes	Segments
A334	PASVA – VKB
B219	Butterwort TMA Boundary East – VKB
B463	KADAX – VKB
G466	VKL – VKB
M644	VKB – ABTOK
M751	A/VKE – VKB – GOLUD (FL240 and above)
M765	VKB – VENLI – IGARI
R208	VKL – GUNBO – VKR – IKUKO – IGARI
R325	ANSOM – MATSU (FL 280 and below)
W540	A/VKE – VKB (FL235 and below)

Table 1.18C - ATS routes or route segments

b) Delegation of Airspace

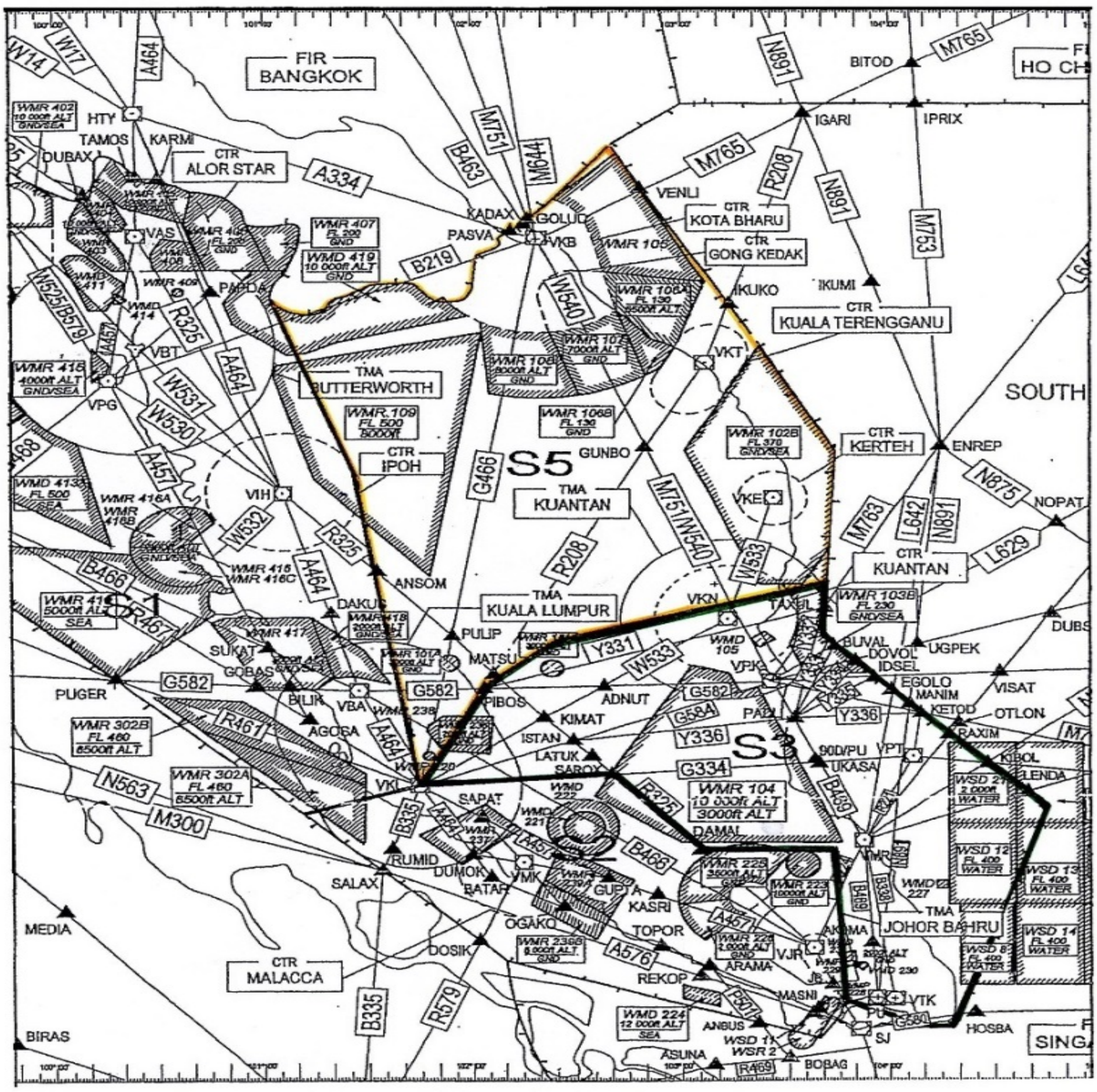
i) Delegation of Airspace from Singapore ACC to Kuala Lumpur ACC (Sector 5)

RNAV route M765 between VENLI and IGARI has been delegated by Singapore ACC. Lumpur Sector 5 shall provide air traffic services and carry out coordination with Ho Chi Minh ACC.

ii) Route segment between IKUKO and IGARI on ATS R208 is released by Singapore ACC subject to daily coordination between Singapore ACC and Kuala Lumpur ACC.

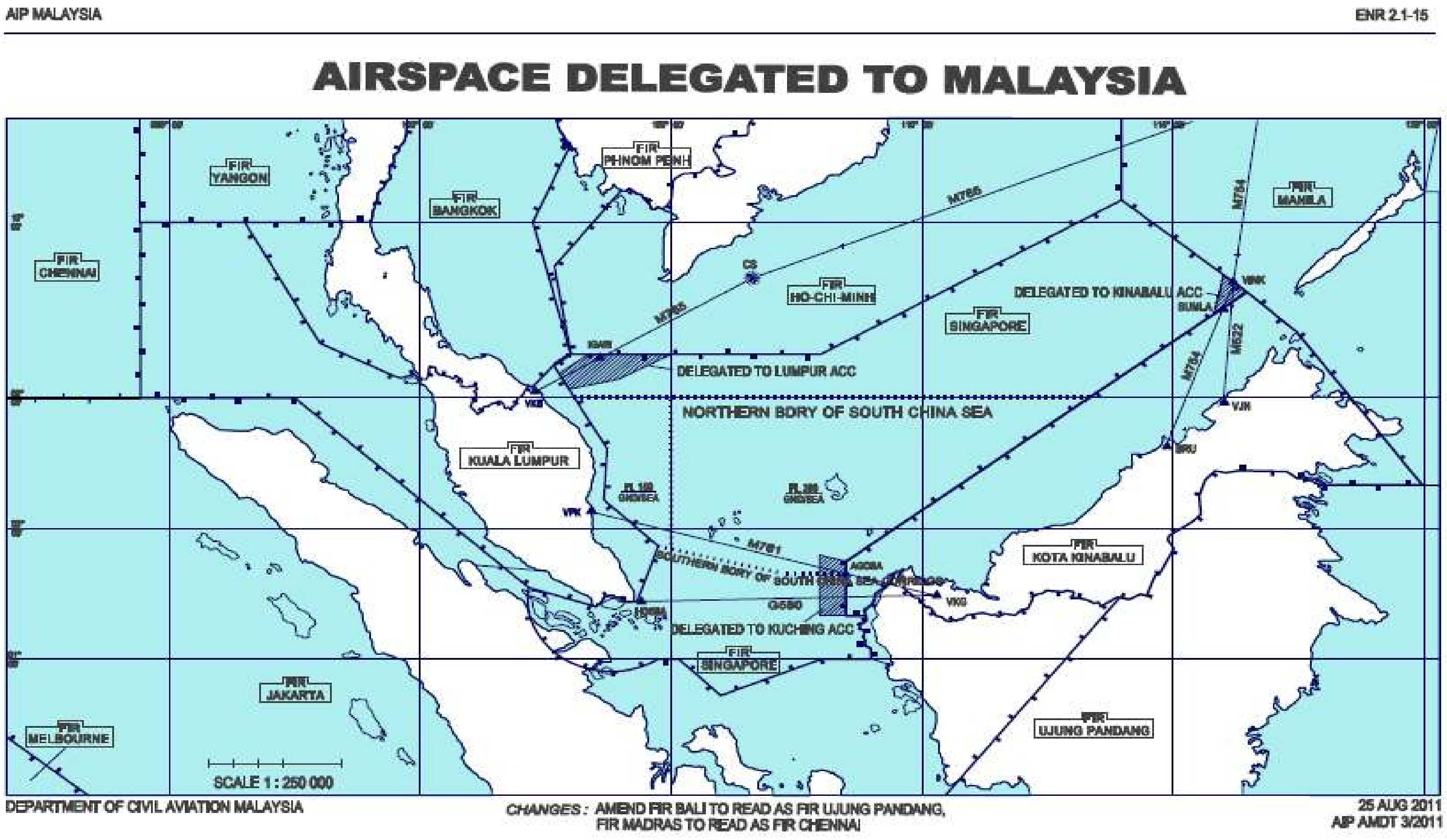
iii) Communication Watch

To ease air traffic management, communication watch is maintained by Lumpur Sector 5 and Lumpur HF between IKUMI and IGARI along N89. Refer *Figure 1.18A - Sector 3 and 5 Area of Responsibilities* (below).



Source: DCA Malaysia

Figure 1.18A - Sector 3 and 5 Area of Responsibilities



Source: DCA Malaysia

Figure 1.18B - Airspace Delegated to Malaysia by Singapore

4) Air Traffic Services Operations

a) The disappearance of MH370 occurred in the Singapore FIR where the airspace is delegated to KL ACC. The portion of airspace delegated is RNAV route M765 between VENLI[13] and IGARI[14], and the portion released is ATS route R208 between IKUKO[15] and IGARI. (References: Malaysia Aeronautical Information Publication (AIP) ENR 2.1-15 (*Figure 1.18B* [below]), ENR 3.1-10 and ENR 3.3-5 and Manual of Air Traffic Services [MATS] Vol. 2 page 2-2-10 paragraphs 2.4.3.1 & 2.4.3.2).

b) KL ACC is responsible for the provision of Air Traffic Control Service, Flight Information Service and Alerting Service to all aircraft within Kuala Lumpur FIR and the "released airspace" on ATS route R208 and the "delegated airspace" on RNAV route M765 (*Figure 1.18B* [above]).

c) MATS part 9, page 9-6-5 para 6.7.2 states that:

> "*If alerting service is required for an aircraft that is flight planned to operate through more than one FIR including the airspace delegated to the Kuala Lumpur and Kota Kinabalu ATSCs and, the position of the aircraft is in doubt, the responsibility for coordinating such service shall normally rest with the ATSC of the respective FIRs:*
>
> *a) Within which the aircraft was flying at the time of last radio contact;*
>
> *b) That the aircraft was about to enter when last radio contact was established at or close to the boundary of the two FIRs.*

d) Operational Letter of Agreement for the Provision of Search and Rescue Services between the Department of Civil Aviation Malaysia and the Department of Civil Aviation Singapore dated August 1984 page 6 para. 7.1 states that:

[13] Coordinates VENLI: 062846N 1024900E
[14] Coordinates IGARI: 065612N 1033506E
[15] Coordinates IKUKO: 054512N 1031324E

"In the event of an aircraft emergency occurring within

the South China Sea Corridor (SCSC), the KL ATSC shall be responsible to take initial alerting action whilst the Singapore RCC shall be responsible for subsequent coordination of all SAR efforts. While the responsibility for the provision of SAR service within the SCSC rests with Singapore RCC, the Singapore RCC may as provided for in paragraph 3.2.2 delegate responsibility for the overall control of the SAR mission to Kuala Lumpur RCC or Kota Kinabalu RCC, whichever is deemed appropriate"

Para. 3.2.2, page 3 of the same agreement, para. (d) above states that:

"*When a transfer of responsibility for the overall SAR co-ordination is to take place, either from subsequent establishment of an aircraft's position or movement, or because an RCC other than the one initiating the action is more favourably placed to assume control of the mission by reason of better communication, proximity to the search area, more readily available facilities or any other reasons, the following procedures shall be adopted:*

i. direct discussions, wherever possible, shall take place between the Search and Rescue Mission Co-ordinators (SMCs) concerned to determine the course of action.

ii. if it decided that a transfer of responsibility is appropriate for the whole mission or part thereof, full details of the SAR mission shall be exchanged.

iii. the initiating RCC shall continue to retain responsibility until the accepting RCC formally assumes control for the mission.

5) KL ATSC Duty Shift System for Air Traffic Controllers

a) The duty shift system *(Table 1.18D* [below]*)* on 07 March 2014 for Air Traffic Controllers was as follows:

Sectors 1, 2, 3, 4 and 5 were manned by a Radar Controller, a Planning Controller and an Assistant Flight Data Controller in each Sector from 1100-1600 UTC [1900-2400 MYT]. Sector

6 was manned by a Radar Controller and Sector 7 was not manned.

Day	Shift	Period
1	Afternoon	• 0500 UTC [1300 MYT] - 1100 UTC [1900 MYT]
2	Morning & Night	• 2300 UTC [0700 MYT] - 0500 UTC [1300 MYT] and • 1100 UTC [1900 MYT] - 1600 UTC [2400 MYT]
3	Midnight shift	• 1600 UTC [0000 MYT] - 2300 UTC [0700 MYT]
4	Off duty	

Table 1.18D - Duty Shift System for Air Traffic Controllers

b) From 1600 UTC [0000 MYT] until 2200 UTC [0600 MYT], the number of Controllers in the KL ATSC were scaled down by or to half to enable the Controllers to take a rostered break - the first half from 1600 UTC [0000 MYT] to 1900 UTC [0300 MYT] and the second half from 1900 UTC [0300 MYT] to 2200 UTC [0600 MYT], as follows:

- Sector 1, Sector 2 and Sector 4 each were manned by a Radar Controller with an AFD Controller.
- Sector 3 and Sector 5 were combined and operating from a Controller working position with a Radar Controller and an AFD Controller.
- The area of responsibility would be that of Sector 3 and Sector 5. Between 1600 UTC [0000 MYT] and 2200 UTC [0200 MYT], Sectors 3 and 5 Assistant Flight Data Controller carried out the duty of Planning Controller.

c) The last radio transmission between KL ACC and MH370 took place at 1719:30 UTC [0119:30 MYT]. A contact should have occurred at around 1722 UTC [0122 MYT] at waypoint IGARI.

Reference is made to Malaysia AIP ENR 6, En-route Charts - IGARI has been designated as a compulsory reporting point, and MATS page 8-2-6, Part 8 Surveillance para 2.4.1 - Controllers may instruct a radar identified aircraft to omit making compulsory position reports unless:

- *the position report is required for control purposes.*

There was no instruction by the KL ACC Controller to MH370 to omit making compulsory position report as stated in MATS.

KL ACC should have declared the Distress Phase[16] at 1827 UTC [0227 MYT] and the transmission of the *DETRESFA*[17] message, as KL ACC was the ATS unit last in contact with MH370 at 1719:30 UTC [0119:30 MYT] when MH370 acknowledged the transfer of control by KL ACC at 1719:26 UTC [0119:26 MYT].

MH370 did not contact Ho Chi Minh ACC on radio frequency 120.9 MHz. and Ho Chi Minh ACC was not able to establish two-way communication with MH370.

<u>Reference</u>

Manual of Air Traffic Services, Part 9 - Emergencies, page 9-6-5, para. 6.7.2 dated 15/3/2009 No.1 states:

> *If alerting service is required for an aircraft that is flight planned to operate through more than one FIR including the airspace delegate to the Kuala Lumpur and Kota Kinabalu ATSCs and the position of the aircraft is in doubt, the responsibility for co-ordinating such service shall normally rest with the ATSC of the respective FIRs:*
>
> - *within which the aircraft was flying at the time of last air-ground radio contact;*
> - *that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;*
> - *within which the aircraft's intermediate stop or final destination point is located:*
>
>   *1) if the aircraft was not equipped with suitable two-way radio communication, or*

[16] *Distress Phase - A situation wherein there is a reasonable certainty that an aircraft and its occupants are threatened by grave and imminent danger and require immediate assistance.*

[17] *DETRESFA - The code for a Distress Phase*

2) was not under obligations to transmit position reports.

and

ICAO Doc 4444 ATM/501 Procedures for Air Navigation - Air Traffic Management (PANS-ATM), page 9-6, para 9.2.2.2, dated 22/11/07 states:

When alerting services is required in respect of a flight operated through more than one FIR or control area, and when the position of the aircraft is in doubt, responsibility for coordinating such service shall rest with the ATS unit of the FIR or control area:

a) within which the aircraft was flying at the time of last air-ground radio contact;

b) that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;

c) within which the aircraft's intermediate stop or final destination point is located:

1) if the aircraft was not equipped with suitable two-way radio communication, or

2) was not under obligations to transmit position reports.

The Team noted that MH370 was operating in the airspace delegated to KL ACC and the last air-ground radio contact was with KL ACC. MH370 did not contact Ho Chi Minh ACC and Ho Chi Minh ACC was unable to establish radio communication with MH370.

Hence KL ACC shall be responsible for the provision of alerting service for MH370.

At 2232 UTC [0632 MYT] KL ARCC transmitted the first *DETRESFA* message. A total of 4 hours and 05 minutes had passed from the time the Distress Phase should have been declared.

d) As the 'custodian' of the airspace, the KL ACC transferred MH370 to HCM ACC 3 minutes before the estimated time of arrival over the Transfer of Control Point[18] (TCP).

The estimate[19] of the aircraft for IGARI which was 1722 UTC [0122 MYT] had been passed to, by KL ACC, and duly acknowledged by HCM ACC, as stipulated in the Operational Letter of Agreement between DCA Malaysia and Viet Nam Air Traffic Management.

e) Page 11 of *Appendix 1.1A - Establishment of Communication* in the Operational Letter of Agreement between DCA Malaysia and Viet Nam Air Traffic Management stipulates that:

"The accepting unit shall notify the transferring unit if two-way communication is not established within five (5) minutes of the estimated time over the TCP".

At 1739:03 UTC [0139:03 MYT] HCM ACC queried KL ACC for news on MH370.

After MH370 was transferred to HCM ACC, the time of transfer was not recorded manually on the paper Flight Progress Strip as stipulated in MATS Part 2-Gen Section 11 FLIGHT PROGRESS STRIPS.

Manual of Air Traffic Services Part 9, Table 9-2.2 Overdue Action - Radio Equipped Aircraft preliminary action stipulates that:

"*When an aircraft fails to make a position report when it is expected, commence actions not later than the ETA*[20] *for the reporting point plus 3 minutes"* and

a) The following actions shall be taken:

---

[18] *Transfer of Control Point - A defined point located along the flight path of an aircraft, at which the responsibility for providing air traffic control service to the aircraft is transferred from one control unit or control position to the next.*

[19] *Estimate - The time at which it is estimated that an aircraft will be over a position or over the destination.*

[20] *ETA* - Estimated time of Arrival.

(1) request information from other ATS units and likely aerodromes;

(2) notify the RCC that the Uncertainty Phase[21] exists;

(3) ensure that RQS[22] message is sent.

b) Full Overdue Action: not later than 30 minutes after the declaration of the Uncertainty Phase:

i. notify the RCC that the Alert Phase[23] exists.

ii. notify the RCC that Distress Phase exists if:

-1 hour has elapsed beyond the last ETA for the destination; or

- the fuel is considered exhausted; or

- 1 hour has elapsed since the declaration of the Uncertainty Phase.

MATS Part 9 para 6.2.3 stipulates that:

"*If Controllers have reason to believe that an aircraft is lost, overdue or experiencing communication failure, they shall:*

a) inform appropriate radar units (civil and military) of the circumstances,

b) request the units to watch out for emergency SSR code display or the triangular radio failure pattern, and

c) notify these units when their services are no longer required."

---

21 *Uncertainty phase - A situation wherein doubt exists as to the safety of an aircraft or a marine vessel, and the Persons on board.*

22 *RQS - Request Supplementary Flight Plan.*

23 *Alert phase - A situation wherein apprehension exists as to the safety of an aircraft or marine vessel and of the persons on board.*

At 1741:23 UTC [0141:23 MYT] KL ACC Sector (3 & 5) Controller made a call on the radio frequency 132.5 MHz to MH370 but there was no response from the aircraft.

Event that followed was at the time of 1804:39 UTC [0204:39 MYT] when KL ACC Radar Controller informed HCM ACC:

> *"…reference to the Company Malaysian Airlines the aircraft is still flying, is over somewhere over Cambodia*".

Thirty-one minutes later, at 1835:52 UTC [0235:52 MYT] MAS Operations Centre (MOC) informed the position of the aircraft was at latitude N14.9 0000 and longitude E109 15500 which was somewhere east of Vietnam. This information was relayed to HCM ACC. At 1930 UTC [0330 MYT] MOC called in and spoke to the Radar Controller, "…*admitting that the 'flight tracker'*[24] *is based on projection and could not be relied for actual positioning or search."* (*Watch Supervisor Logbook's entry*).

6) Chronology of Activities after Notification by HCM ACC

The paragraphs (*Table 1.18E* [below]) describe the chronology of activities after notification by HCM ACC leading to the initiation of the Search and Rescue operations (SAR) and deployment of resources for the MH370 search.

Refer Radiotelephony Transcripts - *Appendices 1.18A to 1.18G - Air-Ground Communications.*

[24] *MAS Operations Centre used the name 'Flight Explore*r'.

a) Chronology of ATC Activities after Notification by HCM ACC

No.	Time	Activities
1.	1739:03 UTC [0139:03 MYT]	Ho Chi Minh ACC first enquired about MH370 and informed KL ACC that verbal contact was not established with MH370 and the radar target was last seen at BITOD.
2.	1741:22 UTC [0141:22 MYT]	Ho Chi Minh enquired for information on MH370 and KL ACC informed HCM ACC that after waypoint IGARI, MH370 did not return to Lumpur Radar frequency.
3.	1741:23 UTC [0141:23 MYT]	KL ACC Radar Controller made a “blind transmission” to MH370.
4.	1746:47 UTC [0146:47 MYT]	HCM ACC queried about MH370 again, stating that radar contact was established over IGARI but there was no verbal contact. HCM ACC advised that the observed radar blip disappeared at waypoint BITOD. HCM ACC stated that efforts to establish communication were made by calling MH370 many times for more than twenty (20) minutes.
5.	1750:28 UTC [0150:28 MYT]	KL ACC queried HCM ACC if there had been any contact with MH370, HCM ACC’s reply was “negative”.
6.	1757:49 UTC [0157:49 MYT]	HCM ACC informed KL ACC that there was officially no contact with MH370 until this time. Attempts on many frequencies and through other aircraft in the vicinity received no response from MH370.
7.	1803:48 UTC [0203:48 MYT]	KL ACC queried HCM ACC on the status of MH370, HCM ACC confirmed there was no radar contact at this time and no verbal communication was established. KL ACC relayed the information received from Malaysia Airlines Operations that the aircraft was in the Cambodian airspace.
8.	1807:47 UTC [0207:47 MYT]	HCM ACC queried for confirmation that MH370 was in Phnom Penh FIR as Phnom Penh did not have any information on MH370. KL ACC indicated it would check further with the supervisor.

Table 1.18E – ATC Activities after Notification by HCM ACC

cont…

a) Chronology of ATC Activities after Notification by HCM ACC *(cont…)*

No.	Time	Activities
9.	1812:15 UTC [0212:15 MYT]	KL ACC informed HCM ACC that there was no update on the status of MH370.
10.	1815 UTC [0215 MYT]	(*No voice recording*). Extracted from the Watch Supervisor Log Book: KL ATSC Watch Supervisor queried Malaysia Airlines Operations who informed that MH370 was able to exchange signals with the Flight Explorer.
11.	1818:50 UTC [0218:50 MYT]	KL ACC queried if the flight plan routing of MH370 was supposed to enter Cambodian airspace. HCM ACC confirmed that the planned route was only through the Vietnamese airspace. HCM ACC had checked and Cambodia had advised that it had no information or contact with MH370. HCM ACC confirmed earlier information that radar contact was lost after BITOD and radio contact was never established. KL ACC queried if HCM ACC was taking Radio Failure action, but the query didn't seem to be understood by the personnel. HCM ACC suggested KL ACC to call Malaysia Airlines Operations and was advised that it had already been done.
12.	1833:59 UTC [0233:59 MYT]	KL ACC Radar Controller enquired with Malaysia Airlines Operations Centre about the communication status with MH370 but the personnel was unsure if the message went through successfully or not. Malaysia Airlines Operations Centre informed that the aircraft was still sending the movement message indicating it was somewhere in Vietnam and giving the last position as coordinates N14.90000 E109 15500 at time of 1833 UTC [0233 MYT].
13.	1834:56 UTC [0234:56 MYT]	HCM ACC queried about the status of MH370 and was informed that the Watch Supervisor was talking to the Company at this time.

Table 1.18E – ATC Activities after Notification by HCM ACC

cont…

a) Chronology of ATC Activities after Notification by HCM ACC (*cont*…)

No.	Time	Activities
14.	1837:34 UTC [0237:34 MYT]	KL ACC informed HCM ACC that MH370 was still flying and that the aircraft was continuing to send position reports to the airline, and relayed to HCM ACC the latitude and longitude as advised by Malaysian Airlines Operations.
15.	1853:48 UTC [0253:48 MYT]	MH386 which was enroute from KLIA to Shanghai and within HCM FIR was requested by HCM ACC to try to establish contact with MH370 on Lumpur Radar radio frequency. KL ACC then requested MH386 to try on emergency frequencies as well.
16.	1930 UTC [0330 MYT]	(*No voice recording*) Extract from Watch Supervisor's Log Book: MAS Operations Centre informed KL ACC that the flight tracker information was based on flight projection and was not reliable for aircraft positioning.
17.	1930:03 UTC [0330:03 MYT]	KL ACC queried if HCM ACC had checked with next FIR Hainan.
18.	1948:52 UTC [0348:52 MYT]	When KL ACC queried whether HCM ACC had checked with the Sanya FIR, HCM ACC informed KL ACC that there was no response until now. At 1956:13 UTC [0356:13 MYT] KL ACC queried Malaysia Airlines Operations for any latest information or contact with MH370.
19.	2025:22 UTC [0425:22 MYT]	HCM ACC Supervisor queried KL ACC on the last position that MH370 was in contact with KL ACC.
20.	2118:32 UTC [0518:32 MYT]	When HCM ACC queried for information on MH370, KL ACC also queried if any information had been received from Hong Kong or Beijing.
21.	2109:13 UTC [0509:13 MYT]	Singapore, on behalf of Hong Kong, enquired for information on MH370.

Table 1.18E – ATC Activities after Notification by HCM ACC

cont…

a) Chronology of ATC Activities after Notification by HCM ACC (*cont*…)

No.	Time	Activities
22.	2120:16 UTC [0520:16 MYT]	Capt. *xxxx [name redacted]* of MAS requested for information on MH370. He opined that based on known information, *“MH370 never left Malaysian airspace”.*
23.	2130 UTC [0530 MYT]	Watch Supervisor activated the Kuala Lumpur Aeronautical Rescue Coordination Centre (ARCC).
24.	2141:20 UTC [0541:20 MYT]	HCM ACC queried for any updates.
25.	2214:13 UTC [0614:13 MYT]	KL ACC queried HCM ACC if SAR was activated.
26.	2232 UTC [0632 MYT]	KL ARCC issued a *DETRESFA* message (*Figure 1.18C* [below]).

Table 1.18E – ATC Activities after Notification by HCM ACC

b) *DETRESFA* Message of MH370

```
KLA637 072232
SS WMKKZQZX WMKKZRZX
072232 WMFCZQZX
(ALR-DESTRESFA/WMFCZQZX/MISSING
-FPL-MAS370-IS
-B772/H-SDFGHIJ3J5M1RWXY/LB1D1
-WMKK1635
-N0470F290 DCT PIBOS R208 IKUKO/M081F330 R208 IGARI M765
 BITOD/N0480F330 L637 TSN/N0480F350 W1 BMT W12 PCA G221
 BUNTA/N0480F370 A1 IKELA/N0480F370 P901 IDOSI/N0480F390 DCT CH
 DCT BEKOL/K0900S1160 A461 YIN/K0890S1130 A461 VYK
-ZBAA0534 ZBTJ ZBSJ
-PBN/A1B1C1D1L1O1S2 DOF/140307 REG/9MMRO EET/WSJC0032 VVTS0042
 ZJSA0210 VHHK0233 ZGZU0304 ZHWH0356 ZPE0450 SEL/QRCS
 RMK/ACASII EQUIPPED
-E/0710 P/TBN R/UVE S/M J/LF D/8 290 GREY A/WHITE WITH RED AND
 BLUE STRIPE C/TBN)
```

JABATAN PENERBANGAN AWAM * PENGURUSAN TRAFIK UDARA * HQ MALAYSIA * AIR TRAFFIC MANAGEMENT * DEPARTMENT OF CIVIL AVIATION

Source: DCA Malaysia

Figure 1.18C - DETRESFA Message

7) Activation of KL Aeronautical Rescue Coordination Centre

KL ARCC was activated at 2130 UTC [0530 MYT]. The *DETRES*FA message was disseminated via the AFTN at 2232 UTC [0632 MYT], 01 hour and 02 minutes later. No activity was recorded in the RCC Logbook between 2130 UTC [0530 MYT] and 2232 UTC [0632 MYT].

The Kuala Lumpur Aeronautical Rescue Co-ordination Centre, Standard Operating Procedure for Search and Rescue, page 11, para 3.1 stipulated:

"The search and Rescue Mission Co-ordinator (SMC) is the officer assigned to co-ordinate response to an actual or apparent distress situation.

In aeronautical search and rescue operations, the SMC is usually in the best position to assess the circumstances of a particular case, and to take whatever steps necessary to promote the safety of life and prevent further loss of property.

The SMC must use his/her best judgment in initiating and coordination operations to ensure use of the most suitable method of planning with least possible delay.

Initial Actions

On receipt of information regarding aircraft in difficulties normally from the Watch Supervisor in the ATCC, or from request of assistance from RSCs, MRCC (vessel or person - maritime distress) or from any adjacent RCCs and is aware that assistance is required the SMC shall act as follows:

- *Activate the SAR operation room;*
- *Appraise the situation.*

Continue to take the following actions if emergency situation involves civil aviation accident:

- *Declare the Distress phase if not done yet by the Duty Watch Supervisor;*
- *Notify the SAR Chief and the SAR Co-ordinator (SC);*
- *Request Supervisor to recall SAR trained staff if deemed necessary;*
- *Initiate ARCC activation message;*
- *Assign specific position accordingly (SMC, ASMC… etc.);*
- *Initiate NOTAM[25] actions;*

[25] *NOTAM (Notice to Airmen) - A notice issued by, or with the authority of the State and containing information or instruction concerning the establishment, condition change in any aeronautical facility, service, procedure or hazard, the timely knowledge of which is essential to persons concerned with flight operations. NOTAM is distributed by AFTN. (Aeronautical Fixed Telecommunication Network).*

- *Initiate RQS[26] request from AIS[27] and weather report from Meteorological Office if not done yet by the Supervisor;*
- *Obtain information of aircraft position if necessary by:*
  - *Information contained in the flight plan or notification;*
  - *Check all airports or possible alighting areas along the route of flight and within the possible flight range of the aircraft concerned;*
  - *Notify other aircraft or agencies to attempt establishment of the aircraft's position, informing them of all known frequencies, request for aircraft lookout made through the ATCC Watch Supervisor);*
  - *Notify the Police, along the route of flight, and request them to verify alighting areas, or obtain information on the aircraft and its occupants;*
  - *Request MRCC[28] to alert the vessels in the area if the flight is over or near water;*
  - *Ascertain the type of emergency equipment carried by the missing or distressed craft;*
  - *When required, request Radar assistance for search from appropriate radar station or Radar Plot.*

8) Recorded Telephone Conversations

From the recorded telephone conversations between the KL ACC Radar Controller and MAS Operations Centre, the Radar Controller at 2123:18 UTC [0523:18 MYT] indicated that he would inform the Watch Supervisor to check on when was the last contact with MH370.

[26] RQS - Request Supplementary Flight Plan.

[27] AIS - Aeronautical Information Service.

[28] MRCC - Maritime Rescue Coordination Centre.

9) Watch Supervisor Air Traffic Services and Sector (3 & 5) Logbook

MATS Part 1 - Admin, page 1-1-7 para 1.7 for recording of entries in the logbook as follows:

a) *The time of entries shall be based on UTC and events recorded in a chronological order;*

b) *Entries shall give sufficient details to give readers a full understanding of all actions taken;*

c) *The time an incident occurred and the time at which each action was initiated shall be stated.*

10) Flight Progress Strip

The FPS (*Figure 1.18D* below) of MH370 on 07 March 2014.contains essential flight and control data and is the basic tool to enable Air Traffic Controllers to visualise the disposition of traffic within their area of responsibility including traffic arriving and departing an aerodrome, assess conflicts and control aircraft in a safe manner.

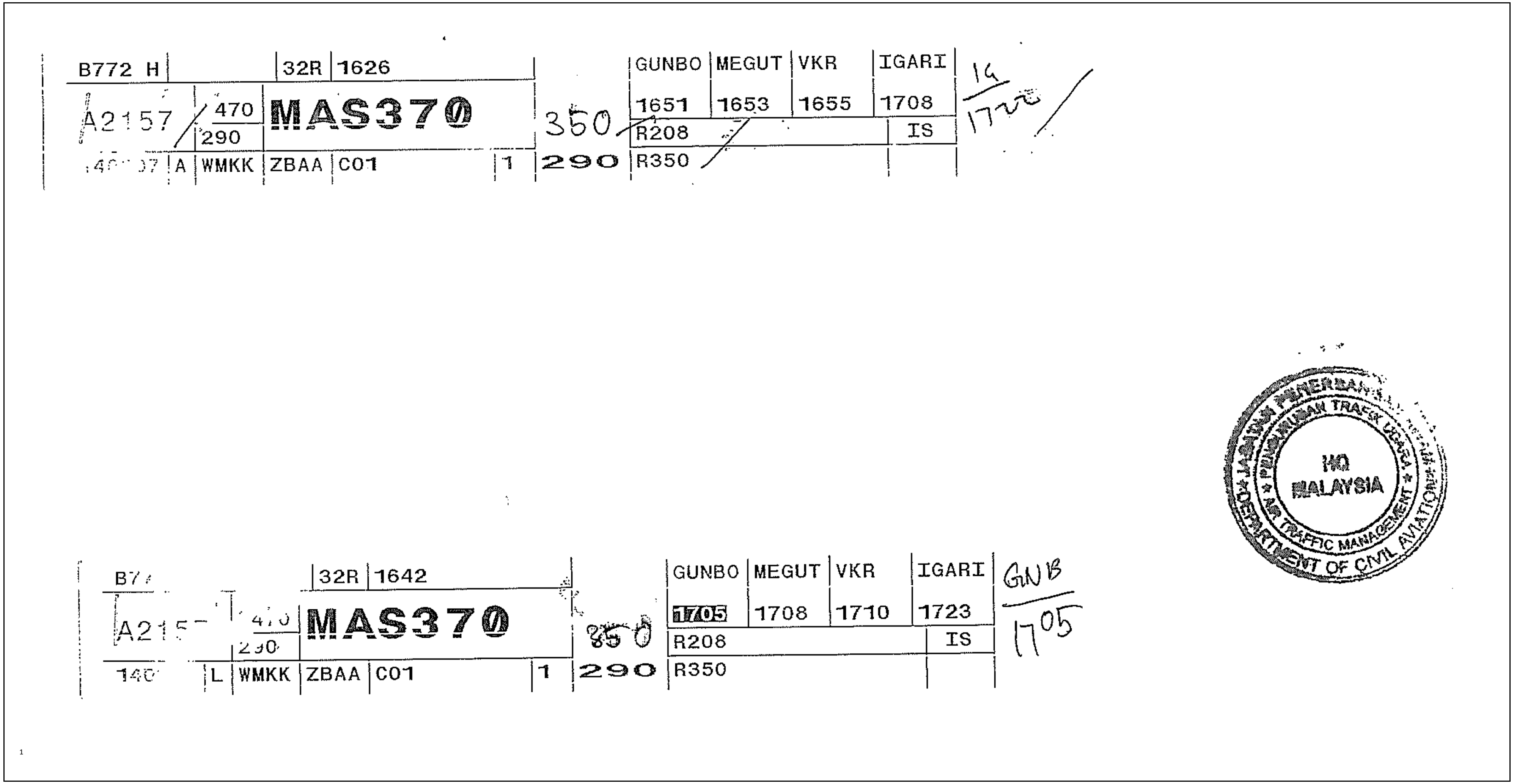


Figure 1.18D - Flight Progress Strip of MH370 on 07 March 2014

1.18.2 Aircraft Cargo Consignment

1) Introduction

During the course of the investigation the Team visited and interviewed the relevant people in MAS at KLIA Sepang, Motorola Solutions Penang, MASkargo Sdn. Bhd. (MASkargo) Penang, NNR Global Logistic (M) Sdn. Bhd. Penang, Poh Seng Kian, Muar, Johore (supplier of mangosteen fruit), Freescale Semiconductor, Petaling Jaya, JHJ International Transportation Co. Ltd. Beijing, China (forwarding agent of Motorola Solutions China), Motorola Solutions China, TianJin, China and Beijing GuangChangMing Trading Co. Ltd. Beijing, China.

On 08 March 2014, MAS B777-200ER MH370 was on a scheduled flight from KLIA to Beijing, China. The aircraft was carrying 227 passengers with a tabulated passenger weight of 17,015 kg, baggage 3,324 kg, cargo 10,806 kg (gross weight) and Max Take-off Weight of 223,469 kg. All these are stipulated in the cargo manifest attached as *Appendix 1.18H*.

The lists of cargo, Airway Bill, Local Agent and Final Destination, are tabulated in *Table 1.18F (*below).

The cargo that had generated interest were:

- Lithium ion Batteries (Li-Ion) and Accessories - 2,453 kg; and
- Mangosteens - 4,566 kg.

No.	COMPANY (MALAYSIA)	AIRWAY BILL	AGENT TRANSPORTER (MALAYSIA)	ITEMS	WEIGHT (nett)
1.	Grolier (M) SB Balakong Selangor	232-2009141	Kerry Logistics (M) Subang Jaya, Selangor	Scholastic assorted books	2,250 kg
2.	Motorola Solutions (M) Bayan Lepas Penang	232-0677085	NNR Global Logistic Batu Maung Penang	Lithium Ion batteries- walkie-talkie accessories & chargers	2,453 kg
3.	Panasonic Industrial Devices Sales, Shah Alam, Selangor	232-12022382	Panalpina Transport (M) MAS Cargo, KLIA,	Electrical parts capacitors	26 kg
4.	Freescale Semiconductor Petaling Jaya, Selangor	232-12022404	Panalpina Transport (M) MAS Cargo, KLIA	Vehicle electronic chips	6 kg
5.	Agilents Technologies Bayan Baru, Penang	232-10664905	Kintetsu World Express MAS Cargo Penang	Electronic measurements	646 kg
6.	Poh Seng Kian Muar, Johore	232-12007306	Poh Seng Kian Muar, Johore	Fresh mangosteens	4,566 kg
7.	Malaysian Express Worldwide, Subang Jaya Selangor	232-11873632	Malaysian Express Worldwide, Subang Jaya, Selangor	Courier materials - documents	6 kg

Table 1.18F - List of Cargo on Board MH370

2) Lithium Ion Batteries

Li-Ion Batteries carried on MH370 were from Motorola Solution Penang. Of the total consignment of 2,453 kg, only 221 kg were Li-ion batteries, the rest were chargers and radio accessories.

The batteries were fabricated in the factory before being packed for export. *Figure 1.18E* (below) shows a raw single cell battery.

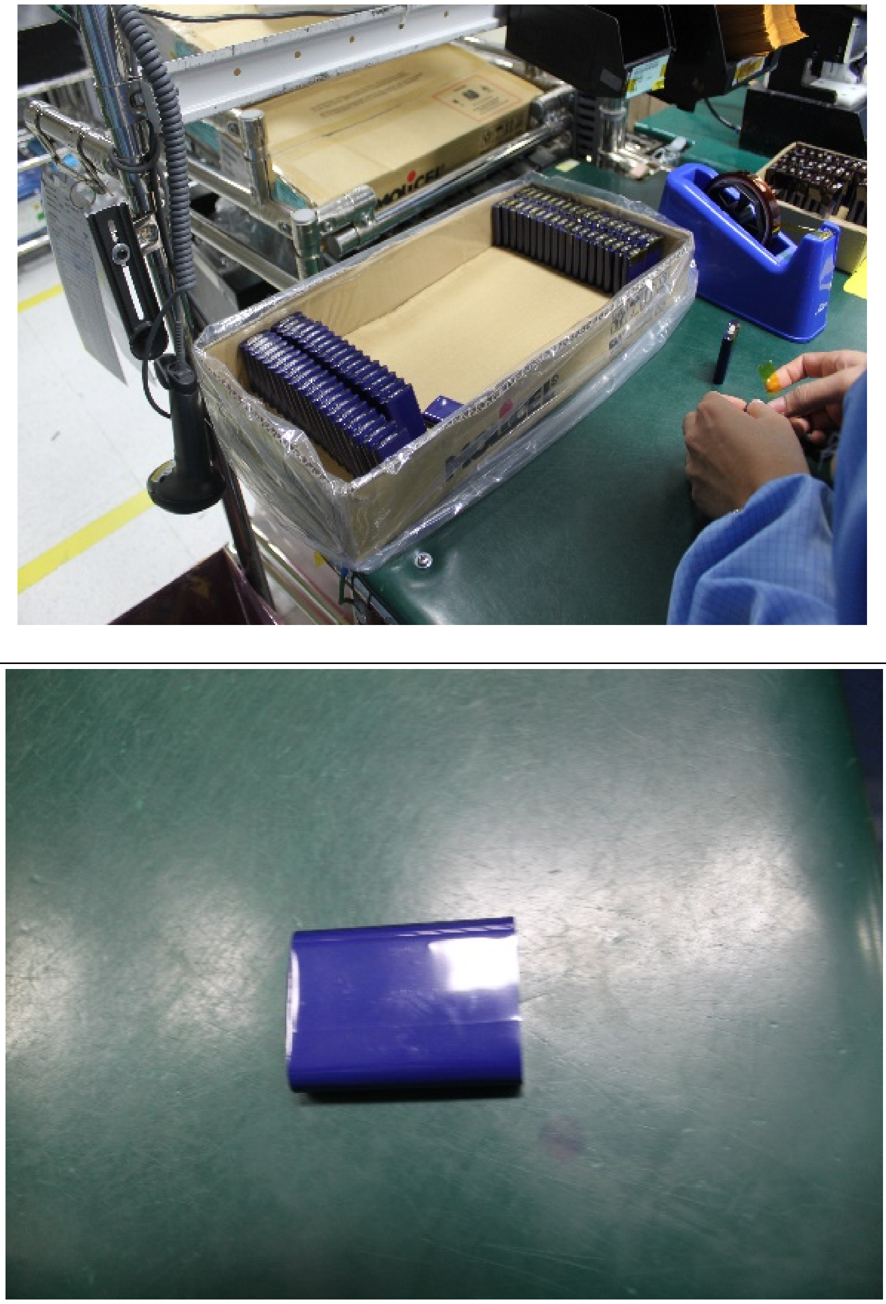


Figure 1.18E - Raw Single Cell Battery

The step-by-step process of fabricating 2 single cell batteries together to form a battery pack for shipment is shown in *Figure 1.18F* (below).

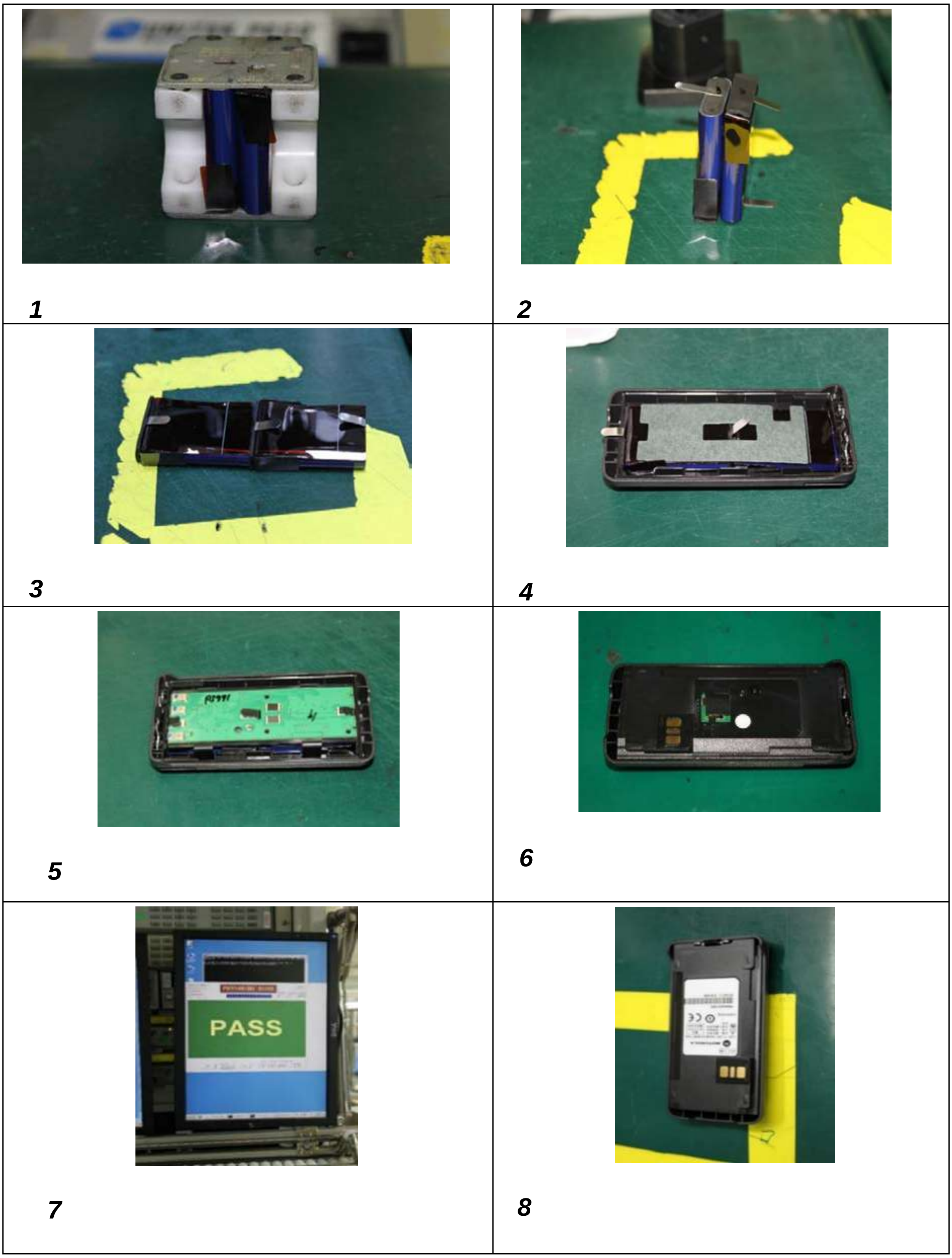


Figure 1.18F - Step-by-step Process of Fabricating 2 Single Cell Batteries to form a Battery Pack for Shipment

The Li-Ion batteries from Motorola Solutions Penang were assembled on 07 March 2014 before being packed, the built-up consigments placed on wooden pallets and delivered by the forwarding agent (NNR Global Logistic (M) Sdn. Bhd.) to MASkargo Penang and subsequently transported by MASkargo truck '*MH6803*' to MAS Cargo Complex, KLIA, Sepang. The shipment did not go through security screening in Penang but was inspected physically by MASkargo personnel and went through Customs' inspection and clearance before the truck was sealed and allowed to leave the Penang Cargo Complex.

The shipment arrived at KLIA Cargo Complex on the evening of 07 March 2014 before being loaded onto MH370 without going through additional security screening.

The Motorola Solutions consignments were loaded in the Aircraft at 90348C (47R) and PMC5871 (23L, 23R) as per Loading Instruction/Report. Illustration as shown in *Figure 1.18G* (below).

There were two (2) different models of Li-Ion battery consignment on MH370 on 08 March 2014:

- PMNN4073AR Li-ion batteries rated at 7.4V, 11.8Wh; and
- PMNN4081BRC Li-ion batteries rated at 7.4V, 11.1Wh.

Both of the batteries were not regulated as Dangerous Goods because the packing had adhered to the guidelines as per Lithium Battery Guidance Document (3. Section II - Packing Instructions 965-970). This document is based on the provisions set out in the 2013-2014 Edition of the ICAO Technical Instructions for Safe Transport of Dangerous Goods by Air and the 55th Edition of the IATA Dangerous Goods Regulations (DGR). The ICAO and IATA documents are as per *Appendix 1.18I.*

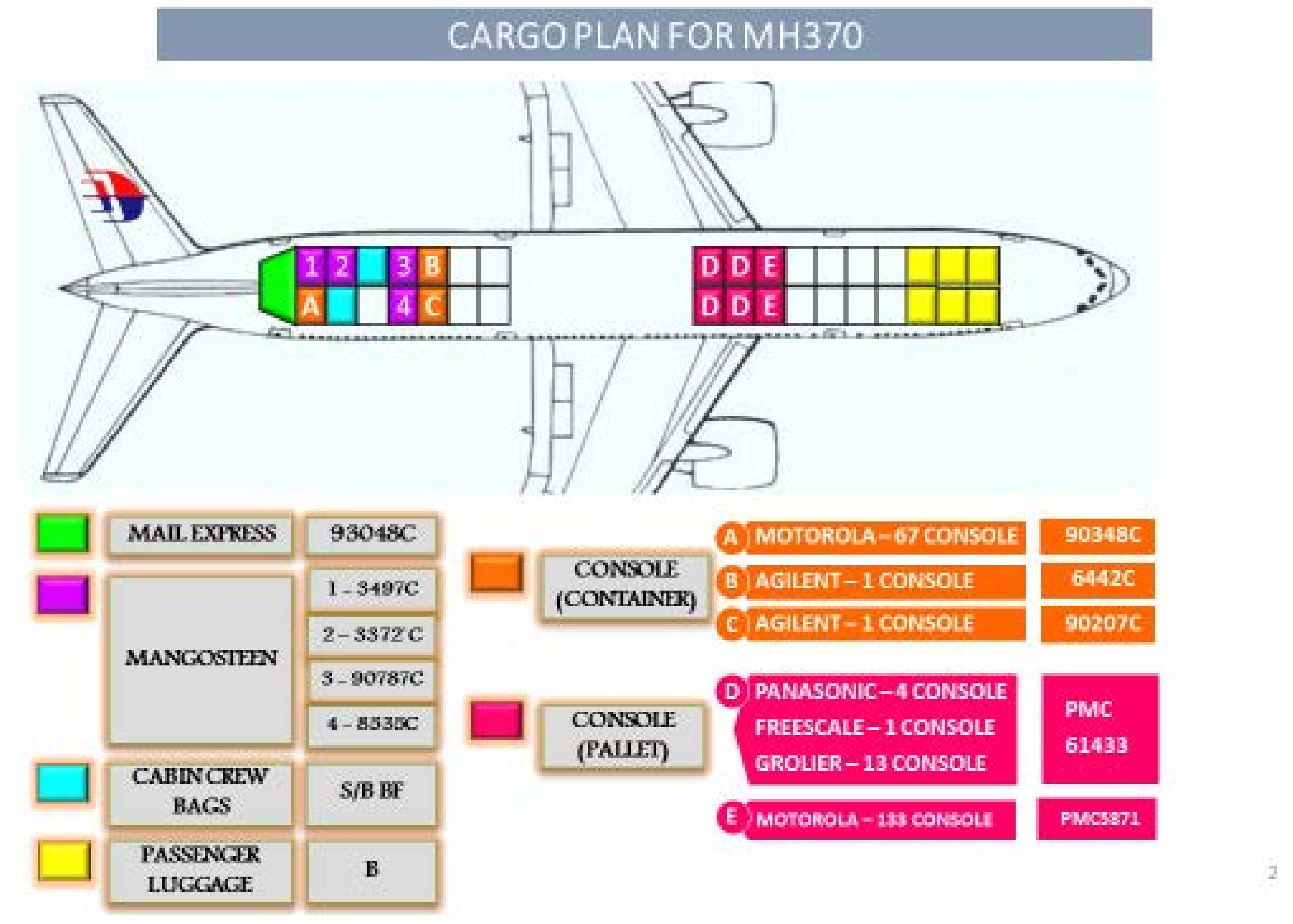
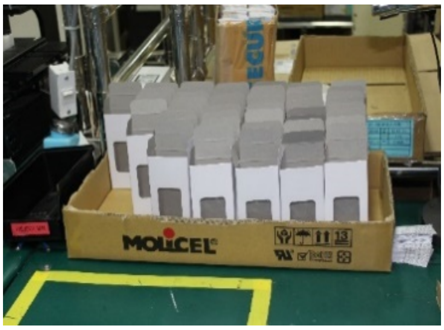


Figure 1.18G - Motorola Solutions Consignment Loading

The packing of the batteries by Motorola Solutions is shown in *Figure 1.18H* (below).

Picture 1



Picture 2

Picture 3

Picture 4

Picture 5

Picture 6

Figure 1.18H - Packing of Batteries by Motorola Solutions

Each Li-Ion battery was placed in a white window box (*Picture 1* [above]) and two of these filled boxes were then placed in a brown box (*Picture 2* [above]) printed with Li-Ion battery warning shipping information (*Picture 3* [above]). The brown box filled with two Li-Ion batteries each was then packed into a larger box. Each box contained twenty-four Li-ion batteries (12 boxes x 2 = 24, *Picture 4, Figure 1.18H* [above]), sealed and weighed (*Picture 5, Figure 1.18H* [above]). All the sealed boxes were placed on a wooden pallet and the built-up consignment was wrapped with plastic and polystyrene sheets for protection (*Picture 6, Figure 1.18H* [above]). They were then scanned, with the number of batteries determined by means of weighing the boxes.

From January 2014 to May 2014 there were ninety-nine shipments of Li-ion Batteries on MAS flights to Beijing.

Refer *Appendix 1.18J - List of Airways Bills.*

3) Mangosteen Fruits

The mangosteens on board MH370 on 08 March 2014 originated from Poh Seng Kian of No.79, 6¼ mile Kesang, 84000 Muar, Johore, Malaysia. About 2,500 kg of the fruit were harvested from Muar and the rest from Sumatra, Indonesia. Photographs of the mangosteen orchard and a typical mangosteen plant are shown as *Figures 1.18I* and *1.18J* (below) respectively.

Figure 1.18I - Mangosteen Orchard in Muar, Johor, Malaysia

Figure 1.18J - Mangosteen Plant/Fruit

The mangosteens were packed in plastic baskets of between 8 to 9 kg per basket with a piece of sponge soaked with water placed on top of the mangosteens to maintain their freshness (*Figures 1.18K and 1.18L* [below]). The packed mangosteens were then loaded on the trucks which proceeded to MASkargo Complex at KLIA, Sepang. At the complex, four ULD containers were provided by MASKargo staff to the forwarding agent. The forwarding agent then loaded the packed fruit into the ULD containers (*Figure 1.18M* [below]). The consignment was then inspected by the Federal Agriculture Marketing Authority (FAMA) of Malaysia. After obtaining the clearance, the forwarding agent handed over the consignments to the MAS loaders for loading into the aircraft.

Figure 1.18K - Plastic Baskets of Mangosteens

Figure 1.18L - Piece of Soaked Sponge placed on Top of Mangosteens

1. MASkargo Perishable Warehouse

2. Unloading crates of mangosteens from plantation

3. Crates of mangosteens ready for loading into ULD

4. Placing large plastic sheet in ULD before loading

5. Loading crates of mangosteens into ULD

6. Filling up crates into ULD .

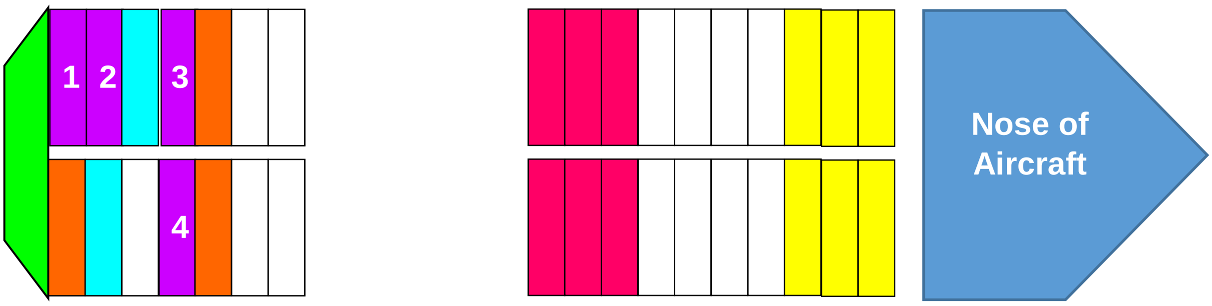
7. Secured crates of mangosteens with plastic sheets before latching ULD cover.

8. Another piece of plastic sheet to cover ULD

9. ULD secured with labels for uploading into aircraft

Figure 1.18M - Processing of Packed Crates of Mangosteens into ULD before Uploaded to Aircraft

Flight MH370 on 08 March 2014 carried four ULD containers of mangosteens - ULD AKE3497MH weighing 1,128 kg was placed at cargo bay 41L, ULD AKE90787MH weighing 1,152 kg at cargo bay 41F, ULD AKE3372MH weighing 1,148 kg at cargo bay 43L and ULD AKE8535MH weighing 1,138 kg at cargo bay 44L. The loading arrangement is shown in *Figure 1.18N* (below). Loading Instruction/Report is shown in the MH370 cargo manifest (*Appendix 1.18H*).



No.	ULD	WEIGHT (KG)	POSITION
1	AKE3497MH	1,128	41F
2	AKE90787MH	1,152	41L
3	AKE3372MH	1,148	43L
4	AKE8535MH	1,138	44L

Figure 1.18N - Loading Arrangement of ULDs of Mangosteens

From January 2014 till May 2014 there were a total of eighty-five shipments of mangosteens to Beijing, China. The list of Airway Bills is shown in *Appendix 1.18J*. The combination of the two cargo shipments (Li-ion Batteries and mangosteens) carried together from January to May 2014 were thirty-six times (*highlighted in red in Appendix 1.18J).*

1.18.3 Crew and Passengers on Board MH370

1) Total Number of Crew and Passengers

Total number crew and passengers on board MH370 are shown in *Table 1.18G* (below).

Crew		Passengers	Total
Flight	Cabin		
2	10	227	239

Table 1.18G - Total Number of Crew and Passengers

2) Nationalities of the Crew and Passengers

The nationalities of the flight crew and passengers on board MH370 are shown in *Table 1.18H* (below).

Countries		Crew		Passengers	Total
		Flight	Cabin		
1.	China	-	-	153	153
2.	Malaysia	2	10	38	50
3.	Indonesia	-	-	7	7
4.	Australia	-	-	6	6
5.	India	-	-	5	5
6.	France	-	-	4	4
7.	United States of America	-	-	3	3
8.	Ukraine	-	-	2	2
9.	Canada	-	-	2	2
10.	New Zealand	-	-	2	2
11.	Netherland	-	-	1	1
12.	Russia	-	-	1	1
13.	Chinese Taipei	-	-	1	1
14.	Italy* (Iran)	-	-	1	1
15.	Austria* (Iran)	-	-	1	1
Total		2	10	227	**239**

Table 1.18H - Breakdown of Nationalities of Passengers

* Travelling on stolen passports and discovered to be Iranian citizen *(Figures 1.18V & W* [below] *on Passengers' Seating Positions).*

a) Crew

All the 12 crew (including the two pilots) were Malaysians.

b) Passengers

A total of 227 passengers (including 3 children and 2 infants) were on board with the majority of them from China, followed by Malaysia and other citizens from different countries.

c) Passengers' Seating Positions

The aircraft was compartmentalised into 2 categories of seating, namely the business class with a total of 35 seats and the economy class with a total of 249 seats. Passengers from the 14 countries were seated throughout the aircraft from Row 1 to Row 41. (*Figure 1.18O* [below]).

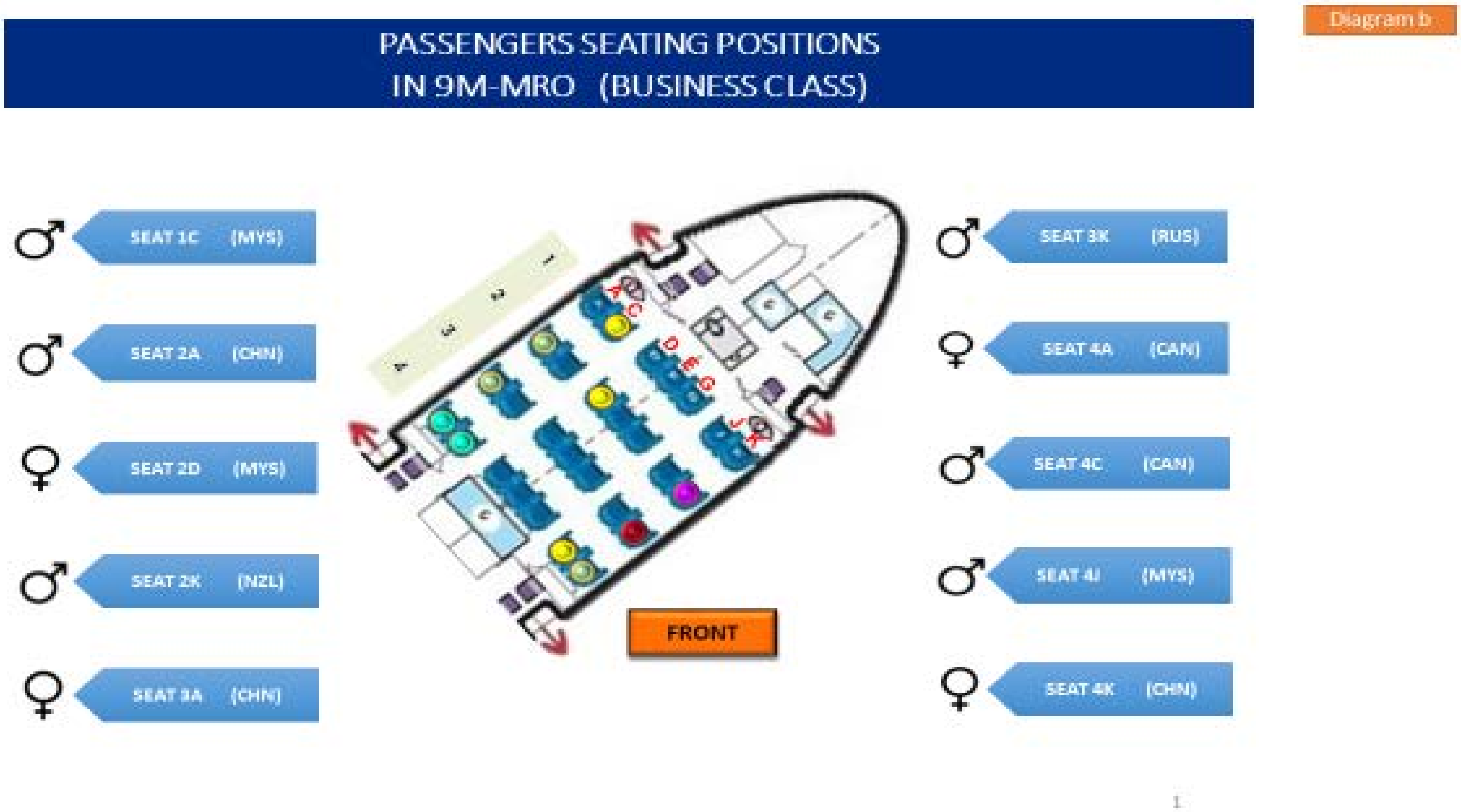
A total of 10 passengers were seated in the Business Class in the front portion of the aircraft, from Row 1 to Row 4. (*Figure 1.18P* [below]).

In the middle portion of the aircraft, the Economy seating started from Row 11 to Row 27. A total of 127 passengers were seated in this middle portion of the aircraft. There were 2 children on seats 17F and 18F respectively (*Figures 1.18Q, 1.18R, 1.18S and 1.18T* [below]).

The rear portion of the aircraft accommodated 90 passengers from Row 29 to Row 41. 2 infants were on board accompanied by adults seated on seats 30E and 37D respectively. There was a child on seat 30H in the rear portion of the aircraft. (*Figures 1.18U, 1.18V and 1.18W* [below]).

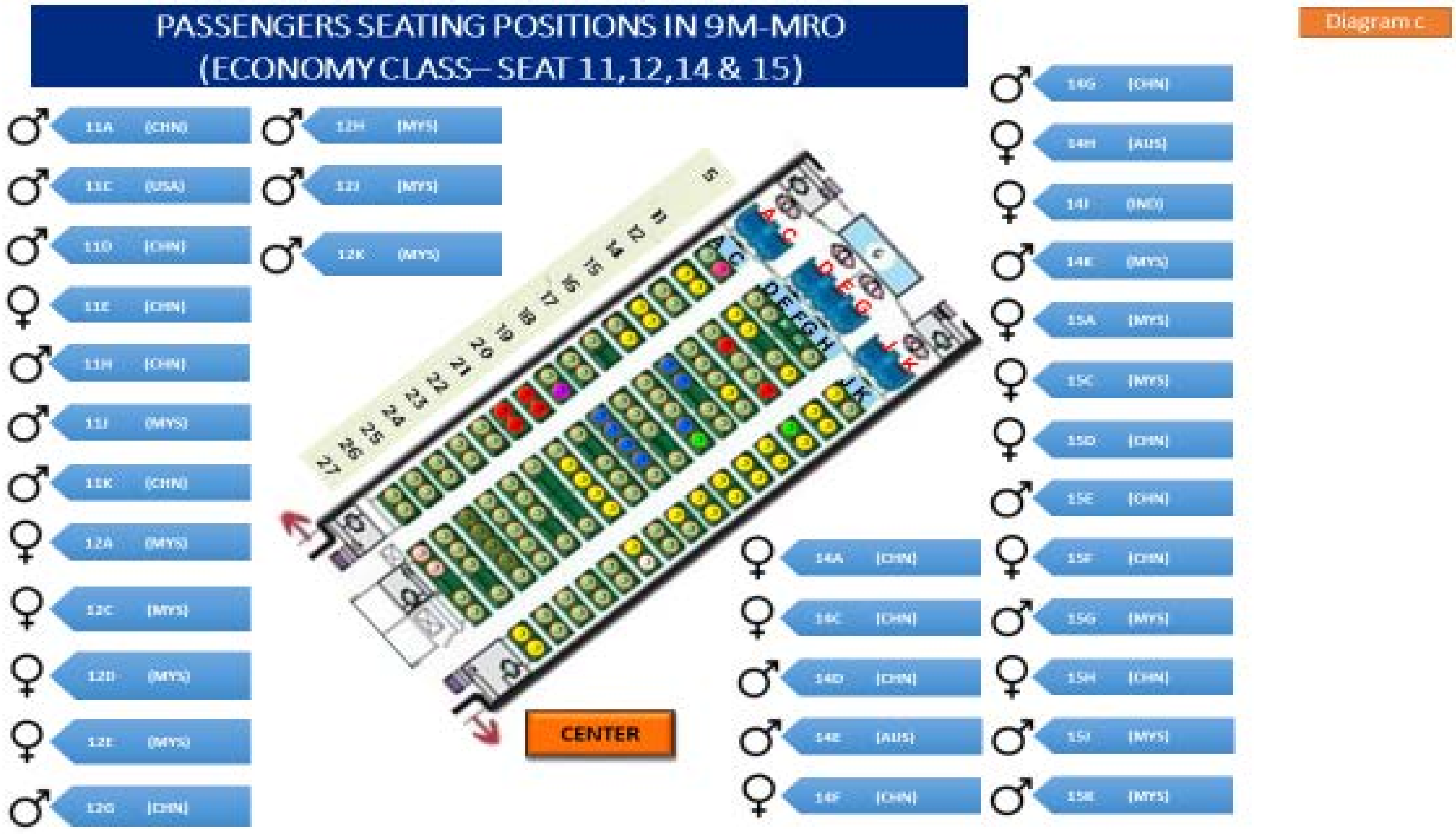
Source: Royal Malaysia Police

Figure 1.18O - Passengers' Seating Positions



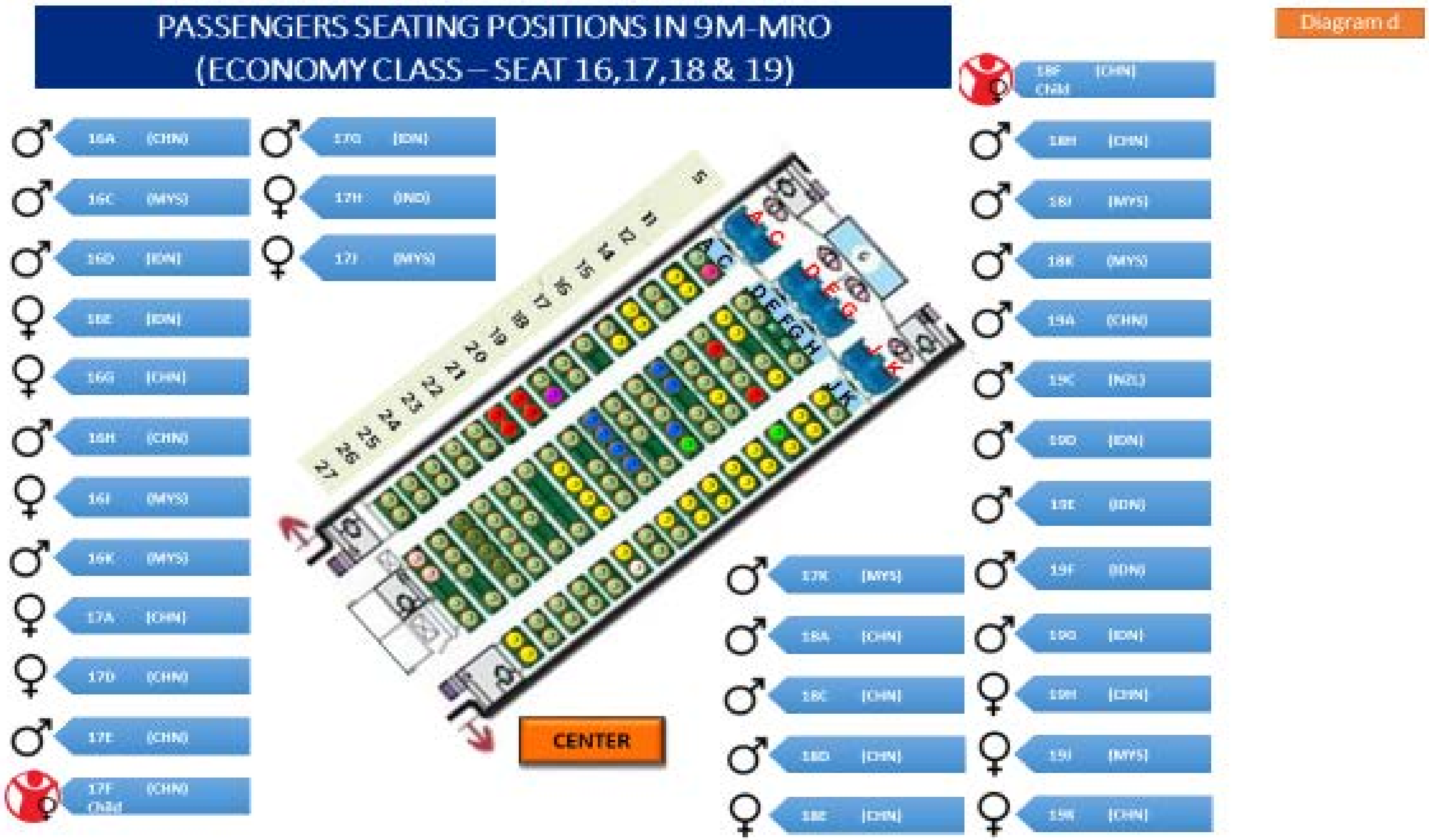
Source: Royal Malaysia Police

Figure 1.18P - Passengers' Seating Positions (Business Class)



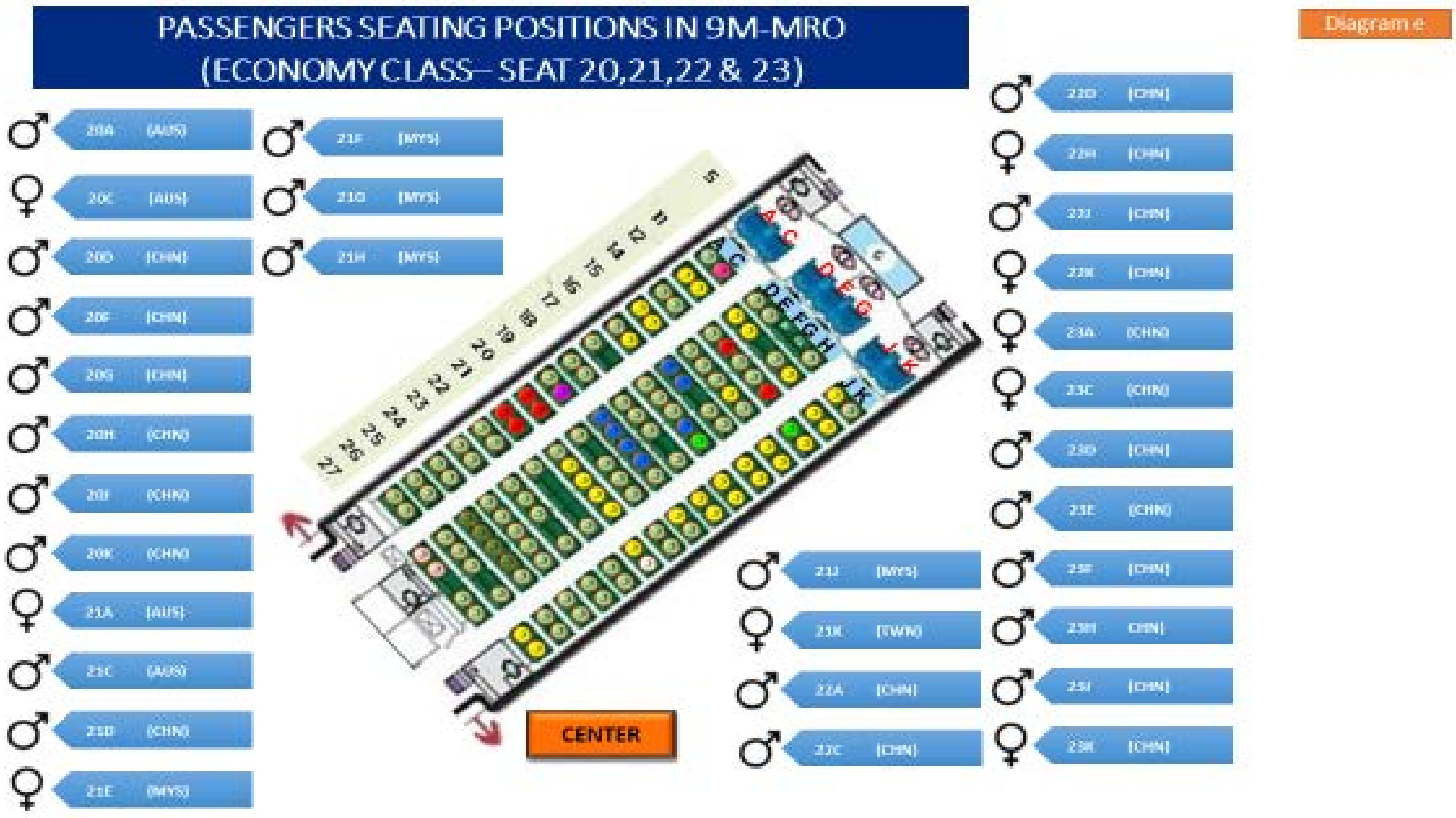
Source: Royal Malaysia Police

Figure 1.18Q - Passengers' Seating Positions (Economy Class - Seats 11, 12, 14 & 15)



Source: Royal Malaysia Police

Figure 1.18R - Passengers' Seating Positions (Economy Class - Seats 16, 17, 18 & 19)

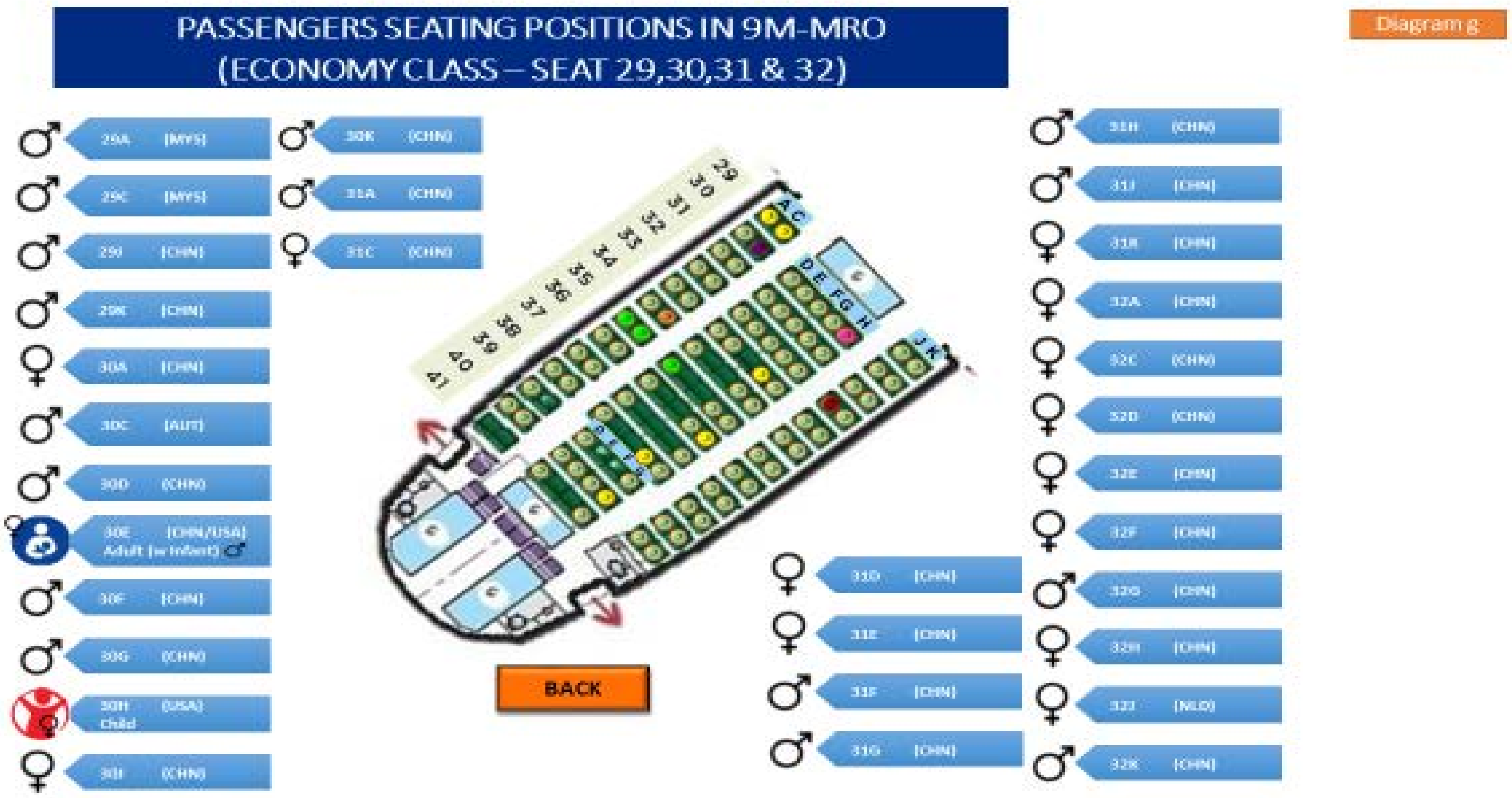


Source: Royal Malaysia Police

Figure 1.18S - Passengers' Seating Positions (Economy Class - Seats 20, 21, 22 & 23)

Source: Royal Malaysia Police

Figure 1.18T - Passengers' Seating Positions (Economy Class - Seats 24, 25, 26 & 27)

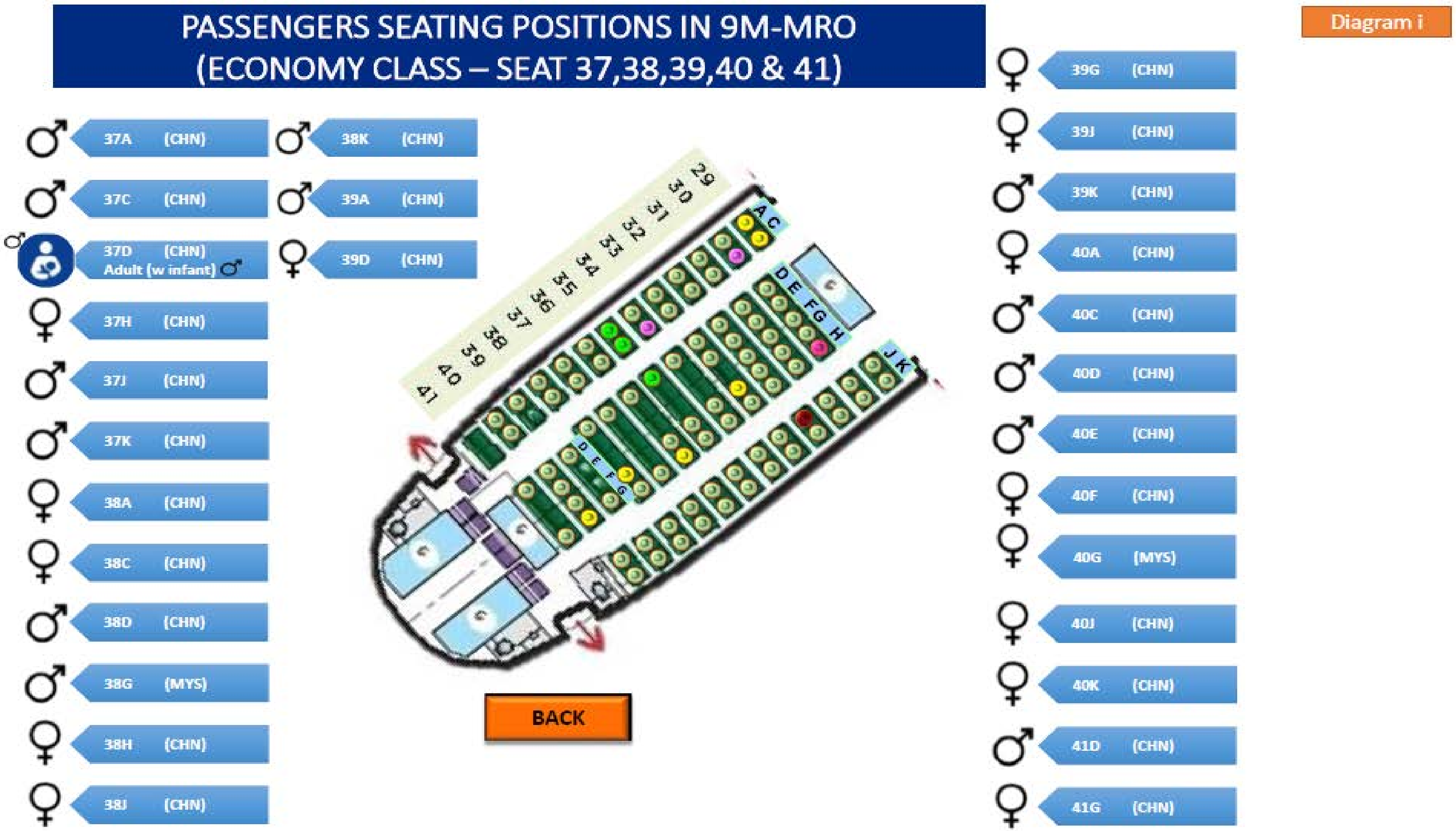


Source: Royal Malaysia Police

Figure 1.18U - Passengers' Seating Positions (Economy Class - Seats 29, 30, 31 & 32)

Source: Royal Malaysia Police

Figure 1.18V - Passengers' Seating Positions (Economy Class - Seats 33, 34, 35 & 36)



Source: Royal Malaysia Police

Figure 1.18W - Passengers' Seating Positions (Economy Class - Seats 37, 38, 39, 40 & 41)

SECTION 1 – FACTUAL INFORMATION

1.19 NEW INVESTIGATION TECHNIQUES

Not applicable.

SECTION 2 – ANALYSIS

INTRODUCTION

Section 2 analyses the relevant issues associated with the disappearance of B777-200ER aircraft, registered as 9M-MRO, and operating as Flight MH370 on 08 March 2014. Recognising that at the time of issue of this Report, the main aircraft wreckage, including the Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR) have not been located, this analysis will necessarily be limited by a significant lack of evidence.

The issues that will be covered in this Section include the following:

1. Diversion from Filed Flight Plan Route;
2. Air Traffic Services Operations;
3. Flight Crew Profile;
4. Airworthiness & Maintenance and Aircraft Systems;
5. Satellite Communications;
6. Wreckage and Impact Information;
7. Organisation and Management of Department of Civil Aviation and Malaysia Airlines; and
8. Aircraft Cargo Consignment.

SECTION 2 – ANALYSIS

2.1 DIVERSION FROM FILED FLIGHT PLAN

2.1.1 Seven Simulator Sessions

To analyse further on how MH370 had diverted from the Filed Flight Plan (FPL) route, the Team conducted a total of seven flight simulator sessions to recreate the two turns of MH370, i.e. six sessions on the left turn past waypoint IGARI and one session on the right turn on reaching the south of Penang Island. Three of the seven sessions were conducted at high speed and the remainders at low speed. The turns were based on the recorded primary radar data that recorded a primary target conducting a left turn from where the SSR code ceased, shortly after the aircraft passed waypoint IGARI. The following data (*Tables 2.1A to 2.1F* [below] on data input for the first six sessions respectively) were introduced to simulate an actual environment:

- Actual weight and meteorological condition prevailing at the time of the turn (extracted from the computerised flight plan); and
- Different speed and rate of turns to determine scenarios closest were made available to the Team.

1) Recreating the Left turn past Waypoint IGARI – Session 1

Initial conditions

Fuel	41,200 kg
Gross weight	215,410 kg
Height	35,000 ft
Speed	IAS 271 (475 knots ground speed)
Simulator setup	Speed/Lateral Navigation/Vertical Navigation (SPD/LNAV/VNAV), autopilot engaged, autothrottle engaged
Entry waypoint	N07.05.7 E103.47.1
Exit waypoint	N07.12.7 E103.38.7

Table 2.1A - Data Input for Session 1

To get the 'aircraft' to track correctly, a flight path from waypoint IGARI to waypoint BITOD was generated with the entry and exit waypoints entered.

The simulation commenced before IGARI and the 'aircraft' turned right on LNAV and tracked to the entry waypoint. Once over the waypoint, the flight management computer (FMC) was directed to fly "direct to" to the exit waypoint. The 'aircraft' entered a left turn, with a maximum bank-angle of 26° (maximum bank-angle in LNAV is 25°).

About half-way through the turn, it was obvious that the 'aircraft' was not going to make it through the exit waypoint as it was overshooting as there was no tracking information in the FMC. The simulator session was then terminated.

2) Session 2

Initial conditions (identical to Session 1)

Fuel	41,200 kg
Gross weight	215,410 kg
Height	35,000 ft
Speed	IAS 271 (475 knots ground speed)
Simulator setup	SPD/LNAV/VNAV, autopilot engaged, autothrottle engaged
Entry waypoint	N07.05.7 E103.47.1
Exit waypoint	N07.12.7 E103.38.7
Additional waypoint	N05.15.6 E100.27.5

Table 2.1B - Data Input for Session 2

To get the 'aircraft' to track correctly, a flight path from waypoint IGARI to waypoint BITOD was generated with the entry and exit waypoint entered. A further waypoint was entered along a track of 244° at the commencement of the right turn south of Penang.

The simulation commenced before IGARI and the 'aircraft' turned right on LNAV and tracked to the entry waypoint. Once over the waypoint, the FMC was directed to fly "direct to", to the exit waypoint. The 'aircraft' entered a left turn, with a maximum bank-angle of 26° (maximum bank-angle in LNAV is 25°).

The ‘aircraft’ made the exit waypoint; however, it took 3 minutes and 45 seconds to achieve it (the recorded radar time was 2 minutes 10 seconds).

3) Session 3

Initial conditions

Fuel	41,200 kg
Gross weight	215,410 kg
Height	35,000 ft
Speed	IAS 250 (425 knots groundspeed)
Simulator setup	SPD/LNAV/VNAV, autopilot engaged, autothrottle engaged
Entry waypoint	N07.05.7 E103.47.1
Exit waypoint	N07.12.7 E103.38.7
Additional waypoint	N05.15.6 E100.27.5

Table 2.1C - Data Input for Session 3

Following discussions, it was decided to reduce the speed in the turn to see if the rate of turn would increase. In this session, the speed was reduced to 250 knots IAS (ground speed of 425 knots). Similar set up as Session 2.

The simulation commenced before IGARI and the ‘aircraft’ turned right on LNAV and tracked to the entry waypoint. Once over the waypoint, the FMC was directed to fly “direct to” to the exit waypoint. The ‘aircraft’ entered a left turn, with a maximum bank-angle of 28° (maximum bank-angle in LNAV is 25°). The ‘aircraft’ made the exit waypoint. However, it took 3 minutes and 3 seconds to achieve it.

4) Session 4

Following further discussions, it was decided to further reduce the speed in the turn.

The simulation commenced before IGARI and the ‘aircraft’ turned right on and tracked to the entry waypoint. Once over the waypoint, the FMC was directed to fly “direct to”, to the exit waypoint. The ‘aircraft’ entered a left turn, with a maximum bank-angle of 23° (maximum bank-angle in LNAV is 25°).

Initial conditions

Fuel	41,200 kg
Gross weight	215,410 kg
Height	35,000 ft
Speed	IAS 220 (400 knots groundspeed)
Simulator setup	SPD/LNAV/VNAV, autopilot engaged, autothrottle engaged
Entry waypoint	N07.05.7 E103.47.1
Exit waypoint	N07.12.7 E103.38.7
Additional waypoint	N05.15.6 E100.27.5

Table 2.1D - Data Input for Session 4

The 'aircraft' made the exit waypoint. However, it took 3 minutes and 30 seconds to achieve it.

5) Session 5 (Manual Flying)

Following discussions, it was agreed that the turn could be executed in LNAV, but not in 2 minutes. It was decided that the bank-angle needed to be increased to reduce the time and that could only be achieved with the autopilot disengaged and the 'aircraft' manually flown, with the auto-thrust managing the speed. Similar set-up as Session 2.

Initial conditions

Fuel	41,200 kg
Gross weight	215,410 kg
Height	35,000 ft
Speed	IAS 271 (475 knots ground speed)
Simulator setup	SPD/LNAV/VNAV, autopilot engaged, then autothrottle engaged
Entry waypoint	N07.05.7 E103.47.1
Exit waypoint	N07.12.7 E103.38.7
Additional waypoint	N05.15.6 E100.27.5

Table 2.1E - Data Input for Session 5

The simulation commenced before IGARI with autopilot and autothrottle engaged and the 'aircraft' turned right on LNAV and tracked to the entry waypoint. Once over the waypoint, the autopilot was disconnected and the 'aircraft' manually turned to the left. Bank-angles around 30°-32° were used. As the entry and exit waypoints were displaced slightly laterally (i.e. not exactly aligned 180° apart), the 'aircraft's wings were rolled level when aligned to intercept the exit waypoint. This was at 2 minutes and 10 seconds. The 'aircraft' then intercepted the exit waypoint at 2 minutes and 40 seconds.

6) Session 6 (Manual Flying)

Finally, it was agreed that the same turn should be executed manually but at a lower speed of 250 knots with the autopilot disengaged and the 'aircraft' manually flown, with the autothrottle managing the speed. Same set-up as Session 2.

Initial conditions

Fuel	41,200 kg
Gross weight	215,410 kg
Height	35,000 ft
Speed	IAS 250 (425 knots ground speed)
Simulator setup	SPD/LNAV/VNAV, then autopilot disengaged, autothrottle engaged
Entry waypoint	N07.05.7 E103.47.1
Exit waypoint	N07.12.7 E103.38.7
Additional waypoint	N05.15.6 E100.27.5

Table 2.1F - Data Input for Session 6

The simulation commenced before IGARI with autopilot and autothrottle engaged and the 'aircraft' turned right on LNAV and tracked to the entry waypoint. Once over the waypoint, the autopilot was disengaged and the 'aircraft' manually turned to the left. Bank-angle around 35° was used (bank-angle warnings sounded several times).

At about half way through the turn (1 minute mark), the stick-shaker activated. The 'aircraft' intercepted the exit waypoint at 2 minutes and 28 seconds.

7) Analysis on Re-enactment Sessions (Sessions 1 - 6)

a) From the various re-enactment sessions tested, it is apparent that the 'aircraft' could make the turn in LNAV, but took a longer time due to bank-angle limitations (25°) and also required the need to reduce speed (Session 3 was the closest at 3 minutes and 3 seconds) in the turn.

b) However, there were issues with the entry waypoint being off the direct track IGARI to BITOD (to the south-east) and this resulted in the 'aircraft' being in a slight right bank when overflying the waypoint and then starting the left turn. This would have increased the time to make the left turn as the 'aircraft' had to roll through level, before rolling west.

c) The 'aircraft' could also make the turn and achieve a closer time to the recorded radar data with the autopilot disengaged and manually flown (Session 5 was closest with 2 minutes 10 seconds to wings-level and 2 minutes and 40 seconds to the exit waypoint).

d) Again, there were issues with the positioning of the entry and exit waypoints as they were not aligned (i.e. not 180° apart) leaving a short straight segment before the 'aircraft' intersected the exit waypoint.

e) Summary of 6 Simulator Re-enactment Sessions and Common Factors

Based on the six simulator re-enactment sessions conducted as summarised in *Table 2.1G* (below) and on the common factors in *Table 2.1H* (below), the Team concluded the following:

i) The turn would have been carried out with the autopilot disengaged, as it was not possible to achieve a turn time of 2 minutes and 10 seconds (as suggested by recorded data) using autopilot. The manoeuvre can be performed by a single pilot. The Team also noted that the aircraft's flight path from after the turn was consistent with the navigation being set to LNAV and/or heading mode, following published and/or manual waypoints that are not normally used with normal route (published airways between Kota Bharu and Penang).

Re-enactment	**Session**					
	1	**2**	**3**	**4**	**5**	**6**
Ground Speed (in knots)	475	475	425	400	475	425
Autopilot Engaged	✓	✓	✓	✓	x	X
Additional Waypoint	x	x	X	N05.15.6 E100.27.5	✓	✓
Bank angle (in degrees)	26º	26º	28º	23º	30-32º	35º
Exit Waypoint Time	Over-Shooting	2 min 45 sec	3 min 3 sec	3 min 30 sec	2 min 40 sec	2 min 28 sec

Table 2.1G - Re-enactment Sessions

Common Factors		
1.	Fuel	41,200 kg
2.	Gross Weight	215,410 kg
3.	Height	35,000 ft
4.	Entry Point	N07.05.7º E103.47.1º
	Exit Point	N07.12.7º E103.38.7º
5.	Autothrottle Engaged	

Table 2.1H - Common Factors

ii) From the data it was determined that the 'aircraft' was on heading mode that varied from 239º to 255º as it flew to the south of Penang where it continued westerly to Waypoint MEKAR where it finally disappeared completely at 1822:12 UTC [0222:12 MYT], about 10 nautical miles north of MEKAR.

iii) Based on the Team's review of the Military recorded radar display and printout, the aircraft's flight path could not be determined, and there is no evidence of rapid altitude and/or speed changes to indicate that MH370 was evading radar.

iv) Without further evidence, the reason for the transponder information from the aircraft ceasing could not be determined;

v) It is determined that only the transponder signal of MH370 ceased from the ATC Controller display whilst displays from other aircraft were still available; and

vi) There is also no evidence to suggest that the aircraft was flown by anyone other than the designated MAS pilots. However, the Team does not exclude the possibility of intervention by a third party.

8) Session 7 – Recreating the Right Turn South of Penang Island

Initial conditions

Fuel	36,000 kg
Gross weight	210,200 kg
Height	35,000 ft
Speed	IAS294 (525 knots groundspeed) M0.86 Note: A tailwind of 30 knots was needed to achieve this
Simulator setup	SPD/LNAV/VNAV, autopilot engaged, autothrottle engaged.
Entry waypoint	N05.15.6 E100.27.5
Exit waypoint	N05.12.0 E100.01.5

Table 2.1I - Data Input for Session 7

To get the 'aircraft' to track correctly (*Table 2.1I* [above]), both the entry and exit waypoints were entered, without a track between them in the FMC. The 'aircraft' was flown on heading mode to turn gently to intercept the exit waypoint.

The simulation commenced before the entry waypoint. Once crossing the waypoint, a heading change to the right was initiated to achieve a bank-angle of 5°. During the turn, the bank-angle was increased to a maximum of 10°. The exit waypoint was easily intercepted at 3 minutes and 5 seconds (the recorded radar time was 3 minutes). No further simulations were done on this turn.

2.1.2 Ho Chi Minh Air Traffic Services Operations

Based on the on-site interviews and briefing from the Team's visit to the Office of the Vietnamese Civil Aviation Authority in Ho Chi Minh City, it was noted that the radar position symbol for MH370 dropped from the radar display at 1720:59 UTC (0120:59 MYT). MH370 had not reached waypoint BITOD which is 37 nm from waypoint IGARI and based on the aircraft speed of 480 kt, it would take approximately five minutes for MH370 to travel from IGARI to BITOD.

The Direct Line Coordination Communication transcripts between KL ACC and Ho Chi Minh ACC suggested that there were uncertainties on the position of the aircraft. This could come about from the level of understanding of the English language. The HCM Duty Controller also could not communicate effectively during the interviews and an interpreter was there to assist him.

Reference:

Ho Chi Minh radar data recording, page 33 to 41 and page 51 to 61 of the Direct Line Coordination Communication KL ACC Sector 3+5 Planner (*Appendix 1.18G*) transcripts between Kuala Lumpur ACC and Ho Chi Minh ACC)

SECTION 2 – ANALYSIS

2.2 AIR TRAFFIC SERVICES OPERATIONS

2.2.1 Review of Flight MH370 before its Disappearance

1) The MH370 from Kuala Lumpur to Beijing was a normal daily scheduled flight. It took off at 1642 UTC [0042 MYT].

2) There was no indication of any unusual operations prior to departure and during the flight until the last secondary radar position symbol was recorded by ATC at 1721 UTC [0121 MYT] as detailed in *Table 2.2A - Chronological of events before disappearance of MH370* below.

3) Preparation of the flight was in order from the time the Filed Flight Plan[29] (FPL) message was filed and transmitted 12 hours before the flight.

4) The flight crew reported on time for duty and there was no delay in the departure of the flight (*Figure 2.2C* [below] - *Departure message*).

5) There was also no report of any significant or unusual health-related issues for the flight and cabin crew.

6) The radiotelephony speech segments from the cockpit with KL ACC were determined from the voice analysis of the ATC radiotelephony communications recording to be that of the FO before take-off and the PIC after take-off.

7) The transfer of control was effected three minutes before the estimate for IGARI. There was no recording of transmission (voice or in written form) of KL ACC informing HCM ACC (via direct land line) when MH370 was transferred 3 minutes earlier than the estimate for the Transfer of Control Point (TCP).

<u>Note</u>:

Based on reconstruction *(Section 2.1)* of the flight profile conducted on the B777 simulator, the flight would be at waypoint IGARI one minute earlier than the original estimate of 1722 UTC [0122 MYT].

[29] Filed Flight Plan – The flight plan as filed with an ATS unit by the pilot or his designated representative, without any subsequent changes.

2.2.2 Chronology of ATC Events before the Disappearance of Flight MH370

No.	Time	Event	Remarks
1.	0444 UTC [1244 MYT]	Filed Flight Plan (FPL) of scheduled flight of MH370 transmitted at 070444 UTC [071244 MYT], about 12 hours earlier over the Aeronautical Fixed Telecommunications Network (AFTN).	As required under Annex 10, Volume II.
		Flight planned on ATS/RNAV Routes R208 IGARI M765 BITOD L637 TSN… ZBAA.	Filed Flight Plan (*Figure 2.2A*)
2.	1450 UTC [2250 MYT]	PIC of MH370 signed in for duty.	As per operational requirements.
3.	1515 UTC [2315 MYT]	FO of MH370 signed in for duty.	
		MAS Operations Despatch Centre (ODC) released flight.	
4.	1625:52 UTC [0025:52 MYT]	Airway clearance request to Lumpur Airways Clearance Delivery.	
5.	1625:52 UTC [0025:52 MYT]	Airway clearance request to Lumpur Airways Clearance Delivery.	.
6.	1627:31 UTC [0027:31 MYT]	Pushback and start-up clearance request to Lumpur Ground.	As per operational requirements.
7.	1640:31 UTC [0040:31 MYT]	Lumpur Tower cleared MH370 for take-off.	
8.	1642 UTC [0042 MYT]	MH370 departed from Runway Three Two Right KLIA.	Departure message (*Figure 2.2C*)
9.	1642:53 UTC [0042:53 MYT]	Lumpur Departure cleared MH370 to climb to FL180 and to cancel the Standard Instrument Departure (SID) clearance by tracking direct to waypoint (*Figure 2.2A*) IGARI.	Normal ATC practice for track shortening.

Table 2.2A - Chronology of ATC Events before the Disappearance of Flight MH370

cont…

2.2.2 Chronology of ATC Events before the Disappearance of Flight MH370 *(cont.)*

No.	Time	Event	Remarks
10.	1643:31 UTC [0043:31 MYT]	KL ACC Sector 3+5 coordinated with HCM ACC via direct land line the estimate of MH370 for waypoint IGARI at 1722 UTC on [0122 MYT], request flight level 350 and the assigned SSR Code 2157.	As per Letter of Agreement between Malaysia and Viet Nam. (*Appendix 1.1A*)
11.	1646:39 UTC [0046:39 MYT]	MH370 transferred to Lumpur Radar (Sector 3+5).	As per operational requirement.
12.	1646:58 UTC [0046:58 MYT]	Lumpur Radar (Sector 3+5) cleared MH370 to climb to FL250.	As per operational requirement.
13.	1650:08 UTC [0050:08 MYT]	Lumpur Radar (Sector 3+5) cleared MH370 to climb to FL350.	
14.	1701:17 UTC [0101:17 MYT]	MH370 reported maintaining FL350.	It was noticed that the PIC made the same statement of "*maintaining flight level three five zero'* twice at 1701:17 UTC [0101.17 MYT] and at 1707:56 UTC [0107:56 MYT].
15.	1707:56 UTC- [0107:56 MYT]	MH370 reported maintaining FL350.	• However, the Team did not find any significance of that statement spoken twice by PIC in a short interval of 6.39 minutes.

Table 2.2A - Chronology of ATC Events before the Disappearance of Flight MH370

cont…

2.2.2 Chronology of ATC Events before the Disappearance of Flight MH370 *(cont.)*

No.	Time	Event	Remarks
15. *cont.*	1707:56 UTC- [0107:56 MYT]	MH370 reported maintaining FL350.	• Also refer *para. 2.2.9 para 1) a) (1-6)* on Radiotelephony Readback on frequency changes for more details.
16.	1719:26 UTC [0119:26 MYT]	The KL ACC radar Controller transferred MH370 to HCM ACC by instructing MH370 to contact Ho Chi Minh on the VHF radio frequency 120.9 MHz.	• Transfer of control was effected 3 minutes before the estimate for IGARI. • KL ACC passed to HCM ACC estimate for IGARI as 1722 UTC. • Transfer of control to HCM ACC was effected at 1719 UTC before MH370 was over IGARI. • There was no arrangement between KL ACC and HCM ACC for an "electronic handoff" or other methods to hand over the radar picture.
17.	1719:30 UTC [0119:30 MYT]	MH370 responded with: "*Good night Malaysian Three Seven Zero".*	Thereafter there was no further voice communication.

Table 2.2A - Chronology of ATC Events before the Disappearance of Flight MH370

2.2.3 Filed Flight Plan of MH370

```
KLA297 070444
FF WMKKZQZX WMKKZRZX
070441 WMKKYOYX
(FPL-MAS370-IS
-B772/H-SDFGHIJ3J5M1RWXY/LB1D1
-WMKK1635
-N0470F290 DCT PIBOS R208 IKUKO/M081F330 R208 IGARI M765
 BITOD/N0480F330 L637 TSN/N0480F350 W1 BMT W12 PCA G221
 BUNTA/N0480F370 A1 IKELA/N0480F370 P901 IDOSI/N0480F390 DCT CH
 DCT BEKOL/K0900S1160 A461 YIN/K0890S1130 A461 VYK
-ZBAA0534 ZBTJ ZBSJ
-PBN/A1B1C1D1L1O1S2 DOF/140307 REG/9MMRO EET/WSJC0032 VVTS0042

ZJSA0210 VHHK0233 ZGZU0304 ZHWH0356 ZPE0450 SEL/QRC RMK/ACASII
EQUIPPED)
```

JABATAN PENERBANGAN AWAM * PENGURUSAN TRAFIK UDARA * HQ MALAYSIA * AIR TRAFFIC MANAGEMENT * DEPARTMENT OF CIVIL AVIATION

Source: DCA Malaysia

Figure 2.2A - Filed Flight Plan of MH370

1) Message Code of FPL of MH370 and Meaning

Message Code	**Meaning**
KLA297 070444	
KL	*KLIA message*
A	*Series*
297	*Sequence Number*
070444	*Date-time-group or the transmission time of the filed flight plan message at 070444UTC*

FF WMKKZQZX WMKKZRZX	
FF	*Priority Indicator for the message category*
WMKKZQZX	*8-letter addressee for Lumpur "Area Control Centre".*
WMKKZRZX	*8-letter addressee for Lumpur "Approach Radar Office".*

070441 WMKKYOYX	
070441	*Message Filling Time (in UTC)*
WMKKYOYX	*8-letter Message Originator for KLIA Aeronautical Information Office*

Field Type 3 - Message type, number and reference data	
(FPL	*Filed Flight Plan Message*
WMKKYOYX	*Message Originator Indicator i.e. KLIA Aeronautical Information Service Office.*

- Field Type 7- Aircraft Identification and SSR mode and code	
-MAS370	*Aircraft identification Malaysian 370*

-Field Type 8 - Flight rules and type of flight	
-I	*Instrument Flight Rules*
-S	*Status: - Scheduled Air Transport*

Field Type 9 - Number and type of aircraft and wake turbulence category	
-B772/H	*Boeing 777-200/wake turbulence category/Heavy*

Figure 2.2B - Message Code of Filed Flight Plan of MH370 and Meaning

cont…

1) Message Code of FPL of MH370 and Meaning (*cont...*)

Message Code	Meaning

Field Type 10 - Equipment and capabilities	
(a) **Radio communication, navigation and approach aid equipment and capabilities**	
-SDFGHIJ3J5M1RWXY/LB1D1	
-S	Equipped with: *Standard COM/NAV/approach aid equipment for the route is carried and serviceable. Standard equipment is considered to be VHF RTF, VOR and ILS.*
D	*DME*
F	*ADF*
G	*GNSS*
H	*HF RTF*
I	*Inertial Navigation*
J3	*CPDLC FANS 1/A VDL Mode 4*
J5	*CPDLC FANS 1/A SATCOM (INMARSAT)*
M1	*ATC RTF SATCOM (INMARSAT)*
R	*PBN approved.*
W	*RVSM approved*
X	*MNPS approved*
Y	*VHF with 8.33 kHz. channel spacing capability/*

(b) Surveillance equipment and capabilities	
L	*Transponder Mode S, including aircraft identification, pressure-altitude, extended squitter (ADS-B) and enhanced surveillance capability*
B1	*ADS-B with dedicated 1090 MHz ADS-B “out” capability*
D1	*ADS-C with FANS 1/A capabilities*

Field Type 13 - Departure aerodrome and time	
-WMKK1635	*-Departure aerodrome KLIA estimated off-block time 1635 UTC*

Figure 2.2B - Message Code of Filed Flight Plan of MH370 and Meaning

cont…

1) Message Code of FPL of MH370 and Meaning (*cont...*)

Message Code	Meaning
Field Type 15 – Route	
-N0470F290 DCT PIBOS R208 IKUKO/M081F330 R208 IGARI M765 BITOD/N0480F330 L637 TSN/N0480F350 W1 BMT W12 PCA G221 BUNTA/N0480F370 A1 IKELA/N0480F370 P901 IDOSI/N0480F390 DCT CH DCT BEKOL/K0900S1160 A461 YIN/K0890S1130 A461 VYK	
-airspeed 470 knots requested flight level 290 - the flight will proceed direct to waypoint PIBOS joining Airway R208 and to waypoint IKUKO, thence the airspeed will be Mach 0.81 flight level 330 on Airway R208 to waypoint IGARI joining Airway M765 thence to waypoint BITOD. Thence the airspeed will be 480 knots and flight level 330 on Airways L637 and proceed to TSN (Tansonnhat), thence the airspeed will be 480 knots and flight level 350. Thence on Airway W1 to BMT (Buon Ma Thout), thence Airway W12 to PCA (Phu Cat), thence on Airway G221 to waypoint BUNTA, thence airspeed will be 480 knots and flight level 370, thence proceed via Airway A1 to waypoint IKELA, thence airspeed will be 480 knots and flight level 370, thence via Airway P901 to waypoint ISODI, airspeed 480 knots and flight level 390. Thence track direct to CH (Cheung Chau), and direct to waypoint BEKOL. Thence the airspeed will be 900 kilometres per hour and level 11600 meters on Airway A461, thence to YIN (Yingde). Thence, the airspeed will be 890 kilometres per hour and level 11300 metres on Airway A461 to VYK (Dawangzhuang).	

Field Type 16 - Destination aerodrome and total estimated elapsed time, destination alternate aerodrome(s)
-ZBAA0534 ZBTJ ZBSJ
-Destination aerodrome ZBAA - Beijing Capital International Airport and total estimated elapsed time 5 hours and 34 minutes *Destination alternate aerodrome(s)* *ZBTJ -* Tianjin Binhai International Airport, and *ZBSJ -* Shijiazhuang Zhengding International Airport

Figure 2.2B - Message Code of Filed Flight Plan of MH370 and Meaning

cont...

1) Message Code of FPL of MH370 and Meaning (*cont..*)

Message Code	Meaning
Field Type 18 – Other information	
PBN/A1B1C1D1L1O1S2 DOF/140307 REG/9MMRO EET/WSJC0032 VVTS0042 ZJSA0210 VHHK0233 ZGZU0304 ZHWH0356 ZBPE0450 SEL/QRC RMK/ACASII EQUIPPED)	
PBN	*Performance Based Navigation/Indication of RNAV and or RNP capabilities.*
	RNAV Specifications
A1	*RNAV 10 (RNP 10)*
B1	*RNAV 5 all permitted sensors*
C1	*RNAV 2 all permitted sensors*
D1	*RNAV 1 all permitted sensors*
	RNP Specifications
L1	*RNP 4*
O1	*Basic RNP 1 all permitted sensors*
S2	*RNP APCH with BARCO-VNAV*
DOF/140307	*Date of flight/2014 March 7th*
REG/9MMRO	*Aircraft registration 9MMRO*
EET	FIR boundary designators and accumulated *estimated elapsed times from take-off to such FIR boundaries.* *Singapore FIR 32 minutes* *Ho Chi Minh FIR 42 minutes* *Sanya FIR 2 hours 10 minutes* *Hong Kong FIR 2 hours 33 minutes* *Guangzhou FIR 3 hours 4 minutes* *Wuhan FIR 3 hours 56 minutes* *Beijing FIR 4 hours 50 minutes*
SEL/QRC	*Selective Calling code/QRC*
RMK/ACAS II EQUIPPED)	*Equipped with ACAS II)*

Figure 2.2B - Message Code of Filed Flight Plan of MH370 and Meaning

2.2.4 Departure Message of MH370

```
Legal Recording                                                  ATS-Message

Type:  DEP          Priority:  FF
                  Originator:  WMFDYFYX         Operator:  1A
                 Filing Time:  071642      Last Stordate:  14-03-07 16:42
                        Legal Recording Informations:
                     Date:  14-03-07 16:42:44    Action:  Creation

ATS Message

(DEP-MAS370/A2157-WMKK1642-ZBAA-DOF/140307)

                         End of Report
```

Source : Dca Malaysia

Figure 2.2C - Departure Message of MH370

1) Message Code of Departure Message of MH370 and Meaning

Message Code	Meaning
(DEP	(Departure
-MAS370/A2157	-Aircraft identification MH370/Secondary Surveillance Radar Code A2157
-WMKK1642	-KLIA1642 (UTC)
-ZBAA	-destination aerodrome: Beijing/Capital
-DOF140307)	-Date of flight 2014March07)

Figure 2.2D - Message Code of Departure Message of MH370 and Meaning

2.2.5 Waypoints - Geographical Coordinates (LAT/LONG) of MH370 Filed Flight Plan

No.	WAYPOINT	LAT	LONG	AIRWAY
1.	PIBOS	N0320.5	E10203.1	R208
2.	IKUKO	N0545.2	E10313.4	R208
3.	IGARI	N0656.2	E10335.1	R208
4.	BITOD	N0715.4	E10407.1	M765
5.	TSN	N1049.0	E10638.7	L637
6.	BMT	N1240.0	E10807.4	W1
7.	PCA	N1357.4	E10902.5	W12
8.	BUNTA	N1650.0	E10923.7	G221
9.	IKELA	N1839.7	E11214.7	A1
10.	IDOSI	N1900.0	E11230.0	P901
11.	CH	N2213.2	E11401.8	DCT
12.	BEKOL	N2232.5	E11408.0	DCT
13.	YIN	N2411.4	E11324.9	A461
14.	VYK	N3911.7	E11634.3	A461

Table 2.2B - Waypoints of MH370 FPL

2.2.6 Analysis on FPL Message of MH370

1) The MH370 FPL had been filed in accordance with the Doc 4444 ATM/501, Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM).

2) However, there are two airways designated as A1/P901 within Hong Kong Flight Information Region (FIR) which required examination. Both airways (A1 and P901) are within the Hong Kong FIR, and have the same alignment and share the same waypoints. The waypoints are IKELA, IDOSI and CH (CHEUNG CHAU). The differences between the two airways are the lower limits and upper limits. The lower limit of A1 is 8,000 ft, and the upper limit is FL285 whereas the lower limit of P901 is FL285 and upper limit unlimited.

   Note:

   Refer to the following for details:

- *Figure 2.2E* (below) - *Route Segment of ATS Route A1 and Performance Based Navigation (PBN) Route P901;* and

- *Figure 2.2F* (below) - *Longitudinal Cross Section of ATS Route A1 and PBN Route P901*

3) It is observed that the fifth group of alphabet/number, written as ZPE0450, in line 13th of the FPL message of MH370 should read ZBPE0450. However, the missing alphabet B from the original text message does not invalidate the FPL.

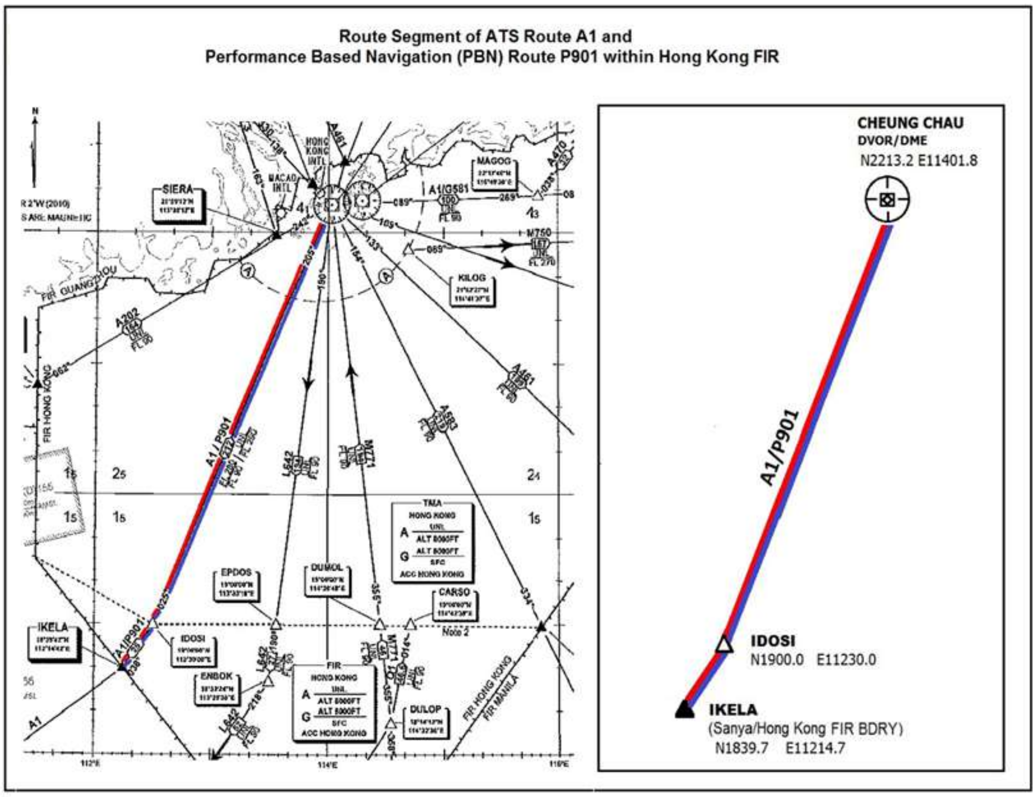


Figure 2.2E - Route Segment of ATS Route A1 and PBN Route P901

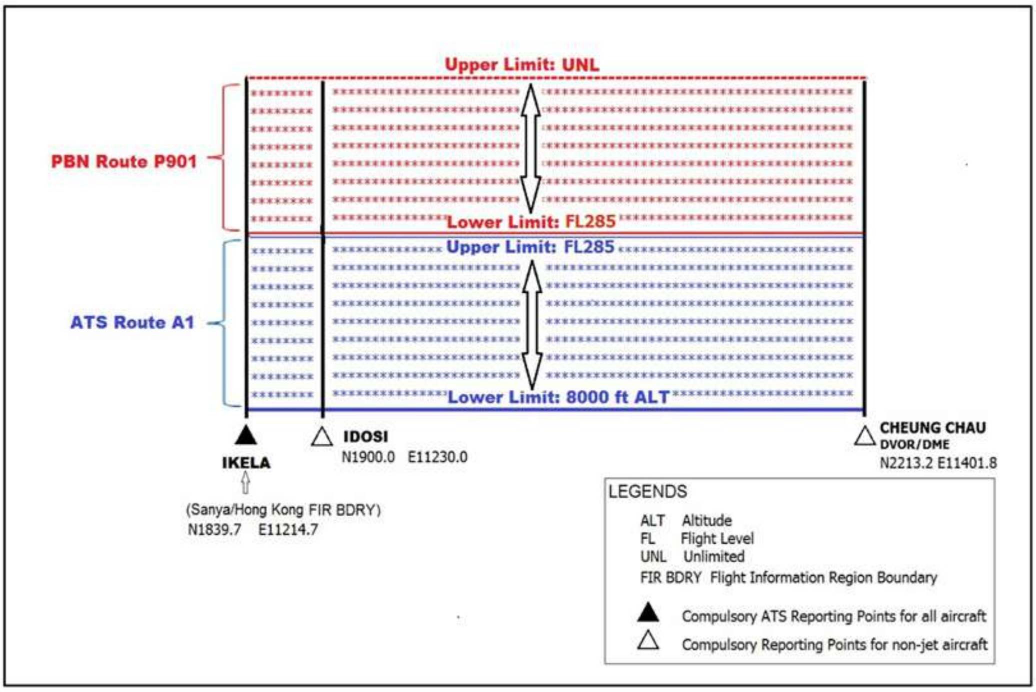


Figure 2.2F - Longitudinal Cross Section of ATS Route A1 and PBN Route P901

2.2.7 Chronology of ATC Events following the Disappearance of MH370 (*Table 2.2C*, below)

No.	Time	Event
1.	1720:31 UTC [0120:31 MYT]	Radar recording showed MH370 passed over waypoint IGARI.
2.	1720:36 UTC [0120:36 MYT]	Mode S radar symbol of MH370 dropped off from radar display.
3.	1721:13 UTC [0121:13 MYT]	3.2 nm after passing IGARI, SSR radar position symbol of MH370 dropped off from radar display. Two radar sources, from Viet Nam and Thailand respectively, captured the disappearance of the radar position symbol of MH370 vis-à-vis Bangkok radar target drop at 1721:13 UTC [0121:13 MYT] and Viet Nam's at 1720:59 UTC [0120:59 MYT].
4.	1739:03 UTC [0139:03 MYT]	HCM ACC queried KL ACC on whereabouts of MH370 and informed KL ACC that verbal contact with MH370 was not established and the radar target was last seen at waypoint BITOD. <u>Note</u>: MH370 did not arrive over waypoint BITOD (Refer to *Item 3* above).
5.	1741:22 UTC [0141:22 MYT]	HCM ACC enquired for information on MH370. KL ACC informed HCM ACC that after waypoint IGARI, MH370 did not return to Lumpur radar frequency.
6.	1741:23 UTC [0141:23 MYT]	KL ACC Radar Controller made a 'blind transmission'[30] to MH370.
7.	1746:47 UTC [0146:47 MYT]	HCM ACC queried on MH370 again, stating that radar contact was established at IGARI but there was no verbal contact. HCM ACC advised that the observed radar blip disappeared at waypoint BITOD. HCM ACC also stated that efforts had been made to establish communications by calling MH370 several times for more than twenty minutes.

Table 2.2C Chronology of ATC Events following the Disappearance of MH370

cont…

[30] Blind transmission - A transmission from one station to another station in circumstances where two-way communications cannot be established but where it is believed that the called station is able to receive the transmission.

2.2.7 Chronology of ATC Events following the Disappearance of MH370 (*Table 2.2C*, below)

No.	Time	Event
8.	1750:28 UTC [0150:28 MYT]	KL ACC queried HCM ACC if there was any contact with MH370. HCM ACC's reply was: "*Negative*".
9.	1757:49 UTC [0157:49 MYT]	HCM ACC informed that there was officially no contact with MH370 until this time. Attempts on many frequencies and aircraft in the vicinity received no response from MH370.
10.	1803:48 UTC [0203:48 MYT]	KL ACC queried HCM ACC on status of MH370. HCM ACC confirmed there was no radar contact at this time and no verbal communications was established. KL ACC relayed the information received from Malaysia Airlines Operations that aircraft was in Cambodian airspace.
11.	1807:47 UTC [0207:47 MYT]	HCM ACC queried for confirmation that MH370 was in Phnom Penh FIR as Phnom Penh did not have any information on MH370. KL ACC indicated it would check further with the supervisor.
12.	1812:15 UTC [0212:15 MYT]	KL ACC informed HCM ACC that there was no update on status of MH370.
13.	1815 UTC [0215 MYT]	Extract from Watch Supervisor Log Book (in written form only, no voice recording): *KL ATSC WS queried Malaysia Airlines Operations who informed that MH370 was able to exchange signals with the Flight Explorer.*
14.	1818:50 UTC [0218:50 MYT]	KL ACC queried if flight planned routing of MH370 was supposed to enter the Cambodian airspace. HCM ACC confirmed that planned route was only through the Vietnamese airspace. HCM ACC had checked and Cambodian had advised that it had no information on or contact with MH370. HCM ACC confirmed earlier information that radar contact was lost after BITOD and radio contact was never established.
15.	1833:59 UTC [0233:59 MYT]	KL ACC Radar Controller enquired with MAS Operations Despatch Centre (ODC) on communications status on MH370. Personnel was not sure if the message went through successfully. ODC informed that aircraft was still sending movement message indicating it was somewhere

Table 2.2C - Chronology of ATC Events following the Disappearance of MH370

cont...

2.2.7 Chronology of ATC Events following the Disappearance of MH370 (*Table 2.2C*, below)

No.	Time	Event
15. *cont..*	1833:59 UTC [0233:59 MYT]	in Viet Nam, and that its last position was at coordinates N14.90000 E109 15500 at 071833 UTC [080233 MYT].
16.	1834:56 UTC [0234:56 MYT]	HCM ACC queried on the status of MH370 and was advised that the Watch Supervisor was talking to the Company at this time.
17.	1854:28 UTC [0254:28 MYT]	Requested MH386, which was then in the HCM FIR, to try to establish contact with MH370 on emergency frequencies.
18.	1930 UTC [0330 MYT]	<u>Extract from KL ACC Watch Supervisor ATS logbook</u>: *MAS Operations Centre informed KL ACC that the flight tracker was based on flight projection and not reliable for aircraft positioning.*
19.	1930:03 UTC [0330:03 MYT]	KL ACC queried if HCM ACC had checked with next FIR HAINAN.
20.	1948:52 UTC [0348:52 MYT]	KL ACC queried if HCM ACC had checked with the SANYA FIR. HCM ACC informed KL ACC that there was no response until then.
21.	1956:13 UTC [0356:13 MYT]	KL ACC queried MAS Operations Centre for any latest information or contact with MH370.
22.	2025:22 UTC [0425:22 MYT]	HCM ACC Supervisor queried KL ACC on the last position that MH370 was in contact with KL ACC.
23.	2109:13 UTC [0509:13 MYT]	Singapore, on behalf of Hong Kong ACC enquired for information on MH370.
24.	2118:32 UTC [0518:32 MYT]	HCM ACC queried for information on MH370, KL ACC queried if any information had been received from Hong Kong or Beijing.
25.	2120:16 UTC [0520:16 MYT]	Capt. *xxxx* [*name redacted*] of MAS requested for information on MH370. He opined that based on known information,"*MH370 never left Malaysian airspace*."
26.	2130 UTC [0530 MYT]	Duty ATSC Watch Supervisor activated the Kuala Lumpur Aeronautical Rescue Coordination Centre (ARCC).

Table 2.2C - Chronology of ATC events following the disappearance of MH370

cont...

2.2.7 Chronology of ATC Events following the Disappearance of MH370 (*Table 2.2C*, below)

No.	Time	Event
27.	2214:13 UTC [0614:13 MYT]	KL ACC queried HCM ACC if SAR was activated.
28.	2232 UTC [0632 MYT]	KL ARCC issued a *DETRESFA* message.

Table 2.2C - Chronology of ATC Events following the Disappearance of MH370

2.2.8 ATS Operational Issues after Last Radio Communication with MH370 and subsequent ATS Activities/Actions

The following analysis are based on the ICAO Doc 4444 ATM/501, Procedures for Air Navigation Services - Air Traffic Management (PANS-ATM), Annex 11 - Air Traffic Services, Aeronautical Information Publication, MATS and MATS Vol 2 Malaysia. Operation Letter of Agreement between DCA Malaysia and Viet Nam Air Traffic Management (effective 1 November 2011/, Letters of Operational Agreement Malaysia - Singapore dated August 1984 DCA/SAR01-84/Doc 04 (a).

They also include the Chronology of events following the disappearance of MH370, as tabulated above (*Table 2.2A)*, the Team had gathered these operational issues regarding activities/actions taken by KL ACC, HCM ACC and others as follows:

No.	Operational Issues
1.	Transfer of Control Point[31] at Waypoint IGARI
2.	Responsibilities of Accepting Air Traffic Control Service Unit on 'Establishment of Communications'
3.	Marking of MH370 Flight Progress Strips[32]
4.	Responsibilities of Air Traffic Controller
5.	Recognising Emergency Situations and ATC Actions

[31] Transfer of Control Point - A defined point located along the flight path of an aircraft at which the responsibility for providing air traffic control service to the aircraft is transferred from one control unit or control position to the next.

[32] Flight Progress Strip - It contains essential flight and control data and is the basic tool which enables Controllers to visualize the disposition of traffic within their area of responsibility including traffic arriving and departing an aerodrome, assess conflicts and control aircraft in a safe manner.

cont..

No.	Operational Issues
6.	Information to be passed to other Radar Stations - Civil and Military
7.	Provision of Alerting Service by an ATSU for flights operated through more than one FIR and ATC actions
8.	Actions taken by Duty ATSC Watch Supervisor
9.	Flight-following System of Malaysia Airlines
10.	Communications Exchanges between KL ACC and HCM ACC, and KL ACC and Malaysia Airlines Operations Centre on MH370
11.	Delegation of Airspace from Singapore ACC to KL ACC
12.	ATC Actions on Strayed/Unidentified Aircraft (Primary Radar Target) within Area of Responsibility
13.	KL ATSC Duty Shift System for Air Traffic Controllers
14.	Roles played by the ATSC Duty Watch Supervisor
15.	Activation of Aeronautical Rescue Coordination Centre
16.	Playback of Radar and Radio Telephony Recordings by Duty ATSC Watch Supervisor
17.	Entries in Air Traffic Services Logbooks of ATSC Duty Watch Supervisor and Sector 3 Controller Working Position
18.	Distress Message
19.	Issues with the Manual of Air Traffic Services

1) Analysis of ATS Operational Issues after Last Radio Communication with MH370 and subsequent Activities/Actions taken

a) Transfer of Control Point at Waypoint IGARI

i) The MH370 flight from Kuala Lumpur to Beijing was planned on ATS/RNAV Routes R208 IGARI M765 BITOD L637 TSN…ZBAA. About one and a half minutes after MH370 took off at 1642 [0042 MYT], KL ACC conveyed to HCM ACC via the direct land line the estimate for waypoint IGARI as 1722 UTC [0122MYT], and requested Flight Level three five zero and Squawk two one five seven. HCM ACC acknowledged: "*two one five seven, three five zero is approved, one seven two two*".

ii) The Transfer of Control Point (TCP) for flights on route R208 IGARI M765 BITOD L637 TSN…ZBAA is IGARI. Aircraft operating on this route shall be transferred by KL ACC to HCM ACC when the Radar Controller observes on the radar display that the aircraft is over IGARI or when the aircraft reports over IGARI.

iii) The transfer of control by KL ACC to HCM ACC is by way of instructing the aircraft concerned on the control VHF (very high frequency) radio frequency 132.5 MHz to contact HCM ACC on VHF radio frequency 120.9 MHz. The ATS infrastructure in KL ACC was not equipped to perform an “electronic handoff” of aircraft or other method to hand over the radar picture to HCM ACC.

References:

MATS Vol. 2, Part 2 KL ATSC - Coordination, para. 3.5.8, page 2-3-53 Coordination between Sector 5 Position and HCM ACC dated 15 March 2013 (*Table 2.2E)* as shown below.

The LOA (*Appendix 1.1A*) between DCA Malaysia and Vietnam Air Traffic Management dated 18 July 2001 and effective on 01 November 2001, para Transfer of Control Point *(Table 2.2D* [below]*),* page 7, as below:

Co-ordination Procedures

Transfer of Control Point

Route	TCP
M765	IGARI (065612N 1033512E)
N891	
R208 / M765	

Table 2.2D - Coordination Procedures

3.5.8 Coordination Between Sector 5 and Ho Chi Minh ACC

Sector 5's Actions				
Destination	Route	Pass EST for	Transfer To	Transfer At
Entering Ho Chi Minh FIR	R208 (E)	IGARI	Ho Chi Minh Sector 3	IGARI
	M765 (E)			
	N891 (N)			

Ho Chi Minh ACC's Actions				
Destination	Route	Pass EST for	Transfer To	Transfer At
Entering Kuala Lumpur FIR/AOR	M765 (W)	IGARI	Lumpur Sector 5	IGARI
	N891 (S)			

3.5.9 Coordination Between Sector 5 and Singapore ACC

Sector 5's Actions				
Destination	Route	Pass EST for	Transfer To	Transfer At
Entering Singapore FIR	N891 (S)	IGARI	Singapore Sector 3	IKUMI
	M904 (S)	TIDAR		A/Beam IKUMI

Singapore ACC's Actions				
Destination	Route	Pass EST for	Transfer To	Transfer At
Entering Kuala Lumpur FIR	N891 (N) N891 (S)	IGARI	Lumpur Sector 5	IKUMI
	M904 (N)	A/Beam IKUMI		A/Beam IKUMI

Table 2.2E - Coordination between Sector 5 and Ho Chi Minh ACC

(1) The Transfer of Control Point as stated in the Doc 4444 Chapter 10 - Coordination, paragraph, 10.1.2.2, page 10-3 dated 10/11/16 is as follows:

10.1.2.2.1 The responsibility for the control of an aircraft shall be transferred from the ATC unit to the next unit at the time of crossing the common control area boundary as determined by the unit having control of the aircraft or at such other point or time as has been agreed between the two units.

10.1.2.2.2 Where specified in letters of agreement between the ATC units concerned, and when transferring an aircraft, the transferring unit shall notify the accepting unit that the aircraft is in position to be transferred, and specify that the responsibility for control should be assumed by the accepting unit forthwith at the time of crossing the control boundary or other transfer control point specified in letters of agreement between the ATC units or at such other point or time coordinated between the two units.

10.1.2.2.3 If the transfer of control time or point is other than forthwith, the accepting ATC unit shall not alter the clearance of the aircraft prior to the agreed transfer of control time or point without the approval of the transferring unit.

10.1.2.2.4 If transfer of communication is used to transfer an aircraft to a receiving ATC unit, responsibility for control shall not be assumed until the time of crossing the control area boundary or other transfer of control point specified in letters of agreement between the ATC units.

(2) KL ACC transferred MH370 to HCM ACC by instructing MH370 to contact Ho Chi Minh on the VHF radio frequency 120.9 MHz at 1719:26 UTC [0119:26 MYT].

(3) MATS Vol. 2, Part 2 KL ATSC and Operational Letter of Agreement between DCA Malaysia and Viet Nam Air

Traffic Management do not have provision for KL ACC to effect transfer of communication of an aircraft to HCM ACC. It is noted that MH370 was transferred to HCM ACC three minutes before the Transfer of Control Point.

(4) The recorded landline communications between KL ACC and HCM ACC suggested that there were confusions on the position of MH370. This was evident when HCM ACC requested KL ACC for information on MH370 at 1739:06 UTC [0139:06].

(5) The following timings were based on recordings vis-à-vis landline/radiotelephony communications and radar recording:

(a) 1643 UTC - KL ACC passed MH370's estimated time over IGARI at 1722 UTC to Ho Chi Minh ACC.

(b) 1719:26 UTC - MH370 was instructed by KL ACC to contact Ho Chi Minh ACC.

(c) 1719:30 UTC - MH370 acknowledged.

(d) 1720:31 UTC - MH370 passed over IGARI.

From the above timings, it is evident that there was a 3-minute lapse from the time MH370 was instructed to HCM ACC and the original estimate.[33]

(6) Radiotelephony Readback

(a) Readback Messages

MATS Part 10 - COM, page 10-3-3 para 3.4.4 states that:

Pilots are required to read back in full messages containing any of the following:

a) Level instructions;

b) Heading instructions;

c) Speed instructions;

d) Airways or route clearances;

[33] See *Table 2.2A* – Chronology of ATC Events before the Disappearance of Flight MH370 for detailed timeline plot.

e) Runway in use;

f) Clearance to enter, land on, take-off, backtrack, cross or hold short of an active runway;

g) SSR operating instructions;

h) Altimeter settings;

i) Frequency Changes

(b) Readback on Frequency Changes

Annex 11 - Air Traffic Services, page 3-7 para 3.7.3 states:

Readback of clearances and safety-related information.

3.7.3.1 The flight crew shall read back to the Air Traffic Controller safety-related parts of ATC clearances and instructions which are transmitted by voice. The following items shall always be read back:

a) ATC route clearances;

b) clearances and instructions to enter, land on, take-off from, hold short of, cross and backtrack on any runway; and

c) runway-in use, altimeter settings, SSR codes, level instructions, heading and speed instructions and, whether issued by the Controller or contained in ATIS broadcasts, transition levels.

3.7.3.1.1 Other clearances or instructions, including conditional clearances, shall be read back or acknowledged in a manner to clearly indicate that they have been understood and will be complied with.

(c) Doc 4444 Air Traffic Management (PANS-ATM) Pages 4-8 para 4.5.7.5 states that:

4.5.7.5.1 The flight crew shall read back to the Air Traffic Controller safety-related parts of ATC clearances and instructions which are *transmitted by voice. The following items shall always be read back:*

a) ATC route clearances;

b) clearances and instructions to enter, land on, take-off from, hold short of, cross and backtrack on any runway; and

c) runway-in-use, altimeter settings, SSR codes, level instructions, heading and speed instructions and, whether issued by the Controller or contained in automatic terminal information service (ATIS) broadcasts, transition levels.

4*.5.7.5.1.1 Other clearances or instructions, including conditional clearances, shall be read back or acknowledged in a manner to clearly indicate that they have been understood and will be complied with.*

(d) Pilot's Readback on Frequency Changes

MATS clearly stipulates that pilots are required to read back radio frequency changes. Similarly, ICAO Annex 11 and ICAO Doc 4444 also stipulate that:

"other clearances or instructions shall be read back or acknowledged in a manner to clearly indicate that they have been understood and will be complied with".

At 1719:26 UTC KL ACC had instructed MH370 to contact Ho Chi Minh on radio frequency one two zero decimal nine (120.9). MH370 was therefore required to read back the frequency change as an acknowledgment and thereby had complied with the instruction. There was no readback from MH370.

There were altogether five instances where MH370 had to change radio frequencies when transferred from an ATC unit to another. They are as follows:

- From Airways Clearance Delivery to Lumpur Ground (*Note 1*, below);

- From Lumpur Ground to Lumpur Tower (*Note 2* below);
- From Lumpur Tower to Lumpur Approach (*Note 3* below);
- From Lumpur Approach to Lumpur Radar (Sector 3+5) [*Note 4* below]; and
- From Lumpur Radar (Sector 3+5) to Ho Chi Minh (*Note 5*, below).

Note 1

When Airways Clearance Delivery transferred MH370 to Lumpur Ground, the radio frequency of Lumpur Ground was not mentioned by the ATC. MH370 responded by transmitting *"Good day sir."*

Note 2

When Lumpur Ground transferred MH370 to Lumpur Tower, the Lumpur Tower radio frequency was transmitted by the Controller even though it was unintelligible in the RT recording, MH370 read back the radio frequency, *"One one eight eight Malaysian Three Seven Zero thank you."*

Note 3

When Lumpur Tower transferred MH370 to Lumpur Approach Control, ATC transmitted the take-off clearance, no radio frequency was included in the take-off clearance and the pilot read back the take-off clearance, *"Three Two Right clear for take-off Malaysian Three Seven Zero thank you bye."*

Note 4

When Lumpur Approach Control transferred MH370 to Lumpur Radar (Sector 3+5), the Sector 3+5 radio frequency was transmitted by Lumpur Approach Control and MH370 read back the radio frequency, *"Night one three two six Malaysian err… Three Seven Zero".*

Note 5

When Lumpur Radar (Sector 3+5) transferred MH370 to Ho Chi Minh, the radio frequency of Ho Chi Minh was transmitted by Lumpur Radar (Sector 3+5), MH370 responded with *"Good night Malaysian Three Seven Zero",* the radio frequency of Ho Chi Minh was not read back by MH370.

There were two instances when radio frequency was not included in the ATC instructions and three instances when radio frequency was included in the ATC instructions, MH370 had read back the radio frequency on two of the instances but did not on the last radio transmission. The Team could not conclude any reason for the absence of the read-back at this stage of the flight but noted that it was not consistent with the previous frequency changes.

(e) Maintaining FL350 Transmitted Twice

At 1701:17 UTC [0101:17 MYT] MH370 made a radio transmission: "*Maintaining flight level three five zero three seven zero"* and again at 1707:56 UTC [0107:56 MYT].

The MAS Standard Operating Procedures (SOPs) for flight crew dictated that the PIC and the FO would have to be on-seat during the following phrases of flight:

- Take-off;
- Climbing and descending; and
- Approach and landing.

However, one of the flight crew could leave the cockpit for a break once the aircraft had maintained the assigned cruising level.

The voice recognition process (*para 1.5.11*) has established that the PIC made the radio transmission of *maintaining flight level three five zero* at 1701:17 UTC [0101:17 MYT] and again at 1707:56 UTC [0107:56 MYT].

The interval between the first and second radio transmission was 6 minutes and 39 seconds.

Repetition of radiotelephony communications happens occasionally. While the Team could not determine the reason for the additional transmission at this stage of the flight, it was noted that it was anomalous at this time.

b) Responsibilities of Accepting Air Traffic Control Service Unit on Establishment of Communications

i) The 3rd paragraph of page 11 of the LOA between DCA Malaysia and Viet Nam Air Traffic Management (*Appendix 1.1A*), titled Establishment of Communication states that:

a. "*The accepting unit shall notify the transferring unit if two-way communication is not established within five (5) minutes of the estimated time for the TCP".*

ii) Since HCM ACC had earlier received from KL ACC MH370's estimate (as 1722 UTC [0122 MYT] for IGARI and also had not been able to establish two-way communication with the aircraft, HC ACC should have notified KL ACC by 1727 UTC [0127 MYT], i.e. 1722 UTC [0127 MYT] plus 5 minutes. Instead HCM only notified KL ACC at 1739 UTC [0139].

iii) The direct line coordination between KL ATCC Sector 3+5 Planner states that, at 1747:09 UTC [0147 MYT]. HCM ATCC informed KL ATCC that: "*we call him many times until na…more than 20 minutes."* This shows that HCM ATCC had commenced communication search for MH370 FROM 1727 UTC [0127 MYT].

iv) At 1757:51 [0157:51 MYT], HCM ATCC again informed KL ATCC: "*Yes sir, we officially no contact from Malaysian Three Seven Zero until now and we try on many frequencies and all the aircraft calling, no response from Malaysian Three Seven Zero."*

v) The 12 minutes lapse on the part of HCM ACC to notify KL ATCC could have come about by their actions to carry out communication search and thereby had resulted in their failure to notify KL ATCC by 1727 UTC [0127 MYT.

Note

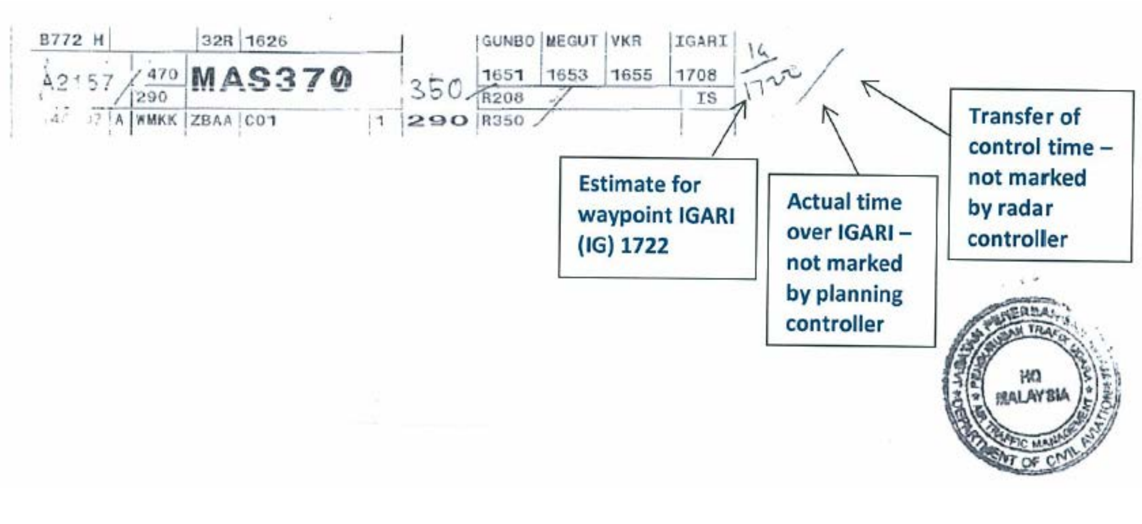
The 12 minutes interval is derived from the timings of the two-way radio communication recording between HCM ACC and KL ACC *(para 2.2.9 para. b) i)* above for details.

c) Marking on MH370 Flight Progress Strip

i) Two markings have been left out on the flight progress strip (FPS), *Figure 2.2G,* (below) of MH370:

(1) The actual time (1721) when MH370 passed over IGARI - FPS' Estimate IG (abbreviation for IGARI) 1722, and

(2) The transfer of control time (1719) on the FPS.



Source: DCA Malaysia

Figure 2.2G - Flight Progress Strip on MH370 from KL ACC

(3) Strip Marking on Flight Progress Strips

MATS Vol 2, Part 2 KL ATSC - General, page 2-1-8 para 1.4 dated 15 March 2009 and page 2-1-9 dated 15 March 2009 shows example of how the flight progress strip of a flight is marked.

Refer (below): *Figure 2.2H - Strip Marking on Flight Progress Strips generated by FDPS,* and *Figure 2.2I - Example on how the PLN strip will appear and Example on how the EXE strip will appear.*

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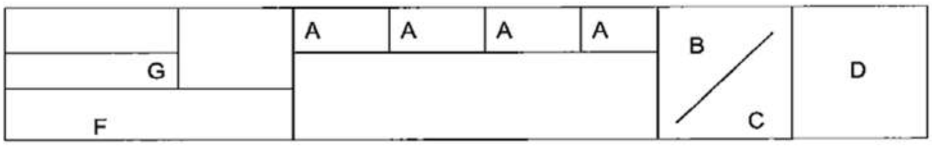
1.4 STRIP MARKING ON FLIGHT PROGRESS STRIPS (FPS) GENERATED BY FDPS



BOX	PLAN	EXE
A		Estimated time over fix
B	Estimated time over fix	Miscellaneous
C	Actual time over fix	
D	Flight level	
E	ATC restriction / requested level / lowest	
F	Level approved	
G	SSR code	

Note : The estimates in Box A are not necessarily accurate. PLN shall use Box B to write down the estimated time over a single fix whereas. EXE will write down the estimated time over the multiple fixes in Boxes A. The actual time over a fix will be reflected in PLN's Box C.

Example of a FPS generated by the FDPS

MAS 72	PE 000	PULIP	VKB	BASIR	IGARI		
	140	0056	0116	0121	0124		
1 / B747 / H		WMKK	G466/M765		VHHH		
IS N503 0045 330					PULIP 32R		

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Figure 2.2H - Strip Marking on Flight Progress Strips generated by FDPS

MATS Vol 2, Part 2 KL ATSC - General, page 2-10-9 para contd. 1.4 dated 15 March 2009:

Example of how the PLN strip will appear

MAS 72	AR	**GUNBO**	**VKR**	**IKUKO**	**IGARI**	IGARI	
	140	**0107**	**0111**	**0115**	**0124**	01~~26~~ 27	330
1/B747/H A2134		WMKK		R208	VHHH	/ 27	~~270~~
IS N503 0045	270	RL330MAS84P10					

Box	Meaning
B	MAS 72 estimates IGARI 0126 and revised to 0127
C	MAS 72 passed IGARI 0127
D	MAS 72 was assigned FL270 initially and recleared FL330
E	Restriction for MAS 72 to depart 10 minutes after MAS 84
F	FL 270 has been approved by ACD
G	Transponder Code A 2134 was assigned by the FDP

Example of how the EXE strip will appear

MAS 73	AR	**IGARI**	**IKUKO**	**GUNBO**	**PIBOS**	IGARI	380 ↓
	150	**1010**	**1018**	**1026**	**1037**	1010	
1/B747/H A3003		VHHH	R208		WMKK	/	
IS N503 0045	380				PIBOS 32R	10	150

Box	Meaning
A	MAS 73 estimates IGARI 1010 IKUKO 1018 GUNBO 1026 PIBOS1037
B	MAS 73 passed over IGARI 1010
D	MAS 73 is at FL 380 and has been cleared down to FL 150

Figure 2.2I - Example on how the PLN strip will appear and Example on how the EXE strip will appear

Since the two recordings on the Flight Progress Strip for MH370 were not marked by the Air Traffic Controllers (Planner and Radar) KL ACC did not have the record of the time of the last radio contact and the actual time of MH370 passing over waypoint IGARI.

d) Responsibilities of Air Traffic Controllers

i) MATS Vol. 1, Part 1 - ADMIN, para 1.2.2, page 1-1-4, which states as below:

Air Traffic Controller is responsible:

- *for maintaining a continuous watch on their assigned communications channels or radar displays.* [Refer para. v) below].

ii) In interviews conducted with the Air Traffic Control Officer (ATCO) who was on duty on the night of the disappearance of MH370, the Sector 3+5 Radar Controller stated that he did not continuously monitor the progress of MH370 because he had to shift his focus to another area, viz. VPK[34] (approximately 214 nm south-southwest of IGARI), as there were four other flights over that area that required his attention.

iii) The radiotelephony transcripts of this sector confirmed that there were other four other flights - one at 1723 UTC [0123 MYT] proceeding to VPK and contacting Lumpur Radar and three others at 1726 UTC [0126 MYT], 1742 UTC [0142 MYT] and 1746 UTC [0146 MYT] respectively.

iv) MH370 was operating in the Sector 3+5 Area of Responsibility (AOR) when the Radar Controller transferred the aircraft to HCM ACC. As he had not been monitoring the progress of the flight of MH370, the Sector 3+5 Radar Controller was not aware when MH370 passed the TCP IGARI, and when the MH370 radar display symbol started to "coast" and dropped from the radar display.

[34] VPK - Pekan DVOR/DME coordinates 032259N 1032524E.

v) Notwithstanding the fact that he had to shift his focus to another area within his AOR, the Radar Controller was still required to monitor the progress of MH370. The responsibility of the Sector 3+5 Radar Controller for MH370 did not end with the transfer of control to HCM ACC. The process of transfer of control is only with regard to Air Traffic Control Service. Therefore, the Sector 3+5 Radar Controller was still responsible for the provision of alerting service to MH370 as it was still operating within his AOR. The responsibility of the provision of alerting service would end when MH370 had a two-way radio communication with HCM ACC.

vi) The Radar Controller was not aware when MH370 radar position symbol dropped off from the radar display.

e) Recognising Emergency Situations and Air Traffic Control Actions

i) Upon receipt of the query from HCM ACC at 1739 UTC [0139 MYT] that HCM ACC had not been able to establish two-way radio communications with MH370, the Lumpur Sector 3+5 Radar Controller should have realised that MH370 could be experiencing an emergency situation. This was especially so after he had tried to establish radio communication with MH370 by making a ‘blind transmission’ on the VHF radio frequency 132.5 MHz at 1741:23 UTC [0141:23 MYT], without success.

ii) Under such circumstances and upon notification from HCM ACC that there were no two-way radio communications with the aircraft and/or subsequent inquiries to other sources had failed to reveal any news of the aircraft, the Sector 3+5 Radar Controller should have immediately notified the ATSC Duty Watch Supervisor and ARCC that an *Uncertainty Phase* had existed. By then, the Radar Controller should have commenced full overdue action (not later than 30 minutes after the declaration of an *Uncertainty Phase*), i.e. notify the KL ARCC that an *Alert Phase* existed.

iii) Manual of Air Traffic Services, Part 9 - Emergencies, page 9-6-5, para. 6.7.2 dated 15/3/2009 states:

If alerting service is required for an aircraft that is flight planned to operate through more than one FIR including the airspace delegate to the Kuala Lumpur and Kota Kinabalu ATSCs and the position of the aircraft is in doubt, the responsibility for co-ordinating such service shall normally rest with the ATSC of the respective FIRs:

within which the aircraft was flying at the time of last air-ground radio contact.

<u>Reference</u>

Manual of Air Traffic Services, Part 9 - Emergencies, page 9-6-5, para. 6.7.2 dated 15/3/2009 No. 1 states:

If alerting service is required for an aircraft that is flight planned to operate through more than one FIR including the airspace delegate to the Kuala Lumpur and Kota Kinabalu ATSCs and the position of the aircraft is in doubt, the responsibility for co-ordinating such service shall normally rest with the ATSC of the respective FIRs:

- *within which the aircraft was flying at the time of last air-ground radio contact;*
- *that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;*
- *within which the aircraft's intermediate stop or final destination point is located:*

  1) *if the aircraft was not equipped with suitable two-way radio communication, or*
  2) *was not under obligations to transmit position reports.*

and

ICAO Doc 4444 ATM/501 Procedures for Air Navigation - Air Traffic Management (PANS-ATM), page 9-6, para 9.2.2.2, dated 22/11/07 states:

When alerting services is required in respect of a flight operated through more than one FIR or control area, and when the position of the aircraft is in doubt, responsibility for coordinating such service shall rest with the ATS unit of the FIR or control area within which the aircraft was flying at the time of last air-ground radio contact:

a) that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;

b) within which the aircraft's intermediate stop or final destination point is located:

1) if the aircraft was not equipped with suitable two-way radio communication, or

2) was not under obligations to transmit position reports.

The responsibility for the provision of alerting service for MH370 therefore rested on KL ACC.

iv) Following the *Alert Phase*, the *Distress Phase* should be declared by the Radar Controller after further unsuccessful attempts to establish communication with the aircraft and more widespread unsuccessful inquiries pointed to the probability that the aircraft was in distress.

<u>References</u>

(1) MATS, PART 9 - EMERGENCIES, para 1.3.1 a) and b) page 9-1-2 Ver.01 stipulates that:

Controller may suspect that an aircraft is experiencing an emergency situation or that an emergency situation exists if one of the following situations becomes apparent:

a) *when radio contact is not established at the time it is expected to be established;*

b) *radio or radar contact is lost;*

c) *pilot reports a malfunction or unusual behaviour of person(s) on board;*

d) *pilot reports of unlawful interference;*

e) *aircraft is observed or reported to be behaving erratically;*

f) *aircraft is overdue at an aerodrome; and*

g) *an ELT signal is heard or is reported.*

(2) MATS PART 9 - EMERGENCIES, SECTION 2 OVERDUE AIRCRAFT, para. 2.1.1, page 9-2-1, No.1, dated 15/03/2009 stipulates that:

ATC action with respect to an aircraft that is overdue should not be considered in isolation, and the emergency actions described in other sections, in particular radio failure procedures, should be applied if they are appropriate. For example, if a radio-equipped aircraft fails to make an expected report, continuous attempts should be made to re-establish communications while at the same time initiating overdue action.

(3) MATS PART 9 - EMERGENCIES, SECTION 2 OVERDUE AIRCRAFT, para. 2.1.3, page 9-2-1, also stipulates that:

Overdue action must be commenced not later than the times stipulated in the procedure herein. Controllers may at their own discretion consider initiating actions before the times stated. The following consideration will assist Controllers in making a decision:

Route - The need for prompt action if the route is over sparsely populated area, mountainous country, and long stretches of water.

(4) MATS PART 9 - EMERGENCIES, Table 9-2-2, page 9-2-3 OVERDUE ACTION - RADIO EQUIPPED AIRCRAFT

ATSC Procedures

Preliminary action

When an aircraft fails to make a position report when it is expected, commence action not later than the ETA for the reporting point plus 3 minutes:

- *Confirm ATD and time of last contact with preceding ATS unit if appropriate;*
- *Request information from other ATS units and likely aerodromes;*
- *Notify the RCC that the Uncertainty Phase exists; and*
- *Ensure that RQS message is sent.*

Full overdue Action

Commence full overdue action not later than 30 minutes after the declaration of the Uncertainty Phase or when advised by the Aerodrome that the aircraft is fully overdue:

- *Notify the RCC that the Alert Phase exists;*
- *Notify the RCC that the Distress Phase exists if:*

i) 1 hour has elapsed beyond the last ETA for the destination; or

ii) the fuel is considered exhausted; or

iii) 1 hour has elapsed since the declaration of the Uncertainty Phase.

(5) ATC actions on the declaration of emergency phases should be taken as shown below:

MATS PART 9 - EMERGENCIES, page 9-6-2 – para

9-6-4, para 6.4 and Annex 11, page 5-1, para 5.2.1 states:

a) Uncertainty Phase when:

1) no communication has been received from an aircraft within a period of thirty minutes after the time a communication should have been received, or from the time an unsuccessful attempt to establish communication with such aircraft was first made, whichever is the earlier, or when an aircraft fails to arrive within thirty minutes of the estimated time of arrival last notified to or estimated by air traffic units, whichever is the earlier, except when no doubt exits as to the safety of the aircraft and its occupants.

b) Alert Phase when:

1) following the uncertainty phase, subsequent attempts to establish communication with the aircraft or inquiries to other relevant sources have failed to reveal any news of the aircraft, or when

2) an aircraft has been cleared to land and fails to land within five minutes of the estimated time of landing and communication has not been re-established with the aircraft, or when

3) information has been received which indicates that the operating efficiency of the aircraft has been impaired, but not to the extent that a forced landing is likely, except when evidence exists that would allay apprehension as to the safety of the aircraft and its occupants, or when

4) an aircraft is known or believed to be the subject of unlawful interference.

c) Distress Phase when:

1) following the alert phase, further unsuccessful attempts to establish communication with the aircraft and more widespread unsuccessful inquiries point to the probability that the aircraft is in distress, or when

2) the fuel on board is considered to be exhausted, or to be insufficient to enable the aircraft to reach safety, or when

3) information is received which indicate that the operating efficiency of the aircraft has been impaired to the extent that a forced landing is likely, or when

4) information is received or it is reasonably certain that the aircraft is about to make or has made a forced landing except when there is reasonable certainty that the aircraft and its occupants are not threatened by grave and imminent danger and do not require immediate assistance.

f) Information to be passed to other Radar Units - Civil and Military

The Sector 3+5 Radar Controller did not inform other radar units, civil and military, of the circumstances surrounding MH370. MATS PART 9 - EMERGENCIES, para 6.2.3, page 9-6-2, stipulates that:

If Controllers have reason to believe that an aircraft is lost, overdue or experiencing a communication failure, they shall:

a) inform appropriate radar units (civil and military) of the circumstances.

b) request the units to watch out for emergency SSR code display or the triangular radio failure pattern.

c) notify these units when their services is no longer required.

g) Provision of Alerting Service for Flight operating through more than one FIRs and ATC Actions

MH370 was operating within the Singapore FIR, in that portion of the airspace which has been delegated to Malaysia (refer to *Figure 2.2K - Singapore Airspace delegated to Malaysia*) for the provision of air traffic services when the last air-ground radio contact was made at 1719 UTC [0119 MYT]. As such, KL ACC should be responsible for the alerting service which would mean that KL ACC would have to declare the Distress Phase at 1827 UTC [0227 MYT] when HCM ACC informed that there had been no two-way radio communications with MH370.

Reference

Manual of Air Traffic Services, Part 9 - Emergencies, page 9-6-5, para. 6.7.2 dated 15/3/2009 No. 1 states:

If alerting service is required for an aircraft that is flight planned to operate through more than one FIR including the airspace delegate to the Kuala Lumpur and Kota Kinabalu ATSCs and the position of the aircraft is in doubt, the responsibility for co-ordinating such service shall normally rest with the ATSC of the respective FIRs:

- *within which the aircraft was flying at the time of last air-ground radio contact;*
- *that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;*
- *within which the aircraft's intermediate stop or final destination point is located:*

  3) if the aircraft was not equipped with suitable two-way radio communication, or

  4) was not under obligations to transmit position reports.

and

ICAO Doc 4444 ATM/501 Procedures for Air Navigation - Air Traffic Management (PANS-ATM), page 9-6, para 9.2.2.2, dated 22/11/07 states:

When alerting services is required in respect of a flight operated through more than one FIR or control area, and when the position of the aircraft is in doubt, responsibility for coordinating such service shall rest with the ATS unit of the FIR or control area within which the aircraft was flying at the time of last air-ground radio contact:

c) that the aircraft was about to enter when last air-ground contact was established at or close to the boundary of two FIRs or control areas;

d) within which the aircraft's intermediate stop or final destination point is located:

3) if the aircraft was not equipped with suitable two-way radio communication, or

4) was not under obligations to transmit position reports.

The responsibility for the provision of alerting service for MH370 therefore rested on KL ACC.

h) Actions taken by Air Traffic Service Centre Duty Watch Supervisor

In interviews conducted with the Duty Air Traffic Controllers on that night, the Team recorded the following:

i) At about 1800 UTC [0200 MYT], the Sector 3+5 Radar Controller had instructed a junior Controller to inform the ATSC Duty Watch Supervisor - who was then in the rest area[35] - on HCM ACC's query on the status of MH370;

ii) The ATSC Duty Watch Supervisor stated that he subsequently left the rest area and returned to the ATSC. He contacted MAS Operations Despatch Centre (ODC) by telephone (albeit not tape-recorded) to inform that HCM ACC had not been able to establish radio and radar contact with MH370. In response ODC informed that the Flight-following System (FFS) or *Flight Explorer* of MAS showed that: "*aircraft in Cambodian airspace*" and added that he

[35] Rest area - It is located in the same building adjacent to ATSC and is furnished with 3 x double-decker beds for the night shift Controllers to rest/sleep during break in between shift.

(ODC) would try to use the ACARS to contact MH370 and also to request the aircraft to contact HCM ACC. The ATSC Duty Watch Supervisor stated that he was satisfied with the information that MH370 was still flying and therefore did not take any further actions.

iii) The junior Controller (who had earlier informed the ATSC Duty Watch Supervisor in the rest area) stated that the ATSC Duty Watch Supervisor then returned to the rest area at around 1830 UTC [0230 MYT] until about 2130 UTC [0530 MYT].

iv) At 2130 UTC [0530 MYT], the ATSC Duty Watch Supervisor initiated the alerting action by instructing the SAR-trained Controller to activate the KL ARCC.

v) At 2232 UTC [0632 MYT], the *DETRESFA* message was disseminated

i) Flight-Following System of Malaysia Airlines

(1) In interviews conducted with the MAS duty personnel in charge of the FFS on the night of 07 March 2014, he was not able to explain clearly on the operations of the system due to "*lack of training*". The Team was also informed that all the personnel in this unit were not adequately trained to operate this system. The MAS personnel also informed the Team that the FFS could not track aircraft on a real-time basis and that the position information was computer-projected, based on the flight plan of aircraft. He added that the status of an aircraft position would only be updated every thirty (30) minutes. He admitted that he had informed KL ACC that MH370 was in Cambodian airspace as during: *"…that point in time, I did not notice that the position was actually projected movement and not actual"*.

Even with this admission, MAS ODC continued to provide information to KL ACC that the aircraft was "*still sending movement messages*", and stated that:

> "*It was somewhere in Vietnam and coordinates of its position as N14.90000 E109 15500 at time 1833 UTC [0233 MYT]".*

(2) KL ACC then relayed the position information to HCM ACC at 1837:41 UTC [0237:41 MYT] informing HCM ACC that MH370 was still flying.

(3) To understand how the *Flight Explorer* works, the Team requested for a copy of the *Flight Explorer User Manual* and was informed that there was none in the office. Later, a copy of the *Flight Explorer User Manual* was provided to the Team.

Note:

Flight Explorer is a computer-based system which is also known as “Flight-Following System” to track aircraft based on input of the aircraft’s Flight Plan data into the computer. The Flight Plan data generates the flight profile and position of the aircraft and updates every 30 minutes. However, the system does not provide real-time tracking.

(4) Whilst air traffic Controllers’ communication with airline operators to obtain flight information is a normal occurrence, however information provided ought to be evaluated and assessed with due diligence as to its accuracy and relevancy. The information of the FFS on MH370 was derived from the *Flight Explorer* which did not provide real-time tracking. The *Flight Explorer* was neither a part of the ATS system nor documented in the Manual of ATS (MATS), International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual Volume IV, Standard Operating Procedure for SAR, Supplementary Operations Instructions (SOIs) or other documents. Therefore, the information derived from the FFS from ODC did not help at all but, instead, further complicated the situation**.**

The Team noted that MAS FFS was not part of the KL ACC Air Traffic Services system and it did not provide real-time tracking of flight. The position information of MH370 provided to KL ACC were computer-generated and not actual.

j) Communication Exchanges between KL ACC and HCM ACC and KL ACC and MAS Operations Despatch Centre on MH370

(1) The period between 1739 UTC [0139 MYT] and 2120 UTC [0520 MYT] revolved with ATC communications activities between HCM ACC and KL ACC, and. between KL ACC and ODC, for information on MH370. It also included KL ACC requesting HCM ACC to check with the adjacent FIRs namely SANYA, HONG KONG and BEIJING.

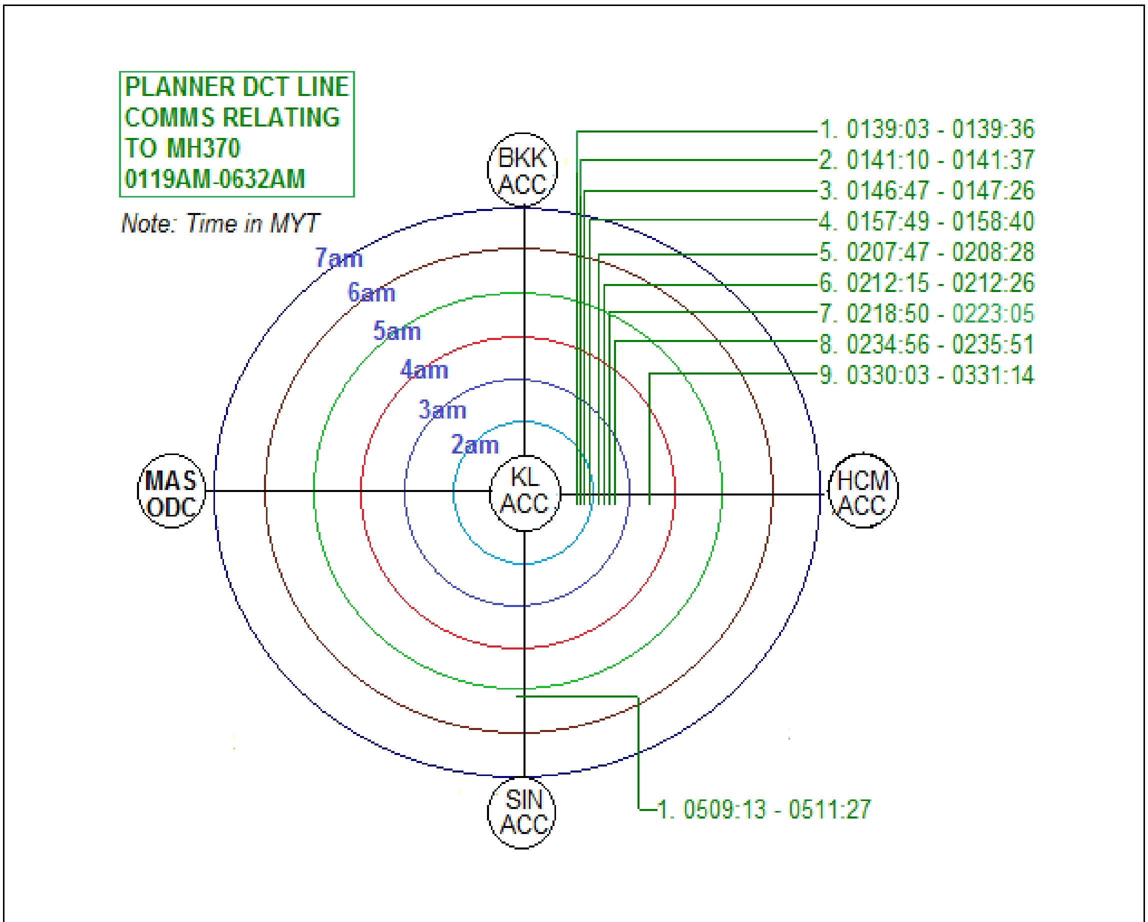


*Figure 2.2J - Planning Controller Direct Telephone Line Communication Exchanges between KL ACC and HCM ACC, KL ACC and Singapore ACC from 0119 to 0632 **[**MYT]*

(2) The time and the Planning Controller's direct line communications exchanges with HCM ACC, and Singapore ACC, from 1719 to 2232 UTC [0119 to 0632 MYT], is illustrated in concentric circles *(Figure 2.2J above)* when MH370 went missing. The illustrations at 0100 (MYT) begins with the innermost concentric circle followed by 0200 [MYT] on the next concentric circle with 0700 [MYT] on the outermost concentric circle (it depicts the timeline for 08 March 2014 on the KL ACC Planning Controller's direct line

communication exchanges with HCM ACC and with Singapore ACC from 0119 to 0632 [MYT] when MH370 was missing).

(3) Direct line communication exchanges (time in MYT) between KL ACC Planning Controller and HCM ACC.

No.	Time [MYT]	Direct-Line Communication Exchanges
1.	0139:03 - 0139:36	HCM ACC initiated the call to enquire about MH370 and notified KL ACC verbal contact was not established with MH370 and the radar target was last seen at BITOD.
2.	0141:10 - 0141:37	KL ACC initiated the call to inform HCM ACC that MH370 did not contact KL ACC after IGARI. HCM ACC informed KL ACC that "*we have radar contact but not verbal contact until BITOD, we are no ADS-B identity and no radar contact.*"
3.	0146:47 - 0147:26	HCM ACC initiated the call /query about MH370 and stated that *"we have radar contact over IGARI not verbal contact and after BITOD we have no radar ident also ADS-B identity. And we call him many times until more than 20 minutes".* KL ACC responded: *"Okay, I will try...give a call and then."*
4.	0157:49 - 0158:40	HCM ACC initiated the call/query and stated: "*we officially no contact from MH370 until now, and we tried on many frequencies and all the aircraft - calling no response from MH370."* HCM ACC added and requested by saying: *"Could you check back for your side?"* KL ACC responded: "*Okay we will do that and the first at IGARI did you ever in contact with the aircraft or not first place."* HCM ACC replied: "*Negative sir, we have radar contact only but not verbal contact."* KL ACC responded: "*But no when passed IGARI, did the aircraft call you?"* HCM ACC replied: *"Negative sir."* KL ACC responded: *"Negative. Why you didn't tell me first within five minutes you should be called me?"* KL ACC, before ending the conversation, indicated that he would try to call the Company.

Table 2.2F - Direct Line Communication Exchanges between KL ACC and HCM ACC

cont…

(3) Direct line communication exchanges (time in MYT) between KL ACC Planning Controller and HCM ACC *(cont…)*

No.	Time [MYT]	Direct-Line Communication Exchanges
5.	0207:47 - 0208:28	HCM ACC initiated the call query to KL ACC for confirmation that MH370 was in Phnom Penh FIR as Phnom Penh did not have any information on MH370.KL ACC responded that he would check with his supervisor again.
6.	0212:15 - 0212:26	KL ACC while coordinating with HCM ACC on another traffic informed that there was no update on the status of MH370.
7.	0218:50 - 0223:05	KL ACC initiated the call and queried if the flight plan routing of MH370 was supposed to enter Cambodian airspace. HCM ACC confirmed that the planned route was only through the Vietnamese airspace. HCM ACC also informed that it had checked and also been advised by Cambodia that it had no information or contact with MH370. HCM ACC confirmed that earlier information on loss of radar contact after BITOD, and radio contact, was never established. KL ACC queried if HCM ACC was taking Radio Failure action but the query did not seem to be understood by the personnel. HCM ACC suggested KL ACC to call MAS Operations and was advised that it had already been done.
8.	0234:56 - 0235:51	HCM ACC initiated the call and queried about the status of MH370 and was informed by KL ACC that the Watch Supervisor was talking to the Company at that time.
9.	0330:03 - 0331:14	KL ACC initiated the call and enquired on news of MH370 and HCM ACC responded: "*not yet.*" KL ACC queried whether HCM ACC had checked with the next FIR Hainan.

Table 2.2F - Direct Line Communication Exchanges between KL ACC and HCM ACC

(4) Direct line communication exchange (time in MYT) relating to MH370 between KL ACC and Singapore ACC *(Table 2.2G* below)

No	Time [MYT]	Direct-Line Communications Exchanges
1.	0509:13 - 0511:27	Singapore ACC initiated the call and informed that it was first alerted by Hong Kong ACC who had made enquiries to ascertain the status of MH370. KL ACC confirmed that it was in contact with MH370 until transferred at IGARI and that MAS on the ground had also no contact with MH370.

Table 2.2G - Direct Line Communication Exchanges between KL ACC and Singapore ACC

(5) *Figure 2.2K* below illustrates the time and the Radar Controller's direct line communications exchanges relating to the missing MH370 between KL ACC and HCM ACC, and between KL ACC and ODC.

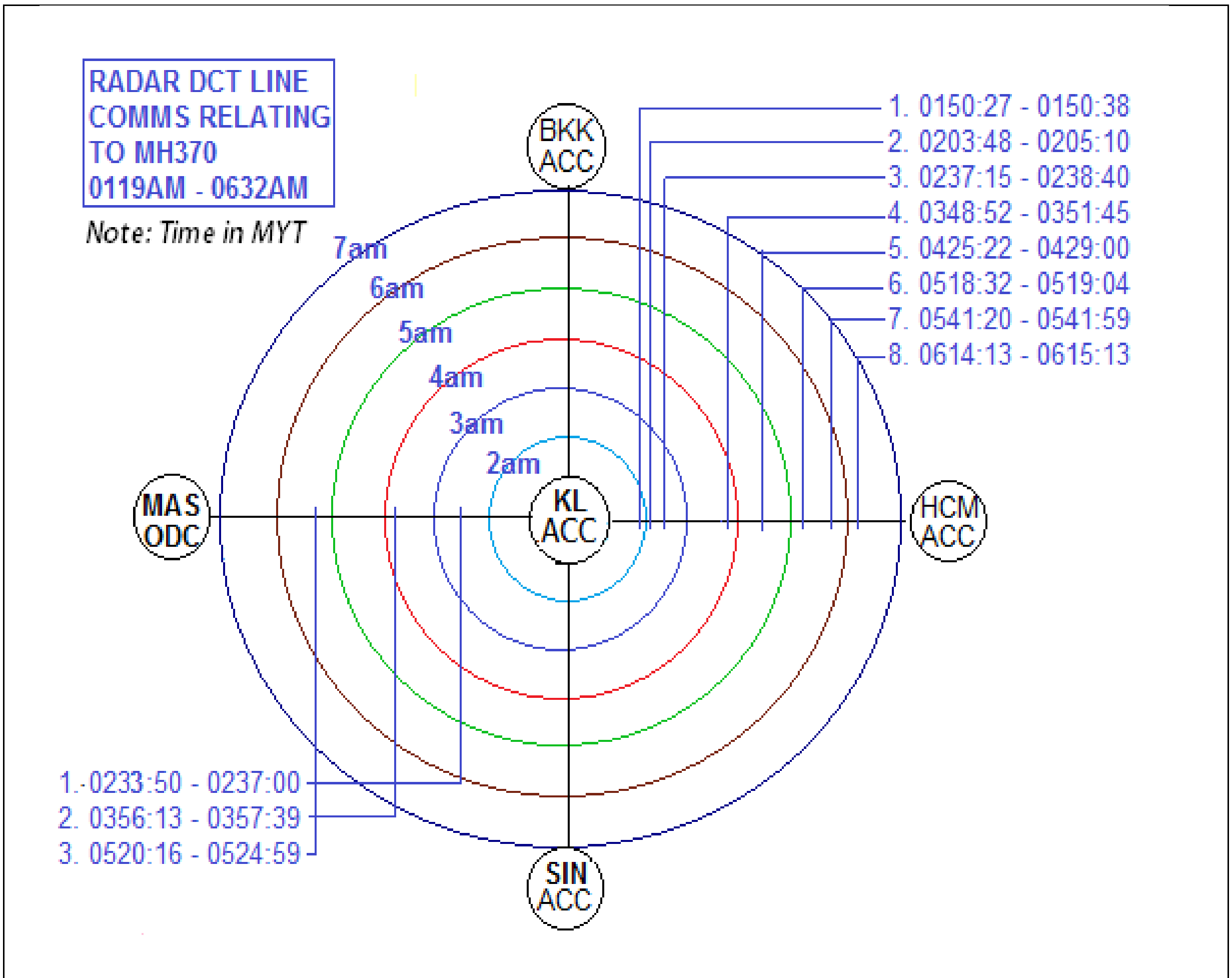


Figure 2.2K - Radar Controller's Direct Line Communication Exchanges

It begins with 0100 [MYT] at the innermost concentric circle followed by 0200 [MYT] on the next concentric circle with 0700 [MYT] on the outermost concentric circle (it depicts the timeline for 08 March 2014 on the KL ACC Radar Controller direct line communication exchanges with HCM ACC and ODC 0119 to 0632 [MYT] when MH370 went missing).

(6) Direct line communication exchanges between KL ACC Radar Controller and HCM ACC (*Table 2.2H*, below)

No.	Time [MYT]	Direct-Line Communications Exchanges
1.	0150:27 - 0150:38	KL ACC initiated the call to enquire about MH370 and HCM ACC replied: "*negative contact.*"
2.	0203:48 - 0205:10	KL ACC initiated the call query to HCM ACC on the status of MH370. HCM ACC confirmed there was no radar contact at that time and no verbal communication was established. KL ACC relayed the information received from MAS Operations that MH370 was in Cambodian airspace.
3.	0237:15 - 0238:40	KL ACC initiated the call and informed HCM ACC that MH370 was still flying, and that the aircraft was sending position reports to the airline. KL ACC then relayed to HCM ACC the position of MH370 in latitude and longitude as advised by MAS Operations Centre.
4.	0348:52 - 0351:45	KL ACC initiated the call and queried HCM ACC for news of MH370. HCM ACC replied: "*Until now nothing.*" KL ACC suggested checking with the next FIR and HCM ACC advised: "*It was SANYA FIR and he had checked with SANYA FIR but no response until now*."
5.	0425:22 - 0429:00	HCM ACC initiated the call and queried to confirm the last position that MH370 was in contact with KL ACC. KL ACC replied: *"The last position we contact that was about IGARI."*

Table 2.2H - Direct Line Communication Exchanges between KL ACC Radar Controller and HCM ACC

cont…

(6) Direct line communication exchanges between KL ACC Radar Controller and HCM ACC (*Table 2.2H*, below)..*cont.*

No.	Time [MYT]	Direct-Line Communications Exchanges
6.	0518:32 - 0519:04	HCM ACC initiated the call and queried for information on MH370. KL ACC queried if any information had been received from Hong Kong or Beijing.
7.	0541:20 - 0541:59	HCM ACC initiated the call and queried for any updates.
8.	0614:13 - 0615:13	KL ACC initiated the call and queried HCM ACC if SAR was activated.

Table 2.2H - Direct Line Communication Exchanges between KL ACC Radar Controller and HCM ACC

(7) Direct line communication exchanges between KL ACC and ODC (*Table 2.2I* below)

No.	Time [MYT]	Direct-Line Communications Exchanges
1.	0233:50 - 0237:00	KL ACC informed MAS that HCM ACC still had no contact with MH370. MAS informed that the aircraft was still sending movement messages and providing latitude 14.90000 longitude 109.15500 at 1833 UTC [0233 MYT].
2.	0356:13 - 0357:39	KL ACC initiated the call and enquired about MH370. MAS replied: *"Not yet".*
3.	0520:16 - 0524:59	KL ACC initiated the call and queried MAS for news on MH370. The Technical Captain said: *"Whatever we have here suggest that the aircraft had never leave Lumpur airspace because he has failed to call Ho Chi Minh"* and suggested to KL ATSC to trace back the record, voice recording and time of the positive handover to Ho Chi Minh. KL ACC replied: *"I wake up my supervisor and ask him to check again to go to the room and check what, what the last contact all this thing."*

Table 2.2I - Direct Line Communications Exchanges between KL ACC and ODC

Investigation revealed that between 0119 and 0632 MYT, the following ATC communications activities on MH370, between HCM ACC and KL ACC, and between KL ACC and ODC, took place:

- There were nine instances KL ACC Sector 3+5 planner Controller communicated with HCM ACC and one with Singapore ACC relating to MH370, and
- There were eight instances KL ACC Sector 3+5 Radar Controller communicated with HCM ACC and three with ODC relating to MH370,

Figure 2.2L (below) illustrates the time and the Radar Controller's direct line communications exchanges, though not relating to the missing MH370, with HCM ACC and Singapore ACC, from 0119 to 0632 [MYT].

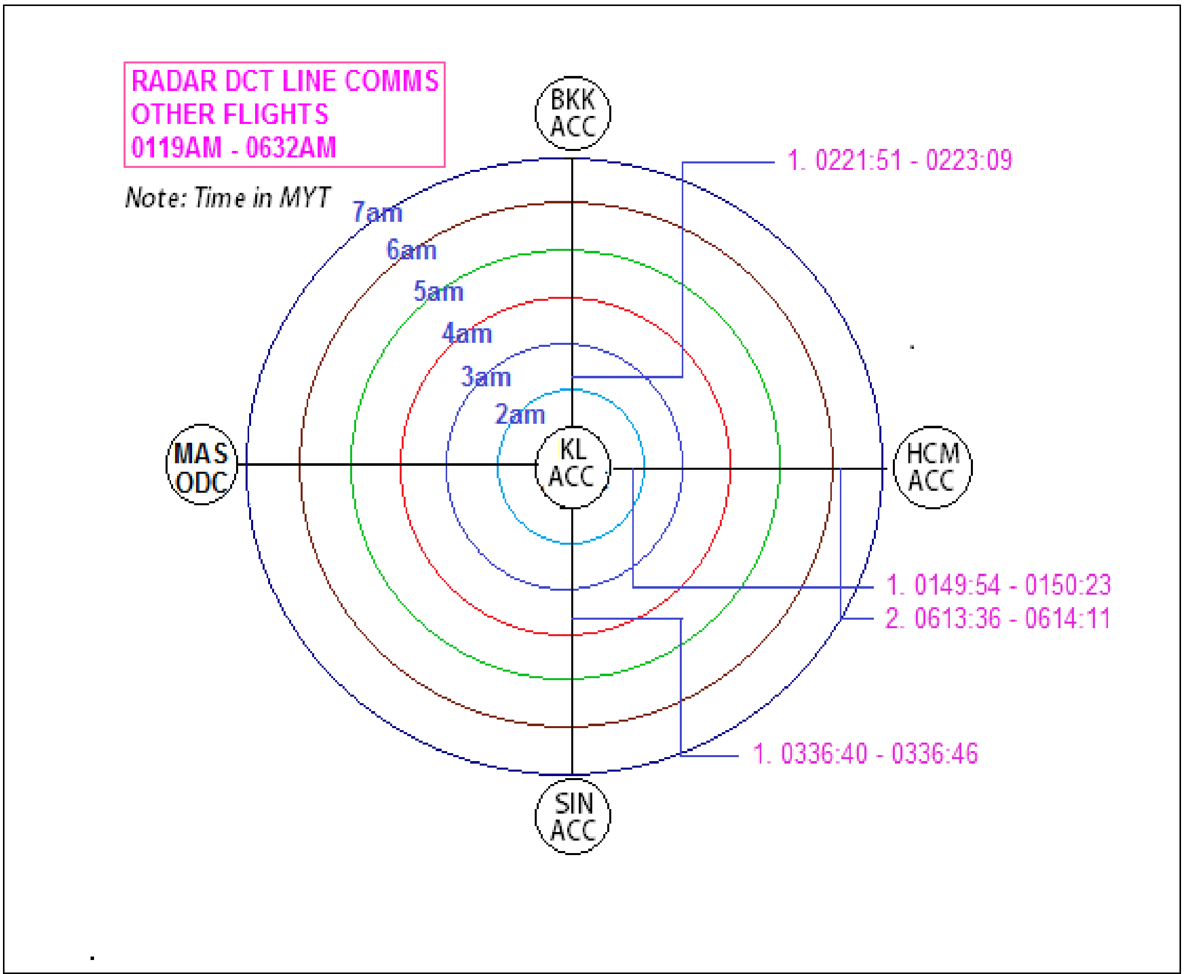


Figure 2.2L - Radar Controller direct telephone line communications exchanges between KL ACC and HCM ACC, KL ACC and Bangkok ACC, KL ACC and Singapore ACC from 0119 to 0632 [MYT] not related to MH370

Figure 2.2M (below) illustrates the time and the Planning Controller's direct line communications exchanges not relating to the missing MH370 with HCM ACC, Singapore ACC and Bangkok ACC, from 0119 to 0632 [MYT]. It begins at 0100am at the innermost concentric circle followed by 0200 [MYT] on the next concentric circle with 0700 [MYT] on the outermost concentric circle (it depicts the timeline for 08 March 2014 on KL ACC Planning Controller direct line communications exchanges with between KL ACC and HCM ACC, KL ACC and Bangkok ACC, KL ACC and Singapore ACC from 0119 to 0632 [MYT] when MH370 went missing).

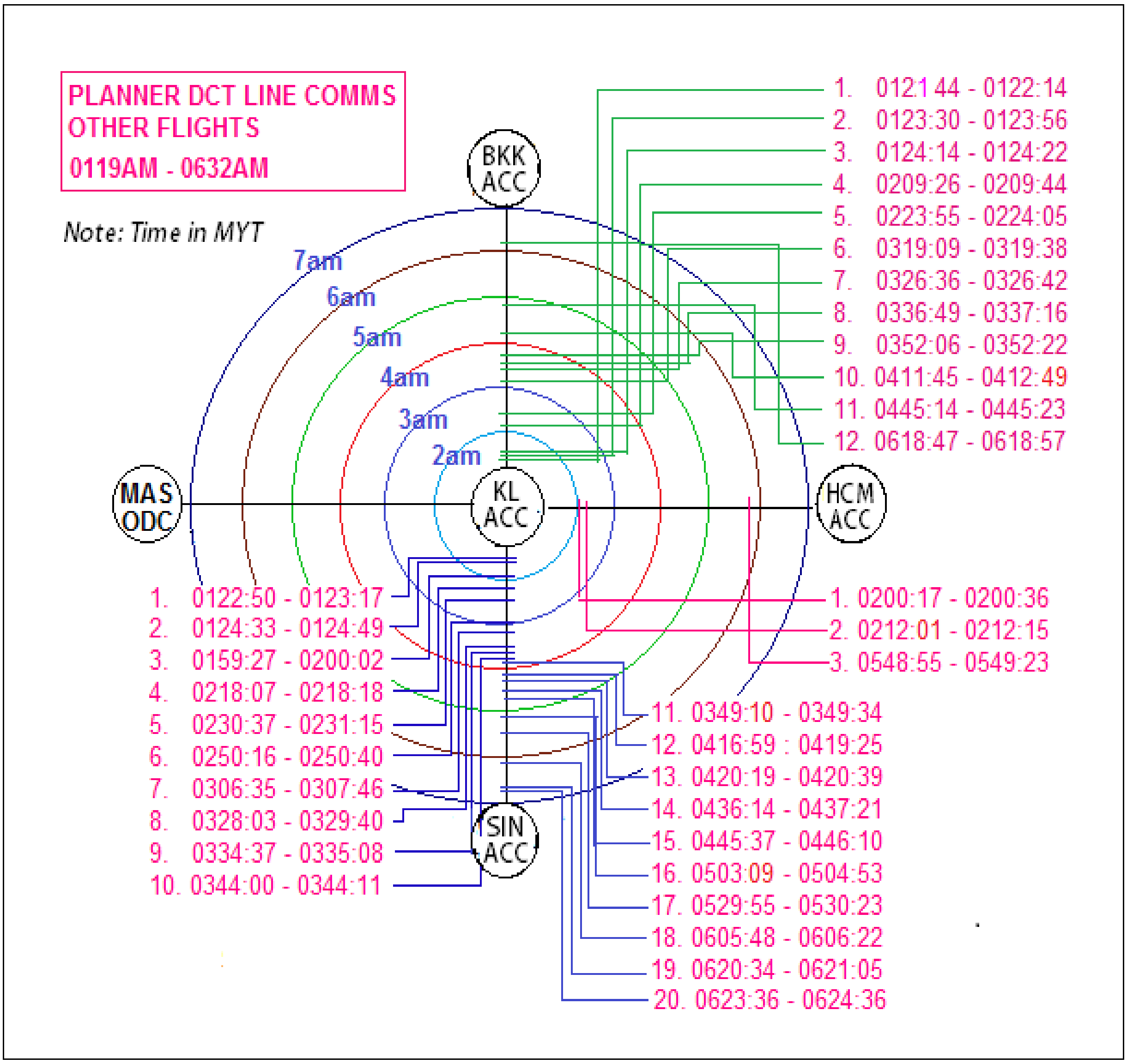


Figure 2.2M - Planning Controller's direct telephone line communications exchanges between KL ACC and HCM ACC, KL ACC and Bangkok ACC, KL ACC and Singapore ACC from 0119 to 0632 [MYT] not related to MH370

It begins at 0100 [MYT] at the innermost concentric followed by 0200 [MYT] on the next circle with 0700 [MYT] on the outermost concentric circle (it depicts the timeline for 08 March 2014 on KL ACC Radar Controller direct line communications exchanges between KL ACC and HCM ACC, KL ACC and Bangkok ACC, KL ACC and Singapore ACC, from 0119 to 0632 [MYT] when MH370 went missing).

The Team noted that between 0119 and 0632 MYT:

- there were two instances KL ACC Sector 3+5 Radar Controller communicated with HCM ACC, one with Bangkok ACC and another with Singapore ACC relating to other flights; and
- there were three instances Sector 3+5 planner Controller communicated with HCM ACC, twelve instances with Bangkok ACC and twenty with Singapore ACC relating to other flights.

k) Delegation of Airspace by Singapore Area Control Centre to KL ACC

i) The delegated airspace *(Figure 2.2N* below) is a portion of airspace within the Singapore FIR over the South China Sea. IGARI is a waypoint along airway M765 which is within the delegated airspace. KL ACC is responsible for the provision of air traffic services to flights operating within the delegated airspace and Singapore ACC is responsible for the provision of SAR service.

ii) At 2109:13 UTC [0509:13 MYT] Singapore ACC contacted KL ACC for information on MH370 following an enquiry on the status of the aircraft by Hong Kong ACC four minutes earlier. By then, over three and a half hours had lapsed.

iii) At 0230 UTC 08 March 2014, KL ARCC advised Singapore RCC on the situation relating to MH370. Singapore RCC informed that a Hercules aircraft (C-130) would be launched to the search area with clearance from Ho Chi Minh. The Hercules aircraft (C-130) was assigned the radiotelephony callsign as *Rescue 71* by Lumpur ARCC.

iv) Although Singapore ACC is responsible for the provision of SAR service within the delegated airspace, KL ACC did not inform Singapore ACC when MH370 was overdue. Nevertheless, Singapore RCC launched a search and rescue aircraft to the search area after KL ARCC advised on the situation relating to MH370.

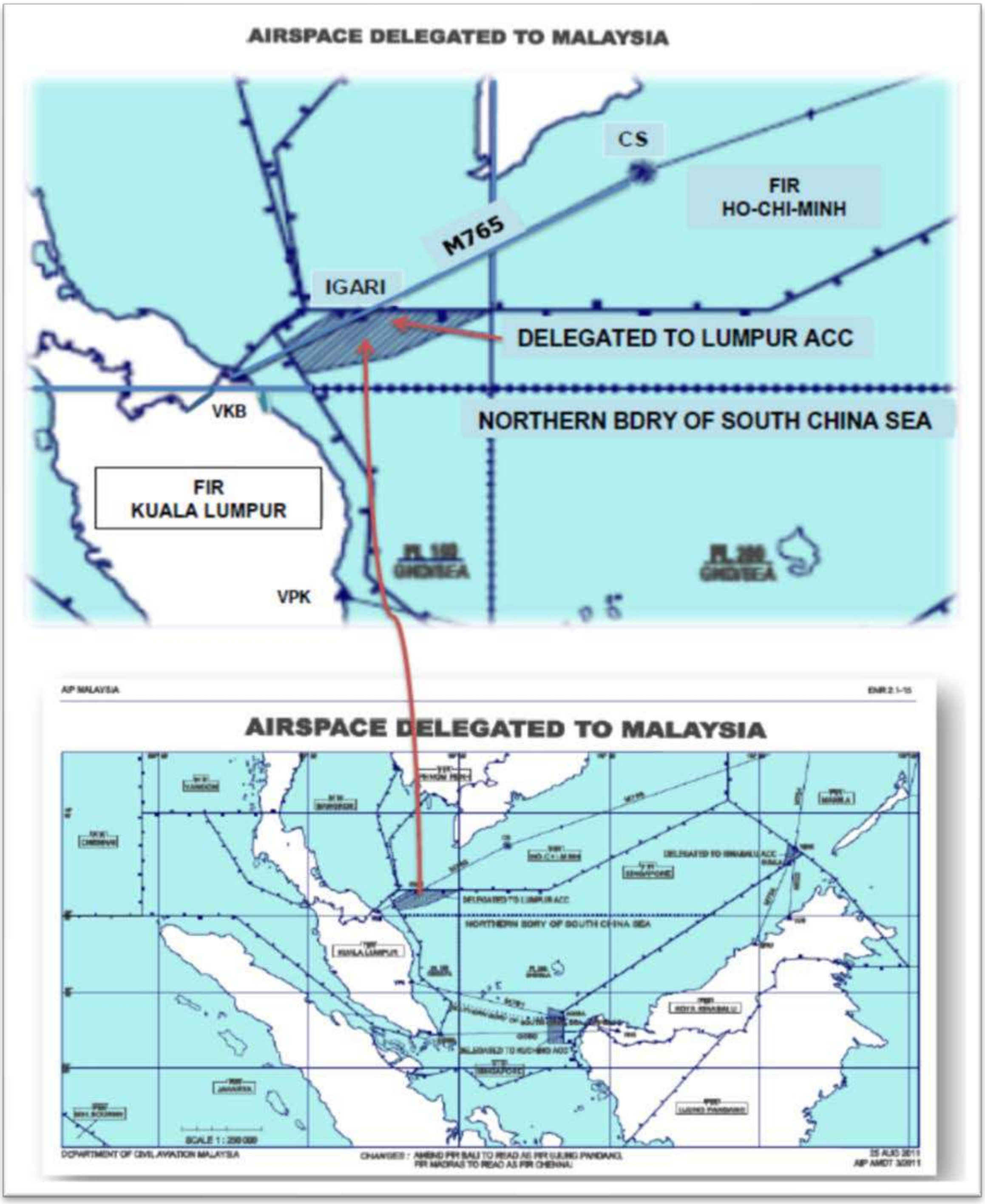


Figure 2.2N - Singapore Airspace delegated to Malaysia

Source: DCA Malaysia

l) ATC Actions on Strayed/Unidentified Aircraft (Primary Radar Target) within the Area of Responsibility

i) At 1730:37 UTC [0130:37 MYT] a strayed/unidentified aircraft (primary radar target) appeared on the Sector 3+5 radar display at approximately 57 nm north east of Kota Bahru and heading to Kota Bahru. This aircraft target dropped off from the radar display at 1737:22 UTC [0137:22 MYT]. It reappeared at 1738:56 UTC [0138:56 MYT], on airway B219 heading towards VPG[36] and dropped off at 1744:52 UTC [0144:52 MYT]. The appearances and reappearances of these strayed/unidentified primary targets on Lumpur Sector 3+5 radar display were for a duration of 6 minutes 45 seconds and 5 minutes 56 seconds respectively. The duration of the strayed/unidentified aircraft appearing on the Lumpur Sector 3+5 radar display was 12 minutes and 41 seconds. When the strayed/unidentified aircraft continued its journey towards VPG, it entered into the Lumpur Sector 1 Area of Responsibility.

ii) On the Lumpur Sector 1 radar display, the strayed/ unidentified aircraft (primary radar target) appeared at 1747:02 UTC [0147 MYT] and dropped off at 1748:39 UTC [0148:39 MYT]; and reappeared at 1751:45 UTC [0151:45 MYT] and dropped off at 1752:35 UTC [0152:35 MYT]. The duration of the strayed/ unidentified aircraft appearing on Lumpur Sector 1 radar display was 2 minutes 27 seconds.

<u>Note</u>

Information on strayed/unidentified aircraft (primary radar target) was obtained from radar recording playback.

iii) In interviews with the ATCOs on duty, the Sector 3+5 and Sector 1 Radar Controllers informed that they were unaware of the strayed/unidentified aircraft (primary radar target) transiting their AORs.

The Sector 3+5 Radar Controller acknowledged that he had to shift his attention to four other aircraft in another area, viz. VPK approximately 214 nm south of IGARI). As such, he did

[36] VPG – Penang DVOR/DME coordinates 051646.7N 1001537.4E.

not observe the strayed/unidentified aircraft (primary radar target).

The Sector 1 Radar Controller stated that he did not observe the strayed/unidentified aircraft (primary radar target) even though he remained at the Controller working position.

MATS Vol 1, Part 1 - ADMIN page 1-1-4 para 1.2.2 which stipulates that:

Air Traffic Controller is responsible:

- *for maintaining a continuous watch on their assigned communications channels or radar displays.* (Point No. 5)

MATS PART 9 - EMERGENCIES, SECTION 15, page 9-15-1 (and ICAO Annex 11 - Air Traffic Services Chapter 2, para. 2.24.1, page 2-14) on *Strayed or unidentified aircraft* states:

1.5.2 The terms "strayed aircraft" and "unidentified aircraft" have the following meanings:

a) Strayed aircraft - An aircraft that has deviated significantly from its intended track or which reports that it is lost.

b) *Unidentified aircraft - An aircraft that has been observed or reported to be operating in a given area but whose identity has not been established.*

ATS PART 9 – EMERGENCIES, SECTION 15, para 15.4, page 9–15–2 (also ICAO Annex 11 - Air Traffic Services Chapter 2, para. 2.24.1.2, page 2-15) stipulates*:*

15.4 As soon as Controllers become aware of an unidentified aircraft operating in their area of responsibility, they shall endeavour to establish the identity of the aircraft for the provision of air traffic services or as required by the appropriate military authorities in accordance with local instructions. Towards this end, Controllers shall take such action as appropriate to establish two-way communication with the aircraft:

a) inquire of other ATS units within the FIR about the flight and request their assistance to establish two-way communication with the aircraft;

b) inquire of ATS units in adjacent FIRs about the flight and request their assistance to establish two-way communication with the aircraft;

c) attempt to obtain information from other aircraft in the area; and

d) notify the appropriate military unit as soon as the identity of the aircraft has been established.

m) KL ATSC Duty Shift System for Air Traffic Controllers

i) 4-cycle Shift System

The 4-cycle shift system (*Table 2.2J* below) for the KL ATSC was, as follows:

Day	Shift	Start	End
1	Afternoon	0500 UTC [1300 MYT]	1100 UTC [1900 MYT]
2	Morning	2300 UTC [0700 MYT]	0500 UTC [1300 MYT]
	Night	1100 UTC [1900 MYT]	1600 UTC [2400 MYT]
3	Morning	1600 UTC [0000 MYT]	2400 UTC [0700 MYT]
4	Off Duty		

Table 2.2J - 4-cycle Shift System of KL ATSC

ii) Operations in Restricted/Collapsed Mode

(1) From 1600 UTC [0000 MYT] until 2200 UTC [0600 MYT] the number of Controllers in the KL ATSC was scaled down by half to enable the Controllers to take a scheduled break from duty:

- the first group from 1600 UTC [0000 MYT] to 1900 UTC [0300 MYT] and
- the second group from 1900 UTC [0300 MYT] to 2200 UTC [0600 MYT].

This practice had been approved by DCA. According to DCA, the scale-down of personnel during lean hours is a norm in air traffic control centres all around the world where air traffic services can continue safely.

(2) MATS 1 Part 2 Section 2 para. 2.3.6, page 2-2-3 stipulates that:

The Supervisor may give periods of relief during a shift to personnel:

- *by arranging for relief personnel if possible; or by combining operating positions provided current and anticipated workload permits and the personnel on relief can be recalled quickly; or*
- *by rotating personnel to less active positions.*

(3) DCA Unit Administrative Instruction UAI 7/2010 details on how shift duty Air Traffic Controllers have their breaks during night shift work where the number of traffic movements is substantially reduced during the early morning period between 0000-0600 hours. Between the hours of 1600-1900 UTC [0000-0300 MYT] and 1900-2200 UTC [0300-0600 MYT], the shift is undertaken by two teams by combining the six working positions into four. However, though combined, they still would cover all the working positions.

(4) The 'Shift Break Time' in *Table 2.2K* below illustrated the manner the Controller working positions was managed. Based on this table, the Controller working positions on the 07 March 2014 is tabulated as shown in the two tables below:

- *Table 2.2L - Controller Working Positions between 1600-1900 UTC [0000-0300 MYT],* and
- *Table 2.2M - Controller Working Position between 1900-2200 UTC [0300-0600 MYT].*

From 1600 to 1900 UTC [0000-0600 MYT] Sectors 3 and 5 were combined while Sectors 1, 2 and 4 remained status quo.

FORM ATCC/OPS(IV)plnd.1/10

SHIFT BREAK TIME

TPP BERTUGAS

NO	NAME	POSITION	POSITION TO BE COVERED	TIME
1		BC	BA	0000 - 0300
2		CA	CA	
3		BD	BB & CB	
4		CD	CD & EB	
5		BE	BC	
6		BF	CC	
7		ED	ED	
8		EE	EC	
9		EA	EA	
10		EF1	EI & EF	
11		EH1	EH	
12		FA3	EB (0000-0200)	
1		BB	BA	0300 -0600
2		CB	CD	
3		BA	BB	
4		CE	BC &CC	
5		CC	CA	
6		EB	ED	
7		EF2	EC & EE	
8		EI	EI & EF	
9		EH2	EH	
10		EC	EB	
1		AF	APP	0000 - 0115
2		AN	APP	0115 - 0230
3		AL	APP	0230 - 0345
4		AS	APP	0345-0500
5		AA	APP	0500-0615
1		EG	CB	0000-0200
2		FB	CPDLC	
1		EG	ANY POSN	0530-0630
2		FB	ANY POSN	
TRAINING / FAMILIARIZATION				
1			ANY POSN	0000 - 0130 & 0530-0630
2				
3				
4				
5				

NOTE 1: Fs SHALL BREAK INTO 2 DURING RESTRICTED WATCH.HOWEVER IF B3 IS NOT AVAILABLE; F SHALL COVER CD POSITION UNTIL 0200 AND BE BACK BY 0530.THE OTHER F SHALL COVER 'C' FROM 0000-0200.

NOTE 2 THE 2ND RESTRICTED WATCH SHIFT SHALL REMAIN AT THEIR RESPECTIVE P(UNTIL RELEIVED BY 1ST RESTRICTED WATCH SHIFT

NOTE 3: WHEN W/S IS RESTING THE SHIFT LEADER SHALL TAKE CHARGE. IF URGENT W/S SHALL BE INFORMED IMMEDIATELY.

NOTE 4: WHEN TFC PERMIT X SHALL PERFORM CPDLC TRIAL FROM 0200-0300

NOTE 5: C3 SHALL REMAIN AT 'U' PSN 1100-0000

APPROVED BY :

....

WATCH MANAGER
ATCC KL FIR

Legends

FS	ATSC Supervisor	**BA**	Sector 1 Radar	**CA**	Sector 1 Area Proc	**FB**	CPDLC
AA	TMA Supervisor	**BB**	Sector 2 Radar	**CB**	Sector 2 Area Proc	**EG**	Clearance Delivery
AN	Approach North	**BC**	Sector 3 Radar	**CC**	Sector 3 Area Proc	**RC**	Relief
AS	Approach South	**BD**	Sector 4 Radar	**CD**	Sector 4 Area Proc	**P**	Check Officer/ Candidate
AL	Approach Low	**BE**	Sector 5 Radar	**CE**	Sector 5 Area Proc	**T**	Training
AF	Flow Control	**BF**	Sector 6 Radar (Sec 1 Upper)	**CR**	Area Proc Relief	**FAM**	Familiarisation
AR	APC ADAR Relief	**BG**	Sector 7 Radar			**F**	Extra Controller
		BH	Area Radar Relief				

Table 2.2K - Shift Break Time

No.	Position	Position To Be Covered	Time (MYT)
1.	Sector 1 Planner	Sector 1 Planner	0000 - 0300
2.	Sector 4 Planner	Sector 4 Planner and Sector 2 AFD	
3.	Sector 3 Radar	Sector 1 Radar	
4.	Sector 4 Radar	Sector 2 Planner and Radar	
5.	Sector 5 Radar	Sector 3 + 5 Radar	
6.	Sector 6 Radar	Sector 3 + 5 Planner (working position not covered by Sector 6 Radar)	
7.	Sector 4 AFD	Sector 4 AFD	
8.	Sector 5 AFD	Sector 3 + 5 AFD and also cover as Sector 3 + 5 Planner	
9.	Sector 1 AFD	Sector 1 AFD	
10.	AFD/FDP 1	Assist FIS & AFD/FDP	
11.	Assist Clearance Delivery 1	Assist Clearance Delivery	
12.	FIS 3	AFD (0000-0200 UTC)	

Table 2.2L - Controller Working Positions between 0000-0300 MYT

No.	Position	Position To Be Covered	Time (MYT)
1.	Sector 2 Radar	Sector 1 Radar	0300 - 0600
2.	Sector 2 Planner	Sector 4 Planner	
3.	Sector 1 Radar	Sector 2 Radar	
4.	Sector 5 Planner	Sector 3+5 Planner and Sector 3+5 Radar.	
5.	Sector 3 Planner	Sector 1 Planner	
6.	Sector 2 AFD	Sector 4 AFD	
7.	AFD/FDP	Sector 3+5 AFD and also cover as 3+5 Planner	
8.	Assist FIS	Assist FIS & AFD/FDP	
9.	Assist Clearance Delivery	Assist Clearance Delivery	
10.	Sector 3 AFD	Sector 2 AFD	

Table 2.2M - Controller Working Positions between 0300-0600 MYT

(5) This analysis is based on the Air Traffic Controller Duty Roster for the month of March 2014, DCA Unit Administrative Instruction UAI 7/2010 and the entry recorded by the WS in the WS ATS logbook on 07 March 2014. From 1500 UTC [2300 MYT] until 1900 UTC [0300 MYT] and 1900 UTC [0300 MYT] until 2200 UTC [0600 MYT] the Sector 3+5 radar working position was manned by a radar-rated Controller. The Controller working positions (CWPs) between 0000 - 0300 MYT on the night of 07 March 2014, as shown in item 6 of *Table 2.2K* above revealed that the Sector 6 Radar Controller who was supposed to cover the Sector 3+5 planner position was not rostered by the ATSC Duty Watch Supervisor (the Radar Controller was rostered to work between 0300 - 0600 MYT). Consequently, the CWP for Sector 3 which was combined with Sector 5 at 1500 UTC [2300 MYT] was manned by a Radar Controller and an assistant flight data (AFD) Controller. Since the CWP planner was not covered (item 8 of *Table 2.2G* above), the AFD Controller stepped in as Sector 3+5 planner (albeit untrained for the planner position). From 1900-2200 UTC [0300 - 0600 MYT], a Radar Controller had to cover the Sector 3+5 radar and planner position (refer item 4 of *Table 2.2H*, above with an AFD Controller (refer to item 7 of *Table 2.2M*) who also stepped in as Sector 3+5 planner.

(6) In interviews with the ATCOs, the Team noted that when the planner positions were not covered, the AFD Controllers would step in as planners to assist the Radar Controllers as this had been the practice.

Shift personnel during scheduled break are allowed to rest in the rest area adjacent to the ATSC. The ATSC Duty Watch Supervisor maintains his/her watch at the Operational Centre until 1730 UTC [0130 MYT]. He/she takes his/her break until 2130 UTC [0530 MYT]. During his/her absence, a shift leader (usually the most senior Controller) is appointed to take charge but the ATSC Duty Watch Supervisor can be recalled at a moment's notice should the need arises.

(7) On the night of 07 March 2014, at 1500 UTC [2300 MYT] the Subang ATSC radar maintenance contractor at KL ATSC received a request from the Sector 5 Air Traffic Controller to absorb functions of control for Sector 5 into Sector 3. The request was successfully executed by the Site Maintenance Engineer (SME).

(8) In interviews with the ATCOs and on listening from the play-back of the direct telephone line recording on the Planning Controller working position, it is confirmed that, from 1600 UTC [0000 MYT] till 2200 UTC [0600 MYT], the Planning Controller working position (*Table 2.2N,* [below]) was manned by unrated Air Traffic Controllers as follows:

No.	Time	Sector 3 + 5 Planner Position
1	1600 UTC [0000 MYT] until 1730 UTC [0130 MYT]	Manned by an unrated ATCO
2.	1730 UTC [0130 MYT] until 1900 UTC [0300 MYT]	Manned by AFD Controller - untrained and unrated.
3.	1900 UTC [0300 MYT] until 2200 UTC [0600 MYT]	

Table 2.2N - Planning Controller Position between 1600-2200 UTC

The Team noted that during the operations in restricted/collapsed mode between 1600 UTC [0000 MYT] and 2200 UTC [0600 MYT], untrained and unrated Air Traffic Controller were manning the Planning Controller working position

n) Roles played by the Duty ATSC Watch Supervisor

i) Refer to *para. 2.2.2 para. l) (5).* b) MATS PART 1 - ADMIN, para 1.2.2, page 1-1-3 stipulates that:

<u>*Watch Supervisor* - responsible for</u>:

- *ensuring that the operating positions are manned adequately by personnel qualified and current in practice.* (Point No. 3).
- *ensuring that staff are operationally proficient (Point No. 4).*

ii) In interviews with the ATCOs on shift duty on the day of the disappearance of MH370, the AFD Controllers confirmed that they were performing the functions as Planning Controller for Sector 3+5 from 1600 UTC [0000 MYT] to 2200 UTC [0600 MYT].

iii) Based on transcripts of the planner's direct telephone line (refer *Factual Information, Appendix 1.18G, pages 1-164*), from 1620 UTC [0020 MYT] to 2200 UTC [0600 MYT], a total of forty-one (*Table 2.2O* below) Planning Controller's direct telephone line exchanges took place - thirty-eight by three ATCOs (one trainee and two AFD Controllers performing the functions of Planning Controller) and the remaining three by a Radar Controller.

<table>
<tr><th rowspan="2">No.</th><th colspan="3">ATCO</th><th rowspan="2">REMARKS</th></tr>
<tr><th>Radar</th><th>Planning (3+5)</th><th>Trainee & AFD</th></tr>
<tr><td>1.</td><td>2</td><td>8</td><td>-</td><td>Relating to MH370</td></tr>
<tr><td>2.</td><td>1</td><td>25</td><td>5</td><td rowspan="3">Not relating to MH370 (mainly coordination with BKK, HCM and SIN</td></tr>
<tr><td>Sub-Total</td><td>3</td><td>33</td><td>5</td></tr>
<tr><td>Total</td><td colspan="3">41</td></tr>
</table>

Table 2.2O - Planner Direct Line Telephone Exchanges

o) Activation of Aeronautical Rescue Coordination Centre

In interviews conducted with the SAR-trained Controller, the Team noted that the Aeronautical Rescue Coordination Centre (ARCC) was activated (*Figure 2.2O - ARCC Activation Form,* below) at 2130 UTC [0530 MYT]. After the activation, the Search and Rescue Mission Coordinator (SARMC) did not have sufficient details to act upon before the distress message was disseminated at 2232 UTC [0632 MYT]. The SARMC also informed the Team that the ARCC did not receive any alerting message from Ho Chi Minh via the Aeronautical Fixed Telecommunication Network (AFTN).

DCA/ASAR/FORM/01

JABATAN PENERBANGAN AWAM MALAYSIA
Department of Civil Aviation Malaysia (DCA)
AERONAUTICAL RESCUE COORDINATION CENTRE
BLOK B, KOMPLEKS KAWALAN TRAFIK UDARA
LAPANGAN TERBANG SULTAN ABDUL AZIZ SHAH
47200 SUBANG, SELANGOR DARUL EHSAN

Telephone No: xx-xxxx xxxx (number redacted)
Fax No: xx-xxxx xxxx (number redacted)

AIRCRAFT INCIDENT NOTIFICATION AND AERONAUTICAL RESCUE COORDINATION CENTRE ACTIVATION

TO :

	AGENCY	FAX	TEL
1	POTU	xx-xxxx xxxx (number redacted)	xx-xxxx xxxx (number redacted)
2	MRCC	xx-xxxx xxxx (number redacted)	xx-xxxx xxxx (number redacted)
3	MCC	xx-xxxx xxxx (number redacted)	xx-xxxx xxxx (number redacted)
4	UNIT UDARA BOMBA	xx-xxxx xxxx (number redacted)	xx-xxxx xxxx (number redacted)
5			

REF NO
1
DATE
8/3/2014
PAGE
1

1 **DISTRESS STAGE**

	ALERTFA
	INCERFA
X	DISTRESFA

INFORMATION OF THE INCIDENT				
Date	:	7/3/2014		
Time	:	17:19	UTC	
		01:19AM	Local	
Last Known Position	:	07 01' 36"		N
		103 31' 23"		E

2 **NATURE OF DISTRESS**

AIRCRAFT MISSING AFTER PASSED WAY POINT IGARI. NO DISTRESS CALL FROM THE PILOT REPORTED. KL ARCC ACTIVATED AT 0530 UTC.

3 **AIRCRAFT DETAILS**

Craft Callsign:	:	MAS 370	Crew	:	12
Type:	:	B777-200	Passenger	:	227
Point of Dep:	:	WMKK, KUALA LUMPUR	Operator	:	MALAYSIA AIRLINE
Destination:	:	ZBAA, BEIJING	Colour/Marking	:	WHITE/RED/BLUE
Route:	:	R208 - IGARI - BITOD	Survival Equipment	:	

SUBMITTED BY : *xxxxxx (Name redacted)*
DUTY SAR MISSION CO-ORDINATOR
KUALA LUMPUR ARCC

TIME SUBMITTED	
21:30	UTC
5:30 AM	LOCAL

COMPLETE THE SECTION BELOW AND RETURN BY FAX TO RCC, IF APPLICABLE

4 **Request details on SRUs that are available for deployment for SAR:**

	Search Unit Craft/Personnel	DEPARTURE & ARRIVAL LOCATION		ETD	POB	Fuel	Cruise Speed	Search Speed
		Departure	Arrival					
1								
2								
3								
4								

5	*Please mark 'YES' if, NIL SRUs AT ALL, WILL ADVISE WHEN AVAILABLE*	YES

Note: PILOT TO BE PRESENT FOR PREFLIGHT BRIEFING AT THE KL AERONAUTICAL RESCUE COORDINATION CENTRE (KLARCC), SUBANG (TIME: BEFORE FLIGHT)

Figure 2.2O - Aircraft Incident and ARCC Activation Form

The Team noted that the distress message was disseminated an hour and two minutes after KL ARCC was activated. There was no alerting message from Ho Chi Minh RCC.

p) Play-back of Radar and Radiotelephony Recordings by ATSC Duty Watch Supervisor

At 2145 UTC [0545 MYT], the ATSC Duty Watch Supervisor requested from the radar maintenance personnel to carry out radar data play-back (with permission granted by KL ATSC's Chief Assistant Director). The SME successfully restored the desired file from the recording play-back back-up hard disc. At 2200 UTC [0600 MYT] the ATSC Duty Watch Supervisor performed radar data and voice recording play-back at the D40 Controller Working Position (D40 CWP).

q) Entries in ATS Logbooks of ATSC Watch Supervisor and Sector 3 Controller Working Position

MATS Part 1 - Admin, page 1-1-7 para 1.7 on recording of entries in the logbook states, as follows:

i. The time of entries shall be based on UTC and events recorded in a chronological order;

ii. Entries shall give sufficient details to give readers a full understanding of all actions taken;

iii. The time an incident occurred and the time at which each action was initiated shall be stated.

MATS PART 1 - ADMIN, para 1.7, page 1-1-7 further states that:

The ATS logbook serves to record all significant occurrences and actions relating to operations, facilities, equipment and staff at an ATS unit. It is an official document and, unless otherwise authorised, its content shall be restricted to those personnel requiring access to the information. All personnel should read those log entries of concern to them, which were made during the period since their last tour of duty before accepting responsibility for an operating position.

1.7.2 Where there is more than one unit within a facility, a logbook shall be maintained for each unit.

1.7.3 The Supervisor or the senior Controller on duty shall be responsible for opening, closing and maintaining the log as applicable. Any Controller may make an entry but all entries shall be made in an indelible manner and no erasure is permitted. Incorrect information shall be struck out and the correct information inserted and initiated.

1.7.4 Information to be recorded in the ATS log should, as appropriate to the facility, include such matters as:

a) Incidents, accidents, non-compliance with regulations or air traffic control clearance, regardless of whether an additional separate report is required;

b) Aerodrome inspection reports, details of work in progress, aerodrome closures, and other essential aerodrome information;

c) Changes in the status of facilities, service or procedure including communications difficulties and tests;

d) Time of receipt of significant meteorological reports, e.g. SIGMET;

e) Any occurrence of a significant nature;

f) Configuration and reconfiguration of operation positions;

g) Any dispensation against the regulations, or special authorisation given by the Director General;

h) Details of approval for Special VFR operations; and

i) Opening and closing of shift or watch.

1.7.5 Controllers should follow the following procedures for recording of entries in the log:

a) Each entry should be accompanied by the signature or the authorised initials of the Controller making the entry.

b) The time of entries shall be based on UTC and events recorded in a chronological order;

c) Entries shall give sufficient details to give readers a full understanding of all actions taken;

d) The time and incident occurred and the times at which each action was initiate shall be stated; and

e) An entry needs to be brought to the attention of the unit chief shall be so annotated to enable him to take follow up action.

1.7.6 If during an emergency or busy period, it is not possible to make detailed entries in the log at the time of occurrence, Controllers are permitted to keep rough notes with exact times. As soon as possible thereafter, a detailed entry shall be made in the log.

a) Extract from the Watch Supervisor Logbook

i. Entry 11 at 1600 - Restricted watch

1st: named
12 names for the "2nd" half)

ii. Entry redacted (12 names for the "1st" half) and 2nd named redacted (12 at 1800:

*At 1800UTC, I was informed by S3 radar (name redacted) Controller then Ho Chi Minh is enquiring the position of MAS370 B777 reg. 9MMRO estimate for IGARI 1720, with a cleared level 35,000 ft. MAS370 is from KLIA to Beijing (ZBBB) with 239 POB. The fact is at time 1719 UTC, Mr. xxxx (name redacted) made a transfer of comm. instruction to MAS370 (MAS370 contact HO Chi Minh 120.9) and the pilot acknowledged by reading its callsign (MAS370). (*The radar label as it rosses Igari eastbound was good, but about 4 to 5 miles east of Igari the radar label starts 'coasting'. *base on radar video recording).*

*Prior to opening up the *replay, Ho Chi Minh indicated the Mr. xxxx (name redacted) that they saw the target until Bitod. At 1815, I check with MAS OPS Centre in KLIA Mr. xxxx, (name redacted) and he mentioned that MAS370 is on their flight tracker and he was able to exchange signals with the flight.*

At 1930 UTC Mr. xxxx (name redacted) MAS OPS Centre call in and spoke to Mr. xxxx (name redacted), admitting that the 'flight tracker' is based on projection and could not be relied for actual positioning or search.

At 2130 I activated RCC by instructing Pn. xxxx (name redacted) to handle this case.

Until 2245 still no cospas sarsat signal receive at ATCC Subang and ATCC Singapore. I spoke to Mr xxxx (name redacted) - watch supervisor Singapore (night shift), he confirmed that the was no cospas sarsat signal pickup on aviation target, only maritime hits was observed.

At 2250 I spoke to Ho Chi Minh W/sup, and advise him that based of video recording, the target starts to coast out about 4 to 5 miles east of Igari.

L/E at 2200, PTU Mr. xxxx (name redacted) who is in xxxx (name of place redacted) was informed, PP En. xxxx (name redacted) was informed by xxxx (name redacted).

Late entry - note - at 1840 Mr. xxxx (name redacted) (MAS OPS) confirmed that MAS370 download from acft giving a coordinate of N14.9000 1091500E timed 1833.

Conclusion - Our response to this incident is based on input by Ho Chi Minh and MAS Operations Centre using their 'flight tracker'. MAS370 was well transferred comms to Ho Chi Minh and acknowledged the instruction by pilot. And lastly the *radar label started to coast about 5 NM. east of IGARI. Lumpur RCC responsibility is to assist Ho Chi Minh to locating the acft posn.*

r) Distress Message

i) The distress message (*DETRESFA*) is intended to convey pertinent information to the recipients that there is a situation wherein there is a reasonable certainty that an aircraft and its occupants are threatened by grave and imminent danger and require immediate assistance.

ii) The *DETRESFA* message with a date-time-group (DTG) 072232 UTC was transmitted at 2232 UTC [0632 MYT].

iii) The contents of the *DETRESFA* message, as shown in *Figure 2.2P* below was not composed in accordance with the standard specified in ICAO DOC 4444, Air Traffic Management (PANS-ATM) Chapter 11, Air Traffic Services Messages, Appendix 3 (*Figure 2.2Q* below). The errors are, as below:

(1) Appendix 3, page A3-9 (*Figure 2.2P* below)

Field type 7 - Aircraft identification and SSR mode and code FPL–MAS370–IS should be "MAS370/A2157"

(2) Appendix 3, page A3-14 (*Figure 2.2P* below)

Field type 13 - Departure aerodrome and time WMKK1635 should be "WMKK1642"

(3) Appendix 3, page A3-29 & A3-30 (*Figure 2.2P* below)

Omission of Field Type 20 - Alerting search and rescue information. This field consists of the following sequence of elements separated by spaces. Any information not available should be shown as "NIL" or "NOT KNOWN" and not simply omitted.

(4) Spelling of ***DESTRESF*A** should read ***DETRESFA*** (*Figure 2.2P* below)

```
KLA637 072232
SS WMKKZQZX WMKKZRZX
072232 WMFCZQZX
(ALR-DESTRESFA/WMFCZQZX/MISSING
-FPL-MAS370-IS
-B772/H-SDFGHIJ3J5M1RWXY/LB1D1
-WMKK1635
-N0470F290 DCT PIBOS R208 IKUKO/M081F330 R208 IGARI M765
 BITOD/N0480F330 L637 TSN/N0480F350 W1 BMT W12 PCA G221
 BUNTA/N0480F370 A1 IKELA/N0480F370 P901 IDOSI/N0480F390 DCT CH
 DCT BEKOL/K0900S1160 A461 YIN/K0890S1130 A461 VYK
-ZBAA0534 ZBTJ ZBSJ
-PBN/A1B1C1D1L1O1S2 DOF/140307 REG/9MMRO EET/WSJC0032 VVTS0042
 ZJSA0210 VHHK0233 ZGZU0304 ZHWH0356 ZPE0450 SEL/QRCS
 RMK/ACASII EQUIPPED
-E/0710 P/TBN R/UVE S/M J/LF D/8 290 GREY A/WHITE WITH RED AND
 BLUE STRIPE C/TBN)
```

JABATAN PENERBANGAN AWAM * PENGURUSAN TRAFIK UDARA * HQ MALAYSIA * AIR TRAFFIC MANAGEMENT * DEPARTMENT OF CIVIL AVIATION

Source: DCA Malaysia

Figure 2.2P - DETRESFA Message sent over AFTN

Excerpt from ICAO DOC 4444, Air Traffic Management (PANS-ATM) Chapter 10, Air Traffic Services Messages, Appendix 3, Field Type 7

Appendix 3 — *A3-9*

Field Type 7 — Aircraft identification and SSR mode and code

FIELD TYPE 7

Format: – (a) Max. 7 characters * / b c

Previous type of field or symbol	*This type of field is used in*	*Next type of field or symbol*
5	ALR	8
3	RCF	21
3	FPL	8
3	CHG	13
3	CNL	13
3	DLA	13
3	DEP	13
3	ARR	13
3	CPL	8
3	EST	13
3	CDN	13
3	ACP	13
3	RQP	13
3	RQS	13
3	SPL	13

SINGLE HYPHEN

(a) *Aircraft identification*

NOT MORE THAN 7 CHARACTERS, being the aircraft identification shown in the filed flight plan and composed as specified in Appendix 2, Section 2.

* This field may be terminated here in messages relating to flights operating within areas where SSR is not used, or when the SSR code information is not known or would not be meaningful to the accepting unit.

OBLIQUE STROKE

(b) *SSR mode*

LETTER A giving the SSR mode related to (c).

(c) *SSR code*

4 NUMERICS giving the SSR code assigned to the aircraft by ATS and transmitted in the mode given in (b).

Examples: –BAW902
–SAS912/A5100

Figure 2.2Q - ATS Messages

Excerpt from ICAO DOC 4444, Air Traffic Management (PANS-ATM) Chapter 10, Air Traffic Services Messages, Appendix 3, Field Type 13 below

A3-14 *Air Traffic Management (PANS-ATM)*

Field Type 13 — Departure aerodrome and time

FIELD TYPE 13

Format: – | a | * | b |

SINGLE HYPHEN

(a) *Departure aerodrome*

4 LETTERS, being

the ICAO four-letter location indicator allocated to the departure aerodrome, as specified in Doc 7910, *Location Indicators*, or

ZZZZ if no ICAO location indicator has been allocated (*see Note 1*) or if the departure aerodrome is not known, or

AFIL if the flight plan has been filed in the air (*see Note 2*).

Note 1.— If ZZZZ is used, the name and location of the departure aerodrome is to be shown in the Other Information Field (see Field Type 18) if this Field Type is contained in the message.

Note 2.— If AFIL is used, the ATS unit from which supplementary flight data can be obtained is to be shown in the Other Information Field (Field Type 18).

* This field shall be terminated here in message types CPL, EST, CDN and ACP. It shall be terminated here in message type RQP if the estimated off-block time is not known.

(b) *Time*

4 NUMERICS giving

the estimated off-block time (EOBT) at the aerodrome in (a) in FPL, ARR, CHG, CNL, DLA and RQS messages and in RQP message, if known, or

the actual time of departure from the aerodrome in (a) in ALR, DEP and SPL messages, or

the actual or estimated time of departure from the first point shown in the Route Field (see Field Type 15) in FPL messages derived from flight plans filed in the air, as shown by the letters AFIL in (a).

Examples: –EHAM0730
–AFIL1625

Previous type of field or symbol	*This type of field is used in*	*Next type of field or symbol*
10	ALR	15
10	FPL	15
7	CHG	16
7	CNL	16
7	DLA	16
7	DEP	16
7	ARR	(16)** 17
10	CPL	14
7	EST	14
7	CDN	16
7	ACP	16
7	RQP	16
7	RQS	16
7	SPL	16

** Only in case of a diversionary landing

Figure 2.2R - ATS Messages

Excerpt from ICAO DOC 4444, Air Traffic Management (PANS-ATM) Chapter 10, Air Traffic Services Messages, Appendix 3, Field Type 20

Appendix 3 *A3-29*

Field Type 20 — Alerting search and rescue information

FIELD TYPE 20

Format: – [ ] (sp) [ ] (sp) * (sp) [ ]

(*EIGHT elements in all)

Previous type of field or symbol	*This type of field is used in*	*Next type of field or symbol*
19	ALR	)

This field consists of the following specified sequence of elements separated by spaces. Any information not available should be shown as "NIL" or "NOT KNOWN" and not simply omitted.

SINGLE HYPHEN

(a) *Identity of operator*

The ICAO two-letter designator of the aircraft operating agency or, if this has not been assigned, the name of the operator.

(b) *Unit which made last contact*

6 LETTERS consisting of the 4-letter ICAO location indicator followed by the 2-letter designator which together identify the ATS unit which made the last two-way contact or, if these are not available, some other description of the unit.

(c) *Time of last two-way contact*

4 NUMERICS giving the time of the last two-way contact.

(d) *Frequency of last contact*

NUMERICS as necessary giving the transmitting/receiving frequency of the last contact.

(e) *Last reported position*

The last reported position expressed in one of the data conventions of 1.6 of this Appendix followed by the time over that position.

Figure 2.2S - ATS Messages

cont…

Field Type 20 (cont.)

(f)	*Method of determining last known position*
	Plain-language text as necessary.

(g)	*Action taken by reporting unit*
	Plain-language text as necessary.

(h)	*Other pertinent information*
	Plain-language text as necessary.

Example: –USAF LGGGZAZX 1022 126.7 GN 1022
PILOT REPORT OVER NDB ATS UNITS
ATHENS FIR ALERTED NIL

Figure 2.2T - ATS Messages

s) Issues with Manual of Air Traffic Services (MATS)

i) MATS 1 PART 2 - GEN, page 2-2-1 stipulates that:

2.1.2 Controllers and other operational staff shall:

a. apply as appropriate the rules, procedures, separation minima and guidance material contained in this manual in the control of air traffic and in the provision of other air traffic service; and

b. additionally comply with directive detailed in SOIs, ROIs, and UOIs and in Operational Letters of Agreement.

2.1.3 Controllers shall not deviate from a rule or separation minima, but may however deviate from a procedure if in the opinion of the Controller the situation warrants.

2.1.4 if a situation that is not covered in this Manual arises, Controllers shall use their best judgement as to the procedure to be applied to handle the situation.

In any uneventful situations, there are specific actions that require ATC personnel to maintain a continuous watch in their respective working positions and not to rely on information from MAS ODC.

SECTION 2 – ANALYSIS

2.3 MEDICAL/HUMAN FACTORS ISSUES

2.3.1 Introduction

This section analyses general human performance issues such as the medical history, professional qualifications, training, factors related to mental and physical fatigue, crew-to-ground communications, psycho-social events, and other relevant factors.

The analysis was done based on the following sources gathered from:

1) Personal records/files of the PIC, FO and the cabin crew from MAS. These documents included the log book, certificates, licenses, medical records and any disciplinary/administrative actions;

2) Investigation details from the Polis Di Raja Malaysia (PDRM) - Royal Malaysia Police. These were statements obtained from the next of kin and relatives, doctors/care givers, co-workers, friends and acquaintances; financial records of the flight crew, CCTV recordings at KLIA and analysis of the radio transmission made between MH370 and ground Air Traffic Control;

3) Medical records from private health care facility and from MAS Medical Centre; and

4) Interviews with MAS staff and several of the next of kin of the crew.

The analysis attained from documentations, CCTV recordings and interviews were conducted ethically, based on professional assessments code of practice of the Team.

2.3.2 General Human Performance Issues

1) The flight-crew's medical background and recent activities were examined. All medical files reviewed showed no significant health-related issues. Information derived from interviews with the medical health care professionals in the MAS organisation, members of the family and some friends of the flight crew, and study of the available medical records indicate that the PIC and FO were in good health and certified fit to fly at the time of the flight.

2) The Team noted that the medical records or reports of the flight crew obtained from the MAS Medical Centre facility did not include medical records or reports from other medical facilities. In fact, the Team has found a medical record of the PIC from another private medical centre which was not recorded in the MAS Medical Centre. The records from the MAS Medical Centre as well as the records from private clinics regularly visited by both the flight crew also seemed to be mainly records related to minor ailments such as coughs and colds and may not be reflective of the complete medical record of the individuals in question.

3) Based on the available medical records, only one cabin crew member, the In-Flight Supervisor, was known to have a history of previous seizures in 2013 but was subsequently certified fit to fly. However, all the cabin crew were fit to fly at the time of the flight.

    a) All cabin crew were adequately rested before the flight based on the flying records.

    b) There is no evidence that members of the cabin crew had received any flight training, based on the '*Basic Flying Training*' and '*Aircraft Type Conversion Training'* (B777) records of the Company and records of DCA.

4) Both the PIC and FO held valid airman licenses and medical certification. They had received all the required training. It was concluded that both the PIC and FO were properly trained, licensed and qualified to conduct the flight.

5) Based on the flying records from the Scheduling Office, both the PIC and FO were within duty-time limits and therefore were adequately rested before the flight.

6) The interpersonal relationship between the PIC and FO was examined. There were no reports of any conflicts or problems between the PIC and FO prior to the flight or before the day of the flight. This is the first time the PIC and FO have flown together after the latter completed his upgraded training to the B777. The Team did not find any evidence of a strain in the relationship between the two. It was the FO's last Line Training flight before he was scheduled to be checked out. The FO's training progress was within the performance of new FOs promoted to the B777 from the smaller fleet.

2.3.3 Specific Human Factors Issues

In this section, the specific personal relationships, financial background, personal insurance coverage and benefits, past medical and medication history, as well as the recent behaviour of the PIC, FO and all the cabin crew were examined.

1) **Personal Relationships**

Information obtained from family and friends of both the PIC and FO suggested no recent changes or difficulties in personal relationships. There was nothing significant observed by the family and friends of the crew. The PIC and FO as well as the crew were not experiencing difficulties in any personal relationships.

2) **Pilot-in-Command**

The investigation into the personal and professional career revealed that the PIC had flawless safety records with a smooth career pathway to his existing position as a Type Rating Examiner on the B777 and has been well respected throughout his flying career. He was considered a leading pilot who was given privileges to be an instructor and examiner.

3) **First Officer**

The investigation into the personal and professional career revealed that the FO had a good safety record with a smooth career pathway to his existing position as a Co-pilot under training on the B777-200ER. The investigation into the FO's personal and professional history revealed no disciplinary records.

4) **Cabin Crew**

There is no evidence to suggest that any members of the cabin crew had experienced career-related incidents or mishaps resulting in major disciplinary records.

5) **Financial Background and Insurance Coverage**

Information obtained on the financial background for the PIC, FO and all the cabin crew showed no evidence of financial stresses or impending insolvency. Analysis of the bank financial statements did not reveal any incidents of unusual financial transactions.

Based on the available data, investment or trading accounts owned by the PIC were mainly inactive or dormant. The FO and cabin crew have no investment or trading accounts. Insurance coverage records were unremarkable which include generally life insurance policy, motor vehicle insurance policy, medical insurance policy and personal accident policy. There is no evidence of recent or additional insurance cover purchased by the PIC, FO or any members of the cabin crew.

6) Past medical and medication history

In the course of the investigation, it was confirmed that the PIC sustained a spinal injury as a result of a paragliding accident in January 2007. He was medically certified to have recovered from the injury, and there is no record of him being on long term medication for this, or other medical ailments. Scrutiny of his credit card transactions failed to reveal a pattern of regular purchase of over-the-counter medication of any significance, either in local or overseas pharmacies. The possibility that such medication may have been purchased by cash cannot be excluded.

The Team has further investigated the overseas over-the-counter prescriptions as there was no recorded transaction on the PIC's credit card on any medications purchased. The Team specifically investigated the possibility of mental/stress-related ailments in the PIC and concluded that there is no medical record or other documentation of the PIC having received psychiatric treatment.

Similarly, there was no documented unusual health-related issues involving the FO. Other than the Inflight Supervisor, the other members of the cabin crew have no significant health-related issues.

7) Recent Behaviour

According to family members and work associates who interacted with the PIC, FO and the cabin crew on the day of the flight and on their most recent flights, there were no behavioural signs of social isolation, change in habits or interest, self-neglect, involvement in drug or alcohol abuse. There were no significant behavioural changes observed on all the CCTV recordings for the PIC, FO and cabin crew related to the flight.

8) Overall Comments

Evidence from the medical/human factors issues showed no unusual issues on the PIC, FO and cabin crew.

2.3.4 Human Factor Aspects of Air Traffic Control Recordings

1) Voice analysis

No Cockpit Voice Recorder (CVR) and Flight Data Recorder (FDR) analysis could be done as the wreckage is yet to be found. From the available information, the speech segments for the first 3 sets of audio recordings (Airway Clearance Delivery, Lumpur Ground and Lumpur Tower) were those of the FO before take-off and the 4^{th} and 5^{th} sets of the audio recordings (Approach Radar and Lumpur Radar) originated from the PIC after take-off.

The Team has noted nothing unusual in the conversations by the PIC and the FO with the assigned traffic Controllers. The last sentence of "*Good Night Malaysian Three Seven Zero"* was spoken by the PIC at 1719:30 UTC [0119:30 MYT].

2) Air Traffic Control Recordings

Radiotelephony recordings between the flight crew and the Air Traffic Controllers were analysed for voice recognition and it was verified that the words spoken before take-off and after take-off were that of the FO and PIC respectively. The Team has made comparison of the voice sample analysis recorded previously and found no evidence that there was any stress or anxiety detected in the conversations. It was noticed that the PIC made the same statement of "maintaining flight level three five zero' twice at 1701.17 UTC [0107.57 UTC [0107.56 MYT]. However, the Team did not find any significance of that statement spoken twice by PIC in a short interval of 6.39 minutes.

SECTION 2 – ANALYSIS

2.4 AIRWORTHINESS & MAINTENANCE AND AIRCRAFT SYSTEMS

2.4.1 Airworthiness & Maintenance

The review of the aircraft Airworthiness and Maintenance records revealed the following:

1) No current airworthiness issues were noted. There was no evidence of any pre-existing aircraft defects that would affect the safety of the flight.

2) An assessment of the Aircraft Log Book since the original issue of the Certificate of Airworthiness by the Department of Civil Aviation, Malaysia on 03 June 2002 indicated that the aircraft maintenance was carried out in accordance with the approved manufacturer's Maintenance Planning Document and in compliance with the Department of Civil Aviation Malaysia Approved Maintenance Schedule requirements. The Certificate of Airworthiness was valid at the time of the occurrence and the next Certificate of Airworthiness was due on 02 June 2014.

3) The last A1 Check was carried out on 23 February 2014 at 53,301:17 hours and 7,494 cycles. It was also noted that the last A4 Check was carried out at Malaysia Airlines Base Maintenance at KLIA, Sepang from 14 to 16 January 2014 at 52,785:37 airframe hours and 7,422 cycles respectively.

4) The right wing tip which was damaged during taxi at Pudong, Shanghai Airport on 09 August 2012 was assessed and repaired by Boeing AOG Team at Pudong, Boeing Shanghai facility from 22 September to 03 October 2012 as per MAS-RE-1209619 instructions. The Boeing repair scheme was approved under DCAM Statement of Compliance Reference Number SC/2012/081. There was no evidence of structural anomaly in the repair scheme. The repair had no bearing on the observed events on the event flight, i.e. it would not have affected any of the on-board equipment. There was a requirement, however, for damage tolerance information to be incorporated in the aircraft maintenance programme within 24 months from 02 October 2012, as stated in the FAA Form 8100-9 for the approval of the repair by the FAA Organisation Designation Authorization (ODA). This damage

tolerance information was not yet included in the maintenance programme for the aircraft at the time of the occurrence. The due date for the incorporation would be by 02 October 2014. Incorporation of the information in the maintenance programme would address any maintenance that becomes necessary as a result of the damage tolerance assessment. However, the investigation assessed that this had no effect on the occurrence flight.

5) The cabin re-configuration was approved under the FAA STC and DCAM SOC and there is no evidence of any documented deviation from stipulated design changes.

6) A review of aircraft concessions during the last year of operation revealed that Malaysia Airlines Quality Assurance Department had requested from the Department of Civil Aviation, Malaysia for a 10-day or 100-hour extension for a C1 check from 22 August to 01 September 2013. This request was approved. There were no other concessions recorded in the Aircraft Log Book.

7) A review of Malaysia Airlines Airworthiness Directives indicated that all the applicable Airworthiness Directives for mandatory compliance were complied with.

8) A review of the recent Technical Log Book entries by the flight and ground crew did not reveal any significant defects or trends.

9) A review of Malaysia Airlines list of Hard Time Components installed on the aircraft showed that the SSFDR ULB battery life was overdue at the time of the occurrence. There was no evidence of other overdue maintenance.

10) According to maintenance records, the SSFDR ULB battery expired in December 2012. There is no evidence to suggest that the SSFDR ULB battery had been replaced before the expiry date. The SSCVR ULB battery however was replaced, as scheduled, with the next expiry in June 2014. There is some extra margin in the design to account for battery life variability and ensure that the unit will meet the minimum requirement. However, once beyond the expiry date, the ULB effectiveness decreases so it may operate, for a reduced time period until it finally discharges. While there is a definite possibility that a ULB will operate past the expiry date on the device, it is not guaranteed that it will work or that it would meet the 30-day minimum requirement.

There is also limited assurance that the nature of the signal (characteristics such as frequency and power) will remain within specification when battery voltage drops below the nominal 30-day level.

Technical Log records showed that the SSFDR (together with the ULB) was replaced on the aircraft on 29 February 2008. Component installation records for the ULB showed that at the time the SSFDR was replaced on the aircraft the expiry date for the battery was December 2012.

Interviews were held with the MAS Engineering Technical records staff to determine why the ULB battery was not replaced before the expiry. It was revealed that the Engineering Maintenance System (EMS, a computer system used to track and call out maintenance) was not updated correctly when the SSFDR was replaced on 29 February 2008. The update involves 'removal' of the old unit in the system followed by 'installation' of the new unit. In this particular instance, although the old unit was 'removed', the new unit was inadvertently not recorded as 'installed' in the system. If the system was updated correctly on the installation, the next due date for removal would have been for the replacement of the ULB battery. Since the system was not updated it did not trigger the removal of the SSFDR for replacement of the ULB battery when it was due. ULB battery replacement is normally done in the workshop by routing the removed SSFDR, together with the ULB, to the workshop. This oversight was not noted until after the disappearance of MH370 when details of the ULBs were requested.

Subsequently, MAS Engineering Technical records staff carried out a fleet-wide record inspection for the ULBs to ensure all records for other aircraft were updated accordingly.

2.4.2 Emergency Locator Transmitters

The aircraft was fitted with four Emergency Locator Transmitters (ELTs) meeting the current ICAO and regulatory requirements at the time. All four ELT battery lives were within the required expiry dates. No ELT signal from 9M-MRO was reported by the responsible Search and Rescue agencies or any other aircraft. There have been reported difficulties with the transmission of ELT signals if an aircraft enters the water, such as in the case of Air France flight AF447. In these instances, the ELT does not activate, or the transmission is ineffective as a result of being submerged under water. Furthermore, the ELT itself could be damaged or, very commonly in the case of fixed ELTs, the antenna or antenna cables become disconnected or broken. This significantly hampers any search and rescue effort and may mean the aircraft location remains undetected for a considerable time. A review of ICAO accident records (refer to *Appendix 1.6D*) over the last 30 years indicates that of 173 accidents involving aircraft fitted with ELTs, only 39 cases recorded effective ELT activation.

Following the disappearance of MH370 and in line with Global Aeronautical Distress and Safety System (GADSS) recommendation an amendment to ICAO Annex 6, Part 1 has been proposed for an Automatic Deployable Flight Recorder (ADFR). The ADFR is a combination recorder fitted into a crash-protected container that would deploy from an aircraft during significant deformation of the aircraft in an accident scenario. Considering the design and deployment features of a deployable recorder, the recorder is usually fitted externally, flush with the outer skin towards the tail of the aircraft. To find a deployed ADFR, an Emergency Locator Transmitter (ELT) is integrated in the ADFR. This ELT has the added advantage to assist in locating the accident site and facilitate search and rescue efforts. In the case of a new generation ELT being fitted, the ELT will provide emergency tracking data before the impact. Furthermore, if the wreckage becomes submerged in water, the traditional ELT signal will be undetectable, but with the deployable recorder being floatable, the ELT signal would still be detectable, and the deployable recorder would be recovered quicker. As the ADFR is floatable, there is no requirement for an underwater locating device.

2.4.3 Aircraft Health Monitoring

The Maintenance Control Centre (MCC) of Malaysia Airlines did not receive any fault messages through ACARS during the event flight even up to the time the last ACARS report was transmitted. Depending on the type of failure, failure of the ACARS itself can be reported by the system. However, no such reports were received for the flight. The traffic log of maintenance messages transmitted for the last 10 flights for the aircraft indicated that the CMCS was functioning appropriately before the event flight. On an average, 11 maintenance messages, of various systems, were transmitted on each flight. A review of the maintenance history showed no evidence of a defect trend on the CMCS.

2.4.4 Aircraft Systems Analysis

The aircraft systems analysis is severely limited by the lack of available evidence. The information in this section is primarily inferred from SATCOM transmissions, aircraft system characteristics, radar data, and the absence of other communications from the aircraft for the majority of the flight.

1) Air-conditioning, Pressurisation and Oxygen

The SATCOM handshake data indicated that the aircraft was airborne for approximately 7 hours, 37 minutes (Take-off: 0042 MYT to Last SATCOM Handshake: 0819 MYT). That the aircraft flew quite some distance over a long period suggests that it flew at high altitude. Refer to the aircraft performance section in *Section 1.6.9*.

There is no evidence from the limited data available on the status of the aircraft air-conditioning and pressurisation systems during the flight. There was no Mandatory Occurrence report raised for this aircraft on pressurisation issues. A review of the Technical Log entries since the last D check in June 2010 did not reveal any defect trends in the air conditioning or the pressurisation systems. There were also no such defects reported prior to the event flight. There was an FAA Airworthiness Directive (AD) issued which made mandatory the accomplishment of Boeing Service Bulletin 777-53A0068 which addresses a crack in the fuselage skin under the SATCOM antenna adapter. This Service Bulletin was issued on 12 June 2013. A crack in the fuselage skin could lead to rapid decompression and loss of structural integrity of the aircraft. However, this AD or the Service Bulletin was not applicable to 9M-MRO due to a different configuration and location of the SATCOM antennas.

In the event of a complete pressurisation failure, however, oxygen would be available for the flight crew through the flight crew oxygen system and masks. Two cylinders located in the left side of the main equipment centre, each of 115 cubic feet (3256 litres), would be able to supply oxygen to a single person for a duration of 27 hours, or for 2 persons for a duration of 13 hours.

For the passengers, oxygen could be supplied by chemical oxygen generators located in passenger service units (PSUs). A door with an electrically operated latch keeps the masks in a box until the oxygen deployment circuit operates. The deployment circuit would operate, and the masks automatically drop from the PSUs if cabin altitude were to exceed approximately 13,500 ft. Oxygen would flow when any mask hanging from that PSU was pulled. Oxygen would be available for approximately 22 minutes. The passenger masks can be manually deployed from the cockpit by pushing the overhead panel PASSENGER OXYGEN switch to the ON position. The electrical power to the latch is supplied through a circuit breaker located in the Main Equipment Centre. It is not possible to deactivate automatic deployment of the masks from the cockpit.

There are also portable oxygen cylinders located throughout the cabin which let the flight attendants move in the aircraft when oxygen is in use. It is also a gaseous oxygen supply for medical emergencies. The cylinders are fitted with a disposable mask. 15 cylinders are located throughout the passenger cabin. Each cylinder is of 11 cubic feet (310 litres) capacity. The flow of oxygen can be controlled by an ‘Off-On’ knob which can be rotated to control the flow from 0 to 20 liters per minute.

A review was carried out of whether there could have been an oxygen leak in the crew oxygen system. A leak of oxygen is a potential source for fire to break-out. A review of the Technical Log entries since the last D check in June 2010 did not reveal any oxygen leak in the system. There had been the usual servicing of the oxygen system when the pressure had dropped from the nominal level. The Stayover check, which is carried out whenever the aircraft planned ground time exceeds 6 hours, calls for the crew oxygen pressure to be checked. It has been the practice of the airline to service the oxygen system whenever time permits, even if the pressure is above the minimum required for dispatch (310 psi at 35°C). Tech Log entries showed that the system was serviced when the pressure dropped to, on an average, 1100 psi. On 07 March 2014, prior to the last flight, the pressure was noted to be 1120 psi and serviced to 1800 psi. However, it was not possible to eliminate the possibility of an oxygen leak on the event flight.

Another potential source of fire fed by oxygen is the issue highlighted in FAA AD 2012-13-05 which made mandatory the accomplishment of Boeing Service Bulletin 777-35A0027, as highlighted in *Section 1.6.4 para. 5)*. An electrical fault or short circuit can result in electrical heating of the low pressure oxygen hoses in the flight crew oxygen system and can cause the low pressure oxygen hose to melt or burn.

This can result in smoke and/or fire in the flight compartment. This service bulletin was already accomplished on 9M-MRO on 17 January 2014 by replacing the low pressure oxygen hoses with non-conductive low pressure oxygen hoses, reducing the likelihood of this potential source of fire.

2) Autoflight

The turn after IGARI was made from a heading of about 060° to a final heading of about 240° (a change of 180°) based on recorded radar data. Simulator sessions indicated that a bank angle of at least 30° is required to accomplish a half rate turn, of 180° in 2 minutes with a Ground speed of about 470 knots. Such a turn is not possible using autopilot as the bank angle is limited up to a maximum of 25° in any of the autopilot modes, such as LNAV or HDG SEL. Using LNAV mode, the time taken to make the turn is greater than 3 minutes. At an Indicated airspeed (IAS) of 250 knots (groundspeed – GS, of 425 knots) it took 3 minutes 3 seconds while at an IAS of 220 knots (GS of 400 knots) it took 3 minutes 30 seconds. Both manoeuvres were at 35,000 ft. Refer to *Section 2.1* on a discussion on this. From the simulator sessions it is evident that the turn itself was most likely made with the autopilot disengaged.

It is unclear how the aircraft was flown for the remainder of the flight, however the aircraft made several other turns and rolled out to level flight after the turn after IGARI. The SATCOM data indicated that the aircraft was airborne for more than 7 hours suggesting that the autopilot was probably functioning, at least in the basic modes.

3) Electrical Power

As the aircraft SATCOM system was providing log-on information to the INMARSAT satellites it can be deduced that at least part of the SATCOM system had electrical power. The SATCOM system components including the Satellite Data Unit (SDU), Radio Frequency Unit (RFU), High Power Amplifier (HPA), Low Noise Amplifier/Diplexer (LNA/DIP) and the Beam Steering Unit (BSO) are powered by the 115V AC, Left Main AC bus. This bus is normally powered by the Left Engine Generator, however a failure of the generator or the power feed to it will cause the Bus Tie Breakers to close and automatically let the Right Engine Generator power the bus.

This bus can also be powered by the Auxiliary Power Unit (APU) Generator, if the APU is started manually or automatically (such as a loss of power to both engines).

The above suggests that at least one generator was operating and providing the power to the SATCOM system after power was restored at 1825 UTC following the interrupt of between 22 to 78 minutes.

SATCOM operation, especially the electronic steering of the Radio Frequency signals through the antenna to the satellite, requires the Air Data Inertial Reference Unit (ADIRU) to be functioning. The ADIRU, which is a single unit on this aircraft, is an integrated unit having internal redundancy and provides the air data and inertial reference functions. It is powered either by the Right 28 Volt DC bus, the Left 28 Volt DC bus or the hot battery bus (a direct connection to the aircraft battery). The DC busses can be powered by the respective Main AC busses (after being rectified to DC) or by automatic switching (in case of failure of the respective AC bus) by the opposite Main AC bus. The battery itself can only supply power for a short duration, so it is highly likely that the source of power for the ADIRU was one of the generators as the SATCOM system was powered for many hours.

The operation of the SATCOM not only depends on the supply of power to its own system, it also depends on the supply of power to other systems feeding it, such as the ADIRUs. This inter-dependency of operation suggests that significant parts of the aircraft electrical power system were probably functioning throughout the flight.

4) Flight Controls and Hydraulics

The primary flight control system is highly redundant, with three operating modes: normal mode, secondary mode, and direct mode. The primary flight controls are powered by redundant hydraulic sources. The hydraulic systems are pressurised from the engines and the electrical actuation systems are similarly highly redundant. The secondary flight controls, high lift devices consisting of flaps and slats, are hydraulically powered with an electrically powered backup system. It is highly likely that the primary flight controls were functional as the aircraft altered the flight path several times and maintained flight for a long duration.

5) Instrumentation

Flight instruments are required only to fly the aircraft manually. The aircraft was equipped with Standby flight instruments which operate independently of the Primary flight instruments. Operation of the autopilot is not dependent on operation of the flight instrument displays.

Due to the lack of available evidence, it was not possible to determine the extent to which the instrumentation was operable throughout the flight. However, the instrumentation system, and the system that feed information to it, are highly redundant and driven from multiple automatically-reconfigurable electrical power sources. Based on the findings that several systems (particularly ADIRS, AIMS and SATCOM) were operable for some or all of the flight, it is very likely that some or all instrumentation was available.

6) Navigation

The main systems that are relevant for consideration are the Air Data Inertial Reference System (ADIRS), the Flight Management System (FMS) and the Global Positioning System (GPS).

If the autopilot (at least the basic modes) was functional, the ADIRS must have been operating satisfactorily because an essential input to the autopilot is the aircraft attitude which is provided by the ADIRU, the main unit of the ADIRS. In addition, the SATCOM continued to transmit during the flight as evidenced by the handshakes (*Section 1.9.5*). The SATCOM was using the High Gain Antenna for tuning. This shows that the ADIRU was operable, otherwise the Low Gain Antenna (LGA) would have been used.

As for the Flight Management System, it is unclear whether the system was functioning properly throughout the flight. This system is not essential for the operation of the autopilot.

The GPS is required for position updates of the FMS. Accurate navigation is dependent on GPS inputs. However, the ADIRU can provide the navigation reference without GPS inputs, although with lesser accuracy.

7) Engines

The aircraft satellite transmission associated with the 7th arc is most likely associated with power interruptions on board the aircraft caused by fuel exhaustion (*Section 2.4.4 para. 9)*. The time of this transmission is consistent with the maximum flight times expected for the MH370 flight, based on the total weight of fuel remaining during the last ACARS transmission at 1707 UTC. It is highly likely that both the engines were operating for the aircraft to have flown for more than 7 hours with that amount of fuel on board.

The Engine Health Monitoring (EHM) system trend reports over the last 3 months which cover ‘snapshot’ data points gathered at take-off, climb and cruise also showed no evidence of unusual engine behaviour for both engines. Similarly, the last report (Climb report) received at 1652 UTC on 07 March 2014 (0052 MYT on 08 March 2014) and the earlier Take-off report, do not show any unusual engine behaviour. Furthermore, there were no fault messages transmitted by the CMCS to indicate any engine abnormalities, before the ACARS last transmission.

8) Fuel Systems

The fuel systems were most probably functioning satisfactorily as the performance of the engines was dependent on this. It is unlikely that there were any problems in these based on the premise that the aircraft most likely flew to fuel exhaustion, as explained in *Section 2.4.4 para. 9)*.

9) Auxiliary Power Unit

The operation of the Auxiliary Power Unit (APU) during the majority of the flight is uncertain although it is possible that it started up automatically (as it should) after both engines shutdown due to fuel exhaustion at the end of the flight. This start-up and power-up of the electrical buses most likely caused the 7th and last, aircraft initiated SATCOM handshake.

Performance calculations indicate the possibility that the aircraft would have reached fuel exhaustion at, or before the time of the 7th handshake. After a single engine shutdown, automatic switching of the electrical tie breakers would ensure the Left and the Right Main busses and the Left and Right Transfer busses were still powered by the remaining generator driven by the running engine. After the shutdown of the second engine following fuel exhaustion, the Main busses and the Transfer busses would have de-energised as there would be no generators powering these busses. An electronic logic in the APU starting system would automatically start the APU, if the aircraft was in the air, and both the Left and Right Transfer busses were not powered. As the fuel inlet for the APU is below that of the engines (left engine main fuel inlet in the left tank) the APU can start up and run for about 14 minutes even though the aircraft engines themselves are exhausted of fuel from the fuel tanks as the difference in the fuel intake levels would provide about 30 pounds of fuel. It would take about 1 minute for the APU to start up and power the busses and once powered, the Satellite Data Unit (SDU) of the SATCOM would take approximately another 1 minute to initiate the 'handshake', which would have been the 7^{th} and last SATCOM handshake. Both the APU start up and the initialisation of the handshake by the SDU would have happened within the 14 minutes of running time available from the 30 pounds of fuel, after which the APU would have shut down due to its own fuel exhaustion.

10) Communications

The aircraft was fitted with many communication systems, available to the flight crew. Among them were the High Frequency (HF) system, the Very High Frequency (VHF) system, the Air Traffic Control system including the Mode S Transponder, the ACARs and the SATCOM. The SATCOM phone in the cabin was available for the cabin crew. Despite the availability of all these systems no communications were received from the aircraft after the last communication at 1719:30 UTC, 07 March 2014 (0119:30 MYT on 08 March 2014) except for the 'handshakes' received from the SATCOM system.

a) High Frequency System

Communication with ATC after take-off is normally through the VHF. The HF system is for communication with ground stations or other aircraft during long overwater flights. There was no evidence to indicate that the HF systems (Left or Right) were used prior to the aircraft's last communication at 1719:30 UTC on 07 March 2014. This communication was through VHF. There was no message received from the aircraft to report on a HF system failure or system technical error prior to the last voice or ACARS communication. There was also no recent defect trend on the HF systems.

b) Very High Frequency System

The aircraft VHF system was operating satisfactorily as evidenced by the communication by the flight crew to ATC up to the last communication at 1719:30 UTC, 07 March 2014 (0119:30 MYT, 08 March 2014). There were three independent VHF communication systems on the aircraft. The crew normal procedure is to use the Left VHF for communications. There was no message received from the aircraft to report on the VHF system failure or system technical error prior to the last voice or ACARS communication. There was also no recent defect trend on the VHF systems.

c) Air Traffic Control/Mode S Transponder System

The aircraft transponder was operating satisfactorily up to the time it was lost on the ATC radar screen at 1720.36 UTC, 07 March 2014 (0120:36 MYT, 08 March 2014). There was no message received from the aircraft to report a system failure prior to the last voice or ACARS communication. The crew procedure for normal operations is to select the left system on the control panel so the left system was likely in use. Failure of the system will be annunciated in the cockpit so that the crew can select the operating system.

The Left ATC/Mode S transponder gets 115V AC power from the AC Standby bus. The Right ATC/Mode S transponder gets 115V AC power from the Right AC Transfer bus. The dual transponder panel gets 115V AC power from the AC Standby bus. The two transponders are powered by highly reconfigurable AC buses; the left one can be powered by the battery if the left AC bus is unavailable (the AC Standby bus can be powered by the left Transfer bus or the battery), and the AC Transfer busses also have their alternate sources (the Main AC busses). It is likely that the Right Main AC bus was available because otherwise the ADIRU would have lost alignment (which it did not). It is likely that the power sources for one or both transponders were available.

This system can be deactivated (turned OFF) by pulling the circuit breakers located at the P11 overhead circuit breaker panel in the cockpit or by selecting the Transponder Mode

Selector (Transponder Panel) to "STBY" position. Selecting the Mode Selector to "STBY" will deactivate both the transponders.

d) Aircraft Communications Addressing and Reporting System

The ACARS communicates through either the VHF or the SATCOM systems. The ACARS datalink connects to the Satellite Data Unit (SDU) of the SATCOM system and the Center and Right VHF Communication Transceivers of the VHF systems. The Center VHF exchanges data with the ACARS modem in the Communications Core Processor Module (CPM/Comm) of the Left AIMS cabinet. The right VHF exchanges data with the ACARS modem in the CPM/Comm of the Right AIMS cabinet. The ACARS does not interface with the Left VHF Transceiver.

For the ACARS operation the Data Communication Management Function (DCMF) of the AIMS uses the voice/data select to set the VHF Communication Transceiver to the data signal mode. At power-up, the DCMF sets the Center VHF Communication Transceiver to the data signal mode. If the Center VHF Communication Transceiver fails, or voice is selected manually by the flight crew, the DCMF selects SATCOM for data transmissions. If SATCOM fails, the DCMF selects the Right VHF Communication Transceiver for data transmissions. The Left VHF Communication Transceiver is voice only. On the event flight, voice was selected for the Center VHF on the ground which resulted in the ACARS using SATCOM for the data transmissions, as shown in the SATCOM Ground Station Logs (refer to *Section 1.9.4*).

As the ACARS function is part of the AIMS there is no direct way of removing electrical power from the ACARS. This would require removing power to the AIMS which would disable many other systems as the AIMS manages data for several integrated avionics systems. However, it is possible to deactivate the ACARS downlink function from the ACARS Manager page in the Communications main menu on the selected Multifunction Display (MFD) in the cockpit. However, this will not affect the SATCOM handshakes. The COMM display switch, located on the display select panel, displays the communications main menu on the selected MFD. The

ACARS Manager page allows the flight crew to select/deselect VHF or SATCOM transmission of data (*Figure 2.4A* below). ACARS is set to auto mode (both boxes selected) at power-up or during a manual data communication system reset. Normally, this permits ACARS to automatically use VHF or SATCOM (if VHF is unavailable). If both boxes are deselected, ACARS loses the capability to send downlink messages, but can receive and display uplink messages.

Once deselected, a power interruption, will not cause the ACARS to be set to auto mode (both the VHF and SATCOM boxes selected) again. For the ACARS to be set to auto mode, either a data communication system reset or a power-up is done. The system does an automatic data link system reset 10 minutes after last engine shutdown and first passenger door open. This would explain why the power resumption at 1825 UTC following the interruption (*Section 1.9.5 para. 4*) did not activate the ACARS downlink again (with the assumption that both the VHF and SATCOM boxes were deselected).

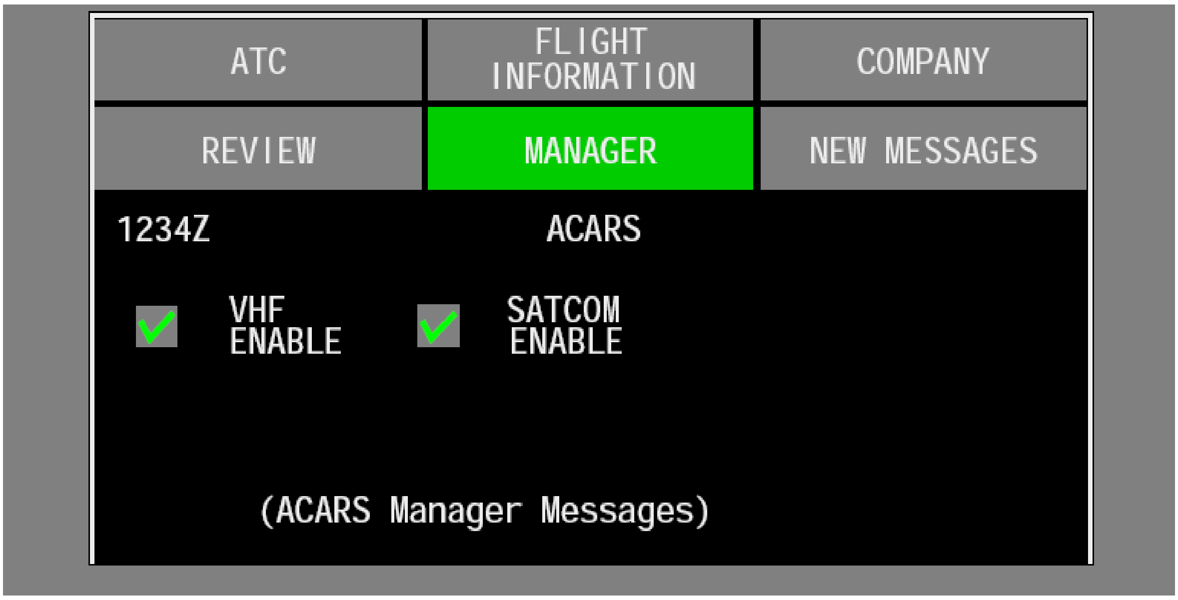


Figure 2.4A - ACARS Manager Page on MFD

The last position report transmitted via ACARS was at 1707:29 UTC, 07 March 2014 (0107:29 MYT, 08 March 2014). Parameters recorded (*Table 2.3A*) were as follows:

Greenwich Mean Time (GMT)	1706:43 UTC
Altitude (ALT)	35004 feet
Calibrated Airspeed (CAS)	278.4 knots
MACH	0.821 Mach
Total Air Temperature (TAT)	-13.1° C
Static Air Temperature (SAT)	-43.8° C
Latitude (LAT)	5.299
Longitude (LONG)	102.713
Gross Weight (GWT)	480,600 lb
Total Remaining Fuel Weight (TOTFW)	43,800 kg
Wind Direction (WINDIR)	70.0
Wind Speed (WINDSP)	17.13
True Heading (THDG)	26.7

Table 2.4A - Last Position Report from ACARS

All programmed communications via ACARS prior to 1707:29 UTC were working satisfactorily.

After this last automatic ACARS transmission over the SATCOM, either the ACARS was turned off or the AIMS had a fault that prevented ACARS transmissions while certain other functions such as inertial data forwarding did not appear to be significantly affected.

e) Satellite Communication System

Refer to *Section 2.5* for the detailed analysis of SATCOM.

11) Airplane Information Management System

The Airplane Information Management System (AIMS) is designed with several redundancies to be failure tolerant. The system consists of two cabinets performing almost identical operations. The signal outputs of these cabinets are fed onto common busses which are shared by the various systems. These two cabinets are also isolated in location, the Left AIMs is located in the forward rack of the Main Equipment Centre (MEC) while the Right AIMS is located in the rear rack of the MEC.

The AIMS cabinets also receive electrical power from different busses. The Left AIMS cabinet gets electrical power from the 28V

DC Capt Flight Instrument bus and the 28V DC F/O Flight Instrument bus. The Right AIMS cabinet gets electrical power from the 28V DC Left bus and the 28V DC Right bus. Each cabinet receives the power from four 28V DC circuit breakers in the overhead circuit breaker panel. The four 28V DC bus inputs, known as power 1 through power 4 enter the cabinets through different routings. Power 1 and power 2, known as left power, enter the cabinet through a connector on the left side of the cabinet. Power 3 and power 4, known as right power, enter the cabinet through a connector on the right side of the cabinet.

Each AIMS cabinet has four Input/Output modules (IOM) and four Core Processor Modules (CPM). These are Line Replaceable Modules (LRM). The IOM transfers data between the software functions in the AIMS CPMs and external signal sources. The CPMs supply the software and hardware to do the calculations for several avionic systems. The software is called functions. To keep a necessary separation between the functions, each function is partitioned. The partitions permit multiple functions to use the same hardware and be in the same CPM. Each LRM receives power from four sources, two for main power and two for monitor power. The main circuitry uses the main power. Special circuits that monitor the condition of the power supply in the LRM use the monitor power. The two main and two monitor sources of power for each LRM come from different power sources. Each LRM must have at least one main and one monitor power input to operate. The loss of any one of the four power buses to the backplane power bus or to any one LRM has no effect on the function of the LRMs. The loss of two power inputs from the same side of the cabinet, left or right, has no effect on the function of the LRMs. The loss of one power input from the left side and one power input from the right side results in the loss of function in four LRMs. The loss of three or four of the power buses to the cabinet chassis power backplane results in the loss of function of all the LRMs.

Each AIMS cabinet also receives power through one hot battery bus circuit breaker in the standby power management panel. The connection to the hot battery bus keeps the LRMs internal memories active. The hot battery bus also makes the AIMS cabinet less likely to have faults due to power transients.

Given the preceding arrangement of dual and distant location of the AIMS cabinets, independent and multiple power sources and separation of the computing functions the likelihood of failure of the AIMS operation is remote. Furthermore, operation of the SATCOM is reliant on satisfactory operation of the AIMS. Regular SATCOM ‘handshakes’ were present, till the 7th and last handshake at 0019 UTC. This indicates that the AIMS, or at least part of it, was operational.

2.4.5 Summary

From the foregoing discussion it can be generally deduced that there is no evidence to suggest that a malfunction had caused the aircraft to divert from its filed flight plan route. The aircraft’s maintenance history and events prior to the last flight do not show any issues that could have contributed and resulted in the deviation and subsequent changes in the flight path. Although it cannot be conclusively ruled out that an aircraft or system malfunction was a cause, based on the limited evidence available, it is more likely that the loss of communication (VHF and HF communications, ACARS, SATCOM and Transponder) prior to the diversion is due to the systems being manually turned off or power interrupted to them or additionally in the case of VHF and HF, not used, whether with intent or otherwise.

Similarly, the recorded changes in the aircraft flight path following waypoint IGARI, heading back across peninsular Malaysia, turning south of Penang to the north-west and a subsequent turn towards the Southern Indian Ocean are difficult to attribute to any specific aircraft system failures. It is more likely that such manoeuvres are due to the systems being manipulated.

The analysis of the relevant aircraft systems taking into account the route followed by the aircraft and the height at which it flew, constrained by its performance and range capability, does not suggest a mechanical problem with the aircraft.

SECTION 2 – ANALYSIS

2.5 SATELLITE COMMUNICATIONS ANALYSIS

2.5.1 Summary of Key Observations of the SATCOM Ground Station Logs

The key observations of the SATCOM Ground Station Logs, with an assessment, are summarised below:

1) Prior to take-off, the SATCOM Logged On (normally) a number of times, the last time being at 1600, when it sent a valid Flight ID to the Ground Earth Station (GES). The SATCOM link was available for both voice and data (known as Log-On Class 3).

2) After take-off, the In-Flight Entertainment System (IFE) Short Messaging System (SMS) e-mail application sent a normal beginning of flight message at 1642 (containing the correct Airborne Earth Station (AES ID), Flight ID "MAS370", origin airport "WMKK", and destination airport "ZBAA"), indicating that the IFE was receiving the valid Flight ID, origin airport and destination airport from Airplane Integrated Management System (AIMS) and the ICAO (AES) ID from the Satellite Data Unit (SDU) at this time.

3) The SATCOM link was available for most of the flight, excluding periods leading up to 1825 on 07 March 2014 and 0019 on 08 March 2014.

4) When the SATCOM link was re-established at the above times, no Flight ID was present. This implies that a valid Flight ID probably stopped being sent to SATCOM at some time between 1642 (when the IFE reported the correct Flight ID) and 1825 (when the SATCOM Logged On with no Flight ID) on 07 March 2014. The possible reasons for the link losses and the subsequent Log-Ons that took place at 1825 and 0019 have been investigated and are detailed in tables in *Section 2.5.2.* There are many quite complicated scenarios that could have caused the 1825 Log-On. However, the most likely reason is a lengthy power interrupt to the SATCOM. The most likely reason for the 0019 Log-On was also a power interrupt to the SATCOM.

5) During the two in-flight Log-Ons at 1825 and 0019, the GES recorded abnormal frequency offsets for four burst transmissions from the SATCOM. After extensive analysis, the following explanations have emerged.

The 1825 Log-On Request had a non-zero BER and could therefore have been logged at the Ground station with a BFO measurement error suggesting that the BFO figure may not be reliable.

a) 1825 Log-On Acknowledge - Most likely due to the power-on drift of the SDU Oven Controlled Crystal Oscillator (OCXO), thus endorsing the belief that the 1825 Log-On was preceded by a lengthy power interrupt.

b) 0019 Log-On Request - Could have been due to uncompensated vertical velocity, indicating that the aircraft was likely to be descending at this time. Alternatively, it could have been due to the OCXO warm up drift, or it could have been due to a combination of uncompensated vertical velocity and OCXO warm up drift.

c) 0019 Log-On Acknowledge - Could have been due to uncompensated vertical velocity, indicating that the aircraft was likely to be descending at this time. Alternatively, it could have been due to the OCXO warm up drift, or it could have been due to a combination of uncompensated vertical velocity and OCXO warm up drift.

d) It has not been possible to attribute specific correction values to the 1825 Log-On Acknowledge and 0019 Log-on Request and Log-On Acknowledge BFOs, so it was excluded from the Doppler calculations undertaken by the Aircraft Flight Path/Performance Subgroup. In the case of the 1825 Log-On Acknowledge, the following subsequent bursts were used instead, as the frequency is more stable at these times:

    i) 1828:05.904 Data-3 R-Channel burst.

    ii) 1828:14.905 Data-3 R-Channel burst.

6) There is no indication of the SATCOM link being manually Logged Off from the cockpit (via a Multi-function Control Display Unit [MCDU]). Such activity would have been captured in the GES logs, but it was not.

7) No Data-2 Aircraft Communications Addressing and Reporting System (ACARS) traffic was observed after 1707 on 07 March 2014.

8) The IFE equipment set up two ground connections over SATCOM (for the SMS e-mail application and Built-In Test Equipment (BITE) application) after the SATCOM re-established the link at 1825 on 07 March 2014 (normal), but not after the SATCOM re-established the link at 0019 on 08 March 2014 (abnormal). In the 0019 case, it is possible that the IFE was no longer powered, or failed, or that the IFE and/or the SATCOM became inoperative before the connections could be set up. At no time during the flight was any user data sent over the link by means of the SMS/e-mail application.

9) Two Ground-to-Air Telephony Calls were placed to the cockpit from the MAS Airline Operations Centre at Airline Operational Communications (AOC) Q10 priority level at 1839 and at 2313 on 07 March 2014. Neither of the calls was answered.

10) The SATCOM responded normally to a series of roughly hourly Log-On Interrogations from the Perth GES, up to and including a Log-On Interrogation at 0011 on 08 March 2014. The two unanswered ground to air calls at 1839 and 2313 reset the Perth GES inactivity timer and hence the Log-On Interrogations were not always hourly.

11) The SATCOM transmissions during the two in-flight Log-Ons and five Log-On Interrogations form the seven ‘handshakes’ that have been used by the Flight Path/Performance Subgroup to calculate the seven geographical ‘arcs’.

12) The last transmission received from the SATCOM occurred at 0019 on 08 March 2014 and the SATCOM failed to respond to a series of three Log-On interrogations starting at 0115 on 08 March 2014. This implies that the SATCOM probably became inoperative at sometime between 0019 and 0115 on 08 March 2014.

2.5.2 Possible Reasons for the 1825 and 0019 Log-On Events and Preceding Link Losses

1) First In-Flight Log-On at 1825 on 07 March 2014

Flight ID Status Change Description	Log-On Reason	Likelihood	Comments
Flight ID stopped being received from AIMS, or being received, but with the Sign Status Matrix (SSM) field not set to Normal Operation.	Power Interrupt	Medium	CBs are not readily accessible, but could have been due to power interrupt.
	Sysfail (software fail)	Very low	Sysfail is a very rare event and usually results in only a few minutes loss of link.
	Loss of Minop[37] or Loss of Link	Not possible	Loss of Minop or link would have resulted in the original Flight ID being sent to the GES at Log-On.
Flight ID received from AIMS, but with null value (zeros) and Sign Status Matrix (SSM) field set to Normal Operation	Power Interrupt	Low	Flight ID would have to have transitioned to null value whilst the SDU was not powered.
	Sysfail (software fail)	Very low	Flight ID would have to have transitioned to null value whilst the SDU was in Sysfail (which is a rare event in itself).
	Loss of Minop or Loss of Link	Low	Flight ID would have to have been cleared whilst the SDU was in loss of Minop or experiencing loss of link (duration at least 22 minutes). Otherwise a Log-On Renewal would have occurred and the GES log shows that a Log-On renewal did not occur.
Flight ID manually cleared via the MCDU	Power Interrupt or Sysfail (software fail)	Not possible	SDU needs to be operational to accept null Flight ID via an MCDU.
	Loss of Minop or Loss of Link	Low	Flight ID would have to have been manually cleared whilst the SDU was in loss of Minop or experiencing loss of link (duration between 22 and 78 minutes). Otherwise a Log-On Renewal would have occurred and the GES log shows that a Log-On Renewal did not occur.

Table 2.5A - Possible Reasons for the 1825 Log-On Events and Preceding Link Losses

From the above table, the most likely reason for the 1825 Log-On is a power interrupt.

[37] Loss of Minop - Is the inability of the AES to Log-On, because of one or more missing or failed resources, (e.g. equipment BITE failure).

2) Second In-Flight Log-On at 0019 on 08 March 2014

Log-On Reason	Likelihood	Comments
Power Interrupt	Medium	The SATCOM CBs are not readily accessible and are therefore unlikely to have been cycled. However, given that MH370 could have been low on fuel at this time, some form of generator transfer may have occurred, resulting in a SATCOM power interrupt.
Sysfail (software fail)	Very low	Sysfail is a very rare event.
Loss of Minop	Low	Loss of Minop - Normally a very low likelihood, but given that MH370 could have been low on fuel at this time, some form of generator-related abnormal operation of a peripheral system (e.g. AIMS) may have occurred.
Loss of Link	Low	Loss of Link would have prompted a new Log-On attempt via the Low Gain Antenna (LGA) subsystem. From the GES records, the subsequent Log-On is known to have been via the High Gain Antenna (HGA) subsystem, so for loss of link to be the Log-On reason, both the HGA and LGA subsystems would have had to have failed to close the link for a while. This is only likely in the case of an abnormal aircraft attitude, but given that MH370 could have been low on fuel at this time, this is a plausible reason.

Table 2.5B - Possible Reasons for the 0019 Log-On Events and Preceding Link Losses

From the above table, the most likely reason for the 0019 Log-On is a power interrupt.

Note:

The above table does not include the ‘Flight ID Status Change Description’ column that appears in the previous table, as there is no change of Flight ID Status for this second in-flight Log-On.

3) Preceding Link Losses

Although the link loss that is believed to have preceded the 1825 Log-On is most likely to have been due to a power interrupt, for completeness, other possible reasons for the link loss are considered in the following table (*Table 2.5C*).

Link Loss Reason	Likelihood	Comments
Automatic Satellite/GES Handover	Very low	Had the SDU initiated a handover, a Log-Off Request should have been recorded in the GES log. No such request was recorded.
Manual Log-Off, via the MCDU	Very low	Had a manual Log-Off been initiated via the MCDU, a Log-Off Request should have been recorded in the GES log. No such request was recorded.

Table 2.5C – Other Reasons for the Link Loss

The above table confirms that the link loss that is believed to have preceded the 1825 Log-On was not due to Satellite/GES handover or manual intervention via the MCDU.

2.5.3 Summary Assessment of Doppler for 1825 and 0019 Log-On Events

1) During each of the two in-flight Log-Ons that occurred during flight MH370, the GES recorded abnormal frequency offsets for the SATCOM transmissions. This is in contrast with the ‘normal’ Log-On behaviour.

2) *Table 1.9D* in *Section 1.9.5* shows the frequencies of these Log-On bursts, as measured at the GES, plus differences from assumed reference frequencies. The table also shows the very high delta frequencies between the respective Log-On Request and Log-On Acknowledge bursts.

3) The following graph *(Figure 2.5A)* shows the delta frequencies between pairs of Log-On Request and Log-On Acknowledge bursts for over one hundred Log-Ons of the SATCOM on-board 9M-MRO, up to and including the two during flight MH370. In every case prior to MH370 the delta frequencies were fairly small. Only the last two pairs of transmissions (the 1825 and 0019 Log-Ons) show significant deltas. Note that for ease of display, only the magnitude is shown for the two MH370 Log-On frequency deltas.

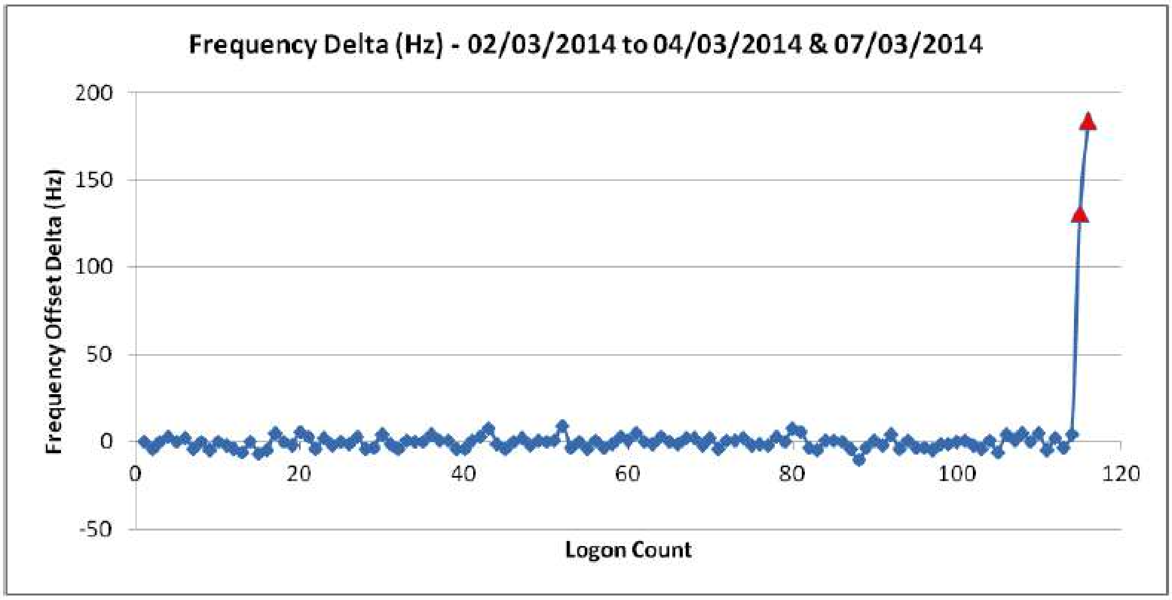


Figure 2.5A – Delta Frequencies between Pairs of Log-On Request and Log-On Acknowledge

4) From the Perth GES logs, the AES is known to have Logged-On as Class 3 (Voice & Packet Data). In order to have done so, the SDU must have been receiving valid Air Data Inertial Reference Unit (ADIRU) data from AIMS. In this case, the AES would apply open loop Doppler compensation, whereby it uses the ADIRU data in order to calculate the transmit frequency Doppler offset.

5) An OCXO provides a stable reference frequency for the SDU Radio Frequency (RF) transmit and receive circuits and also for

SDU modem timing. Within the OCXO, a regulated oven keeps the crystal at an almost constant temperature if the ambient temperature in the crown area is between the ranges -55^{0}C up to above +70^{0}C. The oven also contains extra electrical regulation and isolation to ensure frequency accuracy and stability. The OCXO includes an oven ready flag, which triggers the Log-On initiation when the OCXO reaches its operating temperature. Extensive laboratory testing has revealed that during warm up, the OCXO frequency may vary non-linearly with time, but then settles with almost negligible variation. At power-on, the OCXO can exhibit either a rising or falling frequency gradient, before decaying over time to its normal steady state value. The testing has indicated that reasonable stability (within 2Hz/minute) is typically reached by around five minutes after an initial peak or overshoot. The testing has also shown that there can still be a significant frequency offset at the time that the oven ready flag initiates the Log-On process, so the Log-On request, Log-On Acknowledge and subsequent data bursts can all exhibit significant frequency offsets.

6) These frequency offsets can be seen in the plot (*Figure 2.5B)* below, for a 9M-MRO SATCOM Log-On (believed to have taken place after a lengthy power down), at 1250 on 07 March, whilst the aircraft was on the ground at Kuala Lumpur, prior to the departure of MH370. The frequency has stabilised to a value of around 350Hz, within three minutes of the Log-On Request.

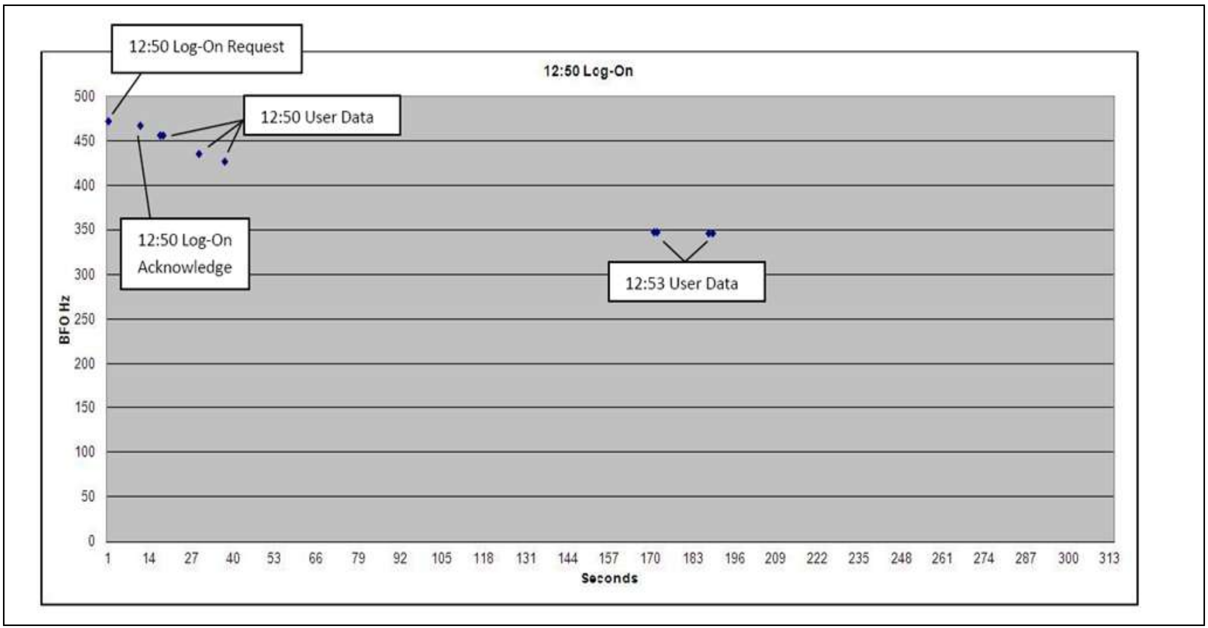


Figure 2.5B - SATCOM Log-On Frequency Offsets at 1250, 07 March 2014

7) These frequency offsets can also be seen in the plot (*Figure 2.5C)* below for the MH370 1825 Log-On. As with the 1250 Log-On, the frequency has stabilised within three minutes of the Log-On Request, this time at around 150Hz.

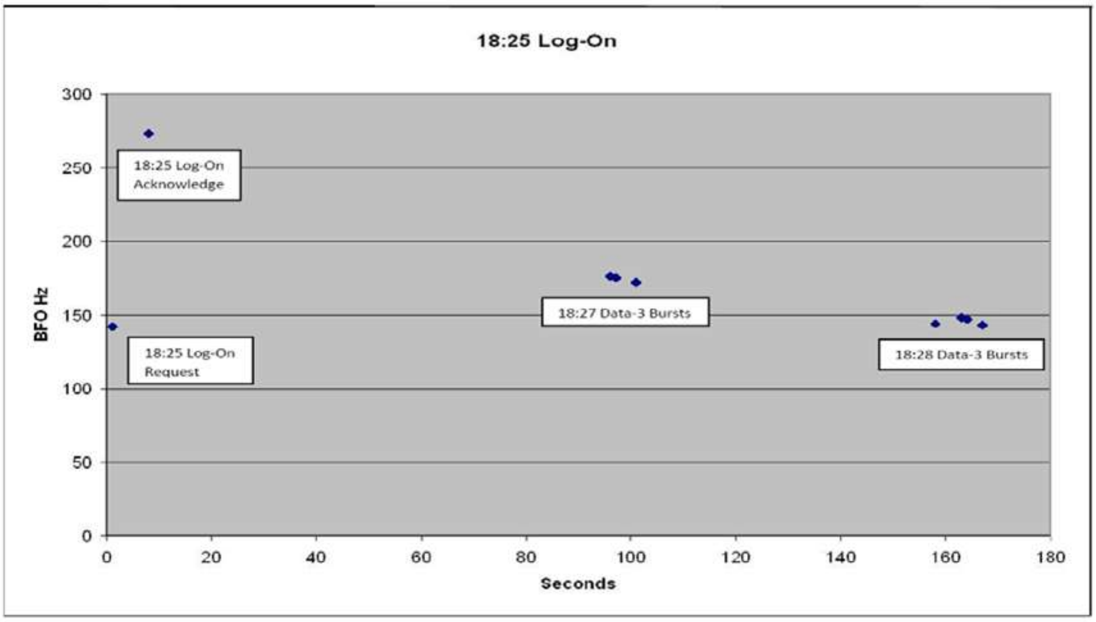


Figure 2.5C - SATCOM Log-On Frequency Offsets at 1825, 07 March 2014

8) The 1825 Log-On Acknowledge and the subsequent Data-3 transmissions exhibit a frequency offset, which decays to the steady state value. This frequency decay endorses the belief that the SATCOM had been powered down prior to the 1825 Log-On.

9) The 1825 Log-On Request does not exhibit the frequency offset decay though. However, it is possible that the OCXO frequency was rising at this time, prior to decaying to its steady state value. It is noted that the 1825 Log-On Request was received at the GES with a low Received Carrier/Noise Density Ratio (C/No) and a channel Bit-Error-Rate (BER) of 5 and could therefore have been logged at the Ground station with a BFO measurement error suggesting that the BFO figure may not be reliable. Non-zero channel BER transmissions are not uncommon for a satellite link. The C/No (and hence channel BER) can be impacted by the gain of the SATCOM antenna and also atmospheric effects, as well as interference due to collisions with a (lower power) burst from another aircraft.

10) In the seven days leading up to flight MH370, 235 out of 6803 (3%) of 9M-MRO SATCOM Class 3 transmissions (via HGA) were received at a GES with a non-zero channel BER and during flight MH370, 5 out of 112 (4%) of transmissions were received at a GES with a non-zero channel BER. So, the MH370 SATCOM performance from a channel BER perspective appears to have been normal.

11) The plot *(Figure 2.5D)* below shows a series of MH370 Log-On Interrogation transmissions, which steadily rise in frequency (due to the satellite ephemeris). However, the 0019 Log-On Request and Log-On Acknowledge transmissions diverge from the steady state slope.

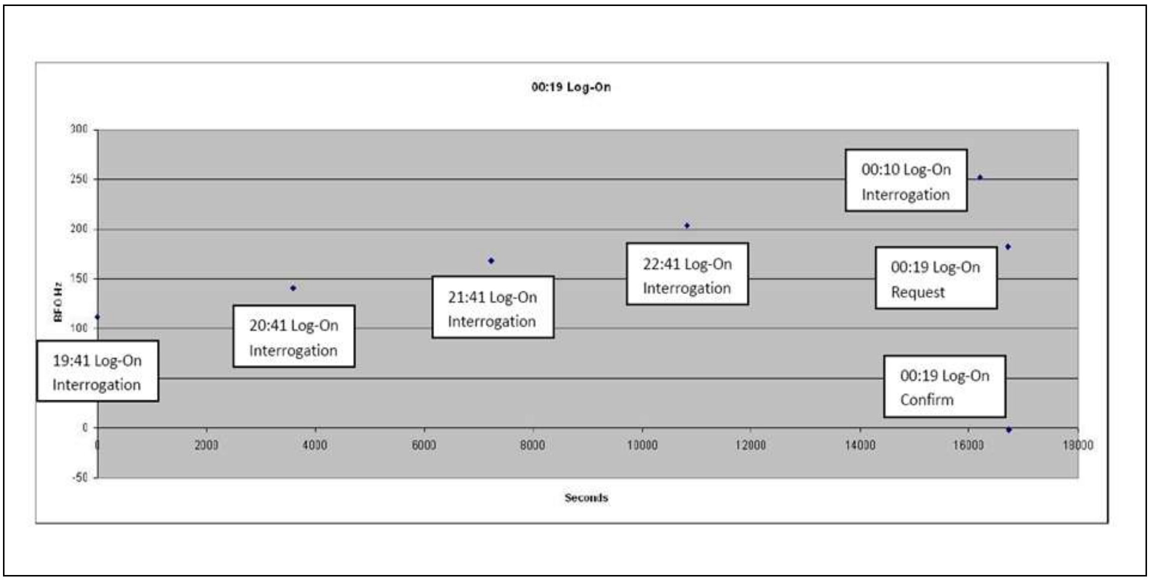


Figure 2.5D - Log-On Interrogation Transmissions

12) For the 0019 BFOs, the following possible error contributions are considered:

a) GES Measurement Errors - There is only evidence to suggest a significant GES measurement error in the case of a burst that is received at the GES with a non-zero channel BER, as in the case of the 1825 Log-On Request. This was not the case with the 0019 BFOs, so it can be discounted.

b) SDU OCXO Reference Error – OCXO stability has been measured over both temperature (circa -0.65Hz/deg. C) and time (as described above). The OCXO double inflection warm up drift could explain at least part of the 0019 Log-On Request and Log-On Acknowledge frequency offsets.

c) Satellite Doppler Towards SDU and GES - Doppler frequency offset due to the relative movement of the satellite could not account for the >100Hz frequency shift in the <10 seconds between the 0019 Log-On Request and the Log-On Acknowledge bursts.

d) Doppler Error due to ADIRU Drift - If the aircraft ADIRU is assumed to have a maximum drift of 2kts (1m/s), then the worst case Doppler offset is 16Hz, significantly smaller magnitude than the >100Hz frequency shift in the <10 seconds between the 0019 Log-On Request and the Log-On Acknowledge bursts.

e) Doppler due to erroneous ADIRU Data - From a SATCOM perspective, the SDU will not use navigation data unless the Sign Status Matrix (SSM) for every one of the required ARINC 429 words (Latitude, Longitude, Groundspeed, Track, Pitch, Roll and Heading) is set to Normal Operation. It is "extremely improbable" that an ADIRU will send erroneous data with the SSM set to normal. In this case, we can conclude that the abnormal frequency offsets are extremely unlikely to be as a result of the SDU receiving or acting upon erroneous navigation data from an ADIRU.

f) Uncompensated Vertical Velocity - The SATCOM SDU does not consider vertical velocity in its Doppler calculation. It has been calculated that a vertical velocity of +100ft/min causes about a +2Hz change in the Doppler shift. Therefore, under normal circumstances, only a small frequency error results from the uncompensated vertical velocity. For example, an ascent or descent rate of 2000ft/minute would cause a 40Hz offset. In the case of MH370, a significant vertical velocity could explain at least part of the 0019 Log-On Request and Log-On Acknowledge frequency offsets.

13) In summary, the abnormal BFOs for the 1825 and 0019 Log-Ons can be explained as follows:

    a) The 1825 Log-On Acknowledge - Most likely due to the power-on drift of the OCXO.

    b) 0019 Log-On Request and Log-On Acknowledge - Could have been due to uncompensated vertical velocity, indicating that the aircraft was likely to be descending at this time. Alternatively, it could have been due to the OCXO warm up drift, or it could have been due to a combination of uncompensated vertical velocity and OCXO warm up drift.

14) It has not been possible to attribute specific correction values to the 1825 Log-On Acknowledge and 0019 Log-on Request and Log-On Acknowledge BFOs, so it was excluded from the Doppler calculations undertaken by the Aircraft Flight Path/Performance Subgroup. In the case of the 1825 Log-On Acknowledge, the following subsequent bursts were used instead, as the frequency is more stable at these times:

    - 1828:05.904 Data-3 R-Channel burst.
    - 1828:14.905 Data-3 R-Channel burst.

SECTION 2 – ANALYSIS

2.6 WRECKAGE AND IMPACT INFORMATION

2.6.1 Debris Considered for Detailed Examination

After the completion of the underwater search no wreckage belonging to MH370 was found. However, a number of debris were washed ashore near and onto the coast of south east Africa. Only the right flaperon, part of the right outboard flap and a section of the left outboard flap were confirmed to be from MH370. So far, 7 other pieces were also determined to be *almost certain* from MH370. To date, 27 items were considered significant for evaluation and the table below lists them and the status.

Ref.	Debris	Status
Item 1	Right Flaperon	*Confirmed*
Item 2	Right Wing No. 7 Flap Support Fairing	*Almost certain*
Item 3	Right Horizontal Stabiliser panel piece	*Almost certain*
Item 4	Engine Nose Cowl	*Almost certain*
Item 5	Door R1 Stowage Closet	*Almost certain*
Item 6	Right Hand Engine Fan Cowling	*Almost certain*
Item 7	Wing Body Fairing	*Likely*
Item 8	No. 1 Flap Support Fairing Tail Cone	*Highly Likely*
Item 9	Left Wing Trailing Edge Panel	*Highly Likely*
Item 10	Left Outboard Aft Flap Section	*Confirmed*
Item 11	Seat Back Trim Panel Encasing IFE Monitor	*Highly Likely*
Item 12	Bottom Panel of Wing or Horizontal Stabilizer	*Likely*
Item 13	Unidentified Part	*Not Identifiable*
Item 14	Unidentified Part	*Not Identifiable*
Item 15	Right Wing Trailing Edge Panel	*Highly Likely*
Item 16	Cabin Interior Panel	*Almost certain*
Item 17	Unidentified Part	*Not Identifiable*
Item 18	Right Forward Nose Landing Gear Door	*Highly Likely*
Item 19	Right Outboard Flap	*Confirmed*
Item 20	Right Aft Wing to Body Fairing	*Highly Likely*
Item 21	Unidentified Part	*Not Identifiable*
Item 22	Right Vertical Stabilizer Panel	*Almost Certain*
Item 23	Unidentified Part	*Not Identifiable*
Item 24	Unidentified Part	*Not Identifiable*
Item 25	Unidentified Part	*Not Identifiable*
Item 26	Right Aileron	*Highly Likely*
Item 27	Right Wing No. 7 Flap Support Fairing	*Highly Likely*

Table 2.6A - List of Debris Found and Considered for Detailed Examination

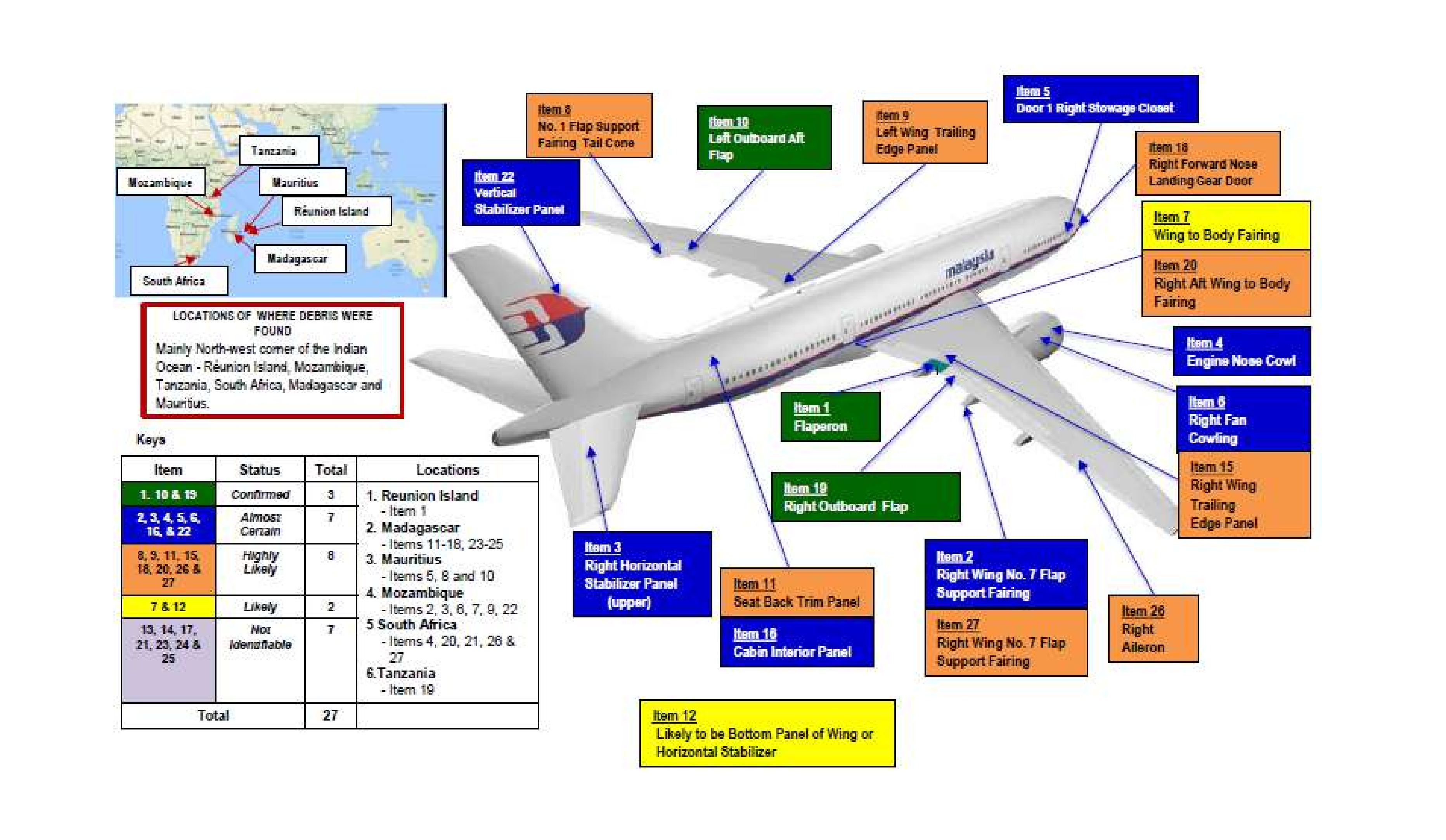
Examination, analysis and test were conducted by ATSB in Canberra, Australia and MH370 Safety Investigation Team in collaboration with STRIDE of Malaysia.

2.6.2 Location of Debris with respect to Aircraft

Figure 2.6A (below) shows the locations of the debris with respect to the aircraft.

Item 4 (part of the Engine Nose Cowl) is depicted to be from the right engine. There were no significant differentiators on the cowling segment to assist in determining whether the item of debris was from the left or right side of the aircraft, or the inboard or outboard side the cowling. Similarly, although Item 6 (part of the RH fan cowl) is depicted to be from the right engine in *Figure 2.6A,* there is a possibility that it could also be from the left engine. As for Item 7 - Wing body fairing - this too could be from either side of the aircraft.

Based on the identification of the parts and debris found, it shows that most of those parts and debris were from the right hand side of the aircraft.



Item	Status	Total	Locations
1, 10 & 19	Confirmed	3	1. Reunion Island - Item 1 2. Madagascar - Items 11-18, 23-25 3. Mauritius - Items 5, 8 and 10 4. Mozambique - Items 2, 3, 6, 7, 9, 22 5 South Africa - Items 4, 20, 21, 26 & 27 6.Tanzania - Item 19
2, 3, 4, 5, 6, 16, & 22	Almost Certain	7	
8, 9, 11, 15, 18, 20, 26 & 27	Highly Likely	8	
7 & 12	Likely	2	
13, 14, 17, 21, 23, 24 & 25	Not Identifiable	7	
Total		27	

Figure 2.6A - Location of Parts and Debris Found with respect to Aircraft

2.6.3 Damage Analysis of Significant Debris

Damage examination on the recovered part of the right outboard flap (Item 19), together with the damage found on the right flaperon (Item 1) indicates that the right outboard flap was most likely in the retracted position and the right flaperon was probably at, or close to, the neutral position, at the time they separated from the wing. This conclusion is based on the following findings and analysis.

There were damages to the internal seal pan components at the inboard end of the outboard flap which were possible with the auxiliary support track fully inserted into the flap. The damages were consistent with contact between the support track and flap, with the flap in the retracted position. The possibility of the damages originating from a more complex failure sequence, commencing with the flaps extended, were considered much less likely.

With the flap in the retracted position, alignment of the flap and flaperon rear spar lines, along with the close proximity of the two parts, indicated a probable relationship between two areas of damage around the rear spars of the parts. This was consistent with contact between the two parts during the aircraft breakup sequence, indicating that the flaperon was probably aligned with the flap, at or close to the neutral (faired) position. Refer to ATSB's report on the Outboard Flap Failure Analysis (*Appendix 2.6C)* for further details.

It should be noted that the DGA/TA, after examining the flaperon soon after it was found in July 2015, had concluded that the flaperon was likely to be deflected at the time of impact. This was primarily based on the damage observed on the trailing edge of the flaperon. However, this scenario was considered a hypothesis only due to lack of corroborating information, and more importantly, it was done without the benefit of the damage information available from the right outboard flap which was found much later. Additionally, the flaperon being rear of the engine, left some doubt as to its loading during the aircraft impact with the water and the phenomena at issue being highly dynamic and thus difficult to exploit. Refer to *Appendix 1.12A-2* for further details.

Two pieces of debris are *almost certain* from the cabin interior suggesting that the aircraft might have broken up. However, there is insufficient information to determine if the aircraft broke up in the air or during impact with the ocean.

Of the pieces tested so far, no traces of explosion were found.

2.6.4 Marine Life Examination

The marine organisms (barnacles) found on the flaperon were examined in detail by marine biologists, under the directive of the French Investigative judge. Below is a summary of the analysis.

The barnacles present on the flaperon belonged to the species *Lepas (Anatifa) anatifera striata*. This sub-species is strictly pelagic, always living on floating objects. It is a cosmopolitan species, widespread in worldwide oceans at tropical and temperate latitudes, in water temperatures above 18-20°C. The size of the biggest specimen indicated that the initial settlement could have occurred 15-16 months prior *to* the discovery of the flaperon at Reunion Island. The locations of the *Lepas* colony on the flaperon indicated that the flaperon was floating with its "belly face" up (the lower surface [intrados] was up, the upper surface [extrados] was immersed). Refer to *Appendix 2.6A* for details.

Temperatures during the growth of the youngest valves and the terminal fringe of the biggest adult valves (25.4 +/- 1°C) were consistent with temperatures observed off the Reunion Island. These results suggest that the barnacles ended up their developments in waters whose thermal characteristics were similar to waters close to Reunion Island, before the discovery of the flaperon.

At the beginning of their growth, the barnacles were immersed in waters with a temperature close to 28.5 +/- 1°C. Temperature distribution maps in the months preceding the discovery of the flaperon suggest that it has drifted in waters located East-North East of Reunion Island.

There are however no elements to determine precisely the duration of the growth of the valves examined, and therefore the period covered by the most developed valves. However, based on two experimental studies dealing with growth speeds of pelagic anatifas (Evans, 1958, Inatsuchi et al., 2010), the biggest valves (scutum) could have grown over a few months period. Refer to *Appendix 2.6B* for details.

SECTION 2 – ANALYSIS

2.7 ORGANISATION AND MANAGEMENT OF DEPARTMENT OF CIVIL AVIATION AND MALAYSIA AIRLINES

2.7.1 Department of Civil Aviation Malaysia

1) Introduction

In light of the disappearance of MH370 on 08 March 2014 [MYT], Malaysia as the State of Registry, State of Operator and State of Occurrence was obliged to conduct an investigation into the incident. Accordingly, the Minister of Transport had on 25 April 2014, instituted an independent international Investigation Team known as *The Malaysian ICAO Annex 13 Safety Investigation Team for MH370* with the sole objective of "prevention of future accidents or incidents and not for the purpose to apportion blame or liability." The Team, headed by an Investigator-in-Charge, comprised of nineteen Malaysians and seven international Accredited Representatives (AR) of seven safety investigation authorities from seven countries (Australia, China, France, Indonesia, Singapore, the United Kingdom, and the United States of America).

2) Department of Civil Aviation Organisation Structure

a) The Department of Civil Aviation (DCA) organisation structure at headquarters and operations resembles a flat or horizontal organisation structure which enables the officers to know what their respective responsibilities are since individual officers are assigned specific roles and functions. It enables the coordination of all activities within the DCA so that there is minimal duplication of effort or conflict and avoids overlapping of functions. As this structure creates fewer management levels, quick decisions and prompt actions can be taken without delay. Fast and clear communication is possible among these few levels of management and subordinates who are free from close and strict supervision and control.

b) This organisation structure is suitable for DCA at headquarters as the activities are rather routine and standardised. The officers at headquarters are assigned specific roles and functions enabling them to carry out their duty efficiently.

c) The DCA does not have sufficient technical personnel to effectively carry out all of its safety oversight tasks and functions due to resignations, delays in the filling of existing vacant posts, and difficulty in increasing the number of established posts in response to the growth of the industry. Uncompetitive employment conditions and the current practice of accepting technical personnel on rotational secondment from other government departments and short-term contracts from industry create difficulties in recruiting and retaining qualified and experienced technical personnel.

d) DCA is looking into the State Safety Programme (SSP) in accordance with Chapter 3, Annex 19 to the Convention on International Civil Aviation which will be applicable on 07 November 2019.

3) Air Traffic Management Sector

a) Organisation Structure

The organisation structure of the Air Traffic Manager (ATM) Sector at headquarters and operations resembles a flat or horizontal organisation structure which enables the officers to know what their responsibilities are since individual officers are assigned specific roles and functions. It enables the coordination of all activities within the ATM headquarters so that there is minimal duplication of effort or conflict and avoids overlapping of functions. As this structure creates fewer management levels, quick decisions and prompt actions can be taken without delay. Fast and clear communication is possible among these few levels of management and subordinates are free from close and strict supervision and control.

b) The ATM Sector at headquarters has a total establishment of 19 posts to manage the ATSUs in Kuala Lumpur and Kota Kinabalu FIRs and all the posts are filled and are sufficiently staffed.

c) This organisation structure is suitable for ATM headquarters as the activities are rather routine and standardised. The officers in this Sector are assigned specific roles and functions enabling them to carry out their duty efficiently. However, the personnel in ATM headquarters should closely monitor the Air Traffic Services Units (ATSUs) in the Kuala Lumpur and Kota Kinabalu

FIRs to ensure that the rules and established procedures are strictly adhered to. Periodical reminders and surprise visits to the respective ATSUs should be carried out so that the operational personnel would not lose touch with current procedures.

d) The ATM headquarters' responsibility with regard to MH370 is through the KL ATSC Director in adherence to and compliance with the rules and established procedures in the MATS Vol. 1 and Vol. 2, ICAO Annexes and Documents, Operational Letter of Agreements and Departmental Directives and Instructions, Supplementary Operations Instructions and Administration Instructions.

4) Air Traffic Inspectorate Division

a) The Air Traffic Inspectorate (ATI) Division organisation resembles a flat or horizontal organisation structure which enables the officers to know what their responsibilities are since individual officers are assigned specific roles and functions. It enables the coordination of all activities within the Division so that there is minimal duplication of effort or conflict and avoids overlapping of functions. As this structure has fewer management levels, quick decisions and prompt actions can be taken without delay. Fast and clear communication is possible among these few levels of management and subordinates are free from close and strict supervision and control. This organisation structure is suitable for the ATI Division as the activities are rather routine and standardised.

b) The ATI Division is headed by a Director and assisted by a Deputy Director. There are three units viz. Safety Oversight of ANS Providers, ATC Examination, ATC Licensing and Safety. There are three Principal Assistant Directors and three Senior Assistant Directors.

c) The ATI Division has conducted six Safety Oversight Audits on the Kuala Lumpur ATSC (KL ATSC). The last audit was conducted from 22 - 25 April 2013. The objective of the audit is to ensure conformity with ATMS prescribed standards and requirements in the provisions of ATMS by the ATM service provider.

d) The relevant ICAO Annexes, Documents and Manuals were used to identify differences between KL ATSC practices and those established by the ATM Sector, and ICAO Standard and Recommended Practices (SARPs).

e) During the on-site audit, the audit team made 6 observations, with only one having a bearing on the ongoing investigation by the Team. The observation was that the "*Direct line at Watch Supervisor console was not connected to recording facility*". During the course of the audit, there were 8 Manual of Air Traffic Services' (MATS) non-compliance reports (NCRs), 21 Annex 4's NCRs (16 Annex Chapter and 5 Annex Chapter 21), 6 Doc 9426 - ATSC Facilities NCRs and 2 ANS Regulatory NCRs. There was a total of 37 new NCRs' findings for the audit conducted in 2013. However, for the audit that was conducted in 2010, 9 out of 11 MATS' NCRs and the entire 8 Doc 9426's NCRs still remain open. There were a total of 17 NCRs still remaining open. There were 6 NCRs brought forward from 2005/2006. KL ATSC has accumulated altogether a total of 60 NCRs after the audit conducted in April A2013.

Notwithstanding the above, the Team does not find any direct link between the NCRs and the disappearance of MH370.

f) There has not been any direct link as to the functions of the ATI Division with regard to the disappearance of MH370. The ATI Division has issued ATC licenses to the ATC personnel in accordance with Personnel Licensing under Regulation 92(1) of the Malaysian Civil Aviation Regulations 1996.

5) Search and Rescue

a) Although there is no legislation specifically to address the provision of assistance to aircraft in distress, Aeronautical SAR (A-SAR) in Malaysia is provided in accordance with ICAO Annex 12 and the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual Vol. I – III (ICAO Doc 9731-AN958). It should be noted that CAR 201 stipulates the use of *'ipso facto'* to address ICAO Annexes 1 to 18, including the application of ICAO Standards and Recommended Practices (SARPs), provided that a regulation has not already been established in CAR and that a difference has not been notified to ICAO. In particular, DCA relies completely on CAR 201 for the implementation of Annexes 3, 4, 5 and 12.

b) IAMSAR Vol. IV - The National Aeronautical and Maritime Search and Rescue Manual (Malaysia), prepared under the direction of the National Search and Rescue Committee, National Security Council (NSC) and the Prime Minister's Department in March 2008, provides guidance to federal agencies concerning the implementation of the National Search and Rescue Plan. This Plan provides specific additional national standards and guidance that build upon the base line established by the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual. The IAMSAR Manual is a three-volume set published jointly by both the International Civil Aviation Organisation (ICAO) and the International Maritime Organisation (IMO) for use by all countries. This Plan provides guidance to all federal forces, military and civilian, that support civil search and rescue (SAR) operations. It should be noted that the land (populated areas) and military SAR elements, under the portfolio of its respective ministries, are intentionally excluded from this document.

c) The IAMSAR Vol. IV is a very comprehensive national SAR manual covering areas viz.:

Part One	Aeronautical and Maritime SAR Authority and Administration;
Part Two	Aeronautical and Maritime SAR Policy
Part Three	Aeronautical and Maritime SAR Resources
Part Four	Aeronautical and Maritime SAR Communications
Part Five	Special Procedures
Part Six	Memoranda of Understanding
Plan of Operation	Part 1 - Aeronautical Part 2 - Maritime

Over the South China Sea, within the Singapore FIR, there are two distinct areas namely the South China Sea Corridor (SCSC) and the airspace delegated to KL ACC by Singapore ACC known as the "Delegated Airspace". There are special arrangements whereby the roles and responsibilities of KL

ARCC and Singapore RCC have been defined in terms of alerting service and SAR operations as follows:

i) South China Sea Corridor

The arrangement for aeronautical search and rescue service by way of the Operational Letter of Agreement between Malaysia and Singapore for the part of the South China Sea (which is within the Singapore FIR) was in force since 1984. The agreement specified the designated area, known as the South China Sea Corridor (SCSC) and stipulates that in the event of an aircraft emergency occurring within the SCSC, the KL ACC shall be responsible to take initial alerting action whilst Singapore RCC shall be responsible for subsequent coordination of all SAR efforts. Whist the responsibility for the provision of search and rescue service within the SCSC rests with the Singapore RCC, the Singapore RCC may delegate responsibility for the overall control of the SAR mission to Kuala Lumpur RCC or Kota Kinabalu RCC, whichever is deemed appropriate.

Letter of Agreement Para 3.2.2 states that*:*

When a transfer of responsibility for the overall SAR coordination is to take place, either from subsequent establishment of an aircraft's position or movement, or because an RCC other than the one initiating the action is more favourably placed to assume control of the mission by reason of better communication, proximity to the search area, more readily available facilities or any other reasons, the following procedures shall be adopted:

i) direct discussions, wherever possible, shall take place between the Search and Rescue Mission Coordinators (SMCs) concerned to determine the course of action,

ii) if it is decided that a transfer of responsibility is appropriate for the whole mission or part thereof, full details of the SAR mission shall be exchanged, the initiating RCC shall continue to retain responsibility until the accepting RCC formally assumes control for the mission.

ii) "Delegated Airspace" in Singapore FIR

The **"**Delegated Airspace" is a defined airspace over the South China Sea within the Singapore FIR that has been delegated by Singapore to Malaysia for the purpose of Air Traffic Services. SAR service is provided by Singapore.

Figure 2.7A - Kuala Lumpur - Aeronautical Rescue Coordination Centre (ARCC)

On 08 March 2014 [MYT], MH370 operated within the "Delegated Airspace". The radar position symbol dropped from the radar display at 1721:13 UTC [0121:13 MYT]. Though the KL ACC was responsible for the provision of Air Traffic Services, no alerting action was taken. At 2130 UTC [0530 MYT] the KL ATSC Duty Watch Supervisor directed the Search and Rescue Mission Coordinator (SARMC) to activate the ARCC (*Figure 2.7A* above and *Figure 2.7B* below). After the ARCC was activated, and due to a lack of details from the KL ATSC Duty Watch Supervisor, the SARMC only managed to disseminate the distress message at 2232 UTC [0632 MYT], an hour and two minutes later.

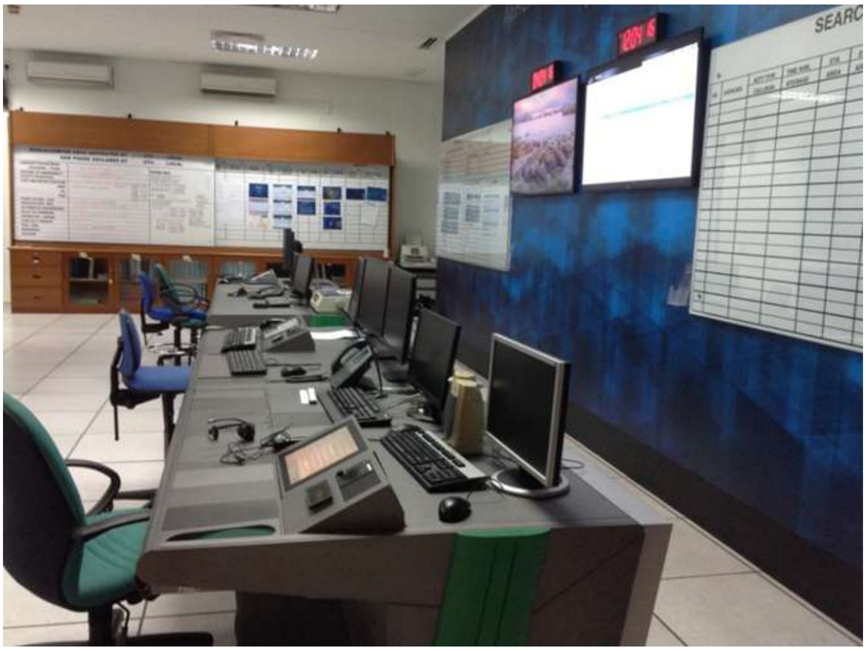


Figure 2.7B - Kuala Lumpur ARCC Work Stations

6) Kuala Lumpur Air Traffic Service Centre

a) Staffing

This analysis on the Organisation Structure of the Kuala Lumpur Air Traffic Service Centre - *Figure 2.7C* below - is based on information obtained from the Department of Civil Aviation. There are altogether 353 approved ATS posts of various grades in the KL ATSC. As of March 2015, there were 110 vacancies and 64 as of December 2014. The reason cited for the posts not being filled was *"considering the opening of klia2, DCA has managed to obtain new posts for KL ACC (Area and Approach) and KLIA on 08 May 2013. But due to the delay of klia2 opening the promotion exercise was also delayed".*

b) Findings of Safety Oversight Audit

The findings of the Final Report of the Safety Oversight Audit (Follow-up) of KL ATSC in April 2013 state that:

- *the organisational charts do not reflect the task currently assigned to and being performed by the ATS staff who are also assigned secondary posts with specific duties.*

- *KL ATCC had not conducted any Refresher Course for its Controllers. There is no training programme developed for ATC staff. All training is conducted on operational and opportunity basis. In addition, training records for ATC staff were not systematically maintained.*

- *No internal audit conducted however it is noted that an audit team will be established consisting of personnel who had previously attended audit course.*

The reasons cited in the audit report were inadequate staffing and inadequate resources to run the programme.

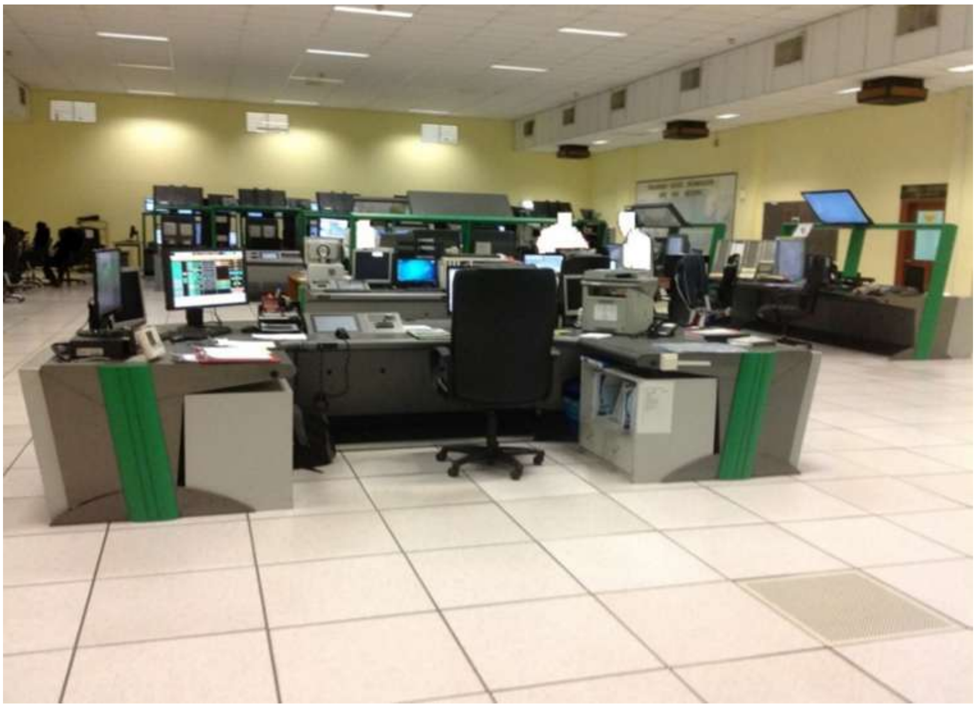


Figure 2.7C - Overview of Kuala Lumpur Air Traffic Control Centre

c) Duty Roster for March 2014

i) This analysis is based on the KL ATSC duty roster for Air Traffic Controllers for the month of March 2014. The Team acknowledges that the duty roster was prepared with the number of Controller working positions (CWPs) in the KL ATSC being filled by qualified Controllers at all CWPs.

ii) On the night of 07 March 2014, at 1500 UTC [2300 MYT] the functions of control for Sector 5 was absorbed into

Sector 3. There was no issue from this time other than that the combination of these two CWPs was carried out an hour earlier than scheduled. From 1600 UTC [0000 MYT] until 1900 UTC [0300 MYT] and 1900 UTC [0300 MYT] to 2200 UTC [0600 MYT] the Sector 3+5 radar working position was manned by radar-rated Controllers. However, it is confirmed that, from 1600 UTC [0000 MYT] till 2200 UTC [0600 MYT], the Sector 3+5 Planning Position was manned by an *OJT Controller* and an *AFD Officer* as the qualified Controllers were having their respective breaks.

Figure 2.7D - Kuala Lumpur Air Traffic Control Centre – Area Control CWPs

7) Airworthiness Sector

a) The Airworthiness Sector is not involved in the frontline operations of the aircraft. Organisational weaknesses or shortcomings of the Airworthiness Sector however may contribute to accidents due to weaknesses in the management systems and culture.

b) Areas Analysed

The following areas were analysed for latent conditions:

- Corporate goals
- Organisational Structure
- Communication
- Planning

- Control and monitoring
- Procedures
- Resources, which include:
  - Regulations
  - Safety Management

i) Corporate Goals

The Airworthiness Sector does not have specific corporate goals. It shares the Vision, Mission and values of the parent DCA. The DCA's Vision is "*to be the world's leading aviation aut*hority". Its Mission is "*to continuously enhance safety, security and efficiency for sustainable aviation industry*". These Vision and Mission do not specifically relate to the roles and functions of the Airworthiness Sector, which is to carry out "*the regulatory function in respect of airworthiness through the establishment of standards recommended practices and guidelines, and their enforcement as required by the Civil Aviation Act [CAA] 1969".* The organisational Vision and Mission are normally related to corporate goals. It is very important to instil values in each staff to achieve the corporate objectives. However, there is no direct evidence that any missing corporate goals in terms of Vision and Mission may contribute to any latent conditions which can lead to the potential failure of the system.

ii) Organisational Structure

The organisational structure of an Airworthiness Organisation is detailed in the ICAO Document 9760. The Airworthiness organisation is divided into the Airworthiness Engineering Division (AED) and Airworthiness Inspection Division (AID), as shown in *Figure 2.7E - Setup of the Airworthiness Organisation (ICAO Document 9760)*.

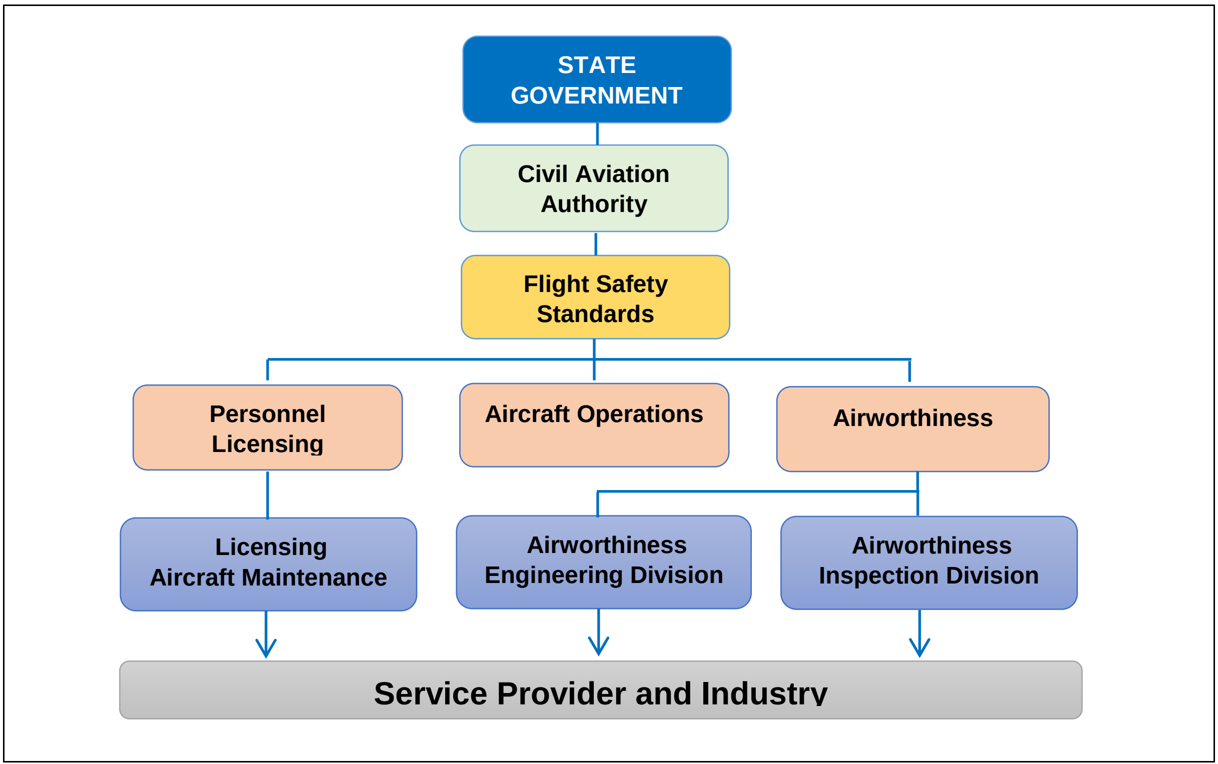


Figure 2.7E - Setup of the Airworthiness Organisation (ICAO Document 9760)

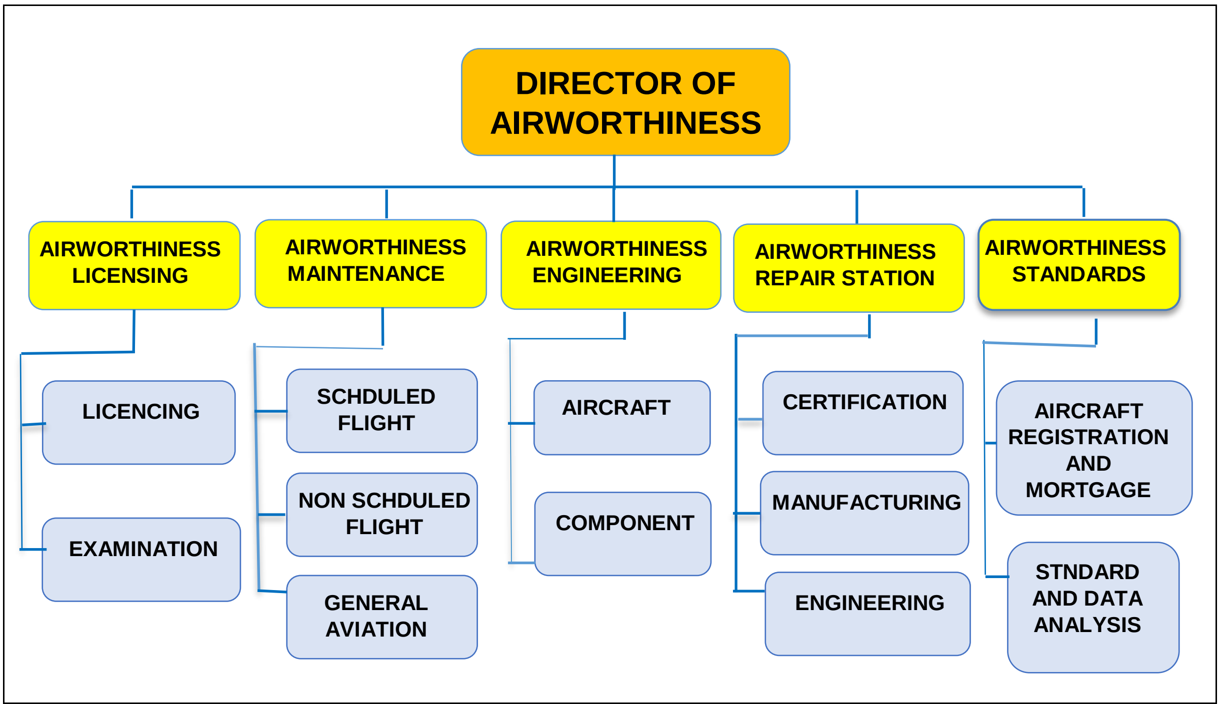


Figure 2.7F - DCA Airworthiness Sector

The DCA Airworthiness Sector is divided into 5 divisions: Airworthiness Licensing, Airworthiness Maintenance, Airworthiness Engineering, Airworthiness Repair Station, and Airworthiness Standards as in *Figure 2.7F* above.

The roles and responsibilities of each division are as follows:

- **Airworthiness Licensing** is responsible for examination of engineers, approval of training organisations, and issuance of licensing of aircraft maintenance engineers.
- **Airworthiness Maintenance** is responsible in initial issuance and renewal of Airworthiness Certificates and approval of aircraft maintenance and facilities, continuing airworthiness maintenance and investigation of incidents and defects.
- **Airworthiness Engineering** is responsible for certification of aeronautical products, issue of Airworthiness Directives (AD), approval of modification and repair, and approval of Design Organisations (DOA) and Production Organisations (POA).
- **Airworthiness Repair Station** is responsible for investigation of incidents and defects and approval of maintenance organizations/repair stations (MRO).
- **Airworthiness Standards** is responsible for registration of all civil aircraft and aircraft mortgage, to develop and update standards, requirement and procedures, analyse airworthiness data, including all occurrence reporting, service difficulties reporting, malfunction and defects.

The organisational structure of the DCA Airworthiness Sector does not clearly show the divisions of AED and AID. The licensing of aircraft maintenance is in the Airworthiness Sector. However, the analysis of the current Airworthiness Sector organisation structure indicates there are elements of AED and AID in the organisation. The AID elements are available in

Airworthiness Maintenance, and Airworthiness Repair Stations. The Airworthiness Standards cover both the AED and AID. The Airworthiness Licensing should be in the Airworthiness Sector because the DCA has a dedicated division to handle all licensing matters. Based on the organisation structure and the roles and responsibilities of each of the divisions within the Airworthiness Sector, there is no evidence of any aspects or characteristics which may lead to a latent condition.

iii) Communication

The effective external and internal communication is essential because ineffective communication and miscommunication have shown to result in unsafe condition. The Airworthiness Sector external and internal communication have been shown to be effective formally by letter and email. The internal communication is by means of meetings and discussions between the staff. The work process and activities are consistent since the Airworthiness Division Manual (ADM) is used by the airworthiness engineers and inspectors as their procedure manual when carrying out their respective tasks. Therefore, there is no evidence of any unsafe condition with respect to communication.

iv) Planning

The Airworthiness Sector carries out continuing airworthiness and surveillance oversight of aircraft maintenance activities of 8 Scheduled Operators and 21 Non-Scheduled Operators, 176 (local and international) Approved Maintenance Organisations (AMO) and 12 Approved Training Organisations (ATO). MAS was one of the major airline operators. The Airworthiness Sector also provides technical audit support in conjunction with the Flight Operations Sector and Air Transport Division to issue an Air Operating Certificate (AOC). The above activities are adequately planned and conducted, based on the schedule established for each organisation.

For the initial airworthiness certification, airworthiness inspectors and airworthiness engineers carry out new aircraft type design certification or the validation of Aircraft

Type Certificate before the aircraft is registered. The Airworthiness Sector also reviews new applications for minor or major modifications and monitoring the applicability of mandatory Airworthiness Directives issued by the State of Design.

The audit and surveillance of the organisation (i.e. MRO, ATO and AOC) and aircraft inspection for Certificate of Airworthiness (C of A) renewal are conducted on a regular basis of at least once a year. The Airworthiness Sector establishes a detailed annual audit and surveillance programme.

In the case of 9M-MRO, it was noted that the last C of A renewal for aircraft physical inspection was not carried out by the Airworthiness Inspector but was renewed based on document submission and a physical inspection report by MAS. The last aircraft physical inspection on 9M-MRO was carried out more than one year prior to the aircraft's disappearance. This is an acceptable practice by the Airworthiness Sector because the annual renewal of the Certificate of Airworthiness is normally supported by an aircraft document/physical inspection report. The mutual arrangement with the operators would indicate that the Sector has a close working relationship with the aviation industry and this arrangement serves to expedite the Certificate of Airworthiness' renewal process. Based on the above analysis, the system of planning and accomplishment are in order and there is no evidence of any latent condition which may contribute any failures.

v) Control and Monitoring

The control and monitoring mechanism requires the organisation to have key performance indicators (KPI) of its performance, hazards identification and risk management policies and programme. The aspects of hazards identification and risk management are essential for the organisation in decision making of its functions and responsibilities. The aspect of organisation key performance indicators is clearly discernible.

vi) Procedures

The Airworthiness Sector uses Airworthiness Department Manuals (ADM) as internal documented policies and procedures for the Airworthiness Engineers and Inspectors. The ADM has detailed most of the Airworthiness Sector's working procedures. However, it has not been reviewed regularly and updated in line with technological advancement. There is no specific unsafe condition, but it could be a latent condition.

vii) Resources

ICAO through Doc 9760 has recommended that inspectors and engineers possess relevant knowledge, experience and competency. The Airworthiness Sector has recruited a number of fresh engineers and inspectors to fill up the relevant posts. These new engineers/inspectors need to undergo training required under ICAO requirements.

Regulation is one aspect of the important resources required by the Airworthiness Sector. All the activities of the Sector were based on the Civil Aviation Act 1969. The Act requires compliance with the ICAO Annexes. The Act also requires the Minister of Transport to make regulations based on ICAO SARPS (Standards and Recommended Practices. The Minister of Transport formulated the Civil Aviation Regulations 1996 under the provisions of the Civil Aviation Act 1969. The analysis on the Malaysian civil aviation laws and regulations indicate that the Civil Aviation Act 1969 and CARs of 1996 may be outdated by present international regulatory standards and practices.

It is anticipated that the future introduction of the Civil Aviation Safety Requirements (CASR), Acceptable Means of Compliance (AMC) and Guidance Materials (GM) would serve to streamline the Malaysian regulatory framework, requirements and procedures, similar to the approach of the European Aviation Safety Agency (EASA) requirements. In the absence of new regulations in CAR 1996, the Airworthiness Sector has adopted and adapted other countries' laws and regulations (i.e. United States of America, European Union) and published these regulations either in notices, circulars, directives or information and issued them under section 240 (Publication of Notices) of the Civil Aviation Act 1969.

8) Flight Operations Sector

a) Corporate goals

The Flight Operations Sector (FOS) is one of the sectors of DCA Malaysia. It does not have specific corporate goals, vision or mission. It rides on the DCA Vision and Mission, which are not specific to the functions and responsibilities of the FOS. A specific vision and mission would focus the FOS inspectors on common values and practices. There is no evidence of any significant safety issue with the absence of a specific Vision and Mission for the FOS. It has no direct bearing on the disappearance of MH370.

b) Organisational structure

The FOS is divided into 5 divisions namely: Flight Crew Licensing, Air Operator Regulations, Flight Simulator, General Aviation and Flight Calibrations.

The FOS is responsible primarily for ICAO Annex 6 (Aircraft Operation) and ICAO Annex 1 (Personnel Licensing) for the flight crew. There is an operational division in the FOS - Flight Calibration Division - which operates a number of aircraft for calibration of airfields and airways. FOS is considered a mixed mode of authority-cum-operator.

c) Resources

The FOS lacks the required number of experienced inspectors (pilots). The shortage of personnel may affect the flight safety standard of the Air Operating Certificate (AOC) holders, especially with respect to the frequency of audit involving station facility inspection, RAMP Inspection for en-route and destination stop, annual inspection at every location, and base inspection for Scheduled Operations and Non-Scheduled Operations. Similarly, the shortage of flight examiners may also affect the standard of the training establishments.

The Flight Operations' Aeronautical Information Circular (AIC) No. 30/2005 November 2015 - Inspections and Investigation of Air Accidents, reiterates the statutory powers of the Minister of Transport to investigate aircraft accidents and serious incidents that occur in Malaysia regardless of nationality of aircraft registration. With respect to aircraft accidents or incidents investigation, the inspectors from the FOS may be called upon to assist the Air Accident Investigation Bureau (AAIB) under the Ministry of Transport. This function would create some constraint to the FOS in view of the shortage of experienced pilots in the Sector. This shortage is potentially a latent condition, which if not addressed, may lead to potential unsafe conditions.

Regulations is another important resource issue with the FOS working within the Civil Aviation Act 1969 and MCAR 1996. The MCAR 1996 is unable to cope with the rapid development in international aviation regulations and practices. Under the provision of section 240 of the Civil Aviation Act 1969, the AICs are published by the DCA. This practice of supplementing the CAR 1996 has been successful. However, it is still unable to cope with the up-to-date rules and regulations in Europe and North America. This condition could not have contributed to the disappearance of MH370. However, this is a latent condition which needs to be appropriately addressed.

Safety management is another important aspect in the organisation. The ICAO Annex 19 (Safety Management) has mandated the aircraft operators to develop their organisations' SMS by January 2009. To comply with the ICAO requirements, the FOS has developed the AIC No. 06/2008 which was issued under section 240 of the Civil Aviation Act 1969 for all Malaysian Air Operating Certificate (AOC) holders to establish their organisational Safety Management System (SMS). Notably, MAS had implemented the SMS into their procedures manual. The requirement for the operators to establish SMS by the FOS is adequate. However, the FOS has to establish its own safety management programme.

2.7.2 Malaysia Airlines

1) Engineering & Maintenance

Based on the factual information provided in *Section 1.17.2 para. 2)* the Engineering & Maintenance Division was well-structured appropriate to a maintenance management and maintenance organisation with key positions manned by persons approved by the Department of Civil Aviation (DCA), Malaysia. The required oversight of the maintenance activities was provided both by internal Quality auditors, as well as by the DCA Malaysia. This was further supported by audits by foreign auditors, such as from the EASA and FAA. There were no significant audit findings suggesting that the organisation was well managed. It is not unusual to have findings during audits; the purpose is to continuously improve by instituting corrective and preventive actions.

Maintenance personnel were appropriately trained and qualified in accordance with approved procedures, as documented in the Maintenance Management and Organisation Exposition (MMOE).

Although recently introduced in the year 2009, Safety Management had been embraced in the organisation and in line with the corporate system.

2) Flight Operations Management

The Flight Operations Management (FOM) office positions were sufficiently manned by qualified individuals and the working guidelines ensure their effectiveness in carrying out duties in their respective management positions. The fleet manager, being on the B777 for more than 10 years and having held the post of Type Rating Examiner (TRE), attests to his level of competency and seniority.

a) Technical Crew of Malaysia Airlines

There was no evidence of irregularities in the standards, performance and capability of pilots in Malaysia Airlines **(**MAS).

b) Medical Check-up

There was no evidence of irregularities in terms of medical and licensing validity of pilots in MAS.

c) Roster Schedule & Management

Data collected indicate that the pilots' roster and rest period are in compliance with MCAR FTL requirements.

There is no evidence to suggest that any of the two pilots infringed any of the required MCAR FTL limits.

d) Confidential Human Factors Incident Report System

In September 2013 to March 2014 over a period of six months, there were a total of six reports submitted, mainly on communications issues between staff.

This suggests that the CHIRPS was capturing adequate data to meet its objective.

There was no evidence to suggest that any of the two pilots were subjected to CHIRP's surveillance.

e) Flight Operations Quality Assurance

Sampling of FOQA data over a 2-year period prior to the event was studied. Capture rates were close to 100% and it is evident that the system works and justifies its role in identifying non-normal operations either deliberate or due to environment factors.

The overall rate for B777 has its average figure comparative to the industry standards.

As an example, the highest event of UA (Unstablised Approach) occurred in the month of August 2013 at a rate of 49.26 per 10,000 flight cycles. This is equivalent to 0.49% for the month.

The highest FOQA trigger was the long flare event which occurred in the month of May 2012 at 243.6 per 10,000 flight cycles. This is equivalent to 2.3% for the month.

Based on these findings, enhanced training on the proper corrective measures was introduced during recurrent simulator checks.

f) Line Operations Safety Audit

The findings were very relevant, and recommendations were implemented via Safety Change Process (SCP). MAS on the average had less findings compared with the other 5 airlines in the Line Operations Safety Audit (LOSA) archive. Safety Change Process was carried out to mitigate the findings. LOSA findings also revealed low prevalence in terms of overall mismanagement rate (unsafe operations) in the B777 fleet as reported in MAS LOSA Report 2011. LOSA was conducted by taking a random sampling on all fleets including the B777. MAS had met the average safety standards of most international airlines.

g) Crew Resources Management

The Team's analysis reveals that the CRM programme had been implemented and had produced positive results over the years. These awareness and regular recurrent training programmes had inculcated good interpersonal relationships between flight crew members and had contributed significantly to the overall safety of the flight operations.

Both the technical and cabin crew were in compliance with CRM requirements.

h) Safety and Emergency Procedures

Findings have indicated that both the technical and cabin crew were in compliance with SEP validity. The training syllabus had met all the regulatory requirements.

i) Flight Deck Security Procedures

At the time of flight MH370, there were no requirements for an additional crew member in the cockpit in the event when one of two pilots were to leave the cockpit. However, in response to flight MH370, MAS has, since introduced this requirement into its safety procedures effective 27 March 2014, a procedure subsequently introduced by other airlines following the GermanWings Flight 9525 accident on 24 March 2015.

j) MAS B777 Training and Standards

The fleet carried sufficient numbers of Type Rating Examiners (TRE) and Type Rating Instructors (TRI) to fulfil the licensing requirements. TRE and TRI were Captains from within the airline, appointed with approval from the Licensing Section of the DCA. They were also tasked with monitoring the overall standards to be maintained by the fleet. This responsibility was under the jurisdiction of the Training and Standards Department, which was headed by a Chief Pilot.

k) Multi-crew Operation MH370

Flight MH370 was operated on a normal 2-man crew operation with one PIC and one FO. A third pilot was not required as a safety pilot as the trainee's performance was reported to be above average and deemed safe by the previous Training Captain.

The duration of the scheduled flight with FDP (Flight Duty Period) of less than 8 hours also justified the 2-man crew operations.

l) Operation Control Centre

During the day of the disappearance of MH370, it was established that the FFS was programmed to receive a download from the aircraft at 30 minute intervals. The last download was transmitted at 1707:29 UTC [0107:29 MYT]. As a result, the track and position shown on the monitor after this time was only the predicted track and position.

Facts gathered during interviews with despatchers on duty during the incident suggested that with the exception of hijack and bomb hoax, there were no quick references to guide the frontline operations staff to react to emergency situations such as a lost aircraft and a crash.

The FFS was observed to be in accordance ICAO Annex 6 Part 1 Chapter 4, AIC 10/2002 dated 25 July 2002 and FOSI[38] Handbook, Vol 3, Chapter 4, para 6. Personal interviews with individual despatchers suggested increased workload which could

[38] This order is referred to as a handbook and directs the activities of Flight Operations Surveillance Inspectors (FOSI) who are responsible for the certification, technical administration, and surveillance of scheduled air carriers and certain other air operators who conduct their operations in accordance with the Malaysian Civil Aviation Regulations 1996, made under the Civil Aviation Act 1969.

have affected the quality of work. There is evidence that the Supervisor/Despatcher-in-charge oversaw an average of 30 flights on that particular night shift, including monitoring seven to eight different flights at one time on the Orient Sector. This suggests the existence of an element of overworked condition.

The Team's investigation into the basic capability of the FFS suggested that there are bound to be discrepancies between the actual aircraft position compared to the projected flight path in the FFS once an automatic update stops. This could explain the state of confusion and uncertainties among all parties involved during the incident. These discrepancies suggest two hypotheses:

- Data downlink failure from the ACARS communication.
- Intentional or unintentional deactivation of ACARS Communications.

The position update on the FFS was programmed at 30 minute intervals on the B777. This interval is the same as the B747-400 but comparatively longer than other aircraft (A380: 10 mins; A330: 10 mins; B737-800: 10 mins).

The displayed aircraft position was erroneous right from the point where the ACARS communication was lost.

m) Fuel Policy

There is no evidence to suggest that the PIC had ordered or carried any extra amount of fuel beyond the minimum amount recommended by the Computerized Flight Plan. This was in compliance with the Company's fuel policy.

No irregularities were found in the fuel computation and fuel flight plan.

n) Flight Plan Routing

There is no evidence in terms of out-of-normal flight planning on the KUL/PEK sector nor any deliberate rerouting to suggest that the PIC might have the intention to carry extra fuel. Nonetheless, it is a captain's authority to carry additional fuel if he thinks it is justified and to override the despatcher's decision.

No irregularities were found in the aircraft flight plan.

3) In-flight Services

a) Cabin Crew Training

The cabin crew of MH370 were provided with proper training on Safety and First Aid. They were also trained to handle:

i) Safety and emergency evacuation.
ii) Disruptive/difficult passengers.
iii) Medical emergency (provision of First Aid).

Crew Resource Management (CRM) is part of the mandatory programme in cabin crew training. It is on record that the IFS did his CRM a day before the departure of the MH370 flight (the most current in the CRM recorded was from the IFS where it was noted that he did his CRM a day before the departure of the MH370 flight).

All the cabin crew of MH370 were trained with Safety procedures and in compliance with regulatory and Company's requirements.

b) Crew Performance Appraiser

The Crew Performance Appraiser (CPA) system was an established process in the organisation to monitor crew performance and standards including safety knowledge.

The organisation had a clear system on the CPA monitoring process that, if a crew member had failed to carry out the required CPA, the crew member was reminded by the system or the Ward Leader[39] to follow up on the crew member apart from alerting the Crew-in-charge to ensure that the crew member would have to fulfil the requirement within the stipulated cycle in a year.

There is no evidence to indicate that the disappearance of MH370 was attributed to poor crew performance.

c) Medical Record

The cabin crew of MH370 had undergone a medical check-up as a requirement during the initial crew training. However, medical check-up was never made compulsory as a yearly pre-requisite. There is no evidence to suggest that the disappearance of MH370 was attributed to medical conditions of the cabin crew.

[39] Ward Leader – An executive assigned to monitor the performance, discipline and welfare of cabin crew.

d) In-flight Operation

To efficiently carry out the duties that include in-flight customer services including serving passenger meals, MAS had established the need to carry 11 cabin crew members. MH370 however departed with only 10 cabin crew members, 1 less than the normal compliment. It is an established fact that, based on regulation, the minimum crew required are 8, consistent with the number of doors/Emergency Exits available on the B777. It is unlikely that any of the crew were subjected to exhaustion before or while on duty on the ill-fated flight.

MAS was then facing acute shortage of cabin crew resulting in flights departing with under-strength crew complements from the numbers normally required on many of their aircraft operations in the past year.

The flight departed within the legal minimum crew requirement as per the local Civil Aviation Requirement. Shortage of manpower can lead to personnel fatigue even though it is within the legal requirement and acceptable operations.

Nevertheless, there is no evidence to indicate that exposure to stress and overwork had contributed to the disappearance of MH370.

e) Flight Time Limitation

The Malaysia Airlines Employee Union (MASEU) was the recognised Union Organisation endorsed by MAS to represent the cabin crew. The Flight Time Limitation (FTL) and the working conditions were governed by the Collective Agreement (CA) signed between the Union and MAS in accordance with the Civil Aviation Regulations 1996, whichever was the more limiting.

Another Union - the National Union Flight Attendants Malaysia (NUFAM) - was later formed and sought recognition to represent the crew's Collective Agreement (CA). A secret ballot was held in July 2013 and NUFAM won the election with a majority of 60% indicating the cabin crew's preference. However, MAS Management did not recognise the Union. This stalemate had delayed the renewal of the Collective Agreement which expired in August 2013.

There was no infringement of the FTL. The cabin crew were in compliance with the requirements of the Civil Aviation Regulations 1996.

There is no evidence to indicate that the disappearance of MH370 was attributed to insufficient rest or exceeding permitted working hours.

FTL is not a contributing factor to the disappearance of MH370. However, the crew's working conditions and FTL were subject to each organisation's MOU with the approval of the DCA as a regulator. The crew were in compliance with the requirements of the Civil Aviation Regulations 1996.

SECTION 2 – ANALYSIS

2.8 AIRCRAFT CARGO CONSIGNMENT

2.8.1 Cargo on Board MH370

1) The gross weight of the cargo carried on board MH370 was 10806 kg (cargo plus packing materials, pallets and ULDs).

2) The nett and gross weight of the cargo are as depicted in *Table 2.8A* (below).

<table>
<tr><th rowspan="2">CARGO ITEMS</th><th colspan="2">WEIGHT (in kg)</th></tr>
<tr><th>NETT</th><th>GROSS</th></tr>
<tr><td>Scholastic Assorted Books</td><td>2,250</td><td>2,320</td></tr>
<tr><td>Lithium Ion Batteries</td><td>221</td><td rowspan="2">2,650</td></tr>
<tr><td>Walkie Talkie and Radio Accessories and Chargers</td><td>2,232</td></tr>
<tr><td>Electrical Parts (Capacitors)</td><td>26*</td><td rowspan="3">(410 + 394)
804</td></tr>
<tr><td>Vehicle Electronic Chips</td><td>6*</td></tr>
<tr><td>Electronic Measurements</td><td>646*</td></tr>
<tr><td>Fresh Mangosteens</td><td>4,566</td><td>4,926</td></tr>
<tr><td>Courier Materials - Documents</td><td>6</td><td>6</td></tr>
<tr><td>Total</td><td>9,953</td><td>10,806</td></tr>
</table>

Table 2.8A - Cargo List

* *shared cargo position*

3) There were 2 items of concern viz. Lithium Ion (Li-ion) batteries and mangosteen fruit. The batteries were speculated to be a fire hazard and the mangosteens were also speculated to be out of season at that time of the year.

4) A total of 36 shipments of Li-ion batteries and accessories and mangosteens were flown together to China on previous flights (*Appendix 1.18J - Airways Bills from January to May 2014)*. There were no reports of any incidents concerning these cargo shipments.

5) During the Team's visit to NNR Logistics, Tianjin, China the forwarding agent for Motorola confirmed that they had reserved cargo space on all MH370 departures out of Kuala Lumpur to Peking for the carriage of Motorola products. NNR Logistics had also highlighted that, in compliance with Motorola's stringent Standard Operating Procedures

(SOP), any damaged boxes would be rejected during physical inspection and loading.

2.8.2 Li-ion Batteries on Board MH370

1) Of the total consignment of 2,453 kg from Motorola Solutions Penang, only 221 kg were Li-ion batteries in compliance with Section II of Packing Instruction 965; the rest comprised Radio Accessories and Chargers.

2) Testing of the Li-ion batteries was carried out by the Company's Research & Development Department in the United States of America as per Certificate of Compliance, Certificate No. 12GEM0185 with Issue Date: 12-09-2012 for PMNN4081BRC; and Certificate No. 13GEM0300 with Issue Date: 2013.10.25 for PMNN4073AR. *Appendix 2.8A - Certificates of Compliance (Rev 14 and 15).*

3) The shipments from Motorola Solutions, transported to the Penang MASkargo Complex by NNR were physically (external visual inspection but did not involve the breaking down of the cargo) inspected by the MASkargo handlers in Penang but not screened by MAS security personnel by means of an x-ray screening machine. At that time there were no available x-ray machines on the landside large enough to screen the consignments. In June 2014, Penang MASkargo had acquired three machines capable of screening large consignments which were fully operational in July 2014.

4) The security procedures are in accordance with Amendment 13 of ICAO Annex 17 which came into force on 15 July 2013 where all cargo are required to undergo physical security screening as per DCA Director General Directive No. 1A/2013 (AVSEC) Physical Security Screening-Enhanced. There is also a Director General Directive No. 2/2013 (AVSEC) on Air Cargo Transhipment in Malaysia effective 15 July 2013 which allows this procedure (*Appendix 2.8B - Director General Directive No. 1A/2013 and Appendix 2.8C - Director General Directives No. 2/2013*).

   After the physical inspection by MASkargo personnel, the loaded consignments went through Customs inspection and clearance. The truck was then sealed by Customs and MAS Security before being allowed to leave the Penang cargo complex enroute to KLIA under escort. The truck made a routine resting stop at Rest and Recreation

(R n R) Centre, Tapah, Perak on the North-South Highway. The two drivers interviewed revealed that the truck was never left unguarded by them or the security escort. The shipment arrived at KLIA Cargo Complex on the evening of 07 March 2014, before the seals were broken and the cargo loaded onto MH370 without further screening.

The security procedures for the cargo from Motorola Solutions to KLIA, Sepang were reviewed and found in accordance to the standard operating procedures.

2.8.3 Mangosteen Fruits on Board MH370

The Team confirmed that MH370 was carrying mangosteens to China. Contrary to speculations that the fruits were out of season, it was found to be in season in Muar, Johore and neighbouring countries. At the time of writing of this report the fruits are still being exported by the same company to Beijing, China.

2.8.4 Dangerous Goods

1) The Li-ion batteries carried on board MH370 were not listed as dangerous goods (DG) and as such they were in compliance with Section II of Packing Instruction 965. Hence, there was no requirement for the pilots to be informed. However, the mangosteens were declared in the Special Load Notification to Captain (Doc. DVC-17957 1529 07Mar14 (*Appendix 2.8D*) and the Letter and Directive by the Director General (*Appendices 2.8B and 2.8C*) as it is classified as a perishable item.

2) Both pilots were trained on DG procedures and were periodically updated (once every two years) in their Safety and Emergency Procedures (SEP) training programme. *Table 2.8B (*below) shows the training programme.

Crew	SEP Expiry Date	CRM Date Attended	DG Cat 10
Pilot	17 August 2014	07 September 2011	24 February 2014

Table 2.8B - Table for Technical Crew SEP/CRM/DG CAT

2.8.5 Laboratory Tests Conducted

After the disappearance of MH370, laboratory tests on Li-ion batteries and mangosteens were conducted by STRIDE, Malaysia to determine their individual and/or combined reactions under certain conditions. Refer to *Appendix 2.8E Laboratory test on Li-ion batteries and mangosteens.* The test results are as follows:

1) Li-ion Batteries

a) High Temperature Tests

i) Point of bulging was at 175º C;

ii) Point of fuming was at 187º C;

iii) Point of eruption was at 207º C;

iv) At peak, release of carbon monoxide (CO) was at 176.5 ppm;

v) At peak, release of carbon dioxide (CO2) was at 471 ppm.

b) Functional and Voltage Capacity Tests

i) All the batteries tested were functioning normally.

ii) Average capacity of 60% or about 7.3V from full capacity of 11V.

c) Drop Tests

The tests were carried out with batteries (window white box in brown box *(Figure 2.8A*, [below]) dropped at a height of 120.92 cm (48 inches) on to a wooden platform. It was found that the batteries had no observable physical damage and functioned normally.

i) Short Circuit Tests

- The batteries produced sparks when electrodes (Positive and Negative) touched directly.
- The batteries did not produce sparks when the electrodes were touched with cardboard soaked in water from sponge or mangosteen extract.

ii) Built-in Voltage and Current Protection Circuit Tests

- The batteries also have a built-in voltage and current protection circuit. "…*Cell protection features consist of internally trimmed charge and discharge voltage limits,* *discharge limit with a delayed shutdown and an ultra-low current sleep mode state when the cell is discharged.*"

Figure 2.8A - 2 Batteries in window white box and placed in a brown box

2) Mangosteen Fruits

a) pH Value Tests

Water from the sponge used to keep the fruit fresh was tested and found to have a pH value of 6 and the mangosteen juice had a pH value of 3.

b) Conductivity Tests

- When current was passed through distilled water, the current flow indicator did not light up (distilled water was not conductive);
- When current was passed through mangosteen extracts, the current flow indicator lit up (mangosteen extract was conductive);
- When current was passed through water from the sponge, the current flow indicator lit up (water from the sponge was conductive).

2.8.6 Effects of Close Proximity of Li-ion Batteries and Mangosteens in Cargo Consignment

1) Location of Cargo

In one of the cargo compartments on MH370 the Motorola Solutions batteries and mangosteens were placed next to each other (No. 1 and ‘A’). Even though they were placed next to each other in the aircraft (*Figure 2.8B* [below]), the mangosteens were packed in plastic crates and placed in Unit Load Device (ULD) containers. The consignment was also wrapped in a plastic sheet to make it water-proof to a certain extent.

Figure 2.8B - Sample ULD and Batteries placed next to each other

2) Results of Tests

There were concerns that the mangosteen extracts could have got into contact with the batteries and produced hazardous fumes or in a worst case scenario caused a short circuit and/or fire. These tests were carried out and the results are as follows:

i) This was highly improbable on board MH370 with a comparatively short flight duration and under controlled conditions.

ii) After carrying out the tests, STRIDE was convinced that the two items tested could not be the cause in the disappearance of MH370. The Team concurs with STRIDE’s findings.

SECTION 3 – FINDINGS AND CONCLUSION

3.1 Findings

3.1.1 Diversion from Filed Flight Plan Route

1) Flight MH370 had diverted from the Filed Flight Plan route.

2) There is no evidence to indicate that MH370 was evading radar.

3) Only the transponder signal of MH370 disappeared from the ATC Controller radar display whilst the (radar) position symbols from other aircraft were still available.

4) The reason for the transponder information disappearing from the aircraft could not be established.

5) It could not be established whether the aircraft was flown by anyone other than the pilots.

6) The reconstruction flight conducted on the B777 flight simulator had established that the turn back was likely made while the aircraft was under manual control and not the autopilot. However, it could not be established that the other two turns over the south of Penang and the north of MEKAR were made under manual control or autopilot.

7) The aircraft primary radar target was designated as ‘friendly’ by the Royal Malaysian Air Force as it did not pose any threat to national airspace security, integrity and sovereignty.

8) There were uncertainties on the position of MH370 by both Kuala Lumpur ACC and Ho Chi Minh ACC.

3.1.2 Air Traffic Services Operations

1) Kuala Lumpur Air Traffic Services

a) KL ATSC operation was normal with no significant observation until 1720 UTC [0120 MYT].

b) KL ACC controllers transferred MH370 to Ho Chi Minh ACC at 1719:26 UTC, 3 minutes before the original estimate time of the transfer of the control point.

c) HCM ACC did not notify KL ACC when two-way communication was not established with MH370 within five minutes of the estimated time for the transfer of control point.

d) KL ACC controllers relied solely on position information of the aircraft provided by MAS Flight Operations Despatch Centre rather than checking up with other ATC authorities.

e) The Air Traffic controllers did not initiate, in a timely manner, the three standard emergency phases in accordance with the standard operating procedures.

f) There is no record to suggest that the KL ACC controllers took any action to alert the RMAF Joint Air Traffic Control Centre (JATCC).

g) There is no evidence to suggest that the Air Traffic controllers at KL ACC had kept continuous watch on the radar display.

h) KL ACC controllers did not comply fully with established ATC procedures.

2) Ho Chi Minh Air Traffic Services

a) There were uncertainties on the position of MH370 by both KL ACC and HCM ACC.

b) The command of the English language in the coordination process between KL ACC and HCM ACC needs improvement.

c) HCM ACC did not notify KL ACC when two-way communication was not established with MH370 within five (5) minutes of the estimated time for the transfer of control point.

3.1.3 Flight Crew Profile

1) General and Specific Human Factors Issues

a) There is no evidence to suggest any recent behavioural changes for the PIC, FO and cabin crew.

b) There is no evidence to suggest a pattern of regular over-the-counter medication purchase by the PIC. However, the possibility that such medication may have been purchased by cash cannot be excluded.

2) Human Factor Aspects of Air Traffic Control Recordings

a) The voice transmission for the first 3 sets of recordings were those of the FO before take-off and the 4^{th} and 5^{th} sets were from the PIC after take-off.

b) The last radio transmission "*Good Night Malaysian Three Seven Zero"* was spoken by the PIC. However, he did not readback the assigned frequency, which was inconsistent with radio-telephony procedures.

c) The radio-telephony communications conducted by the PIC and the FO with the Air Traffic Controllers revealed no evidence of anxiety or stress detected in the conversations.

3.1.4 Airworthiness & Maintenance and Aircraft Systems

1) The maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures, except for the instance of the Solid-state Flight Data Recorder Underwater Locating Beacon (SSFDR ULB) battery which had expired in December 2012.

2) The aircraft had a valid Certificate of Airworthiness.

3) The aircraft was airworthy when dispatched for the flight.

4) The mass and the centre of gravity of the aircraft were within the prescribed limits.

5) Although it cannot be conclusively ruled out that an aircraft or system malfunction was a cause, based on the limited evidence available, it is more likely that the loss of communication (VHF and HF communications, ACARS, SATCOM and Transponder) prior to the diversion is due to the systems being manually turned off or power interrupted to them or additionally in the case of VHF and HF, not used, whether with intent or otherwise.

6) The recorded changes in the aircraft flight path following waypoint IGARI, heading back across Peninsular Malaysia, turning south of Penang to the north-west and a subsequent turn towards the Southern Indian Ocean are difficult to attribute to any specific aircraft system failures. It is more likely that such manoeuvres are due to the systems being manipulated.

7) The SATCOM data indicated that the aircraft was airborne for more than 7 hours suggesting that the autopilot was probably functioning, at least in the basic modes, for the aircraft to be flown for such a long duration. This in turn suggests that the air and inertial data were probably available to the autopilot system and/or the crew.

8) The inter-dependency of operation of the various aircraft systems suggests that significant parts of the aircraft electrical power system were likely to be functioning throughout the flight.

9) Without the benefit of the examination of the aircraft wreckage and recorded flight data information, the investigation is unable to determine any plausible aircraft or systems failure mode that would lead to the observed systems deactivation, diversion from the filed flight plan route and the subsequent flight path taken by the aircraft.

10) No Emergency Locator Transmitter (ELT) signal from the aircraft was reported by the responsible Search and Rescue agencies or any other aircraft.

3.1.5 Satellite Communications

1) Throughout the flight of MH370 the aircraft communicated through the Inmarsat Indian Ocean Region (IOR) I-3 Satellite and the Ground Earth Station (GES) in Perth, Australia.

2) At 1707 UTC (07 March 2014), the SATCOM system was used to send a standard ACARS report, normally sent at every 30 minutes. The ACARS reports expected at 1737 UTC and subsequently were not received. The next SATCOM communication was a log-on request from the aircraft at 1825 UTC, followed by two IFE Data-3 channel setups. From that point until 0011 UTC (08 March 2014), SATCOM transmissions indicate that the link was available, although not used for any voice, ACARS or other data services apart from two unanswered ground-to-air telephone calls. At 0019 UTC, the Airborne Earth Station (AES) initiated another log-on request. This was the last SATCOM transmission received from the AES.

3) Data from the last seven 'handshakes' were used to help establish the most probable location of the aircraft. Both the initial log-on request and the hourly ping have been termed as a 'handshake'. Two unanswered ground-to-air telephone calls at 1839 and 2313 UTC (07 March 2014) had the effect of resetting the activity log and hence increased the period between the ground initiated 'handshakes'.

4) The two Log-Ons, at 1825 UTC (07 March 2014) and 0019 UTC (08 March 2014), were initiated by the aircraft most likely due to power interruptions to the SATCOM avionics.

5) The power interruption leading up to 1825 UTC was probably due to power bus cycling, the reason for it being unknown. The power interruption leading up to 0019 UTC was probably due to low fuel at this time resulting in the loss of both engines and their respective generators. There was probably enough fuel for the APU to start up and run long enough for its generator to power the SATCOM avionics (SATCOM AES) to initiate a log-on request.

3.1.6 Wreckage and Impact Information

1) The main wreckage belonging to MH370 has so far not been found. However, a number of debris were found washed ashore near and onto the south eastern coast of Africa.

2) Only the parts washed ashore on La Reunion Island (the right flaperon), Tanzania (part of the right outboard flap) and Mauritius (a section of the left outboard flap) were confirmed to be from MH370. Although the name plate was missing, which could have provided immediate traceability to the accident aircraft, the flaperon was confirmed to be from the aircraft 9M-MRO, by tracing the identification numbers of the internal parts of the flaperon to their manufacturing records at EADS, CASA, Spain. Similarly, the Italian part manufacturer build records for the numbers located on the right outboard flap part confirmed that all of the numbers related to the same serial number outboard flap shipped to Boeing for aircraft 9M-MRO. As for the section of the left outboard flap, a part identifier on it matched the flap manufacturer supplied records which indicated a unique work order number and that the referred part was incorporated into the outboard flap shipset line 404 which corresponded to the Boeing 777 aircraft line number 404, registered 9M-MRO and operating as MH370.

3) To date, 27 items of debris were considered significant for examination. Of these, other than the flaperon, a part of the right outboard flap and a section of the left outboard flap, 7 items were also considered *almost certain* to be from MH370.

4) Damage examination on the recovered part of the right outboard flap, together with the damage found on the right flaperon indicates that the right outboard flap was most likely in the retracted position and the right flaperon was probably at, or close to, the neutral position, at the time they separated from the wing.

5) Recovery of the cabin interior debris suggests that the aircraft was likely to have broken up. However, there is insufficient information to determine if the aircraft broke up in the air or during impact with the ocean.

3.1.7 Organisational and Management Information

1) Department of Civil Aviation

a) The regulatory system in Malaysia includes Regulation 201 of MCAR 1996 that applies ICAO Annex 1 to 18 "*ipso facto*". However, the resulting regulatory framework under this *"ipso facto"* regulation in Malaysia does not enable an effective implementation of all ICAO Annex provisions. With the introduction of Annex 19 dedicated to a Safety Management System, applicability date 14 November 2013, the *"ipso facto"* provision does not include Annex 19.

b) DCA is looking into the establishment of a State Safety Programme (SSP) for the management of safety in the State that will be applicable on 07 November 2019.

c) The organisation structure is suitable for DCA at headquarters as the activities are routine and standardised.

d) On Search and Rescue, there is a comprehensive arrangement in dealing with an aircraft emergency between Malaysia and neighbouring States which requires the provision of A-SAR services on a 24-hours daily basis fulfilling the international obligations.

e) Kuala Lumpur Air Traffic Control Centre

i) DCA has a policy of retaining retiring ATCOs on a contract basis to ensure that the number of qualified and rated Controllers remains status quo and that there is a transfer of technology, experience and expertise.

ii) Although no internal audit had been conducted, it is noted that an audit team will be established consisting of personnel who had previously attended audit courses.

iii) All ATC training courses were conducted on operational and opportunity basis.

2) Malaysia Airlines

a) Engineering & Maintenance

i) The Engineering & Maintenance Division was a well-structured maintenance management and maintenance organisation with key positions manned by persons approved by the Department of Civil Aviation (DCA), Malaysia.

ii) Proper oversight was provided both by internal and external audits. There were no significant audit findings.

iii) Maintenance personnel were appropriately trained and qualified in accordance with approved procedures.

b) Flight Operations

i) There is no evidence of irregularities of both the pilots in terms of their capability, performance and standard to assume command of a B777 and as First Officer respectively prior to the disappearance of MH370.

ii) There is no evidence of irregularities in terms of Medical & Licencing Validity of both the pilots prior to the disappearance of MH370.

iii) There is no evidence of irregularities in Roster Schedule and Management.

iv) The findings of LOSA were very relevant and recommendations were implemented via a Safety Change Process (SCP). MAS had met the average safety standards of most international airlines.

v) Both the Technical Crew & Cabin Crew were in compliance with CRM requirements.

vi) During the period of the incident there was no enhanced special security alert status declared by MAS.

vii) there were no training records available for the FO from the beginning of his simulator training and initial operating experience (IOE) to his present fleet where he was still under training. All the training reports were with him in his personal training file on board the flight.

viii) Based on past training records, there is no evidence that both the pilots' performance was below the Company's standard since their employment with MAS.

ix) The duration of the scheduled flight with Flight Duty Period (FDP) of less than 8 hours and the training policy justify the 2-man crew operations.

x) An element of overworked condition in the MAS Operation Control Centre existed.

xi) The displayed aircraft position on the Flight-Following System was erroneous right from the point where ACARS communication was lost.

xii) No irregularities were found in the fuel computation and fuel flight plan.

xiii) No irregularities were found in the aircraft flight plan.

xiv) The cabin crew were subjected to thorough medical check-ups as a requirement during the initial recruitment before employment and neither the Company nor the Regulatory body made it a requirement after being employed. However, there was no strict monitoring on the crew's health and mental health in the Standard Operating Procedures (SOP).

xv) The flight departed within the legal minimum cabin crew requirement.

3.1.8 Aircraft Cargo Consignment (Lithium Ion Batteries and Mangosteen Fruits)

1) The two cargo items in question which were carried on MH370 had also been transported via scheduled flights on MAS before and after the event.

2) The Lithium ion batteries (listed as non-dangerous goods), were packed and land-transported out from the production factory to KLIA Sepang in accordance with existing and approved regulations and procedures.

3) Extensive tests conducted on the mangosteens packed with water-soaked foam and juice extracts of mangosteens in contact with Lithium ion batteries revealed that this could only be hazardous if exposed to a certain extreme condition and over a long period of time. This was highly improbable on board MH370 which had a comparatively shorter duration of flight time and was under controlled conditions.

4) There was no cargo classified as dangerous goods on board MH370. The batteries on board were not classified as Dangerous Goods because the packing adhered to the guidelines as stipulated in the Lithium Battery Guidance Document.

SECTION 3.2 – Conclusion

On 08 March 2014, MH370, a scheduled passenger flight from Kuala Lumpur to Beijing, operated by MAS went missing soon after a routine handover from the Malaysian ATC to Viet Nam ATC. Communications with the aircraft were lost after it passed waypoint IGARI, less than 40 minutes after take-off. The aircraft operating the flight was a Boeing 777-200ER, registered 9M-MRO. On board the aircraft were 12 crew and 227 passengers (239 persons in total).

Evidence shows that Flight MH370 diverted from the Filed Flight Plan route. The aircraft's transponder signal ceased for reasons that could not be established and was then no longer visible on the ATC radar display. The changes in the aircraft flight path after the aircraft passed waypoint IGARI were captured by both civilian and military radars. These changes, evidently seen as turning slightly to the right first and then to the left and flying across the Peninsular Malaysia, followed by a right turn south of Penang Island to the north-west and a subsequent (unrecorded) turn towards the Southern Indian Ocean, are difficult to attribute to anomalous system issues alone. It could not be established whether the aircraft was flown by anyone other than the pilots. Later flight simulator trials established that the turn back was likely made while the aircraft was under manual control and not the autopilot.

KL ATSC operation was normal with no significant observation until the handover to Viet Nam ATC. Being *the accepting unit*, HCM ACC did not notify *the transferring unit* (KL ATSC) when two-way communication was not established with MH370 within five minutes of the estimated time of the transfer of control point (Establishment of Communications, page 11 of Operational LOA between DCA Malaysia and Vietnam Air Traffic Management effective 1 November 2001). Likewise, KL ATSC should have taken action to contact HCM ACC, instead, relied on position information of the aircraft provided by MAS Flight Operations. By this time, the aircraft had left the range of radars visible to the KL ATSC. It is noted that about one minute elapsed from the last transmission from MH370 and the SSR being lost from the radar display. The Air Traffic Controllers of both Centres did not initiate the various emergency phases as required then, thereby delaying the activation of the alerting and Search and Rescue operations.

The PIC and FO held valid airman licences and medical certification. There is no evidence to suggest that the PIC and FO experienced recent changes or difficulties in personal relationships or that there were any conflicts or problems between them. All the flight and cabin crew were certified fit to fly and were within duty-time limits at the time of the flight and were adequately rested. There had been no financial stress or impending insolvency, recent or additional insurance coverage purchased or recent behavioural changes for the crew. The radio-telephony communications conducted by the PIC and the FO with the Air Traffic Controllers conformed to the routine procedure and no evidence of anxiety or stress was detected in the communications.

The aircraft maintenance records indicated that the aircraft was equipped and maintained in accordance with existing regulations and approved procedures, except for the instance of the SSFDR ULB battery which had expired. The aircraft had a valid Certificate of Airworthiness and was airworthy when released for the flight and there was no record or report of any defect or malfunction in the aircraft that could have contributed to the event. Although it cannot be conclusively ruled out that an aircraft or system malfunction was a cause, based on the limited evidence available, it is more likely that the loss of communications (VHF and HF communications, ACARS, SATCOM and Transponder) prior to the diversion is due to the systems being manually turned off or power interrupted to them or additionally in the case of VHF and HF, not used, whether with intent or otherwise. No ELT signal from the aircraft was reported by the Search and Rescue agencies or any other aircraft. The SATCOM data indicated that the aircraft was airborne for more than 7 hours suggesting that the autopilot was probably functioning, at least in the basic modes, for the aircraft to be flown for such a long duration. This in turn suggests that the air and inertial data were probably available to the autopilot system and/or the crew. The inter-dependency of operation of the various aircraft systems suggests that significant parts of the aircraft electrical power system were likely to be functioning throughout the flight. The analysis of the relevant aircraft systems taking into account the route followed by the aircraft and the height at which it flew, constrained by its performance and range capability, does not suggest a mechanical problem with the aircraft's airframe, control systems, fuel or engines.

Except for the first report, the ACARS reports normally sent every 30 minutes by the SATCOM system were not received. Data from the last seven SATCOM 'handshakes' were used to help establish the approximate path of the aircraft over the Indian Ocean. The initial log-on request and the hourly pings have been termed as 'handshakes'. SATCOM transmissions indicated that a link was available from 1825 UTC on 07 March 2014 to 0011 UTC on 08 March 2014 although not used for any voice, ACARS or other data services apart from two unanswered ground-to-air telephone calls. Two log-ons, at 1825 UTC (07 March 2014) and 0019 UTC (08 March 2014), were initiated by the aircraft most likely due to power interruptions to the SATCOM avionics. The power interruption leading up to 1825 UTC was probably due to power bus cycling, the reason for it being unknown. The power interruption leading up to 0019 UTC was probably due to low fuel at this time resulting in the loss of both engines and their respective generators. There was probably enough fuel for the APU to start up and run long enough for its generator to power the SATCOM avionics to initiate a log-on request.

To date, the main wreckage of MH370 has still not been found despite a 4-year search in the South Indian Ocean. However, items of debris possibly from MH370, have been found as far north as the eastern coast of Tanzania and far south as the eastern coast of South Africa. This is in addition to several islands and island nations off the east coast of the African continent. Of these, the flaperon, a part of the right outboard flap and a section of the left outboard flap were confirmed to be from MH370. A few other pieces of debris were determined to be almost certain from MH370 which included some cabin interior items. Damage examination on the recovered part of the right outboard flap, together with the damage found on the right flaperon has led to the conclusion that the right outboard flap was most likely in the retracted position and the right flaperon was probably at, or close to, the neutral position at the time they separated from the wing. Recovery of the cabin interior debris suggests that the aircraft was likely to have broken up. However, there is insufficient information to determine if the aircraft broke up in the air or during impact with the ocean. Apart from the above, no other information about in-flight emergencies, aircraft configuration or impact could be inferred from the nature and damage of the debris.

MH370 did not carry any cargo classified as dangerous goods. Two cargo items of interest (the Lithium ion Batteries and Mangosteens) which were carried on MH370 had also been transported via scheduled flights on MAS before and after the event. These items were packed and loaded according to standard operating procedures.

As a result of the identified issues, the investigation has issued safety recommendations to enhance the safety of the aviation system. The recommendations made address the Malaysian and foreign air traffic surveillance systems, cargo scanning, flight crew medical and training records, reporting and following-up of crew mental health, flight-following system, development of a Quick Reference for Operations Control and ELT effectiveness.

It should be recognised that there is a significant lack of evidence available to the Team to determine with any certainty the reasons that the aircraft diverted from its filed flight plan route. However, the change in flight path likely resulted from manual inputs. The lack of evidence includes the exact location and disposition of the main aircraft wreckage and the evidence that it could provide, the information recorded on the Flight Data Recorder, Cockpit Voice Recorder and other recording devices on the aircraft and the absence of any aircraft voice or data transmissions that could indicate why the aircraft flew to the Southern Indian Ocean.

Without the benefit of the examination of the aircraft wreckage and recorded flight data information, the investigation was unable to identify any plausible aircraft or systems failure mode that would lead to the observed systems deactivation, diversion from the filed flight plan route and the subsequent flight path taken by the aircraft. However, the same lack of evidence precluded the investigation from definitely eliminating that possibility. The possibility of intervention by a third party cannot be excluded either.

The disappearance of MH370 and the search effort are unprecedented in commercial aviation history. Improvements must be undertaken to ensure that this type of event is identified as soon as possible, and mechanisms are in place to track an aircraft that is not following its filed flight plan for any reason.

In recent years, several States have expended significant amounts of funds and resources searching for missing commercial aircraft in remote oceanic locations, including AF447 and MH370. In this technological epoch, the international aviation community needs to provide assurance to the travelling public that the location of current-generation commercial aircraft is always known. It is unacceptable to do otherwise.

In conclusion, the Team is unable to determine the real cause for the disappearance of MH370.

SECTION 4 - SAFETY RECOMMENDATIONS

4.1 Safety Recommendation of Preliminary Report

On 09 April 2014, the Ministry of Transport, Malaysia, issued a Preliminary Report that contained the following Safety Recommendation to the International Civil Aviation Organization (ICAO):

"It is recommended that the International Civil Aviation Organization examine the safety benefits of introducing a standard for real-time tracking of commercial air transport aircraft".

Based on the above recommendation, the ICAO Council has adopted Amendments 40 and 42 on 02 March 2016 and 27 February 2017, respectively, to the International Standards and Recommended Practices, Operation of Aircraft - International Commercial Air Transport - Aeroplanes (Annex 6, Part I to the Convention on International Civil Aviation). Excerpts of the amendments are listed below.

Amendment 40

"**6.18 Location of an aeroplane in distress**
(Applicable on 10 November 2016)

6.18.1 All aeroplanes of a maximum certificated take-off mass of over 27 000 kg for which the individual certificate of airworthiness is first issued on or after 1 January 2021, shall autonomously transmit information from which a position can be determined by the operator at least once every minute, when in distress, in accordance with Appendix 9.

6.18.2 **Recommendation.** - *All aeroplanes of a maximum certificated take-off mass of over 5 700 kg for which the individual certificate of airworthiness is first issued on or after 1 January 2021, should autonomously transmit information from which a position can be determined at least once every minute, when in distress, in accordance with Appendix 9.*

6.18.3 The operator shall make position information of a flight in distress available to the appropriate organizations, as established by the State of the Operator."

Amendment 42

"3.5 AIRCRAFT TRACKING
(Applicable on 8 November 2018)

3.5.1 The operator shall establish an aircraft tracking capability to track aeroplanes throughout its area of operations.

3.5.2 **Recommendation.** — *The operator should track the position of an aeroplane through automated reporting at least every 15 minutes for the portion(s) of the in-flight operation(s) under the following conditions:*

a) the aeroplane has a maximum certificated take-off mass of over 27 000 kg and a seating capacity greater than 19; and

b) where an ATS unit obtains aeroplane position information at greater than 15 minute intervals.

3.5.3 The operator shall track the position of an aeroplane through automated reporting at least every 15 minutes for the portion(s) of the in-flight operation(s) that is planned in an oceanic area(s) under the following conditions:

a) the aeroplane has a maximum certificated take-off mass of over 45 500 kg and a seating capacity greater than 19; and

b) where an ATS unit obtains aeroplane position information at greater than 15 minute intervals."

4.2 Safety Recommendations of this Report

As a result of the issues identified in the investigation and in order to enhance greater aviation safety and benefits, the investigation has made the following Safety Recommendations (SR) to the following organisations:

4.2.1 Department of Civil Aviation - SR #01-07

SR	Safety Recommendation
#01	To review the existing coordination procedures/establish new procedures between KL ATSC and Joint Air Traffic Control Centre (JATCC) with regard to unidentified primary target observed by the Radar Controller.
#02	To review the present Duty Roster System for KL ATSC with the objective of improving the working conditions.
#03	To develop a comprehensive *Quick Reference* on ATC actions relating to aircraft emergency to be available at all Controller working positions.
#04	Air Traffic Controllers are to be provided refresher training to ensure established procedures are always complied with.
#05	To review and enhance the training syllabi of the courses for Lead-in and On-the-job training to include ATC actions during aircraft emergencies for ATS personnel at KL ATSC.
#06	To review and introduce more stringent security measures for cargo scanning at Penang International Airport/all airports and the point of entry into airside at KLIA/all airports.
#07	To review the privileging process of the appointment of the designated aviation medical examiners on a regular basis.

4.2.2 Civil Aviation Authority of Viet Nam - SR #08 - 09

SR	Safety Recommendation
#08	To observe the provisions of the Operational Letter of Agreement between Civil Aviation Authorities of adjacent Flight Information Regions.
#09	To observe the requirement of Language Proficiency as outlined from the following document: d) ICAO Annex 1 Personnel Licencing Chapter 1 paragraph 1.2.9.2 Language Proficiency; ii) ICAO Doc 9835 AN/53 Manual on the Implementation of ICAO Language Proficiency Requirements Chapter 6 - Language Testing Criteria for Global Harmonization.

4.2.3 Malaysia Airlines Berhad - SR #10-17

SR	Safety Recommendation
#10	To ensure that the flight crew report to MAB Flight Operations of any serious ailment that can cause medical incapacitation and therapy prescribed at MAB medical facilities as well as MAB-appointed panel clinics.
#11	To ensure that the medical records of the flight crew maintained by the MAB Medical Centre to include records maintained by different panel clinics. The complete medical record of the individual flight crew shall show all visits to any panel clinics, the details of ailments and therapy prescribed.
#12	To review the process of reporting system and the action flow when flight crew and cabin crew's health may become a risk factor for the safety of the aircraft operations.
#13	The personnel manning the Flight-Following System/*Flight Explorer* should be adequately trained and qualified to enable them to provide information relating to flights to the relevant authorities and/or organisations.
#14	The current Flight-Following System/ *Flight Explorer* should be upgraded to the Global real-time Tracking System.

4.2.3 Malaysia Airlines Berhad - SR #10-17 (*cont…*)

SR	Safety Recommendation
#15	To review and introduce new security measures for cargo scanning at Penang International Airport/all airports and the point of entry into airside at KLIA/all airports.
#16	A document back-up system should be implemented on every training sorties, simulator trainings, and flight trainings completed by a trainee should have their original form submitted to the Training Department and a copy retained by the trainee in his personal training file.
#17	To develop a comprehensive *Quick Reference* for the Operations Control Centre that covers every aspect of abnormal operations/situations.

4.2.4 Malaysia Airports Holdings Berhad - SR #18

SR	Safety Recommendation
#18	To review and introduce new security procedures for the scanning of cargo at the point of entry at all airports and the point of entry into the airside at KLIA/all airports in Malaysia.

4.2.5 International Civil Aviation Organization - SR #19

SR	Safety Recommendation
#19	To review the effectiveness of current ELTs fitted to passenger aircraft and consider ways to more effectively determine the location of an aircraft that enters water. Note: The Investigation Team is cognizant of the fact that this effort is already underway.

SECTION 5 – COMMENTS TO THE REPORT AS REQUIRED BY ICAO ANNEX 13, PARAGRAPH 6.3

As required by ICAO Annex 13, paragraph 6.3, the draft Report was sent to the Accredited Representatives of the States participating in the investigation inviting their significant and substantiated comments on the Report. The following is the status of the comments received.

Organisations participating in the Investigation	**Status of Significant and Substantiated Comments**
Air Accidents Investigation Branch (AAIB) of United Kingdom	Accepted and Incorporated
Australian Transport Safety Bureau (ATSB) of Australia	Accepted and Incorporated
Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (BEA) of France	Accepted and Incorporated
Civil Aviation Administration of the People's Republic of China (CAAC)	Accepted and Incorporated
National Transportation Safety Board (NTSB) of United States of America	Accepted and Incorporated
National Transportation Safety Committee (NTSC) of Indonesia	No comments received
Transport Safety Investigation Bureau (TSIB) of Singapore (formerly Air Accident Investigation Bureau [AAIB])	Accepted and Incorporated

OPERATIONAL

LETTER OF AGREEMENT

BETWEEN

DEPARTMENT OF CIVIL AVIATION MALAYSIA

AND

VIET NAM AIR TRAFFIC MANAGEMENT

Effective

1 Nov 2001

Document Management

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2	1 Nov 2001	9	1 Nov 2001
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		15	1 Nov 2001

Overview

Introduction

The following document is an Operational Letter of Agreement (LOA) between Department of Civil Aviation Malaysia and the Viet Nam Air Traffic Management. The LOA details separation standards, level assignment and co-ordination procedures between the following Air Traffic Services (ATS) Units :

Malaysia	: Kuala Lumpur Area Control Centre
Viet Nam	: Ho Chi Minh Area Control Centre

Objective

To define the procedures for the transfer of control/communications of flights traversing Ho Chi Minh FIR and ATS/RNAV routes within the Singapore FIR within which Kuala Lumpur ACC is responsible for providing air traffic services.

The detailed procedures as specified in this LOA shall be applied to all aircraft operating along the ATS/RNAV routes R208, M765 and N891.

Note: The airspace within Singapore FIR within which Kuala Lumpur ACC is responsible for providing air traffic services are referred to as "delegated airspaces". The area is defined under the Airspace Definition column on page 3.

Scope

The procedures contained in this Operational LOA supplement or detail those prescribed by ICAO Annex 2, Annex 11, PANS-RAC (Document 4444), Regional Supplementary Procedures (Document 7030) and local AIP and ATS Instructions.

Effective Date

This Operational LOA becomes effective on 1 Nov 2001 at 1930 UTC and supercedes the previous LOA dated 1 Feb 1999 on the same subject.

Airspace

Airspace Definition

The "delegated airspaces" are the segments of airspace on ATS/RNAV Routes R208 and M765 that lie within the Singapore FIR delegated to Kuala Lumpur Area Control Centre for the provision of ATS. The segments are:
M765 between VENLI and IGARI;
R208 between IKUKO and IGARI.

Kuala Lumpur Area Control Centre is not responsible for the provision of ATS on N891. For ease of communication and to ensure separation between crossing tracks converging at IGARI, Kuala Lumpur Area Control Centre shall maintain communication watch on flights within the Singapore FIR between ENREP and IGARI.

Responsibility

Kuala Lumpur Area Control Centre shall be responsible for the provision of Air Traffic Control Services, Flight Information Service and Alerting Service to all aircraft within Kuala Lumpur FIR and the "delegated airspaces" on ATS/RNAV Routes R208 and M765.

For ease of communication and to ensure separation between crossing tracks converging at IGARI, Kuala Lumpur Area Control Centre shall maintain communication watch on flights within the Singapore FIR between ENREP and IGARI. Co-ordination for all flights on N891 shall be carried out by Kuala Lumpur Area Control Centre on behalf of Singapore Area Control Centre.

Ho Chi Minh Area Control Centre shall be responsible for provision of Air Traffic Control Service, Flight Information Service and Alerting Service to all aircraft within Ho Chi Minh FIR.

When acting as transferring units, both Ho Chi Minh and Kuala Lumpur Area Control Centres shall be responsible to ensure that either vertical or adequate longitudinal separation exist between aircraft converging at or diverging from IGARI.

The addresses of the responsible ATS units are detailed in Attachment A.

Separation

Assignment of Cruising Levels	Assignment of cruising levels shall comply with the IFR table of cruising levels in Appendix C of ICAO Annex 2.
Vertical Separation	The vertical separation minimum shall be: a) 1000 ft at FL290 and below; and b) 2000 ft above FL290
Longitudinal Separation – Same Tracks	The longitudinal separation minima between aircraft flying on the same track shall be ten (10) minutes subject to the application of Mach Number Technique (MNT).
Longitudinal Separation – Reciprocal Tracks	Vertical separation shall be provided for at least ten (10) minutes prior to and after the aircraft are estimated to pass, or are estimated to have passed each other. Provided that it has been determined that the aircraft has passed each other, this separation minima need not apply.
Longitudinal Separation – Crossing Tracks	The longitudinal time separation minima between aircraft operating on crossing route segments shall be ten (10) minutes.

MNT Conditions. In accordance with ICAO Regional Supplementary Procedures (Doc 7030), MNT shall be applied provided the aircraft:

a) is equipped with approved RNAV equipment and the flight crew trained;

b) is instructed to maintain the appropriate Mach Number between entry and exit point in the en-route phase of flight; and

c) has reported over a common point and follow the same or continuously diverging tracks.

The table below details the minimum interval required between aircraft at the entry point. It includes guidance for the application of MNT when the succeeding aircraft is faster.

MNT – Time Separation Minima

Mach No. Difference between aircraft	Time interval required between aircraft at the transfer of control point (TCP)
M0.06 preceding aircraft faster	5
M0.05 preceding aircraft faster	6
M0.04 preceding aircraft faster	7
M0.03 preceding aircraft faster	8
M0.02 preceding aircraft faster	9
Same Mach No.	10
M0.01 preceding aircraft slower	11
M0.02 preceding aircraft slower	12
M0.03 preceding aircraft slower	13
M0.04 preceding aircraft slower	14
M0.05 preceding aircraft slower	15
M0.06 preceding aircraft slower	16
M0.07 preceding aircraft slower	17
M0.08 preceding aircraft slower	18

Co-ordination Procedures

Transfer of Control Point

Route	TCP
M765	IGARI (065612N 1033512E)
N891	
R208 / M765	

Communication Systems

Use of communications systems for co-ordination between Kuala Lumpur and Ho Chi Minh Area Control Centres shall be in the following order of priority:

a) Direct Speech Circuit (DSC);

b) International telephone system;

c) Aeronautical Fixed Telecommunications Network (AFTN);

d) Relay through Bangkok or Singapore Area Control Centre; and

e) Any other means of communication available.

When the DSC resumes normal operation after a period of unserviceability, transfer of control messages sent via the AFTN for aircraft that have not passed the TCP, shall be retransmitted on the DSC for confirmation.

All direct voice communication between Ho Chi Minh and Kuala Lumpur Area Control Centres shall be recorded and kept for a minimum period of thirty (30) days.

ATC Clearance Limit and Co-ordination Timings

The transferring unit shall provide at least twenty (20) minutes notification (EST message) prior to the time the aircraft is estimated to pass over the TCP. If co-ordination cannot be achieved, the clearance limit shall be the TCP. If subsequent co-ordination is achieved, the clearance limit shall be amended accordingly.

When the flying time from departure aerodrome to the TCP is less than thirty (30) minutes, clearances shall be co-ordinated with the adjacent Centre prior to issue.

After the estimate for the TCP has been advised, the transferring unit shall relay any revised TCP estimate that varies by three (3) minutes or more.

No Pre-departure Coordination (No-PDC) Arrangement

Transferring Unit	Route	FL
Kuala Lumpur ACC	R208 , M765	270 and 370
	N891	310 and 350
Ho Chi Minh ACC	M765	260 and 390
	N891	330 and 410

a) Levels indicated above are intended to facilitate initial departure. Level allocation, once airborne, is subject to normal ATC requirements. Higher level, where appropriate, may be offered when traffic permits.

b) Flight levels other than those specified above may be available subject to prior co-ordination.

Contents and Format of Messages

All co-ordination messages by DSC shall contain information in the following format. Certain information may be omitted if it is known that the accepting unit already has the information.

- Prefix (e.g. Estimate, Approval Request, Revision)
- Aircraft Identification,
- Aircraft Type
- Point of Departure
- Route
- Destination
- TCP estimate,
- The assigned level, (maintaining, climbing to, descending to)
- Mach Number (if assigned)
- SSR Code; and
- The requested level
- Other pertinent information

e.g. : *IGARI estimate, Malaysian 72, B747, estimate IGARI 0735, maintaining FL270, Mach .82, Transponder A0304, Requesting FL330 Mach .84*

Confirmation by the accepting unit shall contain the following:

- Aircraft identification
- TCP estimate
- The level assigned by the transferring unit
- Mach Number (if assigned)
- SSR Code
- The word "STANDBY FOR" the requested lev[illegible] necessary)

e.g.: *Malaysian 72, B747, IGARI at 0735, FL270, Mach .82, Transponder A0304, Standby for FL330*

If the accepting unit is able to accept the requested level, phraseology shall include:

- The aircraft identification
- The flight level approved

e.g.: *Malaysian 72, Flight level 330 approved.*

The transferring unit shall acknowledge the flight level approved with the phraseology:

e.g.: *Malaysian 72, transfer Flight Level 330.*

If the accepting unit is unable to accept any element of the EST message, the phraseology shall include:

- The word "UNABLE"
- The aircraft identification
- The element of the transfer that is unacceptable
- A suggestion

e.g.: *Unable Malaysian 72, Flight Level 330, suggest Flight Level 290*

The transferring unit shall, then, acknowledge with the phraseology

e.g.: *Malaysian 72, transfer Flight Level 290.*

AFTN Estimate (EST) and Acceptance (ACP) messages are not required when voice communication has been successful.

When an AFTN message is required the following format shall be used:

Estimate Message
(Designator-Aircraft Identification/SSR Mode and Code-Departure Aerodrome-Estimate data-Destination)

Example
(EST-MAS72/A0304-WMKK-IGARI0735/M082F270-VHHH)

Acceptance Message
Designator-Aircraft Identification/SSR Mode and Code-Departure Aerodrome-Destination)

Example
(ACP-MAS72/A5135-WMKK-VHHH)

Readbacks	The transferring unit shall ensure the readback is correct.
Exchange of Initials	Both the transferring and accepting controller shall exchange their individual two letter initials at the end of the verbal coordination messages.
Establishment of Communication	The accepting unit shall notify the transferring unit if two-way communication is not established within five (5) minutes of the estimated time over the TCP.
Clearance Amendments Involving Level Change	After the estimate for the TCP has been advised, the transferring unit shall not allow any aircraft to effect level change without prior coordination with the accepting unit if the flying time to the TCP is less than fifteen (15) minutes.
Aircraft Deviations	Both Kuala Lumpur and Ho Chi Minh Area Control Centres shall inform each other of aircraft deviating from the designated ATS route in the vicinity of the common FIR boundary.

Agreement

Deviations / Amendments

The procedures outlined in this LOA are intended for use under normal circumstances. In the event that unusual circumstances dictate variations from this LOA, this variation may be imposed with prior co-ordination between the Watch Supervisors on duty at the time.

Amendments to this LOA shall be made only with the concurrence of both Ho Chi Minh and Kuala Lumpur ACCs.

Authority

Mr. Noordin bin Saad
Director
Air Traffic Services Division
Department of Civil Aviation Malaysia
Sultan Abdul Aziz Shah Airport
47200 Subang, Selangor
Malaysia.

Date : 18 TH JULY 2001

Mr. Nguyen Xuan Hien
Deputy Director-General, VATM
Director of SORATS
Civil Aviation Administration of Viet Nam
58, Truong Son Street
Tan Son Nhat International Airport
Ho Chi Minh City
Viet Nam

Date: 18 Jul 2001

	Technical Log S/N, Date Entered and Defect	**Date Entered and Rectification**
1	S/N 4918754 – 07 March 2014 Ref NTC #3 water qty indication inoperative	07 March 2014 Potable water serviced till overflow
2	S/N 4918753 – 07 March 2014 To carry out lavatory waste compartment doors and flaps – AD inspection	07 March 2014 Carried out as per task card SIPCM 2-4-002AD. Satisfactory
3	S/N 4918753 – 07 March 2014 To carry out fwd large cargo door and door to cutout mating surfaces lubrication	07 March 2014 Task carried out as per AMM 12-21-21-640-802. Satisfactory Refer task card SIPL8-5-007 for details
4	S/N 4918753 – 07 March 2014 Main entry task card T1400115-001 Ref TSI/77/CIL/1420. To carry out terrain database loading.	07 March 2014 Said terrain database loading carried out IAW AMM 34-46-00. Satis.
5	S/N 4918752 – 07 March 2014 Night Stop. Crew oxygen system pressure reads 1120 psi (EICAS).	07 March 2014 Crew oxygen system replenished to 1800 psi – EICAS. AMM 12-15-08 refers.
6	S/N 4918752 – 07 March 2014 Maint : To carry out EPESC software down grade.	07 March 2014 EPESC software downgrade carried out IAW TSI/77/SR/14092 IFE of CHI satisfactory.
7	S/N 4918751 – 06 March 2014 Maint: Record APU OPS data	07 March 2014 APU OPS hours: 22089 APU starts: 155697
8	S/N 4918751 – 06 March 2014 Ref NTC #3 potable water qty indications inop	07 March 2014 Potable water serviced to overflow
9	S/N 4880500 – 06 March 2014 Both Eng require oil uplift	06 March 2014 Both Eng require oil uplift 01 QTS added to RH Eng oil consumption 0.02 QTS/HR 01 QTS added to LH Eng oil consumption 0.02 QTS/HR
10	S/N 4880500 – 06 March 2014 To re inspect both eng oil caps	06 March 2014 Both eng oil caps chkd. Found secured
11	S/N 4880499 – 06 March 2014 Maint- ref NTC #3 to service water tank until overflow as rel.	06 March 2014 Servicing c/out and satis
12	S/N 4880498 – 05 March 2014 Autoland Cat III carried out satisfactory	06 March 2014 Info noted.
13	S/N 4880498 – 05 March 2014 Maint entry – refer NTC #3 potable water qty indication inop	06 March 2014 Potable water serviced to overflow
14	S/N 4880497 – 05 March 2014 Hole found at 6 o'clock position of the right engine acoustic panel	05 March 2014 Deferred to MR2 No. K 70331
15	S/N 4880497 – 05 March 2014 maint- ref NTC #3 potable water req. servicing until overflow	05 March 2014 Potable water serviced until overflow

16	S/N 4880496 – 05 March 2013 Maint entry – ref NTC #3 potable water qty ind is inop	05 March 2013 Potable water serviced to overflow satis
17	S/N 4880495 – 05 March 2014 Maint entry: w.r.t card SIPA1-4-033, to check brake accumulator precharge pressure	05 March 2014 Task carried out as per AMM task 32-41-00-720-804. Pressure shown on brake accum press gage within 200 psi to direct reading gage.
18	S/N 4880495 – 05 March 2014 Main entry: w.r.t cards SIPC4-4-0319 and SIPC4-4-032, to check LH and RH ENG BUGEN oil filter bypass condition.	05 March 2014 Task carried out as per AMM task 12-13-07-200-802, nil abnormalities.
19	S/N 4880494 – 05 March 2014 Main entry: w.r.t. card SIPA2-6-008MR, to carry out primary flight control actuation operational check.	05 March 2014 Task carried out as per AMM task 27-02-00-400-801. Test passed satisfactory.
20	S/N 4880494 – 05 March 2014 Maint entry – w.r.t cards SIPC4-5-001 and SIPC4-5-002 to c/out LH and RH eng IDG oil servicing	05 March 2014 Task carried out as per task 12-13-03-600-801 - satisfactory
21	S/N 4880494 – 05 March 2014 Maint entry – w.r.t cards SIPL7-5-001MR and SIPL7-5-002MR, to c/out LH and RH MLG truck beam and inner cylinder pivot joints lube	05 March 2014 Task carried out as per AMM task 12-21-14-640-811-001. Satisfactory.
22	S/N 488093 – 05 March 2014 WRT SIPXE-2-6-034, 035 to carry out Emer Lt sys ops test.	05 March 2014 Ops test carried out satis AMM 33-51-00.
23	S/N 488093 – 05 March 2014 WRT SIPX12-6-027 to carry out GPWS self test.	05 March 2014 Test carried out satis test passed AMM 34-46-00.
24	S/N 488093 – 05 March 2014 Maint entry – w.r.t. NTC item No. 3 potable water quantity indication inop	05 March 2014 Potable water system serviced until overflow
25	S/N 4880492 – 05 March 2014 Please check alignment for left runway turnoff light	05 March 2014 Found slight misalignment towards a/c centerline. Deferred to MR2 for longer grd time Transferred to MR2 K 70330
26	S/N 4880492 – 05 March 2014 Main entry wrt SIPX12-6-030 to carry out FQIS FQPU ops chk.	05 March 2014 Ops check carried out. Test passed. Nil related existing faults. Satis. AMM 28-41-00.
27	S/N 4880492 – 05 March 2014 Main entry wrt SIPX12-4-011 to carry out portable oxy bottle/masks inspection.	05 March 2014 Inspection carried out. Found satis. AMM 35-31-00.
28	S/N 4880491 – 04 March 2014 Ref NTC #3 potable water ind inop	04 March 2014 Potable water serviced to overflow
29	S/N 4880490 – 04 March 2014 During transit check found No. 4 main wheel worn to limit	04 March 2014 No. 4 main wheel assy replaced. Torque load, spin, tyre pressure and security checked. satis
30	S/N 4880490 – 04 March 2014 Maint entry – w.r.t. NTC Item No. 3,	04 March 2014 Potable water serviced until overflow

	water quantity indication inop	
31	S/N 4880489 – 04 March 2014 "shadow" on rudder trim indicator from L 1.5 to R 1.0 units	04 March 2014 Rudder trim indicator replaced. Ops chk c/out ok
32	S/N 4880487 – 03 March 2014 Maint entry – refer NTC #3 water qty ind is inop. Fill all tanks with potable water till o/flow	03 March 2014 Potable water sys sucd to o/flow this transit. Confirmed by MH staff
33	S/N 4880485 – 02 March 2014 For Info: APU in flt start successful	03 March 2014 Info noted
34	S/N 4880485 – 02 March 2014 NTC #3 water qty indication is inop	03 March 2014 Potable water sys serviced to overflow. Ref AMM 12-14-01
35	S/N 4880484 – 02 March 2014 Status mssg WXR sys	02 March 2014 MMSG: 34-44002. WXR transceiver (right) has an internal fault. MSG erased from maintenance page. WXR (R) CB (P11/E16) Nil existing faults. Pls eml and report.
36	S/N 4880484 – 02 March 2014 Maint entry – Refer NTC #3. Water qty ind is inop. Fill all tanks with potable water till o/flow	02 March 2014 Potable water sys sucd to o/flow this transit. Confirmed by MH staff.
37	S/N 4880483 – 02 March 2014 Maint entry – ref: NTC 03 potable water quantity indication inop	02 March 2014 Potable water serviced to overflow
38	S/N 4880483 – 02 March 2014 Maint entry – No 8 Main wheel found with worn spot	02 March 2014 No 8 main wheel assy replaced as per AMM 32-45-01. Spin, torque, leak, security and TPIS check satis.
39	S/N 4880482 – 02 March 2014 Please carry out reinspection for all engine oil tank caps for installation and security	02 March 2014 Both engines oil caps reinspected found secured
40	S/N 4880482 – 02 March 2014 Please remove all landing gear pin prior to departure	02 March 2014 Landing gears down lock pins removed and stowed.
41	S/N 4880481 – 01 March 2014 Right hand nose taxi light lens found cracked on arrival	02 March 2014 Relamped ops check of right hand nose taxi light found satisfactory AMM 33-42-03 refers
42	S/N 4880481 – 01 March 2014 Refer NTC No. 3 potable water indication inop	02 March 2014 Potable water serviced to overflow
43	S/N 4880480 – 28 February 2014 Nil	01 March 2014 Noted with thanks APU data hour: 22056; Starts 15669
44	S/N 4880479 – 28 February 2014 Nil further	28 February 2014 Nil noted. APU data starts 15668, hrs 22049
45	S/N 4880478 – 28 February 2014 LLAR – Vanity light inop	28 February 2014 TXFR to MR2 no K70329
46	S/N 4880477 – 28 February 2014 Nil	28 February 2014 Noted with thanks APU data hour: 22048, starts: 15666

47	S/N 4880477 – 28 February 2014 Maint entry – during W/A check found one of tie bolt missing at nose L/H tire	28 February 2014 Inspected wheel found satis. No leak pressure c/o tire press chk 198 psi with in limit. Transferred to MR2 per MEL K 70327
48	S/N 4880477 – 28 February 2014 Maint entry – seat 4K IFE inop	28 February 2014 TXFR to MR2 K70328
49	S/N 4880476 – 28 February 2014 To update FMC Nav database.	28 February 2014. FMC Nav database updated as per SIPX12-4-004, satis. Disk S/N: MH61403001 eff date: Mar 6-Apr 3, 2014.
50	S/N 4880475 – 28 February 2014 To raise APU inflight start program.	28 February 2014 Task carried out as per TSI/77/NN/09/038 R03. Satisfactory.
51	S/N 4880475 – 28 February 2014 Maint entry – To c/out physically chk both heat exchanger S/No and due date as per card no STR 1400567-001	28 February 2014 Task carried out. Found LH heat exchanger S/No 200310115 and RH Heat exchanger S/No 9709161. Unfortunately can't find due date on both heat exchanger.
52	S/N 4880475 – 28 February 2014 To carry out flt control system ACE Ops test.	28 February 2014 Flt cont ACE ops test c/out as per SIPX12-6-007MR. Satis.

EHM Parameter Key

	Parameter description	Units
A/P	Autopilot status	discrete
A/T	Autothrottle status	discrete
ACID	Aircraft identification	
AOHE	Air Oil Heat Exchanger Position Selected	discrete
ASMT	Assumed Day Temperature	Celsius
AVM	Vibration monitoring system status word	hexadecimal
BBA	Broadband vibration channel A	ACU
BBB	Broadband vibration channel B	ACU
CAS	Calculated airspeed	knots
DATE	Date	dd/mm/yyy
DP	ASCS Duct Pressure	psi
DPT	Departure airport	
DRTE	Thrust derate switch	
DST	Destination airport	
EBFR	Environmental control system bleed flow rate	lb/s
EBLD	Environmental control system discrete	discrete
EECT	EEC temperature	Celsius
EGT	Exhaust gas temperature	Celsius
EPRACT	EPR actual	
EPRACT-L	EPR actual - left	
EPRACT-R	EPR actual - right	
EPRCMD	EPR commanded	
EPRMAX	EPR maximum	
EPRTRA	EPR throttle angle	
ESN	Engine serial number	

	Parameter description	Units
ESTAT	EEC status	
FAV	ASCS FAMV Actual Position	
FCC3	EEC status word	
FCC4	EEC status word	
FCC5	EEC status word	
FCC6	EEC status word	
FLCT	Report Copy number	
FLT	Flight number	
FM	Flight phase	
FMVDMD	Fuel metering valve demanded position	
FMVSEL	Fuel metering valve commanded position	
FNDERATESW	Thrust derate switch	
FUELT	Fuel temperature in a/c tank	Celsius
GENLD	Generator load	shp
GMT	Time	hh:mm:ss
GWT	Gross Weight	lb
LAT	Latitude	degrees
LONG	Longitude	degrees
MACH	Mach number	
N1	N1 shaft speed	%
N1VA	N1 shaft vibration channel A	ACU
N1VB	N1 shaft vibration channel B	ACU
N2	N2 shaft speed	%
N2VA	N2 shaft vibration channel A	ACU
N2VB	N2 shaft vibration channel B	ACU

	Parameter description	Units
N3	N3 shaft speed	%
N3VA	N3 shaft vibration channel A	ACU
N3VB	N3 shaft vibration channel B	ACU
NAC1	Nacelle temperature zone 1 (firewire resistance)	ohms
NAC2	Nacelle temperature zone 2 (firewire resistance)	ohms
OILP	Oil pressure	psi
OILT	Oil temperature	Celsius
P160	P160 pressure (bypass duct)	psi
P2.5	P25 pressure (HPC inlet)	psi
P20	P20 pressure (inlet)	psi
P30	P30 pressure (HPC outlet)	psi
P50	P50 pressure (LP turbine outlet)	psi
PACK	Cabin bleed discrete	discrete
PALT	Pressure altitude	feet
PHF	Vibration phase front	degrees
PHR	Vibration phase rear	degrees

	Parameter description	Units
PKFR	Pack mass flow rate	lb/s
PKWD	ECS status discretes	hexadecimal
PTO	ASCS PC Out temperature	Celsius
RATG	EEC rating	
SFC	Sub-Frame Counter (recorded data point)	number
SWID	Software identification	
T20	T20 temperature (inlet)	Celsius
T25	T25 temperature (HPC inlet)	Celsius
T30	T30 temperature (HPC outlet)	Celsius
TAT	Total Air Temperature	Celsius
TCAF	Turbine cooling air front	Celsius
TCAR	Turbine cooling air rear	Celsius
THDG	True heading	
TRA	Throttle resolver angle	degrees
TRALOC	Throttle resolver angle	degrees
VSV	VSV angle	degrees
WF	Fuel flow	lb/hr

Take-off Report

ACID	FLT	FM	FLCT	DATE	GMT	DPT	DST	GWT
MRO	S370	IC	318	07/03/2014	16:41:58	WMKK	ZBAA	492320

PALT	CAS	MACH	TAT	LAT	LONG	THDG	SWID	SFC
344	173.9	0.265	33	2.778	101.708	-34.9	71002	18676

A/P	A/T	FUELT	PKWD	DRTE	ASMT	RHL	RHR	RHC	TEGTL	TEGTR
0	6	30	50F0	3	50	285	286	286	36	36

	ESN	N1	N2	N3	EGT	FMVDMD	FMVSEL	NAI	WAI
L	51463	88.3	96	96.3	760	77.5	77.5	0	0
R	51462	88.8	95.9	96.7	775.9	78.9	78.9	0	0

	P20	P160	P2.5	P30	P50	T20	T25	T30
L	15.262	23.65	109.31	444.2	19.8	32.9	282.2	595.8
R	15.242	23.778	108.53	444.2	19.8	32.9	279.7	593.9

	OILP	OILT	TRA	EPRACT	EPRMAX	EPRCMD	EPRTRA	VSV
L	103.6	112.5	66.8	1.299	1.497	1.298	1.298	90
R	109.3	111.6	66.8	1.299	1.5	1.299	1.299	92

	AVM	N1VA	N1VB	N2VA	N2VB	N3VA	N3VB	BBA	BBB	PHF	PHR
L	0	1.13	1.18	0.13	0.12	0.31	0.31	0.71	0.73	66	299
R	0	1.46	1.49	0.59	0.58	0.28	0.28	0.9	0.92	159	99

	TCAF	TCAR	PACK	PKFR	EBLD	EBFR	FAV	AOHE	FCC3	RATG
L	427.4	341.2	0	69.7	0	136.6	0	0	0E00	0058
R	425.5	349.2	0	66.8	0	181.5	0	0	0E00	0058

	NAC1	NAC2	GENLD	WF	ESTAT	EECT	TRALOC	PTO	DP
L	3	4	40	22950	3060	38	66.8	366	87
R	1	2	44	23385	3060	39	66.7	408	85

	TOTL1	TOTL2	TOTL3	TOTL4	TOTL5	TOTL6	TOTL7
L	0	0	0	0	0	0	1
R	0	0	0	0	0	0	1

	FCC4	FCC5	FCC6
L	0008	4200	0088
R	0008	4200	0088

Climb Report

ACID	FLT	FM	FLCT	DATE	GMT	DPT	DST	GWT
MRO	S370	CL	318	07/03/2014	16:52:21	WMKK	ZBAA	485880

PALT	CAS	MACH	TAT	LAT	LONG	THDG	SWID	SFC
22278	299.8	0.68	11.8	3.619	102.02	27.5	71002	19299

A/P	A/T	FUELT	PKWD	DRTE	ASMT
1	6	30	5030	8	5) **Note 1**

	ESN	N1	N2	N3	EGT	FMVDMD	FMVSEL	TRALOC
L	51463	93.9	96.6	77.8	778.2	71.3	71.3	65.9
R	51462	94	96.7	78.8	788.1	72.3	72.3	66.1

	P20	P160	P2.5	P30	P50	T20	T25	T30
L	8.39	14.503	70.32	294.8	11.3	11.7	275.2	590.6
R	8.369	14.534	69.79	294.1	11.2	11.7	273.4	590.8

	OILP	OILT	TRA	EPRACT	EPRMAX	EPRCMD	EPRTRA	VSV
L	99	146.8	65.9	1.342	1.363	1.336	1.34	47
R	100	144.8	66.1	1.342	1.366	1.339	1.341	52

	AVM	N1VA	N1VB	N2VA	N2VB	N3VA	N3VB	BBA	BBB	PHF	PHR
L	0	0.62	0.64	0.2	0.21	0.29	0.3	0.48	0.48	25	298
R	0	0.9	0.93	0.55	0.56	0.2	0.2	0.61	0.63	139	) **Note 1**

	TCAF	TCAR	PACK	PKFR	EBLD	EBFR	FAV	AOHE
L	553.5	501.8	0	217.6	0	163.2	0	0
R	547	512.5	0	217.5	0	154.1	0	0

	NAC1	NAC2	GENLD	WF	ESTAT	EECT	PTO	DP	FCC3	RATG
L	35	35	42	15583	3060	38	392	57	0E00	0058
R	27	29	46	15786	3060	41	392	55	0E00	0058

ALT	MACH	TAT	EPRACT-L	EPRACT-R	FNDERATESW
9536	0.449	23.5	1.302	1.302	28
15000	0.601	22.25	1.283	1.283	38
25024	0.722	9.5	1.34	1.34	08

	FCC4	FCC5	FCC6
L	0008	4200	0082
	0008	4400	0082

Note 1: The character,), is generated by the ACMS to indicate that the source of information is valid and the parameter data bits are invalid.

PENGUNTUKAN RADAS
APPARATUS ASSIGNMENT

SKMM
MCMC

Dikeluarkan menurut Akta Komunikasi dan Multimedia 1998
Issued in accordance with the Communications and Multimedia Act 1998

SYARAT-SYARAT PENGUNTUKAN
ASSIGNMENT CONDITIONS

KATEGORI PERKHIDMATAN *SERVICE CATEGORY*	JENIS RADAS *TYPE OF APPARATUS*	TARIKH KUATKUASA *EFFECTIVE DATE*	TARIKH TAMAT *EXPIRY DATE*	NO. PENGUNTUKAN RADAS *APPARATUS ASSIGNMENT NO.*
MOBILE	AIRCRAFT STN	01-01-2013	31-12-2014	01349297-000SU/42013

DIPENGUNTUKAN KEPADA: *ASSIGNMENT TO:*	NO. PELANGGAN: *CLIENT NO.:*	LOKASI STESEN: *STATION LOCATION:*	
MALAYSIAN AIRLINE SYSTEM BERHAD QUALITY ASSURANCE DEPARTMENT, 1ST FLOOR, KLIA HANGAR COMPLEX, 64000 SEPANG, SELANGOR	770	BOEING 777-2H6	
		KEDUDUKAN GEOGRAFI: *GEOGRAFIC CO-ORDINATION:*	
		LATITUD: *LATITUDE:*	LONGITUD: *LONGITUDE:*

FREKUENSI PANCARAN (MHz) *TRANSMIT FREQUENCY (MHz)*	FREKUENSI TERIMA (MHz) *RECEIVE FREQUENCY (MHz)*	LEBAR JALUR (kHz) *BANDWIDTH (kHz)*	KUASA (W) *POWER (W)*	SYARAT-SYARAT PERHUBUNGAN YANG DIBENARKAN *AUTHORISED COMMUNICATIONS CONDITIONS*

Licence Appendix:

2.0 - 27.000 MHZ INTERNATIONAL AND NATIONAL AERONAUTICAL MOBILE SERVICES
ONLY EXCEPT AERONAUTICAL MOBILE SERVICES(OFF ROUTE)
118.0 - 121.4 MHZ INTERNATIONAL AND NATIONAL AERONAUTICAL MOBILE SERVICES
121.5 MHZ EMERGENCY FREQUENCY
121.6 - 121.975 MHZ INTERNATIONAL AND NATIONAL AERODROME SURFACE COMM.
122 - 123.05 MHZ NATIONAL AERONAUTICAL MOBILE SERVICES
123.1 MHZ AUXILIARY FREQUENCY (SAR)
123.15 - 123.675 MHZ NATIONAL AERONAUTICAL MOBILE SERVICES
123.7 - 129.675 MHZ INTERNATIONAL AND NATIONAL AERONAUTICAL MOBILE SERVICES
129.7 - 130.875 MHZ NATIONAL AERONAUTICAL MOBILE SERVICES
130.9 - 135.975 MHZ INTERNATIONAL AND NATIONAL AERONAUTICAL MOBILE SERVICES
243 MHz EMERGENCY FREQUENCY
406 MHz EPIRB - EMERGENCY FREQUENCY

ALL USERS OF RADIO ONBOARD AIRCRAFT MUST HOLD A RESTRICTED RADOTELEPHONE OPERATOR'S (AERONAUTICAL) CERTIFICATE OF PROFICIENCY.

ISYARAT PANGGILAN CALLSIGN
9M-MRO

Pengerusi Suruhanjaya Komunikasi dan Multimedia Malaysia
Chairman of the Malaysian Communications and Multimedia Commission

MAKLUMAT
INFORMATION

REF. NO.: S_AA (v.1)

Pemegang penguntukan radas boleh, tidak kurang daripada enam puluh hari (60) sebelum habis tempoh penguntukan radas, membuat permohonan baru kepada Suruhanjaya bagi mendapatkan penguntukan radas di salah satu daripada alamat-alamat berikut:

The apparatus assignment holder may, not less than sixty days (60) before the expiry of the apparatus assignment, make a fresh application to the Commission for an apparatus assignment at any one of the following addresses:

Suruhanjaya Komunikasi dan Multimedia Malaysia
Off Persiaran Multimedia,
63000 Cyberjaya, Selangor.
(Tel: +60 3 86 88 80 00 Faks: +60 3 86 88 10 01)
(http: //www.mcmc.gov.my)

Suruhanjaya Komunikasi dan Multimedia Malaysia
Pejabat Wilayah Tengah,
Level 17, Wisma SunwayMas,
No.1, Jalan Tengku Ampuan Zabedah C9/C,
Seksyen 9, 40100 Shah Alam, Selangor.
(Tel: +60 3 55 18 77 01 Faks: +60 3 55 18 77 10)

Suruhanjaya Komunikasi dan Multimedia Malaysia
Pejabat Wilayah Utara,
Bangunan Tabung Haji,
No. 2828-1-1, Tingkat 1, Jalan Bagan Luar,
12000 Butterworth Pulau Pinang.
(Tel: +60 4 32 38 228 Faks: +60 4 32 39 448)

Suruhanjaya Komunikasi dan Multimedia Malaysia
Pejabat Wilayah Selatan,
Suite 7A, Level 7,
Menara Ansar, Jalan Trus,
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Suruhanjaya Komunikasi dan Multimedia Malaysia
Pejabat Wilayah Sabah,
6-10-10, 10th Floor,
No. 6, Menara MAA,
Lorong Api-Api 1, Api-Api Centre
88000 Kota Kinabalu, Sabah.
(Tel: +60 88 27 05 50 Faks: +60 88 25 32 05)

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Emergency Locater Transmitter Activation (Source: ICAO)

The parameters in the query for the status of Emergency Locator Transmitters (ELT) after an occurrence were set at:

Dates between 1 January 1983 and 30 June 2014 (approximately 30 years), including all occurrences (accidents and incidents) involving aircraft in the mass group 5 701 kg and above and records with descriptive factors and ELT parameters that have value.

The query found 403 records in the ADREP database in which a response was inserted relating to ELTs. Of these occurrences 257 were classified as accidents. Due to incidents being less severe, a lower probability of ELT implications are expected. The query then focused on accidents. The following table indicates the aircraft mass groupings of the aircraft involved in accidents:

Aircraft mass group	Accidents
5 701 to 27 000 Kg	161
27 001 to 272 000 Kg	87
> 272 000 Kg	9
Total	257

The taxonomy for the attribute to indicate the status of the ELT (whether it worked as designed or why it did not work) was used to compile the following table: (* after 1994)

ELT status	Cases
Battery failed	14
Damaged	11
Internal failure	5
Not activated	22
Not carried	84 (12)*
Operated effectively	39
Other	21
Submerged	1
Terrain shielding	1
Unknown	59
Total	257

In 39 cases of the 257 accident records, the ELT operated effectively, which implies that 15% of the ELTs operated effectively. The data indicated that in 84 cases, *no ELT was* carried. Considering that provisions for the carriage of ELTs became applicable in Annex 6 on 10 November 1994, the *no ELT carried* data was evaluated to determine the situation after 1994 (past 20 years approximately) and the number reduced from 84 to 12.

29 July 2014

Event Report

Malaysia Airlines (MAS) reported that a 777-200ER (WB175/9M-MRO) operating as flight MH370 en route from Kuala Lumpur, Malaysia to Beijing, China lost communication over Vietnam airspace after leaving Malaysia airspace on 8 March 2014.

This event is being investigated by the Malaysian Ministry of Transportation (MOT) with the assistance of accredited representatives from the United States National Transportation Safety Board (NTSB), the Australian Transportation Safety Board (ATSB), and the United Kingdom Air Accidents Investigation Branch (AAIB). Boeing is providing technical support to the US NTSB. As of the date of this report, flight data from the flight data recorder (FDR) and quick access recorder (QAR) are not available for analysis. The data currently available consists of aircraft communications addressing and reporting system (ACARS) data, radar data, and satellite data. The analysis presented in this report will focus on the performance of the airplane and describe how the ACARS data were used to analytically determine position and fuel consumption over the Malay Peninsula, how the radar data were used to track the path of the airplane off its charted course and estimate the amount of fuel used through that segment of flight, and how performance range capability augmented analysis to the satellite data to determine the possible flight profiles.

Available Airplane Position Data

The flight departed Kuala Lumpur International Airport – Sepang (KUL) on March 7, 2014 at 16:42 Coordinated Universal Time (UTC). The airplane lost contact with air traffic control (ATC) at 17:22 UTC during transition from Malaysia to Vietnamese airspace. The last ACARS transmission occurred at 17:06:43 UTC. Primary radar continued the tracking of the flight through time 18:22:12 UTC. Satellite data provided communication data through time 00:19:29 UTC on March 8.

Aircraft Communications Addressing and Reporting System (ACARS)

ACARS data provided time history position via latitude and longitude, along with altitude, computed airspeed, wind speed and direction, total fuel weight, and gross weight of the airplane in 300-second time intervals. The fuel recorded prior to takeoff at time 16:41:43 UTC was 49,200 kilograms (kg) (108,467 pounds [lb]), and the gross weight was 492,520 lb. For reference, the maximum takeoff weight for WB175 is 650,000 lb. The last data point transmitted by ACARS was at time 17:06:43 UTC. At that time, the airplane was positioned approximately 165 nm northeast of KUL with the fuel weight recorded at 43,800 kg (96,562 lb) and gross weight at 480,600 lb.

Radar Data

The radar data originated from two sources and provided time history position information of the airplane in terms of latitude and longitude, along with altitude in 10-second time intervals. One of the sets also provided altitude and ground speed information; however, they were ultimately determined not to be entirely reliable due to their inconsistent values. The radar data originated from two sources and began at KUL, tracked the airplane over the Malay Peninsula, then over the Gulf of Thailand before a left turn was completed taking the airplane back over the Malay Peninsula and over the Malacca Strait where the radar tracking of the airplane ended at time 18:01:19 UTC. One final data point of the position of the airplane was determined through analysis of radar playback that placed the airplane over the waters north of Indonesia at time 18:22:12 UTC. There were a few breaks in the radar data including a 50-second break around the time of the left turn, a 42-second break between the two radar sources, and a 20-minute, 53-second break to the final radar data point.

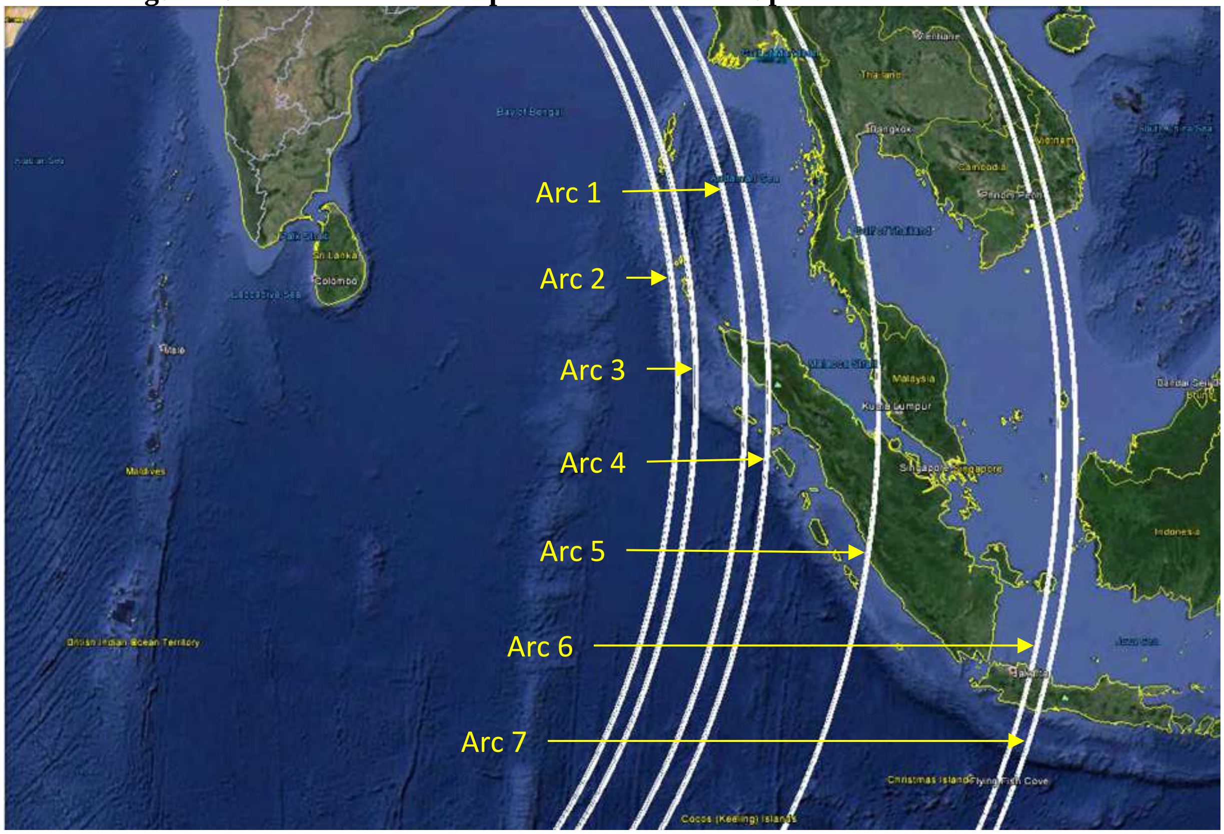
Satellite Data

The satellite communication (SATCOM) system on WB175 was in periodic communication with the Perth Ground Station during the flight starting prior to takeoff until the last signal at time 00:19:29 UTC. The SATCOM system is used for voice and data communications between the airplane and the ground station, and includes transmittal of data such as ACARS and communication between the crew and ATC. As part of the communication mechanism which allows voice and data communications, the airplane and the satellite periodically exchange signals. The fact that SATCOM signals were received from WB175 until time 00:19:29 UTC indicated that the airplane was still powered, and because the response time changed, that the airplane was still moving. Three key pieces of information used to track WB175 came from the satellite data: 1) UTC time of the communication, 2) burst timing offset (BTO), and 3) burst frequency offset (BFO). BTO is the time for the airplane to respond to a message and was used to determine distance from the satellite to the airplane. BFO is the difference between the expected frequency and the measured frequency when received at the ground station and was used to help determine relative motion of the airplane with respect to the satellite. The BTO was used to create arcs along the earth representing the set of possible airplane positions at the time of communication, but provides no information about where along the arc the airplane was located. The BTO was associated with a UTC time which allowed for path constraints to be applied to the airplane position due to speed limitations. However, the BTO data did not provide direction of travel, and it was unknown if the airplane took a northern route over the Andaman Sea or a southern route over the Indian Ocean after the last radar signal. Analysis of the BFO data (not discussed in this report) eliminated the northern routes. The first satellite communication timing used to define the arcs after the end of the radar data occurred at time 18:28:06 UTC with the last transmission occurring at time 00:19:29 UTC, with 5 transmissions in between. The BTO data from the satellite communications are listed in Table 1. The arcs of possible airplane position defined by the BTO from the 7 transmissions are shown in Figure 1.

Table 1: Satellite BTO Data

UTC Time	BTO (microseconds)	Arc
18:28:05.90	12,500	1
19:41:02.91	11,500	2
20:41:04.90	11,740	3
21:41:26.91	12,780	4
22:41:21.91	14,540	5
00:10:59.93	18,040	6
00:19:29.42	18,440	7

Figure 1: Arcs of Possible Airplane Position based upon Satellite BTO Data



Wind Data

Wind data during the time period and covering the region of the flight were obtained for two time periods during the flight (18:00 UTC and 00:00 UTC) and at 8 altitudes (400 feet, 2500 feet, 4800 feet, 9900 feet, 13,800 feet, 18,300 feet, 23,500 feet, and 30,000 feet). The data contained time, latitude, longitude, wind speed, wind direction, and altitude. These data were applied to the available radar data to calculate the true airspeed of the airplane that would be used in the fuel burn analysis. The wind data were also incorporated into the analysis to determine the possible paths of the airplane using the constraints of the satellite data. Linear interpolation of the wind data occurred at the location and time of the assumed flight path in cases where known wind data was not available.

Assumptions

Not all of the parameters needed to calculate the performance range capability of the airplane were available, and many assumptions had to be made to complete this calculation. Below is a list of the general assumptions made about the airplane, its flight path, and the atmosphere:

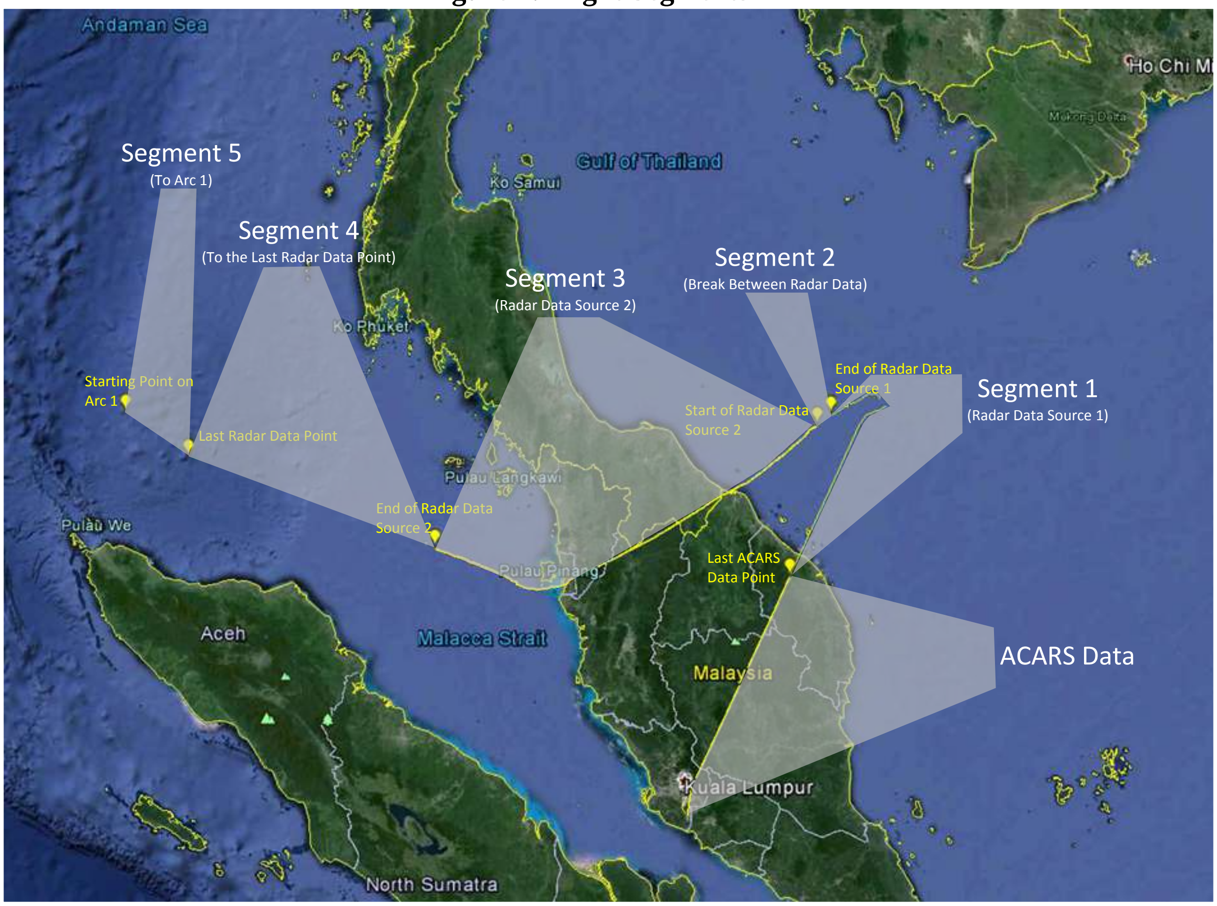
- The airplane weight information (including fuel weight) contained in the final ACARS report was valid and accurate
- Constant last known altitude from ACARS until higher speeds forced altitude restriction
- Constant altitude for each segment after end of ACARS data
- Constant speed during each segment
- No turns during flight segments where data were not available
- Standard day atmosphere

The segments referred to above are in reference to the data sources available that defined the flight path of the airplane from the end of the ACARS data to the first satellite arc. Each segment of data/flight path were analyzed and compiled to arrive at a fuel weight at the first satellite arc. The fuel weight was known at the last ACARS transmission, so the fuel burn analysis started at that point. The flight segments were defined as follows in Table 2 and depicted in Figure 2:

Table 2: Flight Segments

Segment	From	To
1	Last ACARS point	Radar Data Source 1 – End
2	Radar Data Source 1 – End	Radar Data Source 2 – Start
3	Radar Data Source 2 - Start	Radar Data Source 2 – End
4	Radar Data Source 2 – End	Final Radar Data Source 2 Point
5	Final Radar Data Source 2 Point	First Satellite Arc

Figure 2: Flight Segments



Analysis of Fuel Burn

ACARS Data

The airplane departed with 49,200 kg (108,467 lb) of fuel. At the last ACARS transmission, the amount of fuel onboard was recorded at 43,800 kg (96,562.5 lb).

Radar Data

Time and location information from the radar data determined the ground speed along the segments of flight. The ground speed, along with the wind data, allowed for the calculation of true airspeed. During Segment 1, an average ground speed was calculated based on time and distance traveled. The airplane was assumed to remain at 35,000 feet altitude (FL350) through this entire segment based on the last ACARS transmission. The radar data during this portion of the flight also indicated that the airplane was at FL350 for nearly the entire path. The end of the radar data deviated from constant altitude, with unrealistic changes in ground speed, and were considered unreliable and not incorporated into the fuel burn analysis.

Segment 2 consisted of a break between the two radar sources. Knowing the location and time at the end of the first radar source and the location and time at the beginning of the second radar source, the distance between the points was determined and an average ground speed was calculated. The altitude was assumed to remain constant at FL350.

The third segment of the flight consisted of the second radar source that contained unreliable altitude information. The average ground speed increased during this segment of flight, and after incorporating a tailwind, the true airspeed was estimated to be 510 knots. At FL350 and true airspeed of 510 knots, the Mach number would be 0.885 which is above the maximum operating Mach (MMO) of 0.87 at that altitude. While operating above MMO is technically feasible, the condition was considered unlikely as it would induce an overspeed warning, and the overspeed protection control laws would activate. Activation of the overspeed protection control law results in trailing-edge-up elevator to increase the pitch attitude, thereby slowing down the airplane. Pilot intervention would need to occur by pushing forward on the column to keep the airspeed above MMO. During Segment 3, the assumed altitude of the flight path was reduced to 30,000 feet altitude (FL300) to keep the Mach number below MMO.

Segment 4 comprises of the flight path between the end of the second radar source and the last radar data point. The average ground speed was slightly slower than Segment 3 but high enough for the assumed altitude to remain at FL300 for the performance fuel burn calculation to avoid exceeding MMO.

Segment 5 of the flight path continued a northwesterly route from the last radar data point to the first satellite arc. The altitude during this segment was assumed to remain at FL300 for analysis purposes. Boeing 777 performance models were used to determine the fuel flow for each segment. Table 3 shows the details at the end of each flight segment and includes the fuel burn analysis results.

Table 3: Flight Segment Details and Fuel Burn

Segment	Travel Time (hours)	Distance (nm)	Assumed Flight Level	Average Wind Component (+headwind/ -tailwind)	Average True Airspeed (knots)	Mach	Ending Fuel Weight (lb) (Beginning Fuel Weight = 96,563 lb)
1	0.36	175.3	FL350	-14	478	0.829	91,242
2	0.023	11.1	FL350	-19	470	0.815	90,911
3	0.54	282	FL300	-13	510	0.865	81,104
4	0.34	173.5	FL300	-14	502	0.852	75,425
5	0.092	46.4	FL300	-9	494	0.838	73,908

Performance Range Capability and Path Creation

Boeing used 777 performance data to analytically determine range capability during the satellite data portion of the analysis. WB175 was equipped with two Rolls Royce RB211-Trent-892B high-bypass turbofan engines. An engine efficiency analysis using the fuel burn information provided in the ACARS data was performed by the engine manufacturer, Rolls Royce. This analysis showed that the specific fuel consumption of the right engine is slightly greater as compared to the left engine. The analysis results in this report have taken this difference into account.

At the first satellite arc, the calculated fuel on board WB175 was 73,908 lb (see Table 3). At each successive arc point, the satellite data provided a UTC time and the response time (BTO) but did not provide a precise location of the airplane or any information about altitude or airspeed. A series of altitude/speed profiles were analyzed to determine the range capability of the airplane. The speed at each altitude ranged from the top of the amber band (minimum operating speed) to the bottom of the upper barber pole (maximum operating speed) and included the maximum range cruise (MRC) speed. Table 4 shows the results of the performance analysis for the altitude/speed combinations that were analyzed, along with travel time and range from Arc 1 with the MRC speed denoted with a "*".

Table 4: Range Capability for Altitude/Speed Combinations (from Arc 1)

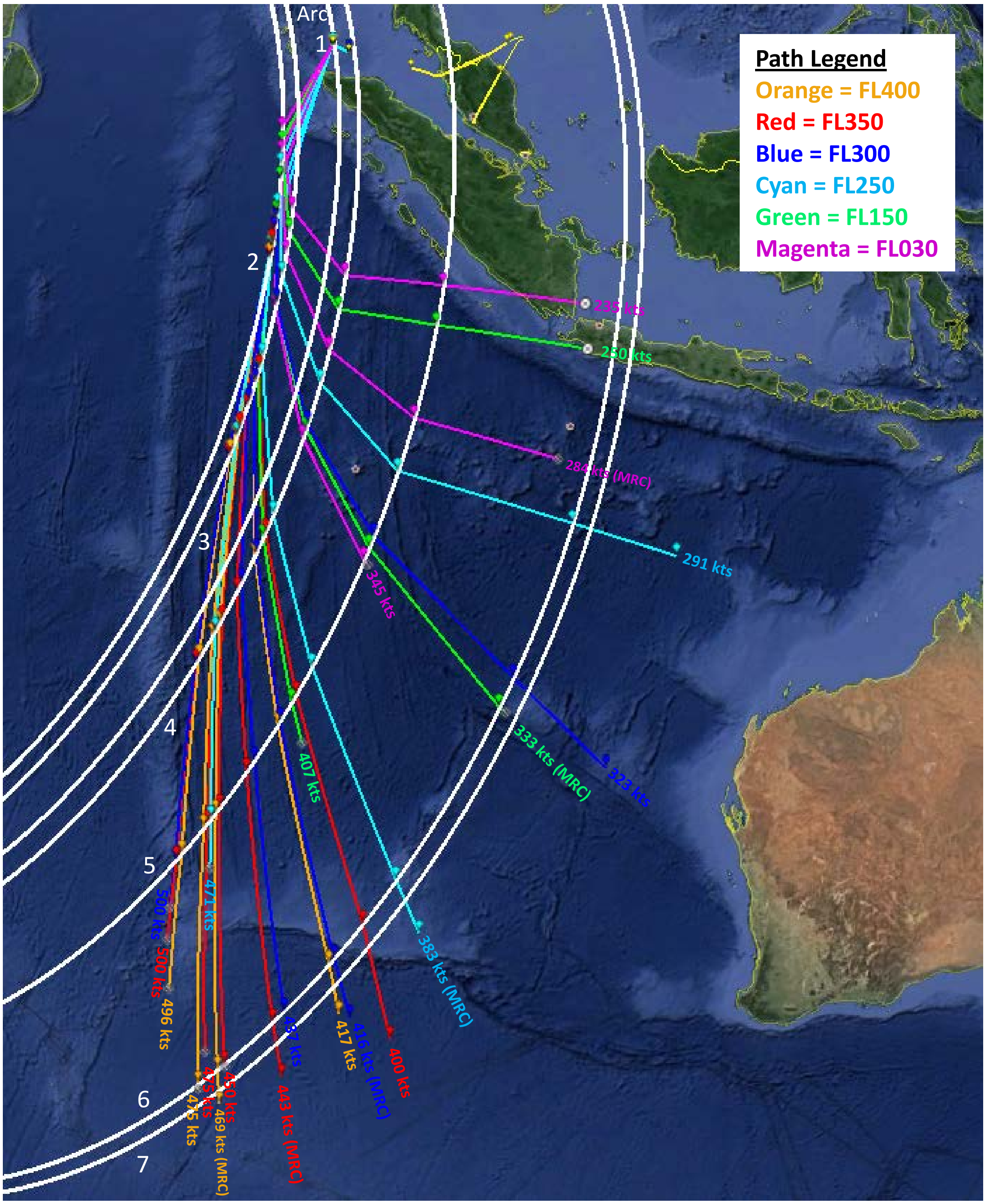
Flight Level	True Airspeed (knots)	Mach (*=MRC)	Time (hours)	Range (nm)
FL400	494	0.861	5.0	2491
FL400	475	0.828	5.9	2803
FL400	469	0.818*	6.0	2806
FL400	417	0.727	6.1	2538
FL350	500	0.867	4.7	2356
FL350	475	0.824	5.6	2657
FL350	466	0.824	5.9	2747
FL350	443	0.769*	6.2	2711
FL350	400	0.694	6.6	2624
FL300	500	0.848	4.5	2270
FL300	437	0.742	5.7	2523
FL300	416	0.706*	6.1	2552
FL300	323	0.548	6.8	2181
FL250	471	0.782	4.6	2151
FL250	383	0.642*	6.1	2363
FL250	291	0.483	6.8	1970
FL150	407	0.65	4.5	1835
FL150	333	0.532*	5.8	1923
FL150	250	0.399	6.75	1662
FL030	345	0.535	4.2	1446
FL030	284	0.437*	5.7	1534
FL030	235	0.359	6.2	1464

Using the time constraints of the satellite data and the wind data to back out ground speed from true airspeed in the performance analysis in Table 4, flight profiles for each altitude/speed combination were created and depicted in Figure 3. There are numerous possible paths that could have been taken between the arcs, and taking these variations into consideration would have resulted in an endless number of possible solutions. To constrain the problem, it was decided to include the following assumptions: 1) an assumption that changes to the flight path heading could only be made at the arc crossings, and 2) the altitude and true airspeed remained constant throughout the flight path. With those constraints in place, a number of possible flight paths were created that met the conditions of the satellite data in terms of time and position. Each color in Figure 3 designates a flight level, and within those flight levels there are several different true airspeeds.

Based on the performance range calculation for each altitude/speed combination, some paths were range-limited, meaning that they did not have enough remaining fuel to make it to the 7th arc. A few paths were time-limited, meaning they couldn't make it to an arc before exceeding the time constraint from the satellite data. Other paths met both the range capability and time constraints to reach the 7th arc.

BOEING

Figure 3: Possible Flight Paths (from Arc 1)



<u>End of Flight Scenarios</u>

Simulation Session: Engine Flame-Out

A simulator session was held to determine possible outcomes of an engine flame-out at the point of fuel exhaustion with no manual intervention. A Boeing 777 fixed-base simulator using the same certified aerodynamic model as a Level D simulator for crew training was used during this session. As such, from a systems and aerodynamic/airplane behavior perspective, the simulator is representative of the expected behavior of WB175 assuming the conditions used in the simulator session existed during the event flight. The initial conditions in some cases were derived from information collected supporting the investigation (i.e. atmosphere, airplane center of gravity [CG]), and in the other cases, the initial conditions were assumptions required to run the simulator that may not be representative of the actual event airplane settings (i.e. autopilot modes, latitude and longitude, heading). Where assumptions were required, there was an attempt to select initial conditions that were considered possible for WB175. The fuel on board was selected to result in the right engine flaming out first due to the performance difference of the right engine stated previously. The simulation was prepared such that the left engine flamed out approximately 4 to 5 minutes after the right engine flame-out. This portion of the simulation was not intended to be representative of WB175 but to provide sufficient time to observe the system effects from the single engine flame-out prior to assessing the dual engine flame-out characteristics.

The simulator session results are as follows. Upon flame-out of the right engine, the thrust asymmetry compensation (TAC) function input left rudder to minimize the yaw asymmetry caused by the asymmetric thrust, per design. TAC is a control law on the 777 that commands rudder when a thrust asymmetry is detected, and the result is representative of what would have occurred on WB175 given an asymmetric engine shutdown. After flame-out of the right engine, the left engine also flamed out as a result of fuel exhaustion. Following the spool-down of the left engine and resulting electrical power loss, the autopilot disconnected. The ram air turbine (RAT) deployed which enabled a few of the flight deck displays to continue functioning as well as provided hydraulic pressure to a reduced number of control surfaces. As the left engine spooled down, TAC reduced the amount of left rudder input, per design. However, the rudder did not completely return to zero deflection before total loss of power. As a result, a residual amount of rudder, approximately 0.2 degrees to the left, remained. This residual rudder caused a slow roll to the left after the autopilot disconnected.

After the autopilot disconnect, the airplane was allowed to freely respond without any commanded inputs from the flight deck. In each case, the airplane began a descending, spiral turn to the left. It was generally a low bank angle turn that lasted for up to 12 minutes as the airplane descended to sea level. In many cases, but not all, a Phugoid oscillation was observed. This caused the airplane to pitch up and down at low frequency during the spirals. Some of the oscillations were large, but the airplane never stalled during the Phugoid cycles. Some exceedances of design dive speed (VD) were observed.

The simulator session flight paths from the point of the final engine flame-out to sea level were contained within a 100 nm^2 box. That box was observed to extend 10 nm beyond the point of fuel exhaustion and 10 nm to the left of the original flight path (at the point of fuel exhaustion) due to the roll to the left.

Possible Additional Range due to Driftdown

The 100 nm^2 box defined by the simulator session at the point of the dual engine flame-out was obtained assuming no inputs were commanded from the flight deck. To quantify the maximum range the airplane could have traveled, the distance covered during driftdown was estimated. The driftdown range is the additional range that the airplane could have achieved after fuel exhaustion if manual control inputs were commanded from the flight deck to maintain wings level flight throughout the glide distance. In general, the airplane could achieve an estimated driftdown range of 0.0034 nm per foot of altitude. Therefore, at FL350 the additional range after the dual engine flame-out would be approximately 120 nm and at FL400 it would be approximately 136 nm.

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [9M-MRO]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
15:54:31 Uplink Sent	46817955	Outgoing Uplink / Frequency Auto-tune -- Frequency Auto-tune B777	9M-MRO	MH0370	KUL / BKKXCXA	MHKULKJACM001	071554	CMD	RELAY

```
QU BKKXCXA
.DPCCAMH 071554
□CMD
AN 9M-MRO/FI MH0370/GL KUL/MA 988I
-  QUDPCCAMH~1RA101071554
Message:
SWITCH VHF3 TO VOICE
(131.550)
IF SATCOM SERVICABLE
FROM MH OPS
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
15:54:31 Routed	46817955	Outgoing Ground	9M-MRO	MH0370	KUL / BATAP_TO_MSW	MHKULKJACM001	071554	CMD	BATAPCNX

```
QU BKKXCXA
.DPCCAMH 071554
□CMD
AN 9M-MRO/FI MH0370/GL KUL/MA 988I
-  QUDPCCAMH~1RA101071554
Message:
SWITCH VHF3 TO VOICE
(131.550)
IF SATCOM SERVICABLE
FROM MH OPS
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
15:54:36 Normal	46817955	Incoming Downlink / MAS-S (successful)	9M-MRO	MH0370	KUL / BKKXCXA	MHKULKJACM001	071554	MAS	RELAY

```
QU DPCCAMH
.BKKXCXA 071554
□MAS
AN 9M-MRO/FI MH0/MA 988S
DT BKK KUL 071554 S05A
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
15:54:41 Normal	46817961	Incoming Downlink / Established SATCOM	9M-MRO	MH0000	POR1 / QXSXMXS	MHKULKJACM001	071554	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071554
□MED
FI MH0000/AN 9M-MRO
DT QXT POR1 071554 S04A
-  0ES155446VS
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
15:54:53 Normal	46817964	Incoming Downlink / Lost VHF	9M-MRO	MH0000	POR1 / QXSXMXS	MHKULKJACM001	071555	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071555
□MED
FI MH0000/AN 9M-MRO
DT QXT POR1 071555 S06A
-  0LV155453S
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

15:54:41 Normal	46817961	Incoming Downlink Established SATCOM	9M-MRO	MH0000	POR1 QXSXMXS	MHKULKJACM001	071554	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071554
MED
FI MH0000/AN 9M-MRO
DT QXT POR1 071554 S04A
-  0ES155446VS
```

15:54:53 Normal	46817964	Incoming Downlink Lost VHF	9M-MRO	MH0000	POR1 QXSXMXS	MHKULKJACM001	071555	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071555
MED
FI MH0000/AN 9M-MRO
DT QXT POR1 071555 S06A
-  0LV155453S
```

15:56:08 Normal	46817982	Incoming Downlink Established SATCOM	9M-MRO	MH0370	POR1 QXSXMXS	MHKULKJACM001	071556	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071556
MED
FI MH0370/AN 9M-MRO
DT QXT POR1 071556 S08A
-  0ES155607S
```

15:57:57 Normal	46818013	Incoming Downlink Established SATCOM	9M-MRO	MH0370	POR1 QXSXMXS	MHKULKJACM001	071558	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071558
MED
FI MH0370/AN 9M-MRO
DT QXT POR1 071558 S10A
-  0ES155759S
```

16:00:13 Normal	46818050	Incoming Downlink Established SATCOM	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071600	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071600
MED
FI MH0370/AN 9M-MRO
DT QXT IOR2 071600 S12A
-  0ES160015S
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:06:15 Uplink Sent	46818160	Outgoing Uplink AGM NOTOC Uplink B777 -- AGM NOTOC Uplink B77 QXSXMXS	9M-MRO	MH0370		MHKULKJACM001	071606	AGM	RELAY

```
QU QXSXMXS
.DPCCAMH 071606
□AGM
AN 9M-MRO/FI MH0370/MA 989I
-
NOTOC MESSAGE
SPECIAL LOAD NOTOC

FLIGHT    DATE       EDNO
MH 0370 /08  08MAR14  01
FROM/TO  AC/REG
KULPEK    9M-MRO

OTHER SPECIAL LOAD

TO  POS PCS QTY/TI IMP
DESCRIPTION
PEK 41L 001 1128KG PER
MANGOSTEEN

PEK 41R 001 1152KG PER
MANGOSTEEN

PEK 43L 001 1148KG PER
MANGOSTEEN

PEK 44L 001 1138KG PER
MANGOSTEEN

THERE IS NO EVIDENCE
THAT ANY DAMAGED OR
LEAKING PACKAGES
CONTAINING DANGEROUS
GOODS HAVE BEEN LOADED
ON THE AIRCRAFT AT THIS
STATION.

END ACARS NOTOC
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:06:15 Normal	46818160	Incoming Downlink MAS-L (link ack)	9M-MRO	MH0370	QXSXMXS	MHKULKJACM001	071606	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071606
□MAS
AN 9M-MRO/FI MH0370/MA 989L
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:06:32 Normal	46818160	Incoming Downlink MAS-S (successful)	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071606	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071606
□MAS
AN 9M-MRO/FI MH0370/MA 989S
DT QXT IOR2 071606 S15A
```


Printed: March 11, 2014

AS.V6R2.4

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
Mar. 7, 2014									
16:06:32	381598235	Outgoing Uplink	9M-MRO	MH0370		MHKULKJACM001	071606	AGM	RELAY
Uplink Sent		Loadsheet FINAL <9M-MR> -- LOADSHEET - AGM(Pı			QXSXMXS				

```
QU QXSXMXS
.DPCCAMH 071606
□AGM
AN 9M-MRO/FI MH0370/MA 990I
-
X LOADSHEET FINAL  1606 01
MH0370/ 07MAR14
KUL PEK   9M-MRO   2/10
ZFW 174369 MAX 195044 L
TOF  49100
TOW 223469 MAX 286897
TIF  37200
LAW 186269 MAX 208652
UNDLD  20675
PAX/10/215       TTL 227
TTL 222/3/2
TTL COMPARTMENTS 014296
 1/2500 2/4530 3/804 4/5
885 5/577    0/0
SEATING
0A/10 0B/127 0C/88

DOI       59.07


LIZFW     67.05
MACZFW    31.65
LITOW     70.05
MACTOW    33.78

DLI       57.29
STAB TO   03.9 MID
SI:
NOTOC YES
TTL PAYLOAD 014296
DOW 143283

WBC K8-45
EXP 20SEP14
NOTOC - YES




-------------------------

PAX/10/215       TTL 227
TTL 222/3/2


0A/10 0B/127 0C/88


*-------------------------------------------*
* PLSE ACK WITH                             *
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

```
* "LS FINAL OK (LIC NO) (DEP STATION-ICAO)" *
* WHEN RECEIVE LS                           *
*-------------------------------------------*
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:06:33 Normal	381598235	Incoming Downlink MAS-L (link ack)	9M-MRO	MH0370	QXSXMXS	MHKULKJACM001	071606	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071606
□MAS
AN 9M-MRO/FI MH0370/MA 990L
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:07:06 Normal	381598235	Incoming Downlink MAS-S (successful)	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071607	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071607
□MAS
AN 9M-MRO/FI MH0370/MA 990S
DT QXT IOR2 071607 S20A
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:09:28 Normal	46818215	Incoming Downlink B777 Final Loadsheet Acknowledgement	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071609	A81	RELAY

```
QU DPCCAMH
.QXSXMXS 071609
□A81
FI MH0370/AN 9M-MRO
DT QXT IOR2 071609 M00A
-  LS FINAL OK
751 KUL
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:10:54 Normal	46818244	Incoming Downlink Established SATCOM	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071611	MED	RELAY

```
QU DPCCAMH
.QXSXMXS 071611
□MED
FI MH0370/AN 9M-MRO
DT QXT IOR2 071611 S21A
-  0ES161101S
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:27:57 Normal	46818462	Incoming Downlink OOOI B777 OUT Report	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071628	M11	RELAY

```
QU DPCCAMH
.QXSXMXS 071628
□M11
FI MH0370/AN 9M-MRO
DT QXT IOR2 071628 M01A
-  OUT01MAS370    /--071627WMKKZBAA
1627 496-----
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:29:33 Normal	46818489	Incoming Downlink B777 APU Report	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071629	DFD	RELAY

```
QU DPCCAMH
.QXSXMXS 071629
□DFD
FI MH0370/AN 9M-MRO
DT QXT IOR2 071629 D00A
-  MAS002A0          B777 APU OPS REPORT            332

ACID   FLT  FM FLCT   DATE      GMT   DPT  DST
MRO    S370 PO  318 07/03/14 16:29:12 WMKK ZBAA

     SWID          SFC
316A-BSM-710-02 17911

APU CYC   APU TOT HRS  APU PREV FLT HRS
 15699       22093              4
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:41:43 Normal	46818633	Incoming Downlink OOOI B777 OFF Report	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071641	M12	RELAY

```
QU DPCCAMH
.QXSXMXS 071641
□M12
FI MH0370/AN 9M-MRO
DT QXT IOR2 071641 M02A
-  OFF01MAS370    /--071641WMKKZBAA
1641 492
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
16:42:43 Normal	46818641	Incoming Downlink B777 TAKE OFF REPORT<03> (RR)	9M-MRO	MH0370	IOR2 QXSXMXS	MHKULKJACM001	071642	DFD	RELAY

```
QU DPCCAMH
.QXSXMXS 071642
□DFD
FI MH0370/AN 9M-MRO
DT QXT IOR2 071642 D01A
-  <03>CSMROS370IC 318070314164158WMKKZBAA492320
319   3441739265 330  2778 101708 -3497100218676
06  3050F03 50  285  286  286 36 36
 51463 883 960 963  760077577500
 51462 888 959 967  775978978900
152622365010931444219 8  329 2822 5958
152422377810853444219 8  329 2797 5939
1036 1125 668129914971298129 8  90
1093 1116 668129915001299129 9  92
011311801301203103107107 3 66299
014614905905802802809009215 9 99
 4274 34120  697013660  00E000058
 4255 34920  668018150  00E000058
  3  4 40229503060  38668 366 87
  1  2 44233853060  39667 408 85
 0  0  0  0  0  0  1
 0  0  0  0  0  0  1
000842000088
000844000088
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

16:55:58	46818816	Incoming Downlink	9M-MRO	MH0370	IOR2	MHKULKJACM001	071656	DFD	RELAY
Normal		B777 CLIMB REPORT<43> (RR)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071656
□DFD
FI MH0370/AN 9M-MRO
DT QXT IOR2 071656 D02A
-  <43>CSMROS370CL 318070314165221WMKKZBAA485880
321 222782998680 118  3619 102020  2757100219299
16  3050308 5)
 51463 939 971 966 7782713713659
 51462 940 967 969 7881723723661
 839014503 70322948113  117 2752 5906
 836914534 69792941112  117 2734 5908
 99 1468 6591342136313361340  47
100 1448 6611342136613391341  52
0062064020021029030048048 25298
0090093055056020020061063139  )
 5535 50180 2176016320  0
 5470 51250 2175015410  0
 35 35 42155833060  38 392 570E000058
 27 29 46157863060  41 392 550E000058
 9536449 2350130213028
15000601 2225128312838
25024722  950134013408
000842000082
000844000082
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

17:07:29	46818992	Incoming Downlink	9M-MRO	MH0370	IOR2	MHKULKJACM001	071707	DFD	RELAY
Normal		DFD B777 Position Report (NEW)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071707
□DFD
FI MH0370/AN 9M-MRO
DT QXT IOR2 071707 D03A
-  MAS001A0         B777 POSITION REPORT           565

ACID   FLT  FM FLCT   DATE   DPT  DST
MRO    S370 TR  318 07/03/14 WMKK ZBAA

     SWID         SFC
316A-BSM-710-02 18661

 GMT    ALT    CAS  MACH  TAT   SAT     LAT     LONG
164143    103 168.4 .255  31.1   27.3   2.767  101.715
164643  10582 261.8 .478  23.4   10.4   3.074  101.760
165143  21193 301.1 .669  11.6  -11.8   3.553  101.988
165643  28938 303.1 .783   2.6  -27.4   4.109  102.251
170143  34998 278.0 .819 -13.4  -43.9   4.708  102.534
170643  35004 278.4 .821 -13.1  -43.8   5.299  102.813

 GWT   TOTFW  WINDIR WINDSP  THDG
492520  49200  140.3   1.25  -33.5
489200  47800  107.6   9.38   27.3
486240  46500   91.8  19.50   27.8
483840  45400   58.4  10.63   26.0
481880  44500   69.6  17.38   26.8
480600  43800   70.0  17.13   26.7
```

18:03:23	46819784	Outgoing Uplink	9M-MRO	MH0370		MHKULKJACM001	071803	AGM	RELAY
Uplink Sent		B777 Cockpit Printer Uplink for ODC -- B777 Cockpit			QXSXMXS				

```
QU QXSXMXS
.DPCCAMH 071803
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

THEY COMPLAIN CANNOT TRACK YOU ON THEIR RADAR

I RECEIVED CALL FROM SUBANG CENTRE

PLS ACK THESE MSG

REGARDS
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

18:03:24	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071803	MAS	RELAY
Normal		MAS-L (link ack)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071803
□MAS
AN 9M-MRO/FI MH0370/MA 991L
```

18:06:25	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071806	MAS	RELAY
Normal		MAS-F (failed)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071806
□MAS
AN 9M-MRO/FI MH0370/MA 991F
-  UP INTERCEPT AIRCRAFT NOT LOGGED ON                    234

QU QXSXMXS
.DPCCAMH 071803
AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT
```

18:08:09	46819784	Outgoing Uplink	9M-MRO	MH0370		MHKULKJACM001	071808	AGM	RELAY
Retransmitted		B777 Cockpit Printer Uplink for ODC -- B777 Cockpit			QXSXMXS				

```
QU QXSXMXS
.DPCCAMH 071808
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

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I RECEIVED CALL FROM SUBANG CENTRE

PLS ACK THESE MSG

REGARDS
```

18:08:11	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071808	MAS	RELAY
Normal		MAS-L (link ack)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071808
□MAS
AN 9M-MRO/FI MH0370/MA 991L
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

18:08:13	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071808	MAS	RELAY
Normal		MAS-F (failed)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071808
□MAS
AN 9M-MRO/FI MH0370/MA 991F
-  UP INTERCEPT AIRCRAFT NOT LOGGED ON                    234

QU QXSXMXS
.DPCCAMH 071808
AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT
```

18:10:00	46819784	Outgoing Uplink	9M-MRO	MH0370		MHKULKJACM001	071810	AGM	RELAY
Retransmitted		B777 Cockpit Printer Uplink for ODC -- B777 Cockpit			QXSXMXS				

```
QU QXSXMXS
.DPCCAMH 071810
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

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I RECEIVED CALL FROM SUBANG CENTRE

PLS ACK THESE MSG

REGARDS
```

18:10:00	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071810	MAS	RELAY
Normal		MAS-L (link ack)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071810
□MAS
AN 9M-MRO/FI MH0370/MA 991L
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

18:10:02	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071810	MAS	RELAY
Normal		MAS-F (failed)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071810
□MAS
AN 9M-MRO/FI MH0370/MA 991F
-  UP INTERCEPT AIRCRAFT NOT LOGGED ON                      234

QU QXSXMXS
.DPCCAMH 071810
AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT
```

18:11:50	46819784	Outgoing Uplink	9M-MRO	MH0370		MHKULKJACM001	071811	AGM	RELAY
Retransmitted		B777 Cockpit Printer Uplink for ODC -- B777 Cockpit			QXSXMXS				

```
QU QXSXMXS
.DPCCAMH 071811
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

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I RECEIVED CALL FROM SUBANG CENTRE

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REGARDS
```

18:11:50	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071812	MAS	RELAY
Normal		MAS-L (link ack)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071812
□MAS
AN 9M-MRO/FI MH0370/MA 991L
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
18:11:52 Normal	46819784	Incoming Downlink MAS-F (failed)	9M-MRO	MH0370	QXSXMXS	MHKULKJACM001	071812	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071812
□MAS
AN 9M-MRO/FI MH0370/MA 991F
-  UP INTERCEPT AIRCRAFT NOT LOGGED ON                        234

QU QXSXMXS
.DPCCAMH 071811
AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC              |
=======================================
URGET REQUEST

PLS CONTACT
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
18:13:40 Retransmitted	46819784	Outgoing Uplink B777 Cockpit Printer Uplink for ODC -- B777 Cockpit	9M-MRO	MH0370	QXSXMXS	MHKULKJACM001	071813	AGM	RELAY

```
QU QXSXMXS
.DPCCAMH 071813
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC              |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

THEY COMPLAIN CANNOT TRACK YOU ON THEIR RADAR

I RECEIVED CALL FROM SUBANG CENTRE

PLS ACK THESE MSG

REGARDS
```

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
18:13:41 Normal	46819784	Incoming Downlink MAS-L (link ack)	9M-MRO	MH0370	QXSXMXS	MHKULKJACM001	071813	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071813
□MAS
AN 9M-MRO/FI MH0370/MA 991L
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application

Mar. 7, 2014

18:13:42	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071813	MAS	RELAY
Normal		MAS-F (failed)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071813
□MAS
AN 9M-MRO/FI MH0370/MA 991F
-  UP INTERCEPT AIRCRAFT NOT LOGGED ON                    234

QU QXSXMXS
.DPCCAMH 071813
AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT
```

18:15:23	46819784	Outgoing Uplink	9M-MRO	MH0370		MHKULKJACM001	071815	AGM	RELAY
Retransmitted		B777 Cockpit Printer Uplink for ODC -- B777 Cockpit			QXSXMXS				

```
QU QXSXMXS
.DPCCAMH 071815
□AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT HO CHI MING ATC ASAP

THEY COMPLAIN CANNOT TRACK YOU ON THEIR RADAR

I RECEIVED CALL FROM SUBANG CENTRE

PLS ACK THESE MSG

REGARDS
```

18:15:23	46819784	Incoming Downlink	9M-MRO	MH0370		MHKULKJACM001	071815	MAS	RELAY
Normal		MAS-L (link ack)			QXSXMXS				

```
QU DPCCAMH
.QXSXMXS 071815
□MAS
AN 9M-MRO/FI MH0370/MA 991L
```

Traffic Log

From Mar. 07, 2014 15:54:00 to Mar. 07, 2014 18:15:59

Filter: Aircraft registration [MRO], Source/destination [QXSXMXS]

Time / Status	Trans.	Direction / Message Type	AN	FI	Medium / Source/Destination	Machine	Raw DTG	SMI	Application
Mar. 7, 2014									
18:15:25 Normal	46819784	Incoming Downlink MAS-F (failed)	9M-MRO	MH0370	QXSXMXS	MHKULKJACM001	071815	MAS	RELAY

```
QU DPCCAMH
.QXSXMXS 071815
□MAS
AN 9M-MRO/FI MH0370/MA 991F
-  UP INTERCEPT AIRCRAFT NOT LOGGED ON                        234

QU QXSXMXS
.DPCCAMH 071815
AGM
AN 9M-MRO/FI MH0370/MA 991I
-
=======================================
| MALAYSIA AIRLINES - ODC             |
=======================================
URGET REQUEST

PLS CONTACT
```

D119/4

AIRBUS
DEFENCE & SPACE

Memorandum – HIGHLY CONFIDENTIAL

From:
Fernando Peces Morate
Location:
Seville – Tablada
Telephone:
T +34 669 554090
E-mail
Fernando.Peces@airbus.com
Date:
02 September 2015

Ref.: AER-M-049-15

To:

Mr Jose Manuel Rueda Negri,
International Cooperation Attorney

Mr François Grangier,
Expert to French Supreme Court

Mr Luis Gracia,
Head of Product & Flight Safety

Subject/ Asunto: MH370

On August 24 Fernando Peces Morate, Head of Aerostructures Programmes within Airbus Defence And Space, was contacted by Mr. François Grangier, as expert to French Supreme Court. The reason for that to be notified that as part of the investigation, being held at French Court, on the remains of a piece of aircraft structure found at Reunion Island, ADS would be requested to collaborate in the detailed identification of such a component.

The part had been previously recognized to be a B777 right hand side flaperon, component that has always been manufactured at Airbus Defence and Space SAU facilties, or any former legal entity designations:

- Construcciones Aeronaúticas S.A. (CASA) till year 2000
- EADS CASA from year 2000 to 2014

To facilitate the tracking of the part found Mr. Grangier allowed Mr. Pierre-Charles Rolland, appointed as Airbus Engineer to assist the Court in this case, to deliver the photographic file regarding part and serial numbers found during the boroscope inspection of the flaperon. See annex 1

ADS proceeded to trace the Serial Numbers that appeared in the photographs, and as a result of it, we can ensure that the flaperon assembly was delivered to Boeing in 2002, with destination to **MSN 404, allocated to customer MAS (Malasyan airlines) unit number WB175**. See annex 2, 3 and 4.

5

Confidential

AIRBUS
DEFENCE & SPACE

Fernando Peces Morate, Director de Aeroestructuras de la empresa Airbus Defence & Space S.A.U., fue contactado el pasado 24 de Agosto por el Sr. Grangier, perito de la Corte Suprema Francesa; la razón de este contacto era comunicar, que como parte de la investigación sobre los restos del avión encontrado en la Isla de la Reunión, le sería requerida su colaboración para la identificación exacta del avión origen de los mismos.

Los restos hallados pertenecen a un flaperon derecho del avión Boeing 777, cuya fabricación ha sido siempre realizada en instalaciones de la actual ADS S.A.U., que en el pasado tuvo como entidad legal otras designaciones:

- Construcciones Aeronaúticas S.A. (CASA) hasta el año 2000
- EADS CASA desde el año 2000 hasta 2014

Para permitir la traceabilidad del elemento, Mr. Grangier permitió al Sr. Rolland, designado como ingeniero de Airbus para asistir al tribunal francés en este caso, que enviase los registros fotográficos de los números de parte y serie obtenidos durante la inspección boroscópica al Sr Peces. Ver anexo 1.

ADS SAU procedió a revisar la documentación de fabricación, y como consecuencia de ello se puede asegurar que los restos pertenecen a un flaperon derecho, enviado a la línea de montaje final de Boeing en Everett en el año 2002, con destino al avión **MSN 404, asignado al cliente MAS (Malasyan Airlines), unidad de cliente WB175**. Ver anexos 2, 3 y 4.

En Sevilla a 2 de septiembre 2015

Firmado:

Fernando Peces Morate
Head of Aerostructure Programmes
Military Aircraft. Operations.
Airbus Defence and Space S.A.U.

AIRBUS
DEFENCE & SPACE

Annex 1 / Anexo 1

Photographs received to trace component.
Fotografias recibidas para tracear el origen del componente.

Annex 2 / Anexo 2

Copy of the relevant production order sheets.
Copia de las hojas de la orden de producción pertinentes.

Annex 3 / Anexo 3

Delivery documentation
Documentación de entrega

Annex 4 / Anexo 4

Master Schedule

D1119/7

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Annex 1 / Anexo 1

- Photographs received to trace component.
- Fotografias recibidas para tracear el origen del componente.

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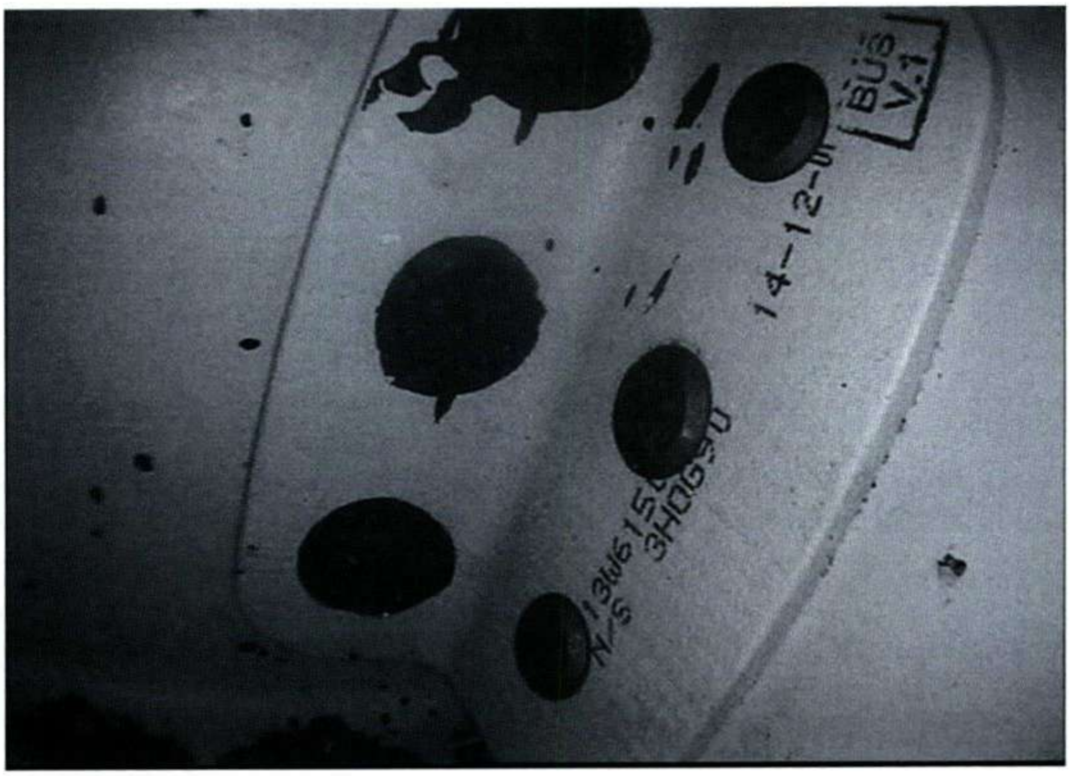
Photograph 1 /Fotografías 1



Cornière

P/N: 113W6150-1 CLEAT/REFUERZO- NON RECORDABLE PART/PIEZA CON S/N NO REGISTRABLE

D119/9

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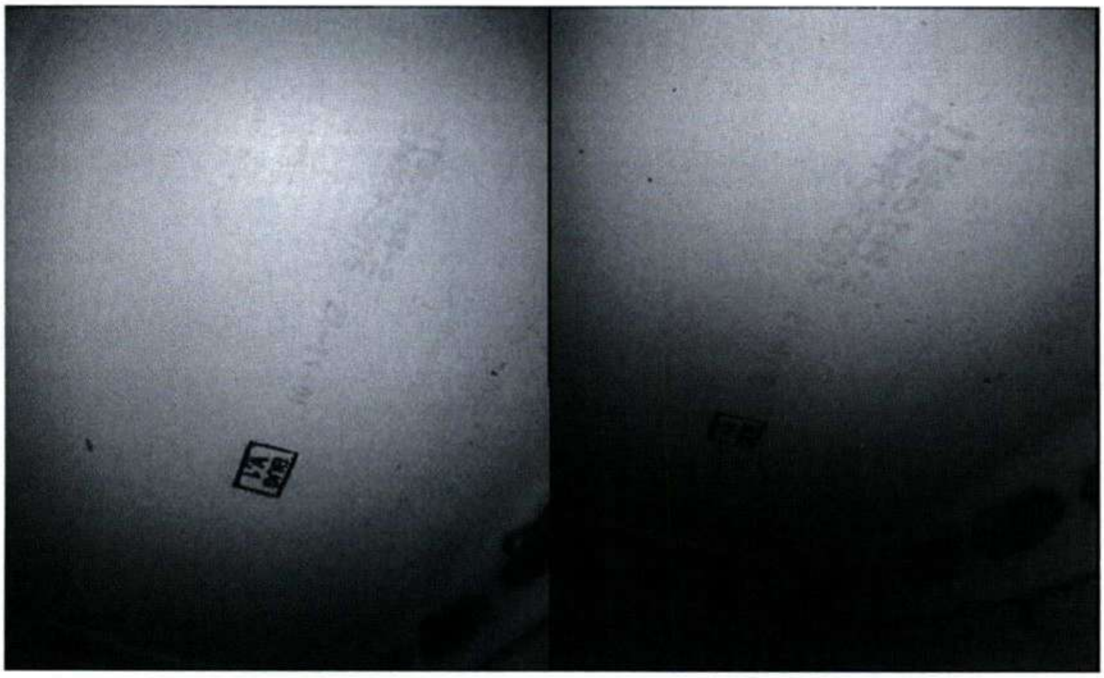
DEFENCE & SPACE

Photograph 2 /Fotografías 2



Nervure (outboard selon Boeing)

P/N: 113W6144-2 REAR SPAR/LARGUERO POSTERIOR RECORDABLE PART BUT NOT CLEARLY READABLE / PIEZA CON S/N REGISTRABLE PERO ILEGILBLE

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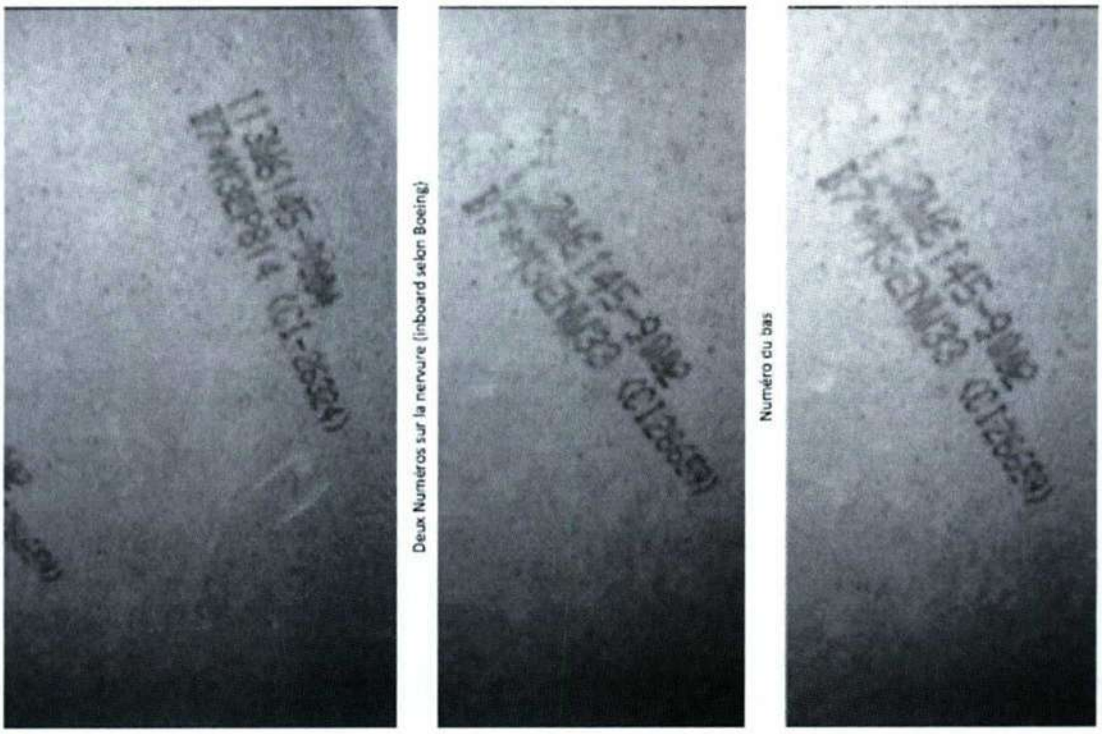
Photograph 3 / Fotografías 3



P/N: 113W6145-2 & 4 ACTUATOR FITTINGS/NON RECORDABLE PART/
HERRAJES DE ACTUADOR PIEZA CON S/N NO REGISTRABLE

DM9/11

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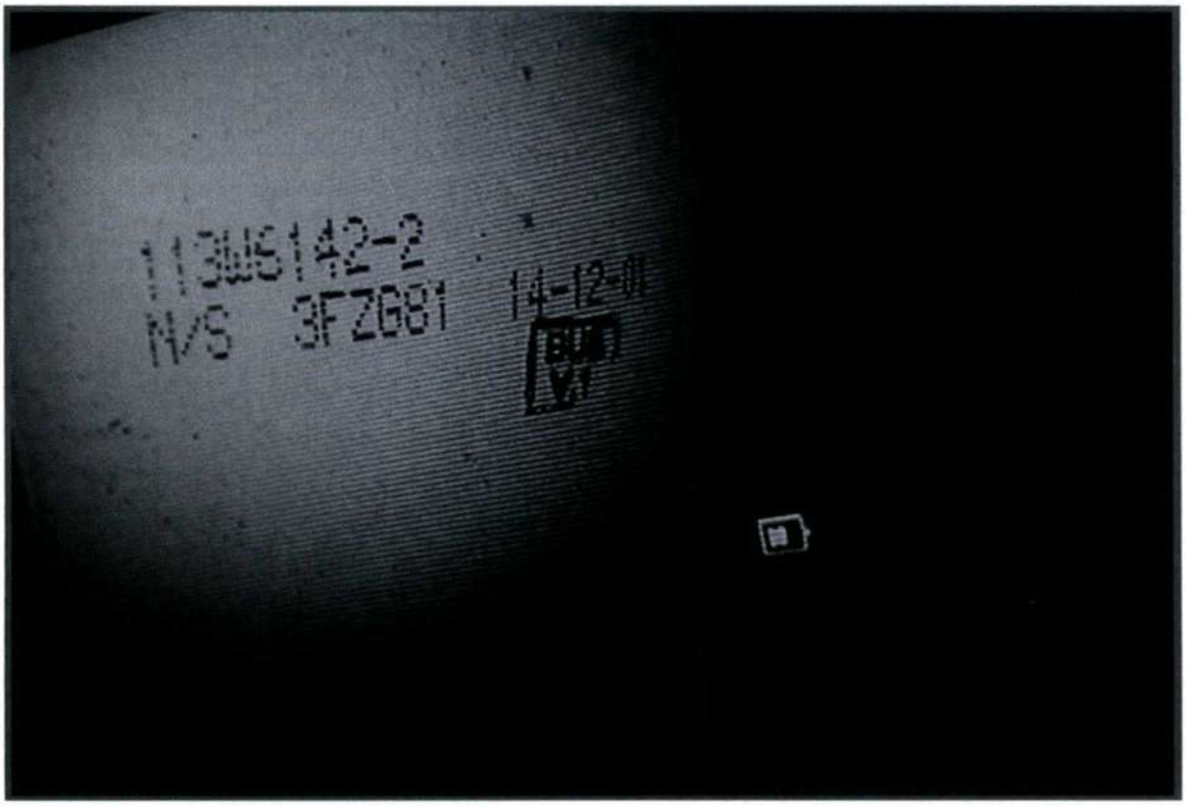
AIRBUS DEFENCE & SPACE

Photograph 4 /Fotografías 4



P/N: 113W6142-2 FRONT SPAR RECORDABLE PART N/S 3FZG81/
/LARGUERO ANTERIOR PIEZA CON S/N REGISTRABLE N/S 3FZG81

D119/12

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AIRBUS DEFENCE & SPACE

Annex 2 / Anexo 2

- Copy of the relevant production order sheets.
- Copia de las hojas de la orden de producción pertinentes.

D119/13

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AIRBUS
DEFENCE & SPACE

Orden de Trabajo 1
Production Sheet 1

C.I. 20057

C.A.S.A. ** SPRINT ** 22 ENE 2002 FECHA IMP:25-11-01 PAG:01
FECHA SIS:23-11-01

ORDEN DE PRODUCCION

FACTORIA :SAN PABLO

NUM.ORDEN :B7*-M-38G175
NUM. PARTE :113W6100-9010C03
586110
DESIGNACION :CONJ.FLAPERON (GRADA)
REVISION ESTR. :AC
FECH. EFF. RUTA :11-07-00

ORDEN ASOCIADA :N/A
PRO/E.F. :B03
COD. TIPO PARTE:F
REVISION RUTA :06
LOCALIZACION :B70PLANTA

*** PARTE SERIABLE ***

FAC-CTA-TT-ORD	CANT.	ORDEN	U.D.C.	EFECTIVIDAD DE LA PARTE	CODIGO SUBCONT.	NUM. SERIE
	1		AE	H03 N/A 0405	N/A N/A	

OPERACION	S.G.M.	DESCRIPCION OPERACION / UTIL	VERIFICACION CANT.UTIL SELLO
1000-0-0	345070	SITUACIONES SOBRE UTIL MTGR-01-FAJ113W6100-2(H)	

COMPROBAR QUE LA REGLETA DE TALADRAR EL BORDE DE SALIDA (CONJUNTO 701 DEL UTIL), ESTA SITUADA Y FIJADA MEDIANTE TORNILLOS Y PASADORES.

MONTAR LAS REGLETAS DE TALADRAR EL LARGUERO ANTERIOR (REF. CONJUNTO 1501 DEL UTIL) Y EL LARGUERO POSTERIOR (REF. CONJUNTO 1601 DEL UTIL) Y CUCHILLAS (CONJ. 802,825,830 ZONA EXTRADOS DEL UTIL).

DESPLAZAR HACIA EL INTERIOR LOS 2 EMBOLOS TOPES DEL UTIL PARA LA SITUACION DE CENTRADO DEL REVESTIMIENTO SUPERIOR E INSERTAR LOS PASADORES EN LOS TALADROS DE BLOCAJE.

SITUAR SOBRE EL UTIL EL REVESTIMIENTO SUPERIOR Y FIJAR MEDIANTE 2 BULONES POSICIONADORES, INSERTANDOLOS EN LOS TALADROS DE LAS OREJETAS DEL REV. Y DE TOPES . INTERCALAR CALA DE 1,00 MM. ENTRE EL REV. Y TOPES. LLEVAR EL BORDE DE SALIDA DEL REV. CONTRA LOS TOPES DE LA REGLETA INTERCALANDO GALGA DE 5,00+/-0,01 MM. ENTRE LA REGLETA DE

PI 28832
15 ENE 2001

Production Sheet/: B7*-M-38G175
Orden de trabajo: B7*-M-38G175

Flaperon Assembly 405 RH
Montaje de Flaperon 405 RH

(Installed in shipset MSN 404
Instalado en Avión MSN 404)

P/N: 113W6100-9010C03

Sheet/Hoja 1

AIRBUS
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Orden de Trabajo 2
Production Sheet 2

C.A.S.A. LISTA COMPONENTES SERIABLES FECHA IMP:25-11-01 PAG:01
FECHA SIS:23-11-01

NUM. ORDEN :B7*-M-38G175 ORDEN ASOCIADA :N/A

NUMERO PARTE :113W6100 9010C03
586110
DESIGNACION :CONJ.FLAPERON (GRADA)
NUMERO PARTE /

PRO/E.F. :B03
N.SER TEO./REAL :

N.SER TEO./REAL	CODIGO CASA		DESIGNACION
3F2TØ8	113W6131-2 823449	PI 99053 10 ENE 2002	REVESTIMIENTO SUPERIOR UPPER SKIN
3F2R54	113W6132-2 823451	PI 27546 12 ENE 2002	REVESTIMIENTO INFERIOR LOWER SKIN
3F2Q16	113W6144-2 823453		LARGUERO POSTERIOR REAR SPAR
3F2055	113W6153-2 823455	PI 99053 10 ENE 2002	COSTILLA ENCOLADA BONDED PART RIB
3F2I55	113W6154-2 826252	PI 27546 10 ENE 2002	COSTILLA ENCOLADA BONDED PART-RIB
3F2G81	113W6142-2 826698		LARGUERO ANT. ENCOLADO BONDED PART, FRONT SPAR

REALIZADA COMPROBACION ABSCR

FECHA SELLO PI 20930 15 ENE 2002 PI 20930 14 [illegible] 2002

-------- FIN DE LISTA --------

Production Sheet: B7*-M-38G175
Orden de trabajo: B7*-M-38G175

Flaperon assembly 405 RH
Montaje de Flaperon 405 RH

(Installed in shipset MSN 404
Instalado en Avión MSN 404)

P/N: 113W6100-9010C03
Sheet/Hoja 60.

Parts with serial numbers/
Elementos con Nº Serie

SERIAL NUMBER SHOWN ON PHOTOGRAPH 4/
NUMERO DE SERIE RECOGIDO EN LAS FOTOGRAFÍA 4

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Orden de Trabajo 3
Production Sheet 3

Production Sheet: B7*-M-38G175
Orden de trabajo: B7*-M-38G175

Flaperon Assembly 405 RH
Montaje de Flaperon 405 RH: P/N: 113W6100-9010C03

(INSTALLED IN SHIPSET Msn 404/
INSTALADO EN AVION MSN 404)

Complete Document (63 pages)
Documento completo (63 páginas)

PDF
Adobe Acrobat
Document

Annex 3 / Anexo 3

- Delivery documentation
- Documentación de entrega

DA19/17

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AIRBUS
DEFENCE & SPACE

Delivery Document Relevant Page
Documentación de entrega Hoja Pertinente

Planned Location of Flaperon 404
Destino previsto del Flaperon 404

Página 10 de 44

BOEING END ROUTING: PCA 155U	
MODEL	B-777
PART NO.	113W6100-10
BASIC AIRPLANE UNIT NO.	404
BOEING CUSTOMER DESIGNATOR AND CUSTOMER UNIT NUMBER	MAS WB175
MANUFACTURED BY:	C.A.S.A.

D119/18

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AIRBUS
DEFENCE & SPACE

Annex 4 / Anexo 4

- Master Schedule

AIRBUS
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Parts comprising Boeing Flaperon S/N 404: CASA 406 LH + CASA 405 RH
Delivered to Boeing on February 18, 2002

Elementos que componen el Flaperon Boeing S/N 404: CASA 406 LH + CASA 405 RH
Entregado a Boeing el 18 de Febrero de 2002

MASTER SCHEDULE OF FLAPERON

PREP. DOC.	L/H	C.M.	R/H	C.M.	L/BOEING	S/N	CUST.	DELIV.	DIST.
C-387	388	Y	386	Y	385	WB332	AFA	02/11/01	-9/10
C-388	389	Y	388	Y	386	WB273	LAL	10/11/01	-9/10
C-389	391	Y	390	Y	387	WB453	DAL	15/11/01	-9/10
C-390	390	Y	389	Y	388	WB088	UAL	21/11/01	-9/10
C-391	393	Y	392	Y	389	WB241	SIA	24/11/01	-9/10
C-392	392	Y	393	Y	390	WB189	SIA	03/12/01	-9/10
C-393	359	Y	394	Y	391	WB387	CAL	07/12/01	-9/10
C-394	396	Y	398	Y	392	WB333	AFA	29/12/01	-9/10
C-395	395	Y	397	Y	393	WB434	AAL	04/1/02	-9/10
C-396	394	Y	396	Y	394	WB174	MAS	08/1/02	-9/10
C-397	397	Y	395	Y	395	WB334	AFA	08/1/02	-9/10
C-398	400	Y	401	Y	396	WB638	EAD	22/1/02	-9/10
C-399	398	Y	399	Y	397	WB388	CAL	11/1/02	-9/10
C-400	401	Y	402	Y	398	WB207	SIA	18/1/02	-9/10
C-401	399	Y	400	Y	399	WB435	AAL	22/1/02	-9/10
C-402	403	Y	404	Y	400	WC113	AAR	13/2/02	-9/10
C-403	402	Y	403	Y	401	WB335	AFA	04/2/02	-9/10
C-404	409	Y	408	Y	402	WB633	EAD	04/3/02	-9/10
C-405	404	Y	391	Y	403	WC114	AAR	11/2/02	-9/10
C-406	406	Y	405	Y	404	WB175	MAS	18/2/02	-9/10
C-407	407	Y	406	Y	405	WC104	ELA	20/2/02	-9/10
C-408	408	Y	407	Y	406	WB190	SIA	25/2/02	-9/10
C-409	405	Y	409	Y	407	WB208	SIA	04/3/02	-9/10
C-410	410	Y	410	Y	408	WB634	EAD	08/3/02	-9/10
C-411	411	Y	411	Y	409	WB242	SIA	14/3/02	-9/10
C-412	412	Y	412	Y	410	WC241	JAL	22/3/02	-9/10
C-413	414	Y	414	Y	411	WB137	KAL	01/4/02	-9/10
C-414	413	Y	413	Y	412	WB209	SIA	15/4/02	-9/10
C-415	416	Y	416	Y	413	WC281	ALI	25/4/02	-9/10
C-416	415	Y	415	Y	414	WB635	EAD	02/5/02	-9/10

Pagina 4

Annexe 1 : **Ordonnance of commission d'expert**

- APPENDICES -

COUR D'APPEL DE PARIS Tribunal de Grande Instance de Paris Cabinet de Alain GAUDINO Vice-Président chargé de l'instruction en co-saisine avec Carole RAMET et Quentin DANDOY, juges d'instruction	**ORDONNANCE DE COMMISSION D'EXPERT** (Adjonction, à la demande de l'expert, de personnes nommément désignées, spécialement qualifiées,art.162 du CPP)

N° du Parquet : . 1413400160 .
N° Instruction : . 2108/15/5 .
PROCÉDURE CRIMINELLE

Le 03 août 2015,

Nous, Alain GAUDINO, Vice-Président chargé de l'instruction au tribunal de grande instance de Paris, étant en notre cabinet,

Vu l'information suivie contre :

X.,

QUALIFICATIONS :

Réquisitoire Introductif du 24 avril 2015

• détournement d'aéronef ayant entraîné la mort de plusieurs personnes de nationalité française, en relation avec une entreprise terroriste,

Faits commis entre KUALA LUMPUR (MALAISIE) et PEKIN (CHINE), le 8 mars 2014 (heure locale),

Au préjudice de :

- Laurence BEHERAY épouse WATTRELOS, née le 30 mars 1962 à DIEPPE (76),
- Hadrien WATTRELOS né le 12 février 1994 à LEVALLOIS-PERRET (92),
- Ambre WATTRELOS née le 28 novembre 2000 à LEVALLOIS-PERRET (92).

Faits prévus et réprimés par les articles 113-7, 113-11, 224-6, 224-7, 224-9, 224-10, 421-1, 421-3, 422-3, 422-4,422-5 et 422-6 du Code pénal et les articles 203 et 706-16 du Code de procédure pénale,

ORDONNANCE DE DESSAISISSEMENT de Quentin DANDOY, Juge d'instruction au Tribunal de Grande Instance de Paris, le 22 juin 2015 (dossier d'information : 2386/14/17)

Réquisitoire Introductif du 07 mai 2014

• Homicide involontaire par manquement délibéré d'une obligation dparticulière de prudence ou de sécurité imposée par la loi ou le règlement (Vol MH370 de la Malaysia Airlines – 08 mars 2014),

Faits prévus et réprimés par les articles 221-6, 221-8, 221-10 du Code pénal,

Au préjudice de :

- Laurence BEHERAY épouse WATTRELOS, née le 30 mars 1962 à DIEPPE (76),
- Hadrien WATTRELOS né le 12 février 1994 à LEVALLOIS-PERRET (92),
- Ambre WATTRELOS née le 28 novembre 2000 à LEVALLOIS-PERRET (92).

Réquisitoire Supplétif du 26 août 2015

• Détournement d'aéronef ayant entraîné la mort de plusieurs personnes
Faits prévus et réprimés par les articles 224-6, 224-7, 224-9 du Code pénal

Au préjudice de :

- Laurence BEHERAY épouse WATTRELOS, née le 30 mars 1962 à DIEPPE (76),
- Hadrien WATTRELOS né le 12 février 1994 à LEVALLOIS-PERRET (92),
- Ambre WATTRELOS née le 28 novembre 2000 à LEVALLOIS-PERRET (92).

Parties Civiles :

- Mme BEHERAY Pascale ép. DERRIEN domiciliée 38 rue du Guet 92310 SEVRES ayant pour avocat :Me Stéphan OUALLI
- Mme TU Hualhong domiciliée chez Me DOSE Marie, 25 rue du Louvre 75001 PARISayant pour avocat :Me Marie DOSE
- M. WATTRELOS Alexandre domicilié 97 rue des Landes 78400 CHATOU ayant pour avocat :Me Stéphan OUALLI
- M. WATTRELOS Ghislain domicilié 97 rue des Landes 78400 CHATOU ayant pour avocat :Me Marie DOSE
- M. ZHAO Shugo domicilié chez Me DOSE Marie, 25 rue du Louvre 75001 PARIS ayant pour avocat :Me Marie DOSE

Vu les articles 156 et suivants du Code de Procédure Pénale;

Vu la désignation de :

Monsieur François GRANGIER
Expert en aéronautique
Inscrit sur la liste nationale de la Cour de Cassation

suivant mission en date du 30 juillet 2015;

Attendu que Monsieur GRANGIER, expert, Nous sollicite, conformément aux dispositions de l'article 162 du Code de procédure pénale, afin de l'autoriser à s'adjoindre un sachant spécialisé, en la personne de :

La Direction Générale de l'Armement – Techniques Aéronautiques (DGA-TA)
prise en la personne de Monsieur Jean-Christophe PLOTKA,
Sous-Directeur Technique de la DGA-TA
47, Rue Saint-Jean
31130 Balma

Expert non-inscrit qui prêtera, vu l'urgence, serment par écrit dans les conditions prévues à l'article 160 du Code de procédure pénale;

aux fins de procéder aux opérations ci-dessous indiquées.

L'expert remettra dans le meilleur délai, un rapport détaillé contenant son avis motivé et l'attestation qu'il a personnellement accompli la mission qui lui a été confiée.

Vu l'urgence et l'impossibilité de différer les opérations d'expertise et le dépôt des conclusions pendant un délai de dix jours, la présente ordonnance n'a pas été communiquée aux parties ; en conséquence, les opérations d'expertise peuvent commencer sans délai ;

le Vice-Président chargé de l'instruction

Alain GAUDINO

Annexe 2 : **Prestation of serment**

Liberté . Égalité . Fraternité
RÉPUBLIQUE FRANÇAISE
MINISTÈRE DE LA DÉFENSE

DGA
DIRECTION GENERALE DE L'ARMEMENT
DGA Techniques aéronautiques

Tribunal de Grande Instance de Paris
Cabinet de M. Alain GAUDINO
Vice-président chargé de l'instruction

4 Boulevard du Palais
75 001 PARIS

Balma, le 22 SEP. 2015
N° 141534 /DGA TA/SDAR

Affaire suivie par :
Gracienne LENNE
Tél. : 05 62 57 55 06
Fax : 05 62 57 55 04
e-mail : gracienne.lenne@intradef.gouv.fr

Objet : Ordonnance de commission d'expert (adjonction à la demande de l'expert, de personnes nommément désignées, spécialement qualifiées, art. 162 du CPP) du 03 aout 2015

Références : N° du Parquet : 1413400160
N° d'instruction : 2108/15/5

P. jointe : Prestation de serment d'un expert

Monsieur le Juge,

Par votre ordonnance d'adjonction de spécialiste du 03 août 2015 relative à l'instruction n° 2108/15/5, vous commettez DGA Techniques aéronautiques prise en la personne de monsieur Jean-Christophe Plotka, Sous-Directeur Technique, afin d'assister monsieur François Grangier, expert judiciaire désigné, dans le cadre de l'expertise technique d'un débris d'épave retrouvé sur l'île de la Réunion le 29/07/2015.

Conformément à votre demande, je désigne monsieur Christophe Bordes, expert à la Division Matériaux et Technologies, pour conduire la mission au nom de DGA Techniques aéronautiques, en liaison directe avec M. François Grangier.

Vous trouverez en pièce jointe la prestation de serment de l'expert.

Jean-Christophe PLOTKA
Sous-Directeur Technique
DGA Techniques aéronautiques

Direction générale de l'armement
DGA Techniques aéronautiques
47 rue Saint-Jean - BP n° 93123 - 31131 BALMA Cedex
Téléphone : +33 (0)5.62.57.57.57 – Télécopie : +33 (0)5.62.57.54.47

V-01/2010

Cour d'Appel de Paris

PRESTATION DE SERMENT
(EXPERT NON INSCRIT)

Tribunal de Grande Instance
de Paris
Cabinet de GAUDINO Alain
Vice-Président chargé de l'instruction

N° du Parquet : . **1413400160**
N° de l'Instruction : . **2108/15/5**
PROCEDURE CRIMINELLE

En co-saisine avec Carole RAMET
et Quentin DANSOY, juges d'instruction

Le soussigné, Christophe BORDES désigné par Jean Christophe Plotka, Sous-Directeur Technique de DGA Techniques aéronautiques, 47 rue Saint-Jean – BP 93123 – 31131 BALMA Cedex, désigné en qualité d'expert par ordonnance du 03 aout 2015 pour procéder aux opérations prévues suivant ordonnance du 03aout 2015 relative à l'information contre :

X

QUALIFICATIONS :

Réquisitoire introductif du 24/04/2015
Détournement d'aéronef ayant entraîné la mort de plusieurs personnes de nationalité française, en relation avec une entreprise terroriste,

Au préjudice de :
- Laurence BEHERAY épouse WATTRELOTS, née le 30mars 1962 à DIEPPE (76)
- Hadrien WATTRELOTS né le 12 février 1994 à LEVALLOIS PERRET (92)
- Ambre WATTRELOTS née le 28 novembre 2000 à LEVALLOIS PERRET (92)

Faits commis entre KUAKA LUMPUR (Malaisie) et PEKIN (Chine), le 8 mars 2014 (heure locale)

Faits prévus et réprimés par les articles 113-7, 113-11, 224-6, 224-9, 224-10, 421-1, 421-3, 422-3, 422-4, 422-5 et 422-6 du Code pénal et les articles 203 et 706-16 du Code de procédure pénale,

Ordonnance de dessaisissement du 22/06/2015 dossier 14/17 cabinet de M. DANDOY :

- Réquisitoire introductif en date du 07/05/2014 : homicide involontaire par manquement délibéré d'une obligation particulière de prudence ou de sécurité imposée par la loi ou le règlement (vol MH370 de la Malaysia Airlines – 8 mars 2014 dans le sud Vietnam)
Victimes françaises : Laurence BEHERAY épouse WATTRELOTS, Ambre WATTRELOTS, Hadrien WATTRELOTS, Anne ZAHO,

Frais prévus et réprimés par les articles 221-6, 221-8, 221-10 du code pénal (natinf 12279)

- Réquisitoire supplétif en date du 26/08/2014 : détournement d'aéronef aggravé par la mort d'une ou de plusieurs personnes,
Crime prévu et réprimé par les articles 224-6 , 224-7 et 224-9 du code pénal (natinf 11513)

Et après avoir pris connaissance de la mission confiée, prête serment de bien et fidèlement la remplir en mon honneur et conscience.

Fait à Balma, le 18/09/2015

L'expert

Annexe 3 : **Repair temporaire appliquée au Flaperon**

malaysia airlines	TECHNICAL SERVICES ENGINEERING NOTE	77 EN- 57 - 20215 SHEET 1 OF 3	ISSUE A
~~MAJOR /~~ MINOR	ETOPS: ~~YES /~~ NO — For ETOPS requirement, refer to resp. ETOPS MM	EMS NO: E1300190/T	
ACFT REGN/~~COMP/ENGINE TYPE:~~	9M-MRO	S/DOC:	
PART NUMBER: 113W6100-10	SERIAL NUMBER: WB175	DISTRIBUTION	

SUBJECT:	DISTRIBUTION	
RH WING – FLAPERON SEAL RETAINERS FOUND WITH SEAL SECURING FASTENER HOLE ELOGATED AND TORN – TEMPORARY REPAIR OF.	SNR MANAGER MAINTENANCE PLANNING	1
	HEAD ENGINEERING MATERIALS	1
	QUALITY ASSURANCE SUPT (TR)	1
	AMU L4	1
(Ref : B777-200 IPC 57-63-51-01)	ASM	1

DESCRIPTION:

MECH. DATE | LIC/APP HLDR DATE

During aircraft C-Check at KUL on Sep 2013, the RH Wing Flaperon Seal Retainers were inspected per SI/777/60/57 R01 and found with 3-off seal holes torn and 2-off seal holes elongated. Due to insufficient spares and nil SRM repair, only 3-off seal retainers were replaced. One of the seal retainers with a torn hole has to be partially replaced and the elongated hole is to be trim-out (final dimension 0.45" X 0.8"). Nil other damage was reported on the seal retainers, surrounding area and under-lying sub-structures. Detail Visual Inspection was also performed and found satisfactory.

This EN provides the following instructions :

1. Trim-out the damage as shown in Figure 1 and maintain a 0.50" edge radius where applicable.

2. Perform DVI to surrounding seal retainer, skin and internal structure, nil further damages allowed.

3. Carry out a repair as per below as shown in Figure 1:
   a. For trim-out:
      (i) Fabricate a strap from 0.050" thick 2024-T3 Clad Sheet per AMS-QQ-A-250/5.
      (ii) Fabricate the filler to suit the trim-out section from 0.050" thick 2024-T3 Clad Sheet per AMS-QQ-A-250/5.
      (iii) Drill new holes for strap repair by temporarily assembling the repair parts. Maintain 2D edge distance.
      (iv) Disassemble these repair parts.
      (v) Remove the nicks, scratches, gouges, burrs, and sharp edges from the repair parts and the initial extruded section. Refer to 51-10-02, GENERAL.
      (vi) Apply a chemical conversion coating to the repair parts and the bare surfaces of the initial extruded section. Refer to 51-20-01, GENERAL.
      (vii) Apply two layers of BMS 10-11, Type I primer to the repair parts. Refer to SOPM 20-41-02.
      (viii) Install Strap and Filler using Blind Rivet P/N: CR3222-5-*.
      (ix) Apply the finish if necessary.
      (x) Reinstall the affected seal.

SIGNATORY (REFER MMOE 2 – 16 – 00)

REPETITIVE ACTION: Para 5	TERMINATING ACTION: Para 6

FOLLOW UP ACTION: ~~NIL /~~ AS SPECIFIED ABOVE

ISS:	DATE:	CHANGE	COMPILED	CHECKED	APPROVED
D					
C					
B					
A	26-SEP-2013	INITIAL ISSUE	FITRI	[signature] DESIGN	[signature] DESIGN 38-AS

Form No: 308008 R21 04/2013 — APPROVAL NO: DOA/2012/03

malaysia airlines	TECHNICAL SERVICES **ENGINEERING NOTE**	77 EN- 57 - 20215 SHEET 2 OF 3	ISSUE **A**
~~MAJOR~~ / MINOR	ETOPS: ~~YES~~ / NO For ETOPS requirement, refer to resp. ETOPS MM	EMS NO: E1300190/T	
ACFT REGN/~~COMP/ENGINE TYPE~~:	9M-MRO	S/DOC:	
PART NUMBER: 113W6100-10	SERIAL NUMBER: WB175	**DISTRIBUTION**	

SUBJECT:	DISTRIBUTION	
RH WING – FLAPERON SEAL RETAINERS FOUND WITH SEAL SECURING FASTENER HOLE ELOGATED AND TORN – TEMPORARY REPAIR OF.	SNR MANAGER MAINTENANCE PLANNING	1
	HEAD ENGINEERING MATERIALS	1
	QUALITY ASSURANCE SUPT (TR)	1
	AMU L4	1
(Ref : B777-200 IPC 57-63-51-01)	ASM	1

DESCRIPTION: (MECH DATE / LIC/APP HLDR DATE)

b. For sectional replacement:
   (i) Trim and discard the damage area as shown in Figure 1.
   (ii) Remove the nicks, scratches, gouges, burrs, and sharp edges from the initial extruded section. Refer to 51-10-02, GENERAL.
   (iii) Apply a chemical conversion coating to the repair parts and the bare surfaces of the initial extruded section. Refer to 51-20-01, GENERAL.
   (iv) Apply two layers of BMS 10-11, Type I primer to the repair parts. Refer to SOPM 20-41-02.
   (v) Install a similar cross-section profile using Bolt P/N: BACB30NZ5K5 per CMM 57-63-05.
   (vi) Apply the finishing if necessary.
   (vii) Reinstall the affected seal.

4. Return area to serviceable conditions.

5. Perform DVI on repair area at every A-Check from 26-September-2013. Inform STSE (STR) of any adverse findings.
   [Estimated Total Elapse time = 0.5 hr]

6. Replace the affected seal retainers per CMM 57-63-05 prior to accomplishment of MB V13037 tentatively before 28 Jan 2014.

7. HEM to ensure the availability of the following:
   - QTY: 01 P/N: 113W6182-12,
   - QTY: 23 P/N: BACC30AB5C,
   - QTY: 05 P/N: BACB30NZ5K5
   - QTY: 04 P/N: BACB30NZ5K4
   - QTY: 14 P/N: BACB30NZ5K3
   - QTY: 01 P/N: 113W6182-14
   - QTY: 04 P/N: BACB30VT5HK3
   - QTY: 03 P/N: BACB30VT5HK4
   - QTY: 07 P/N: NAS1149DN823J
   - QTY: 07 P/N: BACN10YR08CD

8. QAS (Tech. Record) to note Para 5 & 6. HEM to note Para 7. Planning to schedule.

SIGNATORY (REFER MMOE 2 – 16 – 00)

REPETITIVE ACTION: Para 5	TERMINATING ACTION: Para 6

FOLLOW UP ACTION: ~~NIL~~ / AS SPECIFIED ABOVE

ISS	DATE	CHANGE	COMPILED	CHECKED	APPROVED
D					
C					
B					
A	26-SEP-2013	INITIAL ISSUE	FITRI	(signature)	(signature)

Form No: 308008 R21 04/2013   APPROVAL NO: DOA/2012/03

malaysia airlines	TECHNICAL SERVICES ENGINEERING NOTE	77 EN- 57 - 20215 SHEET 3 OF 3	ISSUE A
~~MAJOR /~~ MINOR	ETOPS: ~~YES /~~ NO For ETOPS requirement, refer to resp. ETOPS MM	EMS NO: E1300190/T	
ACFT REGN/~~COMP/ENGINE TYPE:~~	9M-MRO	S/DOC:	
PART NUMBER: 113W6100-10	SERIAL NUMBER: WB175	DISTRIBUTION	
SUBJECT: RH WING – FLAPERON SEAL RETAINERS FOUND WITH SEAL SECURING FASTENER HOLE ELOGATED AND TORN – TEMPORARY REPAIR OF. *(Ref : B777-200 IPC 57-63-51-01)*		SNR MANAGER MAINTENANCE PLANNING	1
		HEAD ENGINEERING MATERIALS	1
		QUALITY ASSURANCE SUPT (TR)	1
		AMU L4	1
		ASM	1

DESCRIPTION:

MECH. DATE	LIC/APP HLDR DATE

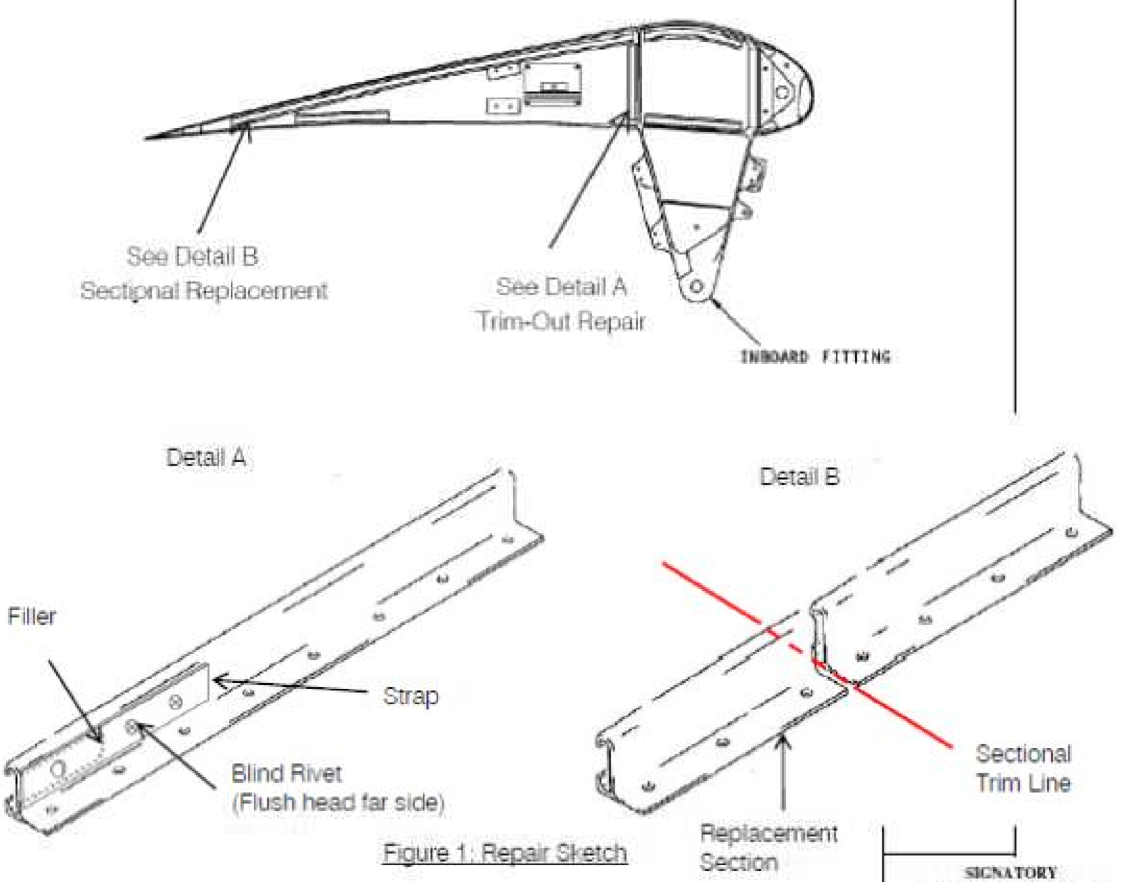


Figure 1: Repair Sketch

SIGNATORY
(REFER MMOE 2 – 16 – 00)

REPETITIVE ACTION:	Para 5	TERMINATING ACTION:	Para 6

FOLLOW UP ACTION: ~~NIL /~~ AS SPECIFIED ABOVE

D					
C					
B					
A	26-SEP-2013	INITIAL ISSUE	FITRI		
ISS:	DATE:	CHANGE	COMPILED	CHECKED	APPROVED

Form No: 308008 R21 04/2013

APPROVAL NO: DOA/2012/03

Annexe 4 : **Fiche d'analysis 62-15 – Analysis of the samples of paint**

MTA	Fiche d'analyses	N°:62-15	1/14

OT	*P1501516001003*
Demandeur	
Programme	*Expertise au profit du ministère de la justice*
Activité	*Flaperon Boeing 777*

Travaux demandés objectif, contexte

Analyses de toutes les peintures et comparaison avec les spécifications Boeing

Documents d'entrées	Document de sortie
CMM Boeing	*Rapport simplifié*
	Rapport d'essai et/ou d'expertise
	Fiche d'analyses MTA + compte rendu

Spécimen, nature (état de surface), origine…	
Nombre de spécimens/ date mise à disposition :	
Précautions particulières (échantillon, personnel)	

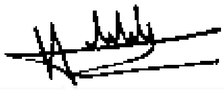
Prévision		Responsable prestation MTA	Demandeur	**Réalisation**	Responsable prestation MTA	Garant technique MTA
Nombre d'heures		Nom : Date :	Nom : Date :		Nom : hakenholz Date :19/8/15	Nom : Hakenholz Date : 19/8/15
Fournitures						
Début des travaux						
Fin des travaux						

NOTA : informations italiques remplies avec le demandeur par le responsable   version : 02/2015

MTA	Fiche d'analyses	N°:62-15	2/14

Analyse	Mode opératoire	Devis (H)	Réalisé (H)	Responsable de l'analyse
FTIR	DGA/TA N° 70 SCAT			Hakenholz
Coupe micrographique				Bottin
MEB/EDX	CEAT N°77 SCAT			Ben Rhouma

Fin de réalisation des analyses : 19/8/2015

Ecarts	Validation (par le responsable de la prestation)
néant	

Traitements/ destination des spécimens et reliquats après analyse		
	Destruction	Date de reprise spécimens et prélèvements par le demandeur :
	Stockage local	
	Retour au demandeur	

NOTA : Zone grisée remplie avec le demandeur, zone blanche par MTA version : 02/2015

MTA	Fiche d'analyses	N°:62-15	3/14

1. GÉNÉRALITÉS

Données d'entrées : spécification de la peinture de finition utilisée en intrados et extrados spec BMS 10-72 type VIII ou IX, il s'agit d'une finition « topcoat » polyurethane avec charge de Ti.

Il existe, en l'état actuel de nos connaissances, 243 industriels pouvant formuler et commercialiser cette peinture conforme à la spec BMS 10-72 type VIII ou IX.

Les exigences de cette spec sont surtout des exigences de performances fonctionnelles (applicabilité, tenue aux environnement agressifs, dureté, durée de vie en pot etc...) et quelques exigences sur les composés de base majoritaires (nature chimique du liant et charge principale). Les additifs caractéristiques d'une formulation de peinture de type plastifiant, antioxydant etc... sont laissés à charge des formulateurs de peintures, seuls la tenue des exigences exprimées dans la spec compte.

On note quelques fournisseurs majeurs cependant : PPG aerospace avec la gamme Desothane et AKZO-Nobel avec la gamme Eclypse.

Plusieurs échantillons prélevés sur le flaperon sont à notre disposition :

- Système de peinture intrados
- Système de peinture extrados
- Système de peinture de la zone de « retouche » extrados

Sur la zone de retouche, le CMM Boeing recommande que cette zone du paneau composite soit protégée par un système de peinture de type BMS 10-86 I sur la finition BMS 10-60 II.

La peinture BMS 10-86 I est composée d'un liant polyurethane, et de particules de téflon conférant ainsi à cette zone du panneau des propriétés supplémentaires de tenue à l'usure par frottement.

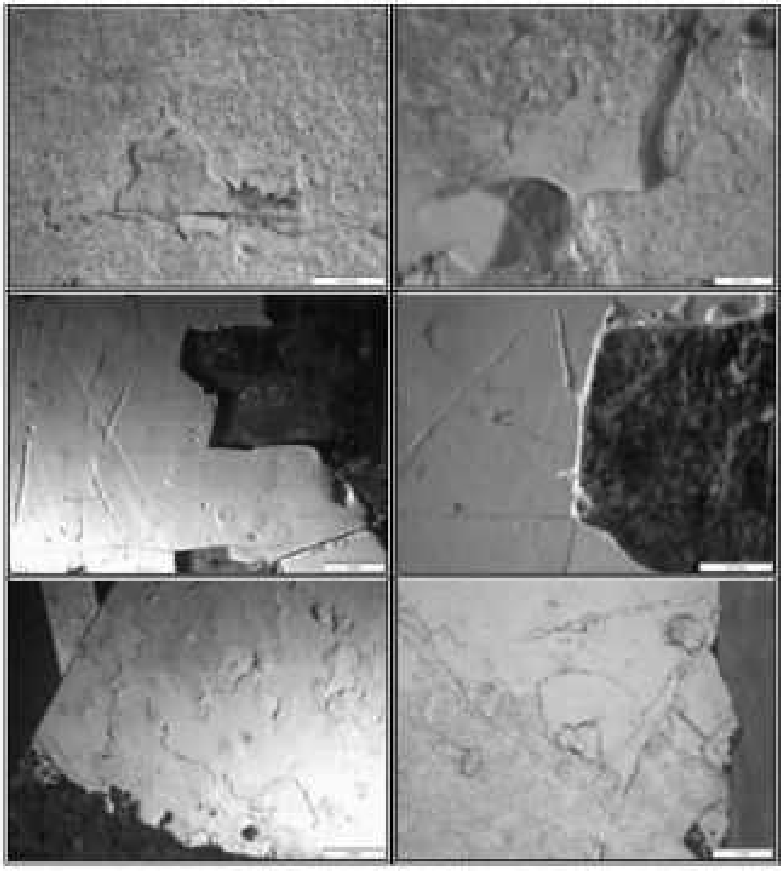
MTA	Fiche d'analyses	N°:62-15	4/14

2. RESULTATS DES ANALYSES

2.1. SYSTEME DE PEINTURE INTRADO

2.1.1. OBSERVATIONS MACRO

Photo échantillon



On constate une forte dégradation du système, la couche superficielle est par endroit suffisamment dégradée pour apercevoir les couches profondes plus granuleuses (aspect granité), on observe trois couches distinctes : primaire, intermédiaire, finition.
Différents types de dommages observés sur la peinture : faïençage, rayures et décollement.

2.1.1.1. OBSERVATION EN COUPE MICROGRAPHIQUE

Sur une zone la plus saine possible (avec les trois couches intègres) → coupe micrographique pour caractériser les systèmes de peinture en présence.

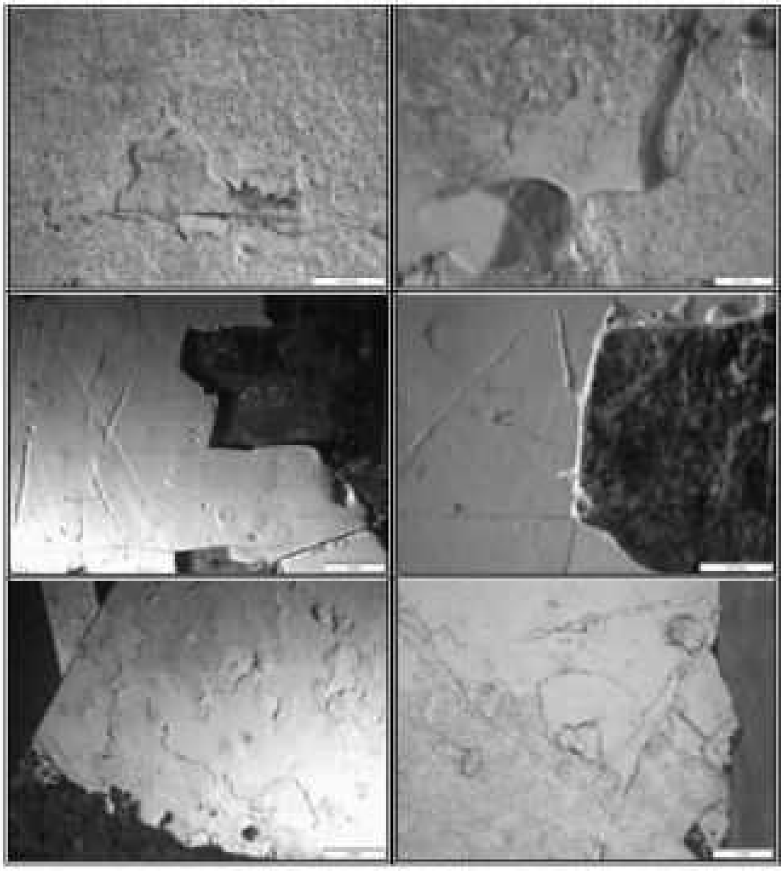
MTA	Fiche d'analyses	N°:62-15	4/14

2. RESULTATS DES ANALYSES

2.1. SYSTEME DE PEINTURE INTRADO

2.1.1. OBSERVATIONS MACRO

Photo échantillon

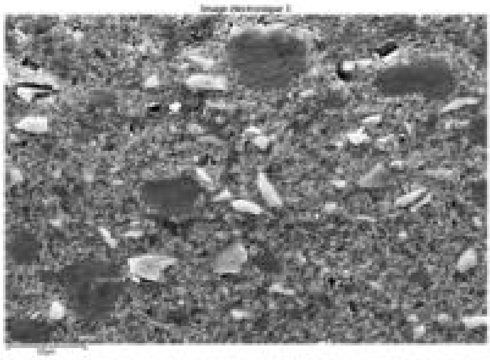


On constate une forte dégradation du système, la couche superficielle est par endroit suffisamment dégradée pour apercevoir les couches profondes plus granuleuses (aspect granité), on observe trois couches distinctes : primaire, intermédiaire, finition.
Différents types de dommages observés sur la peinture : faïençage, rayures et décollement.

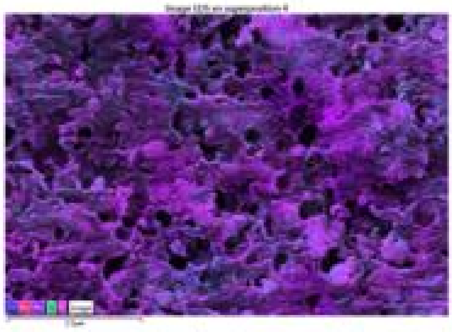
2.1.1.1. OBSERVATION EN COUPE MICROGRAPHIQUE

Sur une zone la plus saine possible (avec les trois couches intègres) → coupe micrographique pour caractériser les systèmes de peinture en présence.

MTA	Fiche d'analyses	N°:62-15	6/14



2. Couche intermédiaire moins chargé, nature des charges différentes avec plus d'oxyde de titane, taille plus faible des particules (inférieure à 2μm) parfaitement enrobées par le liant. Eléments en présence : Ti, Ba, O, S



3. Couche de finition avec grains plus fins, moins de charges minérales.b éléments présents : Al, Ti, Ba, O et S.

L'ensemble forme un système de peinture fortement cohésif.

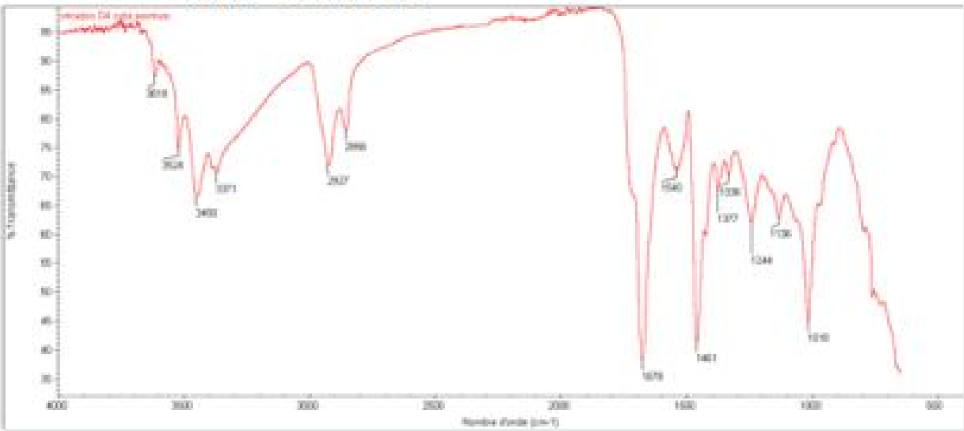
2.1.3. FTIR

2.1.3.1. CONDITIONS OPERATOIRES

Menées au moyen du spectromètre Nicolet 380 Thermo, sur la plage 4000-400cm-1 selon le mode opératoire DGA TA 70-SCAT en mode ATR.

MTA	Fiche d'analyses	N°:62-15	7/14

2.1.3.2. RESULTATS



Polyuréthane avec cyanate aromatique

Spectre IRTF de la peinture, revêtement blanc : polyuréthanne	
Attribution des principales bandes d'absorption	
Bandes caractéristiques (cm⁻¹)	*Attribution*
3524, 3450	**ν C-H aromatiques**
3371	**ν N–H de l'uréthane**
2927, 2856	ν C–H du groupement méthylène et méthyle
1726	**ν C–O de l'uréthane**
1678	**ν C=O de l'urée**
1540	δ N–H et C-N
1461, 1377, 1336	δ C–H
1244	**ν –C–O–C et N-CO-O**
1136	C-O-C
1018	γ –C–H du groupement méthylène

2.1.3.3. CONCLUSION

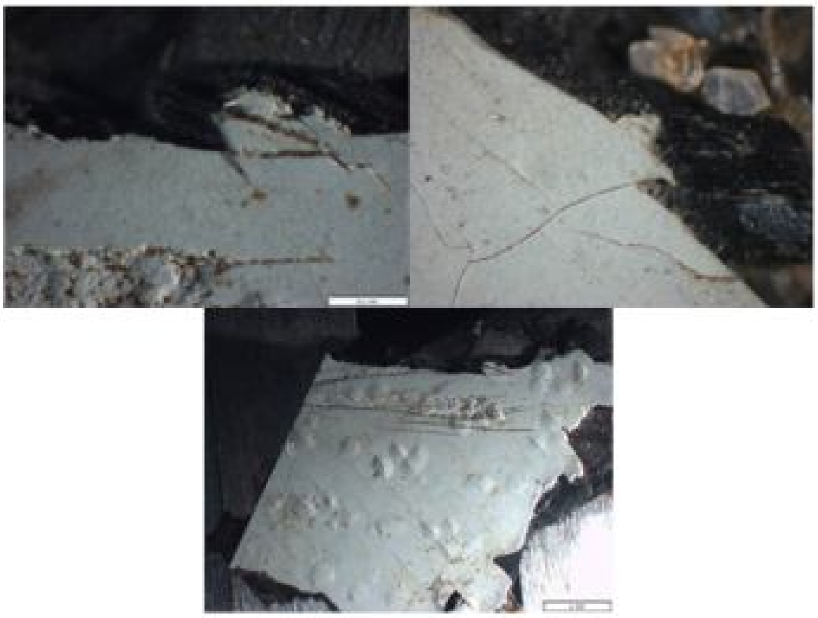
Les systèmes de peinture utilisé est conforme aux spec du CMM

2.2. SYSTEME DE PEINTURE EXTRADOS

2.2.1. OBSERVATIONS MACRO

Photo échantillon

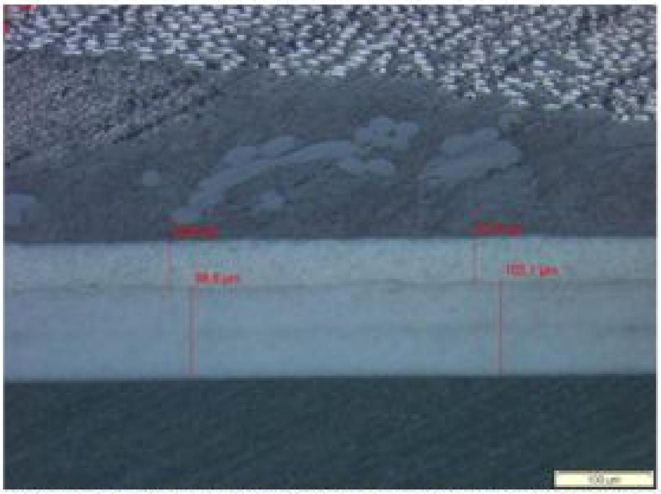
MTA	Fiche d'analyses	N°:62-15	8/14



2.2.1.1. CONCLUSION

Peinture qui présente une structure intègre en comparaison avec l'échantillon de peinture intrados, faïençage présent néanmoins avec rayures. Cloquage présent liés à l'osmose.

2.2.2. MICROGRAPHIE, MICROSCOPIE OPTIQUE

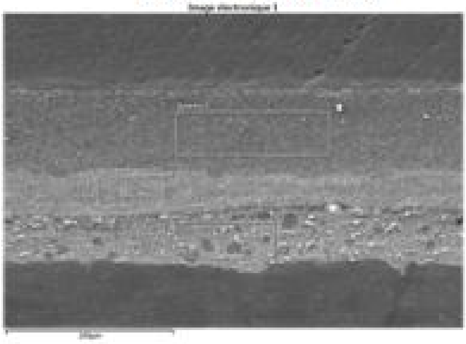


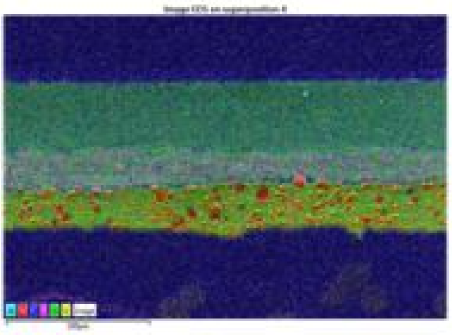
En extrados, le primaire mesure 50µm d'épaisseur et les couches superficielles environ 100µm.

MTA	Fiche d'analyses	N°:62-15	9/14

2.2.3. MICROSCOPIE ELECTRONIQUE A BALAYAGE ET EDS

2.2.3.1. RESULTATS

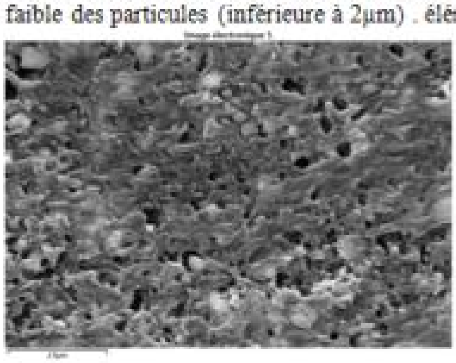




L'on distingue trois couches distinctes, de bas en haut :

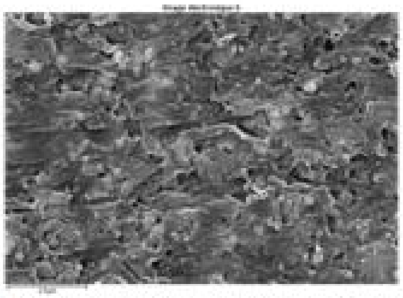
1. Primaire fortement chargé, grains de alumino-silicates de formes irrégulières tailles de grains 5 à 10µm , charges oxyde de titane plus fines (inférieures à 2µm) et ensemble amalgamé liant/charge très cohésif. Eléments en présence : Ti, Si, O

2. Couche intermédiaire moins chargé, nature des charges différentes avec plus d'oxyde de titane, taille plus faible des particules (inférieure à 2µm) . éléments en présence : Ti, Ba, S.



3. Couche de finition avec grains plus fins, moins de charges minérales. Eléments en présence : Al, Ti, O.

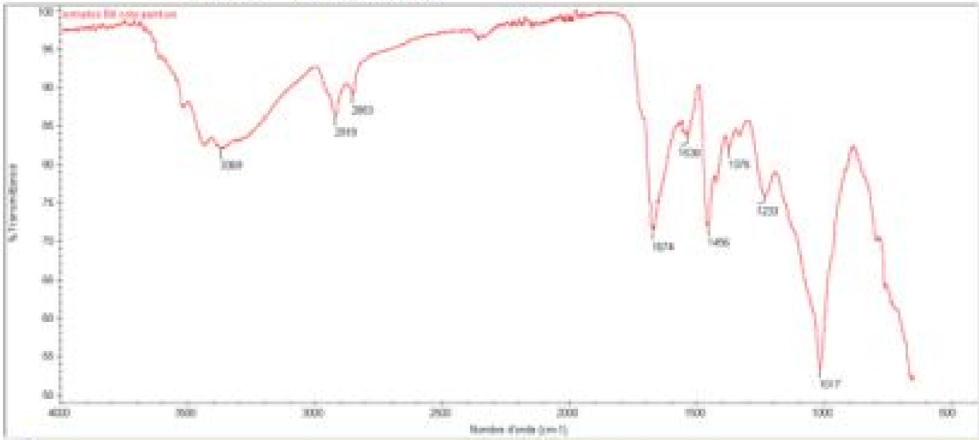
MTA	Fiche d'analyses	N°:62-15	10/14



L'ensemble forme un système de peinture fortement cohésif.

2.2.4. FTIR

2.2.4.1. RESULTATS



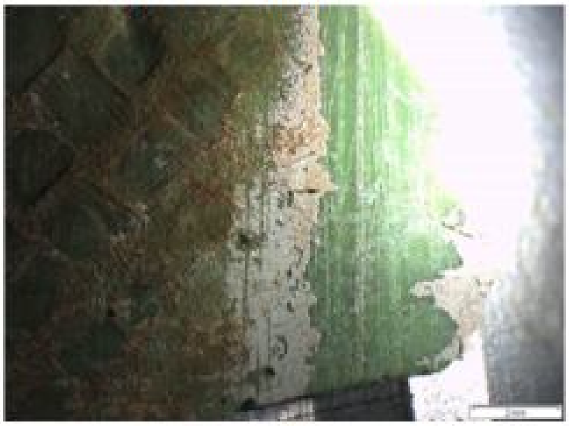
Spectre IRTF de la peinture, revêtement blanc : polyuréthanne	
Attribution des principales bandes d'absorption	
Bandes caractéristiques (cm^{-1})	*Attribution*
3524, 3450	**ν C-H aromatiques**
3369	**ν N–H de l'uréthane**
2919, 2853	ν C–H du groupement méthylène et méthyle
1726	**ν C=O de l'uréthane**
1674	**ν C=O de l'urée**
1538	δ N–H et C-N
1456, 1376	δ C–H
1233	**ν –C–O–C et N-CO-O**
-	C-O-C
1017	γ –C–H du groupement méthylène

Ce système est conforme aux spécifications du CMM.

MTA	Fiche d'analyses	N°:62-15	11/14

2.3. SYSTEME DE PEINTURE EXTRADO ECHANTILLON REPARATION

2.3.1. OBSERVATIONS MACRO

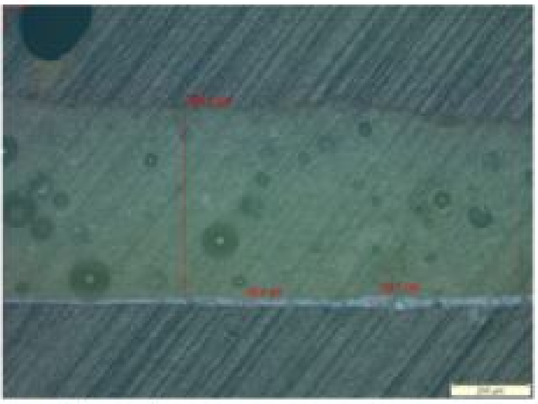


2.3.1.1. CONCLUSION

Sur cet échantillon, on observe visuellement : résine du panneau composite (empreinte du tissage carbone), couche de peinture blanche, et une couche épaisse de peinture verte.

2.3.2. MICROGRAPHIE, MICROSCOPIE OPTIQUE

2.3.2.1. RESULTATS



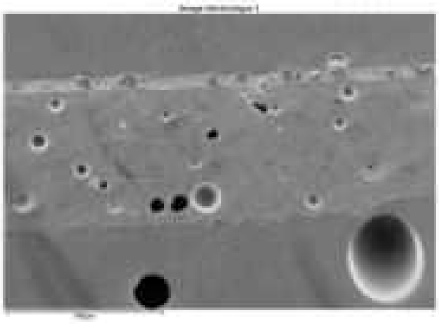
- Primaire 500µm d'une peinture verte
- Finition 20µm

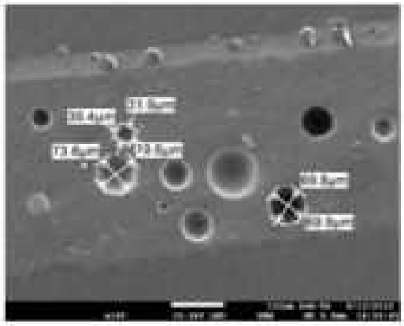
DIFFUSION RESTREINTE

MTA	Fiche d'analyses	N°:62-15	12/14

2.3.3. MICROSCOPIE ELECTRONIQUE A BALAYAGE ET EDS

2.3.3.1. RESULTATS



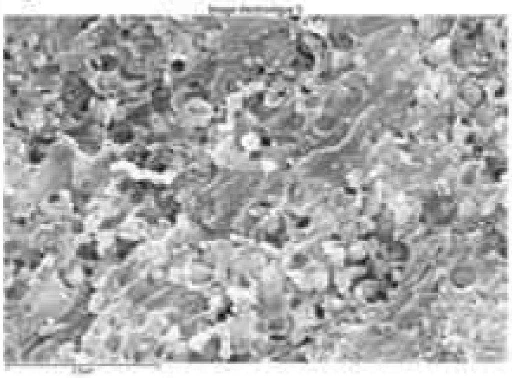


2.3.3.2. CONCLUSION

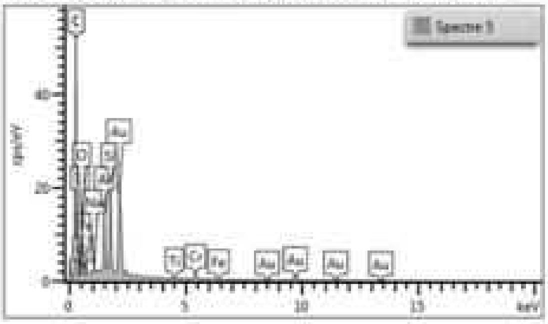
Deux couches observées :

1. Zones hétérogènes dans la peinture de finition, répartition différentielles des charges d'oxyde de Titane, les zones apparaissant plus sombres sont des zones pauvres en charges ou seul est présent le polymère du liant. NaCl présent en surface.

Eléments en présence : Ti, Si, Al.



2. Couche « verte » épaisse, poreuse, avec présence importante de Silicates d'aluminium et de pigment chromique (mis en évidence par spectre EDS 5 ci-dessous). Eléments en présence : Si, Al, Cr, Ti

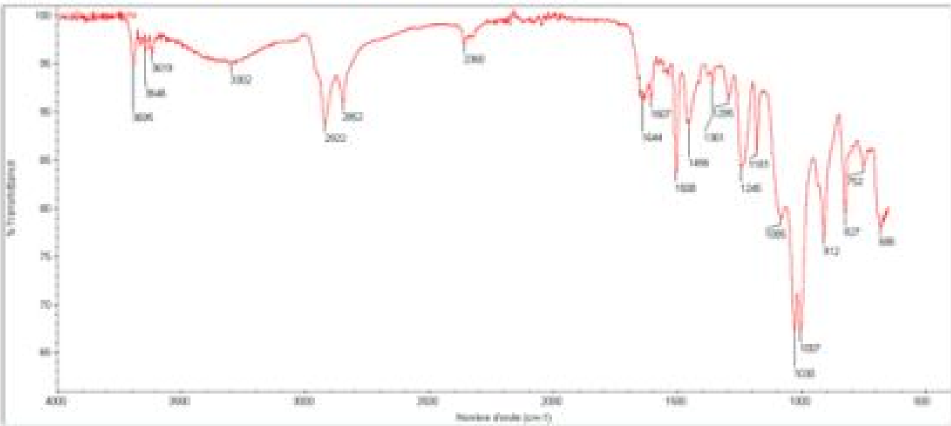


Les porosités sphériques (bulles de gaz qui se créent probablement lors de l'application) sont de quelques dizaines de µm. (30 à 80µm de diamètre)

MTA	Fiche d'analyses	N°:62-15	13/14

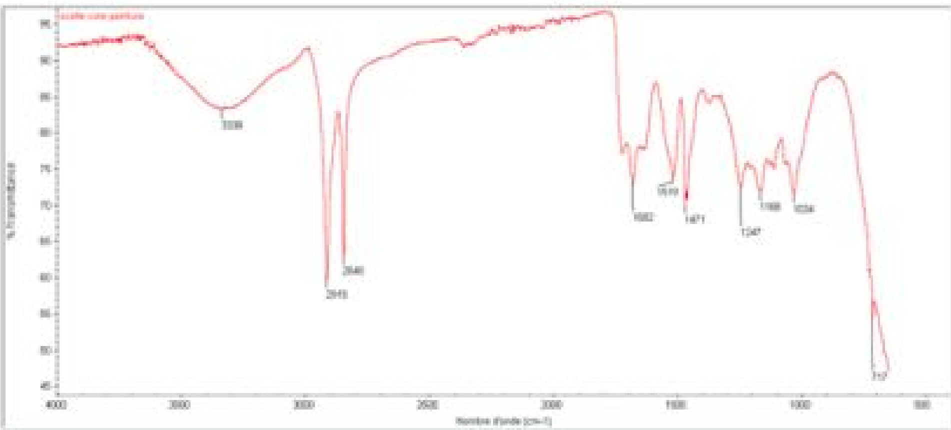
2.3.4. FTIR

2.3.4.1. RESULTATS



Résine verte epoxy

Spectre IRTF de la peinture polymérisée : Epoxyde	
Attribution des principales bandes d'absorption	
Bandes caractéristiques (cm-1)	*Attribution*
	Ph-OH
3056	**CH-O-CH$_2$ (oxirane)**
3030	**= C-H Aromatique**
2922	-CH$_2$- , -CH$_3$- assym
2852	-CH$_2$- , -CH$_3$- sym
1607 - 1580 - 1508	**-C=C-H Aromatique**
1456 - 1362	-CH$_2$- , -CH$_3$-
1245 - 1181	-C-C-O-C-
1030	-C-O-C-
912	**CH$_2$-O-CH epoxy (oxirane)**
827	**substitution 1,4 du cycle aromatique**



Peinture blanche top coat

MTA	Fiche d'analyses	N°:62-15	14/14

Spectre IRTF de la peinture, revêtement blanc : polyuréthanne	
Attribution des principales bandes d'absorption	
Bandes caractéristiques (cm-1)	*Attribution*
3524, 3450	**ν C-H aromatiques**
3371	**ν N–H de l'uréthane**
2927, 2856	ν C–H du groupement méthylène et méthyle
1726	**ν C=O de l'uréthane**
1678	**ν C=O de l'urée**
1540	δ N–H et C-N
1461, 1377, 1336	δ C–H
1247	**ν –C–O–C et N-CO-O**
1136	C-O-C
717	γ –C–H du groupement méthylène

2.3.4.2. CONCLUSION

La peinture de finition est conforme à la spec du CMM (BMS 10-60 II).
En revanche on ne retrouve ni la peinture de type BMS 10-86 I (Téflon) sur finition BMS 10-60 II, ni le primaire :
On retrouve en effet l'utilisation d'une peinture primaire epoxy verte (avec charges chromiques). Ce primaire n'est pas de type BMS 10-103 type I comme préconisé dans le CMM. Mais plutôt de type BMS 10-79 type III.

Annexe 5 : **Fiche d'analysis 63-15 – Analysis at the level d'une glissière joint moulding**

MTA	Fiche d'analyses	N°:63-15	1/8

OT	*P1501516001003*
Demandeur	
Programme	*Expertise au profit du ministère de la justice*
Activité	*Flaperon Boeing 777*

Travaux demandés objectif, contexte

Glissière boeing 777, identification matière des composés en présence

Documents d'entrées	***Document de sortie***	
CMM 57-63-05 Boeing		*Rapport simplifié*
		Rapport d'essai et/ou d'expertise
	X	*Fiche d'analyses MTA + compte rendu*

Spécimen, nature *(état de surface)*, ***origine…***	*Dépôt d'une glissière support de joint mise sous scellé.*
Nombre de spécimens/ date mise à disposition :	*2 prélèvements de peinture, pièce métalliques (3prises d'essai de 200mg), examen complet otique et micrographique de la pièce en expertise*
Précautions particulières *(échantillon, personnel)*	

Prévision		Responsable prestation MTA	Demandeur	**Réalisation**	Responsable prestation MTA	Garant technique MTA
Nombre d'heures		Nom : Date :	Nom : Date :	30	Nom :Hakenholz Date :19/8/2015	Nom : Hakenholz Date : 19/8/2015
Fournitures						
Début des travaux				10/8/2015		
Fin des travaux				19/8/2015		

NOTA : informations italiques remplies avec le demandeur par le responsable version : 02/2015

MTA	Fiche d'analyses	N°:63-15	2/8

Analyse	Mode opératoire	Devis (H)	Réalisé (H)	Responsable de l'analyse
FTIR	DGA/TA N° 70 SCAT		2	Hakenholz
MEB/EDX			12	Ben Rhouma
ICP	DGA/TA N° 81 SCAT		8	Hakenholz
Coupe micrographique			8	Bottin

Fin de réalisation des analyses : 19 août 2015

Ecarts	Validation (par le responsable de la prestation)
néant	[signature]

Traitements/ destination des spécimens et reliquats après analyse		
	~~Destruction~~	Date de reprise spécimens et prélèvements par le demandeur :
	Stockage local	
	~~Retour au demandeur~~	

NOTA : Zone grisée remplie avec le demandeur, zone blanche par MTA version : 02/2015

MTA	Fiche d'analyses	N°:63-15	3/8

1. GÉNÉRALITÉS

Données d'entrées du CMM :

La glissière ou seal retainer est en Alliage Al 6061 protégée par une OAB (oxydation anodique Borique). Revêtue d'un système de peinture composée de deux couches :

1. Primaire epoxy répondant aux spécifications BMS 10-79 III
2. Revêtement polyurethane répondant aux spécifications BMS 10-60 I

2. RESULTATS DES ANALYSES

2.1. ANALYSE SUBSTRAT ET TRAITEMENT DE SURFACE

2.1.1. ICP

	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ga	Ti	Zr	Be	Li	Pb	Sn	Sb	Al
glissière	0,63	0,22	0,21	0,015	0,85	0,058	0,004	0,004	0,000	0,017	0,001	0,000	0,000	0,002	0,000	0,001	98,8
incertitude*	0,04	0,01	0,01	0,003	0,03	0,004	0,002	0,002	0,001	0,003	0,002	0,001	0,001	0,002	0,001	0,002	valeur calculée

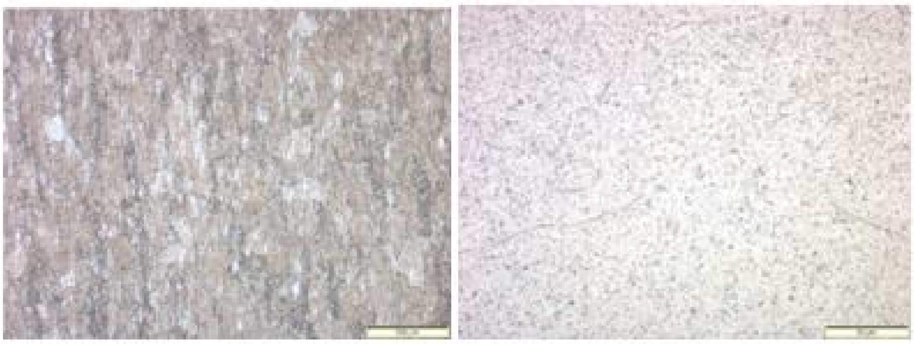
* incertitude élargie avec K=2

[illegible]

6061	0,40-0,80	<0,70	0,15-0,40	<0,15	0,80-1,20	0,04-0,35	<0,05	<0,25	<0,05	<0,15	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05

Les résultats de l'analyse ICP correspond à celle de la nuance 6061, conformément à ce qui est indiqué dans le CMM.

2.1.2. MICROSTRUCTURE DU SUBSTRAT ALUMINIUM



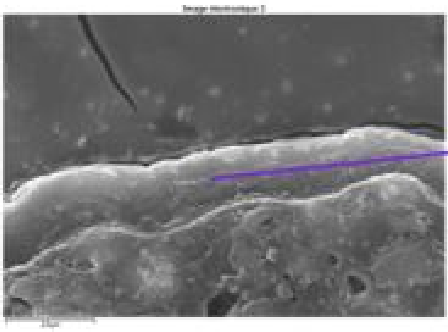
La microstructure observée est cohérente par rapport à cette nuance d'aluminium 6061.

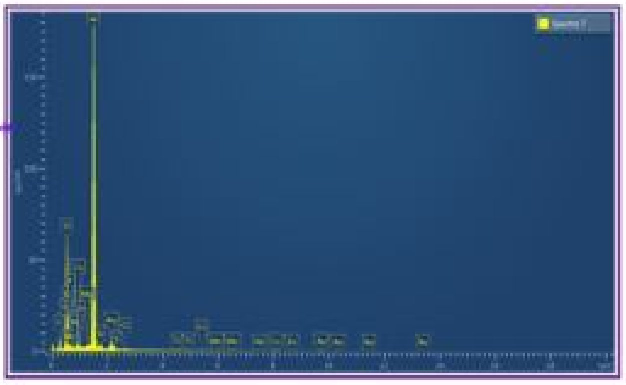
2.1.1. DURETE BRINELL ET CONDUCTIVITE

Les valeurs de dureté Brinell (99 HB1/10 en moyenne) et de conductivité (25.2 MS/m en moyenne) correspondent à l'alliage 6061 à l'état T6 selon l'IGC 04.02.110B.

MTA	Fiche d'analyses	N°:63-15	4/8

2.1.2. MEB EDS





On observe clairement la couche d'anodisation. Celle-ci mesure de 1 à 2µm d'épaisseur.
Selon le CMM, il s'agit d'une couche anodisation à l'acide borique. A noter que le bore ne peut être détecté avec cette technique (élément léger).

2.1.3. CONCLUSION

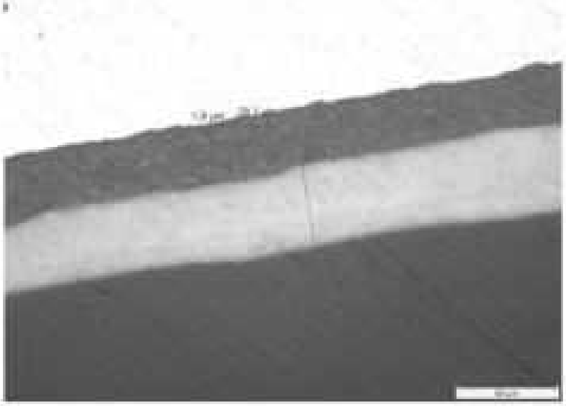
Matériaux conforme aux spécifications du CMM concernant l'item « seal retainer »

MTA	Fiche d'analyses	N°:63-15	5/8

2.2. SYSTEME DE PEINTURE

2.2.1. OBSERVATIONS OPTIQUES

En micrographie optique on distingue nettement, la couche d'anodisation du substrat de 2µm d'épaisseur, le primaire anticorrosion de 30µm d'épaisseur environ, la peinture de finition sur 40µm environ.

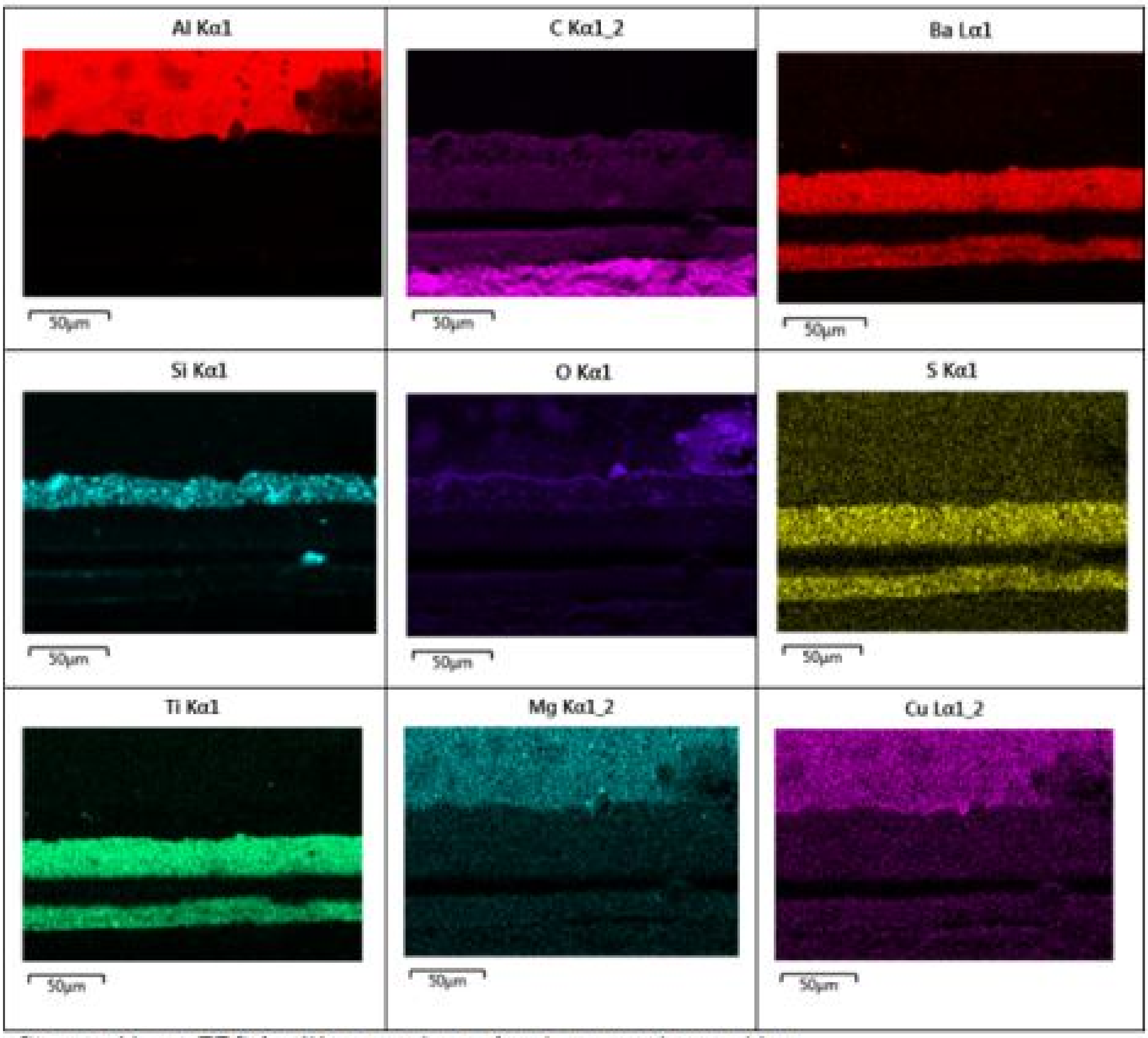


2.2.2. MEB EDS

Le système de peinture se compose de trois couches dictinctes :

1. Primaire, directement sur la couche d'anodisation. Eléments en présence : Si, O.
2. Deux couches de peinture de finition identique en termes de répartition des charges. Eléments en présence : Ti, Ba, S
   Les deux couches présentent une décohésion à l'interface certainement liée au vieillissement du système résultant de son exposition à l'eau de mer (phénomène de cloquage)

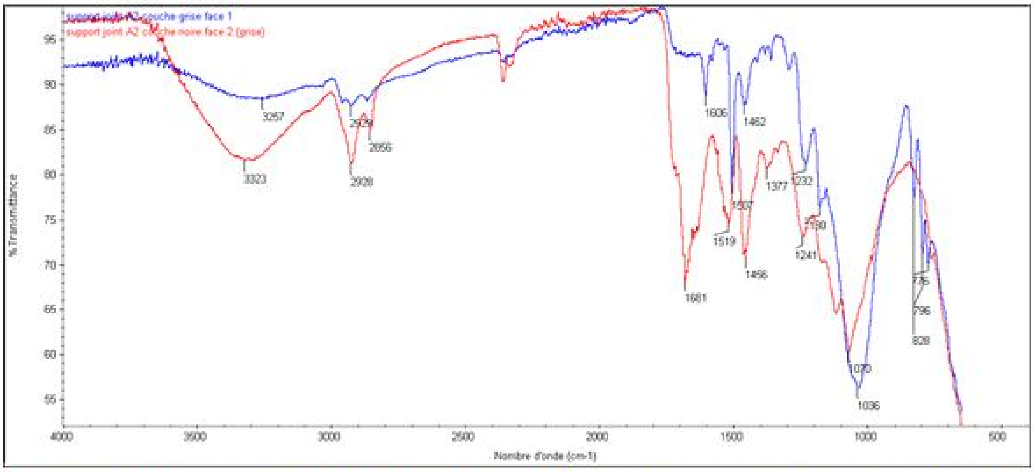
MTA	Fiche d'analyses	N°:63-15	6/8



Cartographie par EDS des éléments présents dans la coupe micrographique.

MTA	Fiche d'analyses	N°:63-15	7/8

2.2.3. FTIR



On identifie deux liants différents sur les couches analysées : un primaire epoxy et une finition polyuréthane
Identification et attribution des fonctions chimiques
Tracé rouge couche de finition polyuréthane, cyanate aliphatique:

Spectre IRTF de la peinture, revêtement blanc : polyuréthanne	
Attribution des principales bandes d'absorption	
Bandes caractéristiques (cm⁻¹)	*Attribution*
3323	**ν N–H de l'uréthane**
2928, 2856	ν C–H du groupement méthylène et méthyle
1720	**ν C=O de l'uréthane**
1681	**ν C=O de l'urée**
1519	δ N–H et C-N
1456, 1377	δ C–H
1241	**ν –C–O–C et N-CO-O**
1136	C-O-C
1070	γ –C–H du groupement méthylène

Tracé bleu, couche de primaire epoxy :

Spectre IRTF de la peinture polymérisée : Epoxyde	
Attribution des principales bandes d'absorption	
Bandes caractéristiques (cm⁻¹)	*Attribution*
3056	**CH-O-CH₂ (oxirane)**
2922	-CH₂- , -CH₃- assym
2852	-CH₂- , -CH₃- sym
1606 - 1507	**-C=C-H Aromatique**
1456 - 1362	-CH₂- , -CH₃-
1180	-C-C-O-C-
1036	-C-O-C-
827	**substitution 1,4 du cycle aromatique**

MTA	Fiche d'analyses	N°:63-15	8/8

2.2.4. **CONCLUSIONS**

Le système de peinture est conforme aux spécifications du CMM concernant l'item « Seal retainer »

Annexe 6 : **Metrological inspection**

DGA Techniques Aéronautiques
Etablissement de Toulouse
Division « Ingénierie des moyens d'essai »
Section : Mesures en laboratoire
Affectation : IML

RAPPORT DE CONTROLE

N°L-45-2015

DESTINATAIRE(S) : BORDES Christophe **ENTITE :** MT/MTI

CONTROLE EFFECTUE :

Mesure de point sur flaperon du Boeing 777

OPERATEURS : LAVAL Claude

DATE DU CONTROLE : 06/08/2015

DATE D'EMISSION : 07/08/2015

L'AGENT TECHNIQUE DE MESURE

Claude LAVAL

1. OBJET DU CONTROLE

Flaperon Boeing 777

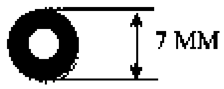
2. BUT DU CONTROLE

Mesurer dans un référentiel lié au flaperon la position de points significatifs.

3. MOYENS UTILISES

Système de mesure par photogramétrie TRITOP

Diamètre extérieur des pastilles d'acquisition des points :



4. INCERTITUDE DU MOYEN DE MESURE

U = ± 5 µm + 7µm.L   L en mètres

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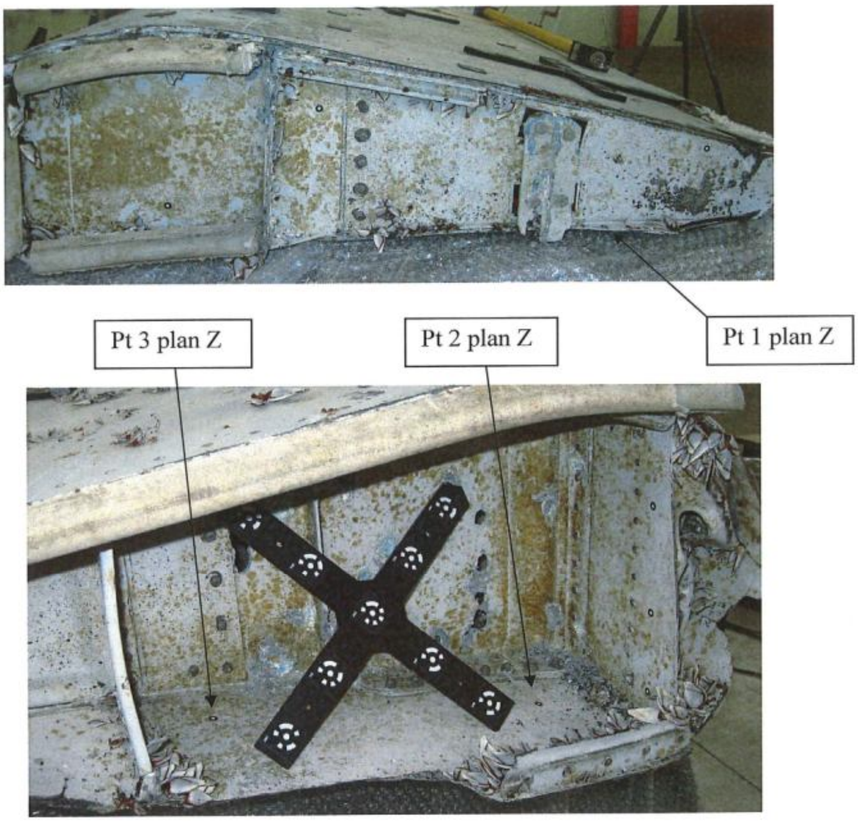
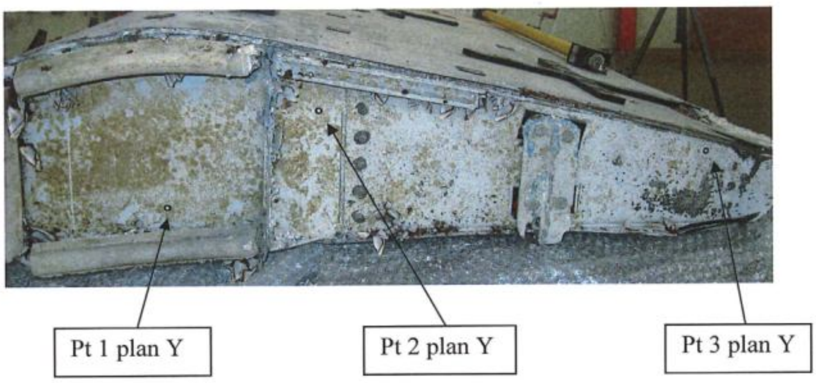
5. REFERENTIEL

Plan Z : 3 points : Pt1 plan Z - Pt2 plan Z - Pt3 plan Z



Axe des Y : Intersection plan Y et plan Z

Plan Y : 3 points : Pt1 plan Y - Pt2 plan Y - Pt3 plan Y



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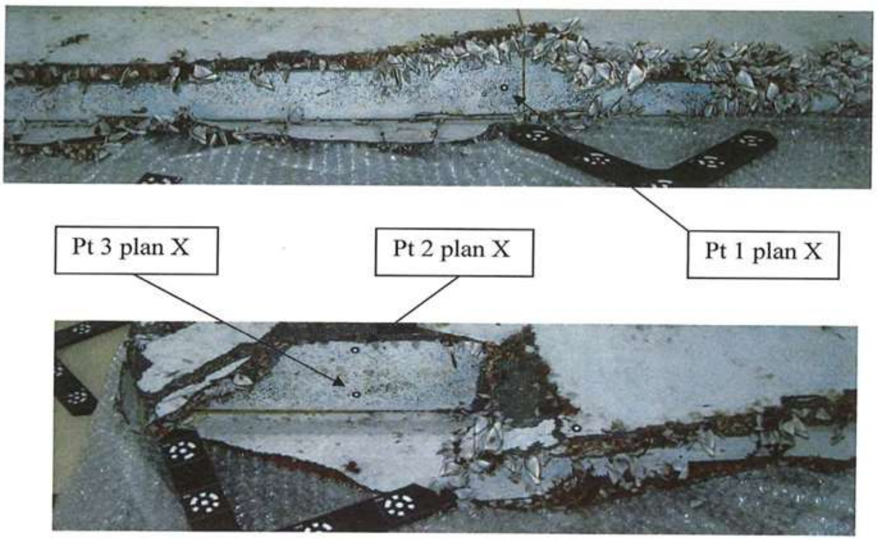
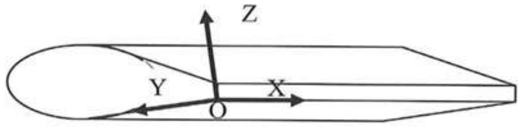
Axe des X : Intersection plan X et plan Z

Plan X : 3 points : Pt1 plan X - Pt2 plan X - Pt3 plan X



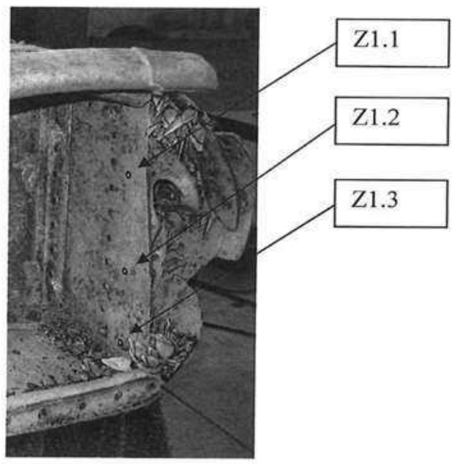
Origine du repère : intersection plan Z, plan Y, plan Z



Toutes les coordonnées des points dans la suite du rapport sont données dans ce référentiel

6. REPERAGE DES POINTS PAR ZONE

Points Zone 1



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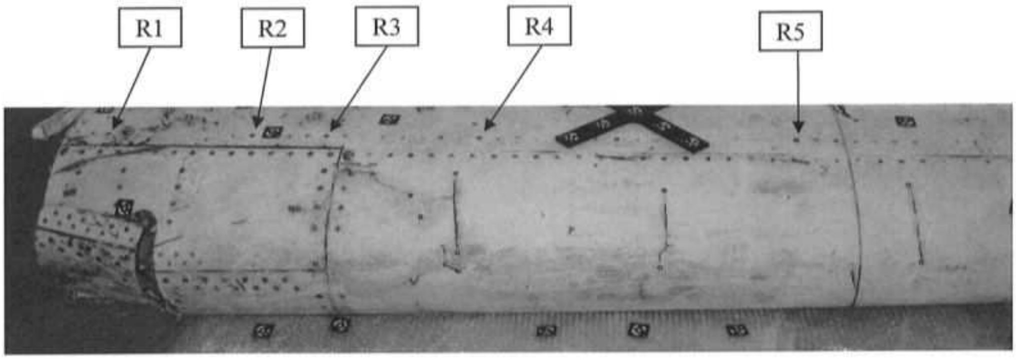
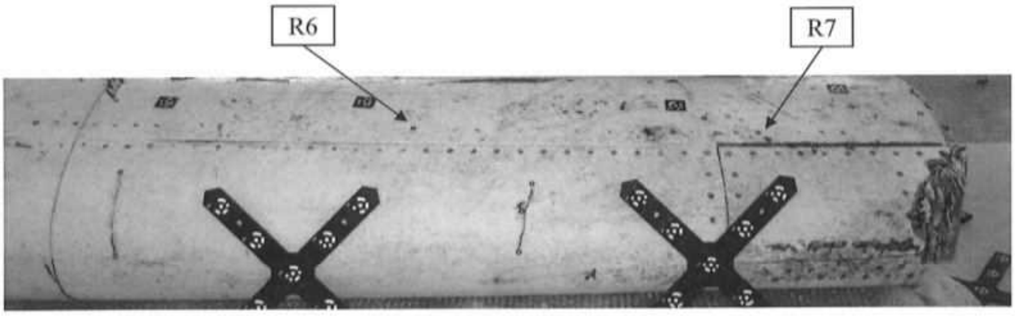
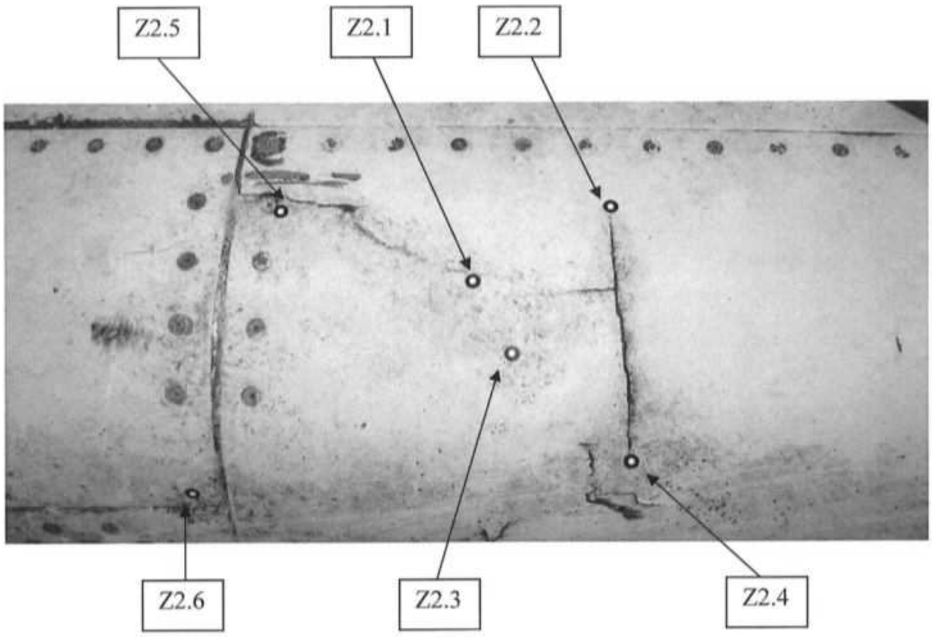
Ligne de rivets





Zone 2



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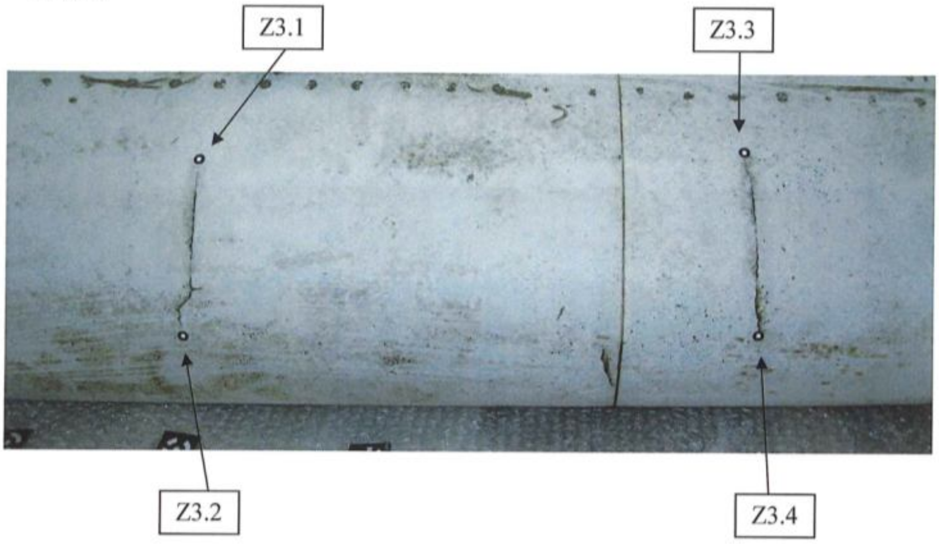
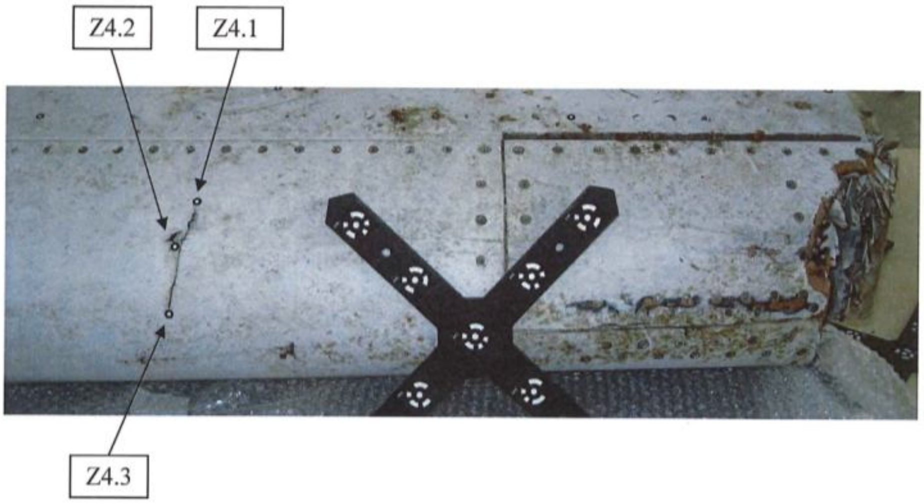
Zone 3



Zone 4



Zone 5

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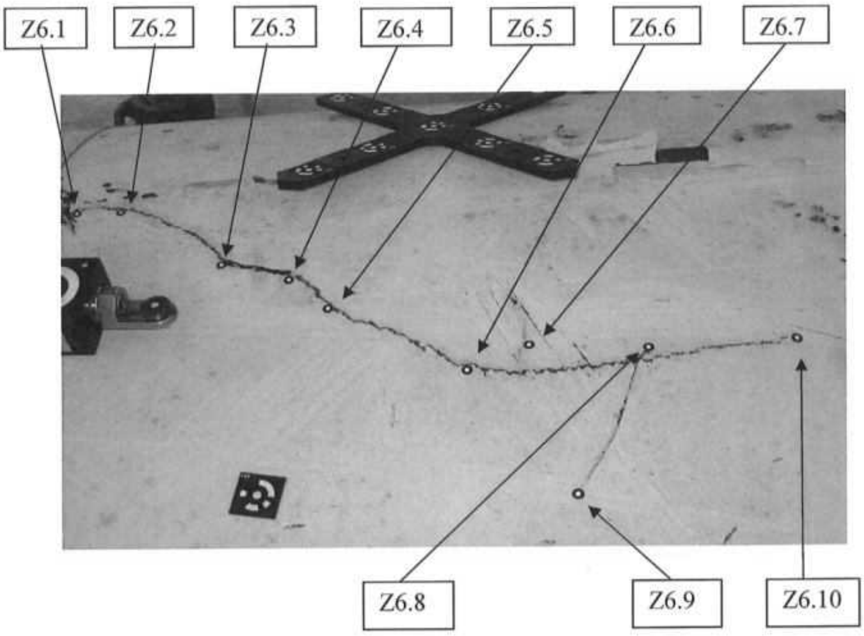
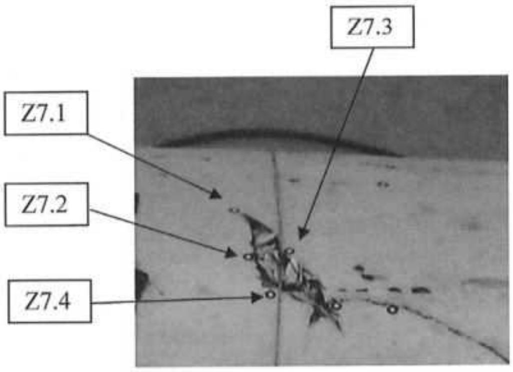
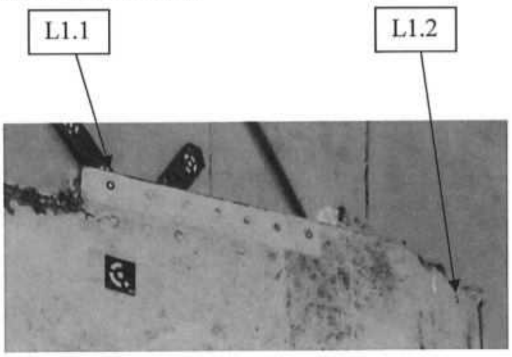
Zone 6



Zone 7



Ligne 1 : point positionné sur les rivets



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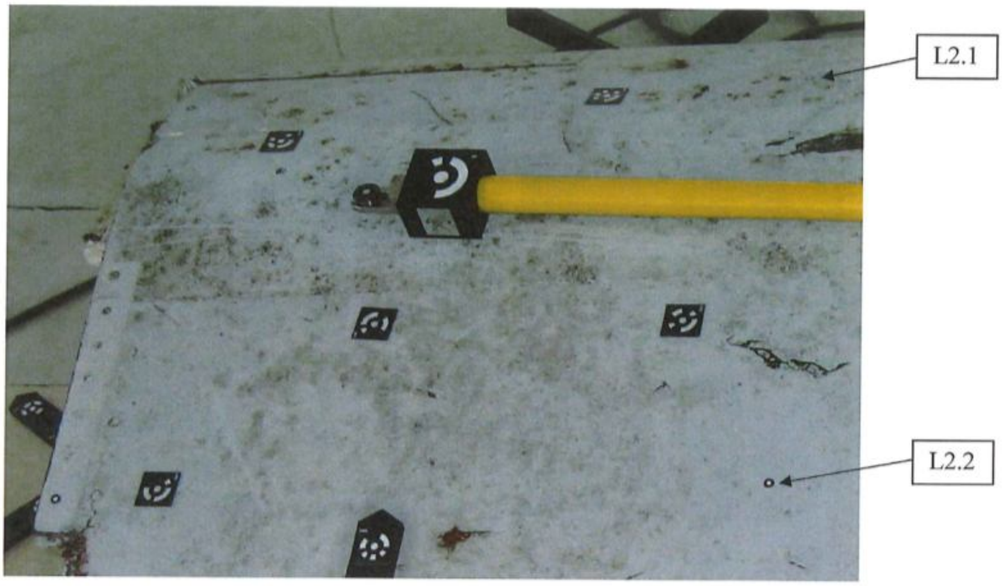
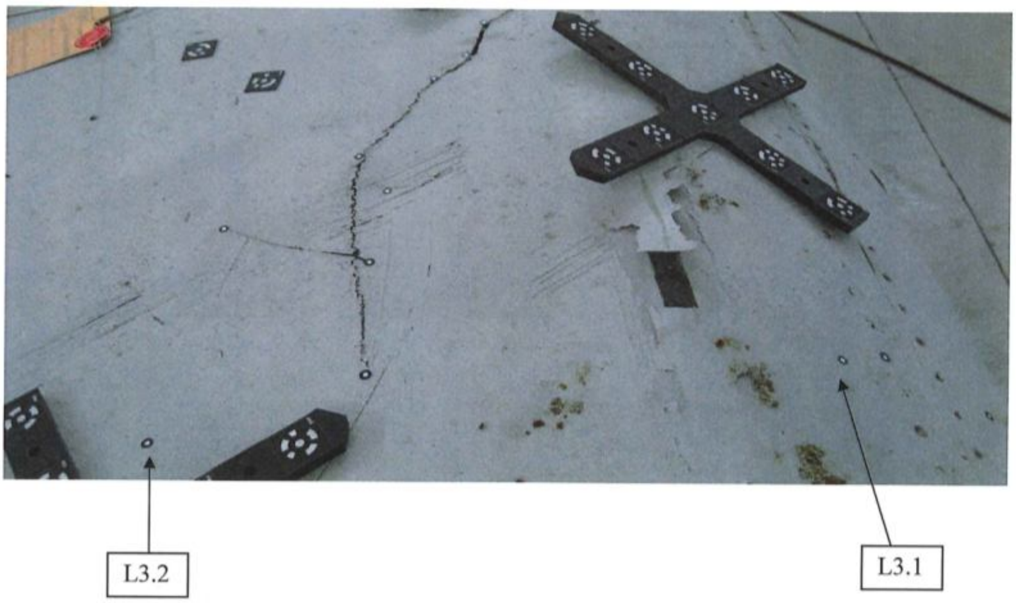
Ligne 2



Ligne 3



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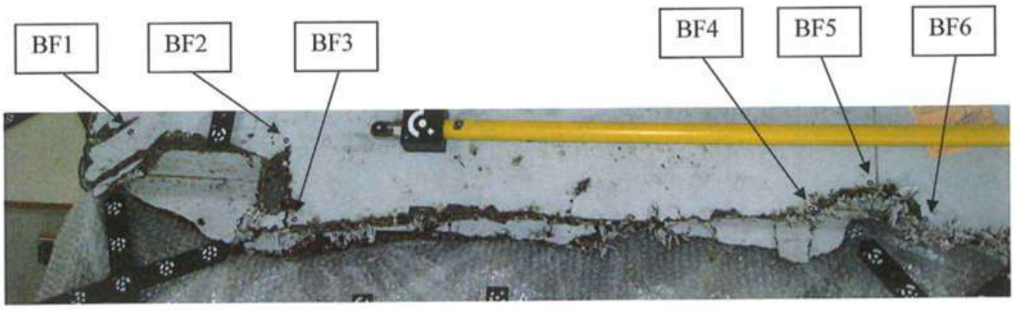
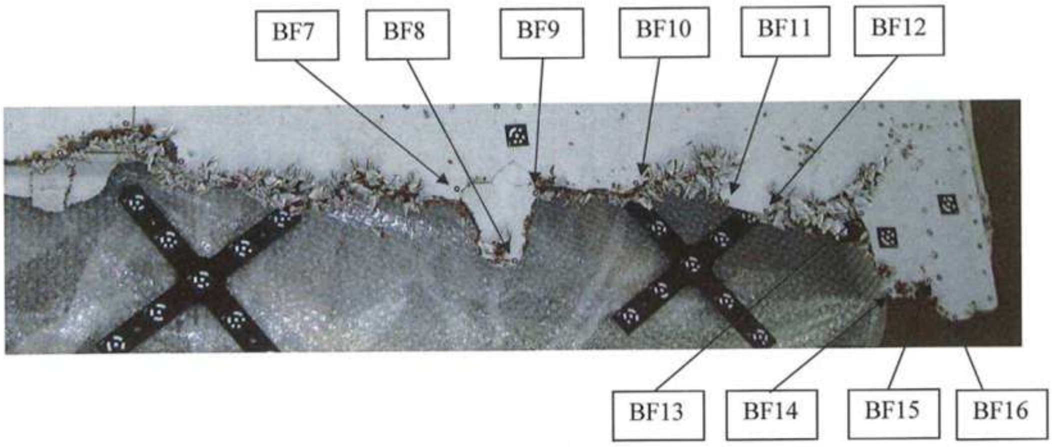
Bord de fuite





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7. COORDONNEES DES POINTS PAR ZONE

Bord de fuite			
Point	coord-x	coord-y	coord-z
BF1	69.99	3.35	73.50
BF2	301.32	3.16	75.67
BF3	333.09	-96.82	37.11
BF4	987.25	-55.36	58.01
BF5	1060.72	-22.26	71.07
BF6	1124.55	-64.03	55.41
BF7	1449.22	-94.78	44.36
BF8	1513.70	-175.75	11.67
BF9	1547.38	-100.01	41.13
BF10	1678.99	-90.83	46.29
BF11	1798.89	-115.23	36.71
BF12	1851.89	-128.33	32.19
BF13	1989.27	-134.48	30.35
BF14	2006.88	-230.76	-2.90
BF15	2069.48	-221.57	-0.11
BF16	2096.61	-267.46	-16.65
Ligne 1			
Point	coord-x	coord-y	coord-z
L1.1	-42.40	262.93	169.55
L1.2	-73.10	641.67	257.06
Ligne 2			
Point	coord-x	coord-y	coord-z
L2.1	419.69	668.81	266.75
L2.2	454.89	291.07	180.06
Ligne 3			
Point	coord-x	coord-y	coord-z
L3.1	1607.67	735.84	284.71
L3.2	1643.14	349.65	200.38
Ligne de rivet			
Point	coord-x	coord-y	coord-z
R1	2173.82	802.45	283.68
R2	1940.27	789.78	281.37
R3	1824.94	782.51	280.50
R4	1596.02	770.48	278.69
R5	1137.40	746.32	273.86
R6	620.92	719.57	264.69
R7	162.43	697.01	254.03
Zone 1			
Point	coord-x	coord-y	coord-z
Z1.1	2219.55	823.97	192.07
Z1.2	2223.81	838.58	100.74
Z1.3	2229.67	846.86	29.25

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Zone 2			
Point	coord-x	coord-y	coord-z
Z2.1	1678.12	876.81	236.38
Z2.2	1617.71	845.67	257.83
Z2.3	1658.94	903.00	217.37
Z2.4	1604.02	929.50	177.98
Z2.5	1768.71	854.95	255.72
Z2.6	1803.34	949.56	160.47
Zone 3			
Point	coord-x	coord-y	coord-z
Z3.1	1325.06	852.25	243.40
Z3.2	1327.64	922.76	161.37
Z3.3	988.98	821.88	244.71
Z3.4	977.53	900.06	167.20
Zone 4			
Point	coord-x	coord-y	coord-z
Z4.1	459.73	801.53	231.44
Z4.2	471.20	833.80	210.73
Z4.3	473.23	866.32	171.16
Zone 5			
Point	coord-x	coord-y	coord-z
Z5.1	-43.82	753.18	168.33
Z5.2	-26.61	783.18	120.58
Z5.3	-44.42	768.60	110.97
Zone 6			
Point	coord-x	coord-y	coord-z
Z6.1	1108.97	591.98	275.88
Z6.2	1143.02	591.97	275.99
Z6.3	1228.79	537.48	260.75
Z6.4	1277.96	522.82	256.14
Z6.5	1307.07	498.48	248.14
Z6.6	1399.07	448.30	232.31
Z6.7	1438.49	469.87	235.10
Z6.8	1513.95	462.08	236.01
Z6.9	1462.68	363.55	205.25
Z6.10	1609.43	465.05	237.05
Zone 7			
Point	coord-x	coord-y	coord-z
Z7.1	1043.68	687.53	280.37
Z7.2	1054.23	630.79	281.71
Z7.3	1079.24	639.92	282.62
Z7.4	1069.06	597.40	276.82

Toutes les valeurs sont en mm

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8. ANALYSE DES POINTS POSITIONNES SUR LES RIVETS

Une droite a été tracée entre les points R1 et R7.

Le tableau ci-dessous donne la différence de coordonnée Z entre le point et sa projection sur la droite. Les points sont au-dessus de la droite dans la direction de l'axe Z

Points	Distance à la ligne
R2	1.127
R3	1.964
R4	3.527
R5	5.455
R6	3.898

La différence de coordonnée suivant l'axe Y n'est pas significative dans le mesure ou les pastilles ont été placées approximativement au centre du rivet. Elle est de l'ordre de 1.5 mm avec peu d'écart entre les points.

9. ANALYSE DES POINTS DE LA ZONE 1

Une droite a été tracée entre les points Z1.1 et Z1.3.

La différence de coordonnée Y entre le point Z1.2 et sa projection sur la droite est : 1.75 mm. Le point se situe à droite suivant l'axe Y par rapport à la droite

La distance entre les points Z1.1 et Z1.3 est : 164.7 mm

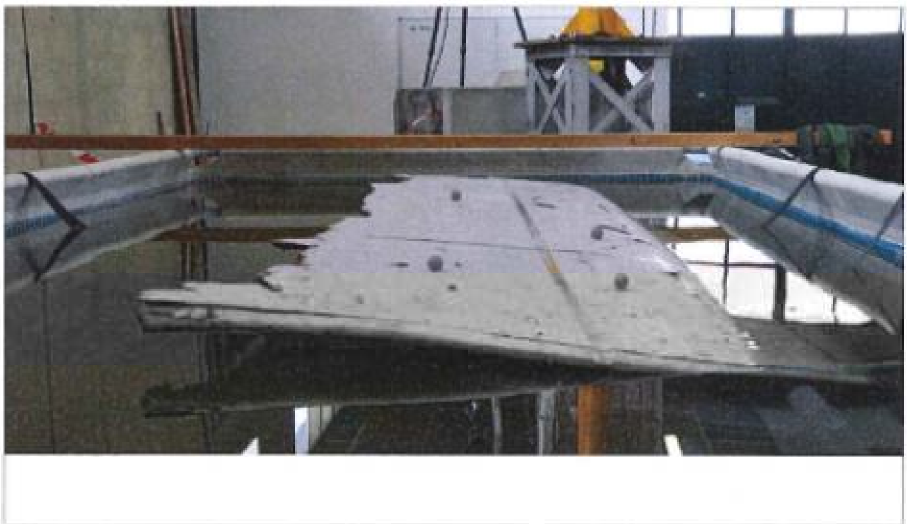
Annexe 7 : **Report DGA TH E11374 part 1 - Compte rendu d'tests**

DIFFUSION RESTREINTE

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE LA DÉFENSE

DGA
Direction Générale de l'Armement
Direction Technique
DGA Techniques hydrodynamiques



E 11374
ESSAI DE FLOTTABILITE POUR DGA TA

PIECE N° 1
COMPTE RENDU DES ESSAIS D'AOUT 2015

Enregistrement :	N°15-501367 DT/DGA TH/SDT/UP_Perf du 14/09/2015
Réf. et date de commande :	En attente de contractualisation avec le ministère de la Justice
Auteur :	F. Legrand, P. Perdon
Manager d'affaires :	F. Lorin
Validation :	Sous-Directeur Technique
Classification :	Diffusion restreinte
Déclassification :	30 ans à valider par l'officier de sécurité
Nb de pages du document :	13 pages

Direction Générale de l'Armement
DGA Techniques hydrodynamiques
Chaussée du Vexin - BP 510 - 27105 Val de Reuil Cedex
Téléphone : 33 (0) 2.32.59.78.00 - Télécopie : 33 (0)2.32.59.77.77
E-mail : dga.techniques-hydrodynamiques@dga.defense.gouv.fr

AFFAIRE N°E11374
Pièce N°1

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

Type de rapport

☐ Rapport final	☒ Rapport intermédiaire	☐ Rapport provisoire

Indice du rapport

Version	Date	Description des pages modifiées ET justification de la modification	Auteur
Initiale	04/08/2015	création du document	F. Legrand, P. Perdon

Diffusion

Diffusion externe :

Organisme	Nom du Destinataire	Nb	Livrables (CDROM,…)
DGA Techniques aéronautiques	C. Bordes	1	
DGA Techniques aéronautiques	C. Blayac	1	
Ministère de la Justice	M. le Juge en charge du dossier	1	

Diffusion interne :

DGA Techniques hydrodynamiques	Nom du Destinataire	Nb	Livrables (CDROM,…)
SDT UP Perf	F. Legrand	1	
SDT UP Perf	P. Perdon	1	
SDA	F. Lorin	1	

AFFAIRE N°E11374
Pièce N°1

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

Résumé

A la demande de DGA TA, et dans le cadre d'une expertise judiciaire, DGA TH a apporté son concours à la caractérisation hydrostatique de l'élément de flaperon trouvé en juillet 2015 à La Réunion. Une équipe de deux personnes de DGA TH s'est rendue à Balma du 24 au 28 août 2015, afin de procéder aux essais dit de flottabilité. Ce document rend compte de ces essais.
Il apparait que l'élément de flaperon possède une réserve de flottabilité assez importante. Sa position d'équilibre, qui est sensiblement la même que l'intrados soit vers le haut ou vers le bas, est telle que le bord d'attaque est immergé alors que le bord de fuite est légèrement dégagé de la surface.

Type de clients :	DGA (code 1800)
Famille de navires :	Sans objet
Domaine :	Tenue à la mer
Moyen :	Autres
Programme :	
Mots clés :	

AFFAIRE N°E11374
Pièce N°1

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

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DGA Techniques hydrodynamiques

1 Objet du rapport

A la demande de DGA TA, et dans le cadre d'une expertise judiciaire (Réf. [a]), DGA TH a apporté son concours à la caractérisation hydrostatique de l'élément de flaperon trouvé en juillet 2015 à La Réunion. Une équipe de deux personnes de DGA TH s'est rendue à Balma du 24 au 28 août 2015, afin de procéder aux essais dit de flottabilité. Ce document rend compte de ces essais et donne quelques éléments qualitatifs et quantitatifs. A l'issue du dépouillement complet des mesures et de leur analyse, un rapport final sera édité.

2 Moyens mis en œuvre

2.1 Flaperon

L'élément de flaperon étudié à pour dimensions principales :

- Envergure moyenne = 2200 mm
- Corde moyenne = 1120 mm
- Epaisseur max = 300 mm

Sa masse en air, mesurée par DGA TA est de 39.7 kg.

2.2 Bassin

Les mesures ont été effectuées dans une piscine hors sol installée dans les locaux de DGA/TA. Ses dimensions sont 2.5x5.2 m. Lors des essais, la profondeur d'eau était d'environ 1.1 m.

La piscine était remplie d'eau salée. La température était de 20° C, la densité mesurée par DGA TH de 1023,5 kg m^{-3}, ce qui est légèrement en deçà de la densité généralement considérée pour les mers ouvertes qui se situe autour de 1025-1026 kg m^{3}.

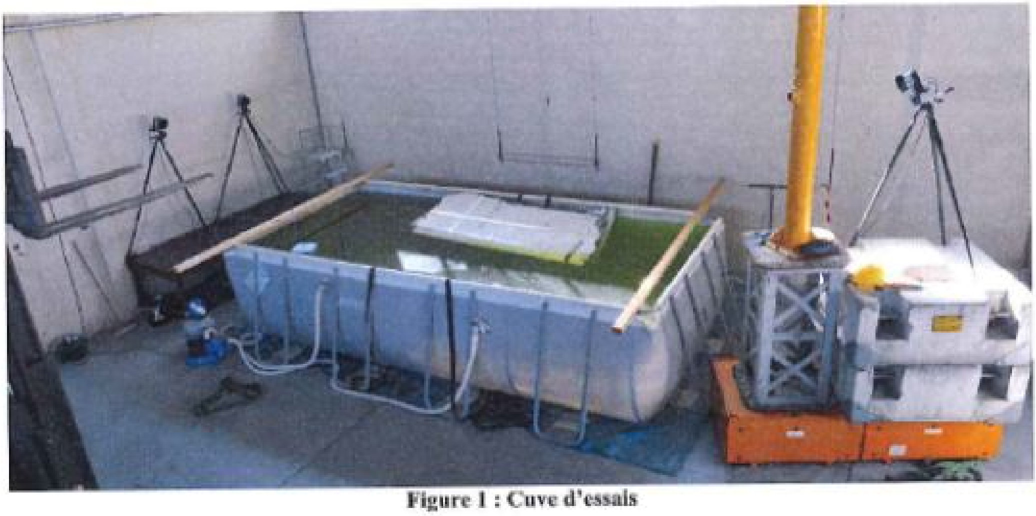

Figure 1 : Cuve d'essais

2.3 Mesures

Les mesures d'assiette et d'enfoncement ont été réalisées par DGA TH à l'aide d'un système de trajectographie optique Qualisys®. Pour cet essai, le système se composait de trois caméras situées sur les bords de la cuve (visibles sur la Figure 1). Quatre sphères réfléchissantes fixées sur la partie émergée du flaperon définissaient le repère lié.

Le repère lié au flaperon est présenté sur la Figure 2. L'axe Ox est parallèle à la ligne de vis qui court selon l'envergure du flaperon près de son bord de fuite. L'axe Oy est orienté vers le bord d'attaque parallèlement à la direction de la corde. L'axe Oz complète le trièdre direct.
Par analogie avec les navires de surface on appellera gîte (roulis) et assiette (tangage) les déplacements angulaires autour d'axes respectivement parallèles à l'axe Ox et à l'axe Oy.

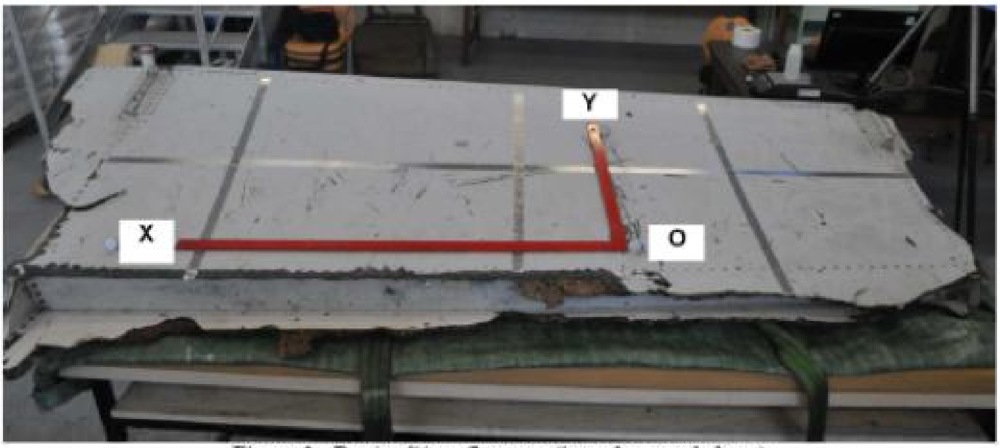

Figure 2 : Repère lié au flaperon (intrados vers le haut)

La mise en assiette et en gîte du flaperon a été réalisée en appliquant différentes masses en 5 points de la surface émergée du flaperon notés A, B, C, D et E et représentées sur la Figure 3. Les différentes valeurs de masse ont été obtenues par la combinaison de trois masses de 1 kg vérifiées par une balance de précision ± 0.1 gramme.

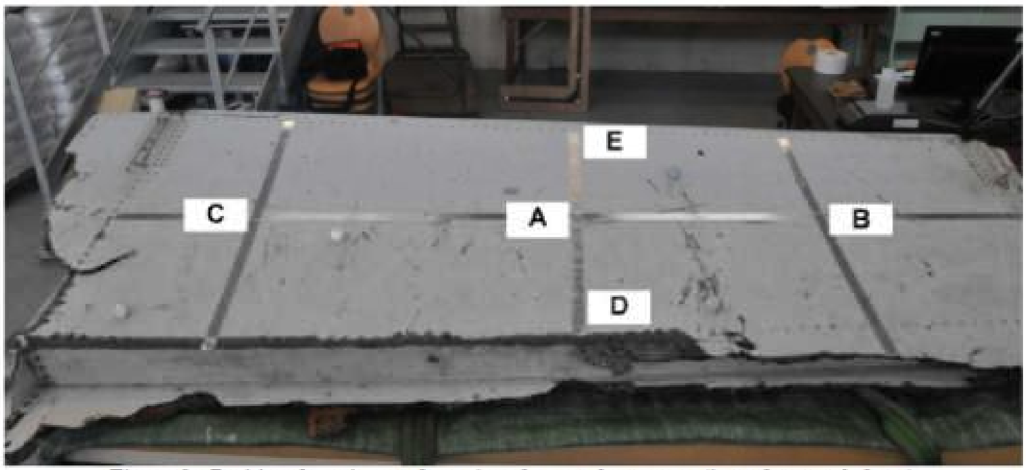

Figure 3 : Position des mires et des points de pose des masses (intrados vers le haut)

Une fois le flaperon stabilisé, l'acquisition d'une position se faisait sur une durée de 20 secondes à la fréquence d'acquisition de 20 Hz. Les valeurs des positions exploitées étant obtenues sur la moyenne des positions acquises.
Il a également été procédé à l'acquisition de la position d'une sphère placée sur un flotteur de façon à repérer la position de la surface libre dans le référentiel fixe définit par les caméras.

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3 Programme d'essais

Le programme d'essais a consisté à évaluer la flottabilité de l'engin pour deux situations : intrados vers le haut et extrados vers le haut.
Dans la situation intrados vers le haut une tentative a été faite de reprendre les mesures décrites ci-avant en ayant obturé à l'adhésif les trous imputables à la corrosion. Cette mesure avait pour objectif de vérifier si l'attitude du flaperon en surface avait pu varier sensiblement à mesure que la corrosion le dégradait. Il a très vite été constaté que l'obturation des trous ralentissait le remplissage du flaperon mais ne modifiait pas la position finale d'équilibre. Il n'a donc pas été procédé à des mesures pour cette configuration qui ne différait finalement pas de celle déjà étudiée.

4 Résultats préliminaires

4.1 Premières constatations

Avant de procéder aux premières mesures, le flaperon a été déposé dans la piscine, intrados vers le haut, afin d'avoir une première idée de son attitude au repos. Posé doucement sur la surface, le flaperon flotte relativement haut sur l'eau et se remplit lentement. Il met approximativement 20 minutes à atteindre sa position d'équilibre.
Intrados vers le haut le flaperon flotte avec le bord de fuite dégagé de la surface et le bord d'attaque sous la surface (Figure 4). Dans sa grande direction, la ligne de flottaison est sensiblement parallèle à l'envergure.

Figure 4 : Equilibre en surface, intrados vers le haut

Posé avec l'extrados vers le haut, le flaperon se stabilise dans une position relativement comparable (Figure 5).

Figure 5 : Equilibre en surface, extrados vers le haut

La réserve de flottabilité est importante puisque pas moins de 41 kg de lest supplémentaires ont été nécessaires pour l'immerger totalement. En pratique la réserve de flottabilité est légèrement inférieure à 41/1023.5= 0.040 m^3 puisqu'une partie des lests utilisés se trouvait immergée (Figure 6).

Figure 6 : Immersion complète, intrados vers le haut

4.2 Résultats

Par analogie avec les études de stabilité des bâtiments de surface et bien que l'objet étudié ne présente pas de plan de symétrie, on caractérise la stabilité du flaperon par les valeurs de hauteur métacentrique longitudinale et transversale GM_L et GM_T correspondant à des inclinaisons en assiette et gîte (Figure 7).

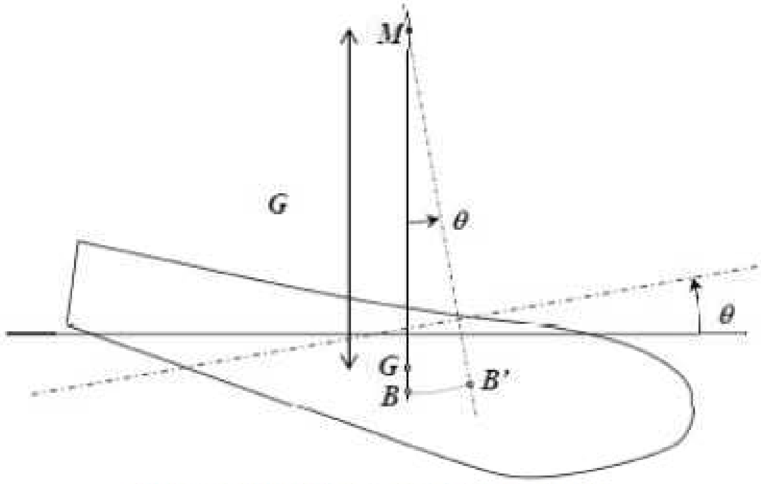

Figure 7 : Stabilité (transversale dans l'exemple)

La raideur en enfoncement est caractérisée par l'enfoncement sans inclinaison par unité d'effort vertical appliqué dZ/dF_Z. Cette raideur peut également se traduire sous forme d'une surface de flottaison effective $A_W = \frac{dF_Z}{\rho dZ}$. Le point d'application d'un effort vertical, ne provoquant pas d'inclinaison, se situe sur la verticale passant par le centre F de cette surface de flottaison effective.
Le Tableau 1 synthétise les résultats obtenus lors des mesures effectuées sur le flaperon.

	Inclinaison longitudinale	Inclinaison transversale	Raideur en enfoncement	
	GM_L (m)	GM_T (m)	dZ/dFz (mm/N)	Flottaison effective A_W (m^2)
Intrados émergé	2.01	0.50	0.76	0.131
Extrados émergé	2.22	0.21	0.56	0.178

Tableau 1: Données hydrostatiques

4.3 Flottaison

Les essais réalisés ont montré qu'en l'état, la flottabilité du flaperon était relativement importante et que la ligne de flottaison ne correspondait pas à sa position suggérée par les zones d'implantation des crustacés.
Afin d'évaluer les conditions dans lesquelles cette flottaison était réalisée, le flaperon a été lesté pour faire coïncider la flottaison effective avec celle délimitée par la présence des crustacés.
Dans le cas intrados vers le haut, il a été nécessaire d'ajouter 13.5 kg sur le long du bord de fuite (Figure 8). Dans le cas où l'extrados est placé vers le haut, seuls 5 kg ont été nécessaires (Figure 9).

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Figure 8 : Intrados émergé

Figure 9 : Extrados émergé

Références

[a] Lettre de Monsieur François Granger du 03/08/2015 définissant les analyses à mener.

Annexe 1 : Nomenclature

A_W	Surface de flottaison	m^2
B	Centre de carène (volume immergé)	
F	Centre de flottaison	
G	Centre de gravité	
GM_L	Hauteur métacentrique longitudinale	m
GM_T	Hauteur métacentrique transversale	m
g	Accélération de la pesanteur	$m\ s^{-2}$
m	Masse	kg
ρ	Densité de l'eau	$kg\ m^{-3}$
∇	Déplacement (volume)	m^3

Annexe 8 : **Report DGA TH E11374 part 2 – Characteristics Hydrostatiques of the Flaperon**

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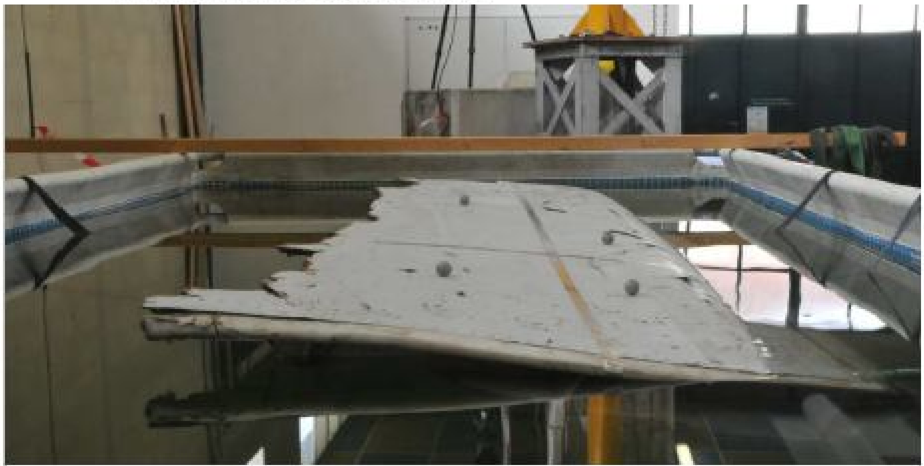
DGA Techniques hydrodynamiques



E 11374
ESSAI DE FLOTTABILITE POUR DGA TA

PIECE N° 2
HYDROSTATIQUE

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Nb de pages du document :	37 pages

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AFFAIRE N°E11374
Pièce N°2

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

Type de rapport

☒Rapport final	☐ Rapport intermédiaire	☐Rapport provisoire

Indice du rapport

Version	Date	Description des pages modifiées ET justification de la modification	Auteurs
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Diffusion

Diffusion externe :

Organisme	Nom du Destinataire	Nb	Livrables (CDROM,...)
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DGA Techniques aéronautiques	C. Blayac	1	
TGI de Paris (Section anti-terroristes)	M. le Juge A. Gaudino	1	

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AFFAIRE N°E11374
Pièce N°2

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

Résumé

Par l'intermédiaire de DGA Techniques aéronautiques, et dans le cadre d'une expertise judiciaire menée à la demande du Tribunal de grande instance de Paris, DGA Techniques hydrodynamiques a apporté son concours à la caractérisation de l'élément de flaperon trouvé en juillet 2015 à La Réunion. Une équipe de deux personnes de DGA Techniques hydrodynamiques s'est rendue à Balma du 24 au 28 août 2015 afin de procéder aux essais dit de flottabilité. Un premier rapport rend compte de ces essais. Le présent rapport détaille les mesures faites et en exploite plus avant les résultats.
Ces essais montrent que l'élément de flaperon possède une flottabilité assez importante en l'état. Pour une masse à sec de 39.7 kg, 37 kg de lests supplémentaires sont nécessaires pour l'immerger totalement. Sa position d'équilibre qui est sensiblement la même que l'intrados soit vers le haut ou vers le bas, est telle que le bord d'attaque est immergé alors que le bord de fuite est légèrement dégagé de la surface.
Pour ces deux attitudes, ce rapport fournit les caractéristiques hydrostatiques et l'estimation de grandeurs géométriques définissant les parties immergées et émergées.

Type de clients :	DGA (code 1800)
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Moyen :	Autres
Programme :	
Mots clés :	

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RAPPORT

N° 16-DGATA-MTI-P1501516001002-DR-F-A

AFFAIRE N°E11374
Pièce N°2

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

1 Objet du rapport

Par l'intermédiaire de DGA Techniques aéronautiques, et dans le cadre d'une expertise judiciaire menée à la demande du Tribunal de grande instance de Paris (Réf. [a]), DGA Techniques hydrodynamiques a apporté son concours à la caractérisation de l'élément de flaperon trouvé en juillet 2015 à La Réunion. Une équipe de deux personnes de DGA Techniques hydrodynamiques s'est rendue à Balma du 24 au 28 août 2015 afin de procéder aux essais dit de flottabilité. Un premier rapport (réf. [b]) rend compte de ces essais. Le présent rapport détaille les mesures faites et en exploite plus avant les résultats.

2 Essais

2.1 Flaperon

L'élément de flaperon étudié à pour dimensions principales :

- Envergure moyenne = 2200 mm
- Corde moyenne = 1120 mm
- Epaisseur max = 300 mm

Sa masse, mesurée par DGA TA est de 39.7 kg.

2.2 Conditions des mesures

Les mesures ont été effectuées dans une piscine hors sol installée dans les locaux de DGA TA. Ses dimensions sont 2.5x5.2 m. Lors des essais, la profondeur d'eau était d'environ 1.1 m.

La piscine était remplie d'eau salée dont la température était de 20° C, la densité mesurée par DGA TH de 1023,5 kg/m^3.

Cette densité est inférieure à celle généralement admise pour l'eau des mers ouvertes qui se situe autour de 1025-1026 kg/m^3. Ce faible écart est sans incidence notable sur les résultats des mesures puisqu'il correspondrait à une différence d'enfoncement inférieure à 1 mm.

2.3 Repères

Sur la base de relevés photogramétriques, DGA TA a établi un fichier CAO du flaperon référencé Flaperon1.igs. Par commodité, le repère de ce fichier CAO dont l'axe des x est sensiblement parallèle au bord de fuite mais dont l'origine ne correspond à aucun point remarquable du flaperon sera utilisé pour localiser différents points sur l'objet. La Figure 1 donne des vues de la modélisation CAO sur lesquelles ce repère est figuré par des flèches de couleur.

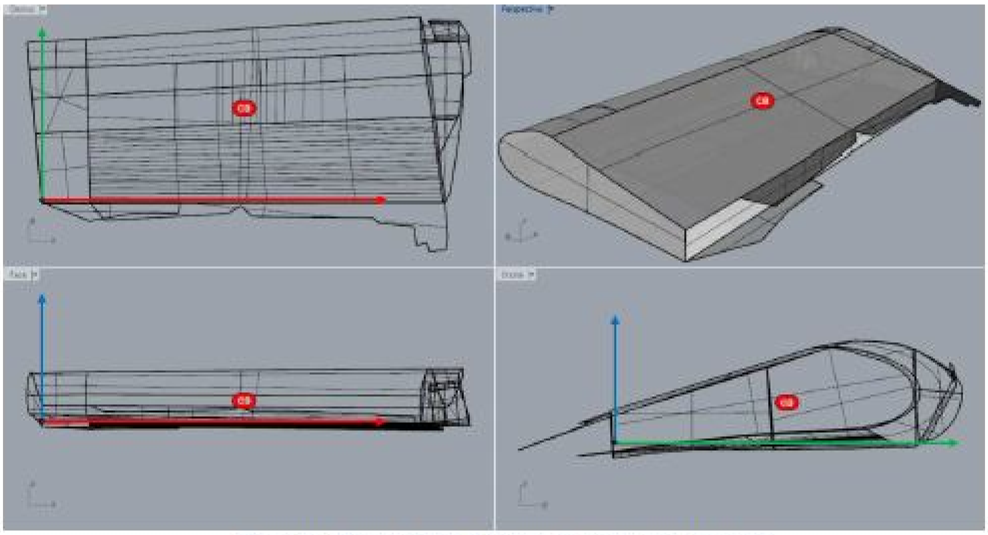

Figure 1 : Repère lié au flaperon (intrados vers le haut)

Les mesures d'assiette et d'enfoncement ont été réalisées par un système optique Qualisys® composé de trois caméras visant des sphères réfléchissantes fixées sur la partie émergée du flaperon (sphères notées « O », « X » et « Y » sur la photographie de la Figure 2). Pour les besoins des mesures, une 4ème boule Qualisys a été installée sur la face émergée du flaperon. Cette 4ème boule ne sert que dans le cas où une des trois autres boules serait masquée par l'environnement de la piscine pour certaines attitudes.

La mise en assiette et en gîte du flaperon a été réalisée en appliquant différentes masses en 5 points de sa surface émergée, notés A, B, C, D et E et représentées sur la Figure 2.

Les différentes valeurs de masse ont été obtenues par la combinaison de trois masses de 1 kg vérifiées par une balance de précision ± 0.1 gramme.

Pour prendre en compte les éventuelles variations du niveau de l'eau de la piscine, une 5ème boule a été installée sur un flotteur en mousse de 40 mm d'épaisseur. Ce flotteur chargé de cette boule présente un tirant d'eau proche de 1 mm, ce qui place le centre de la boule à une hauteur de 51.7 mm au dessus du niveau de l'eau.

Les mesures de hauteur (z), sont comptées entre le pied de la boule « Origine » (placée en O) et la surface libre. Les inclinaisons en gîte et en assiette correspondent à des déplacements angulaires autour d'axes respectivement parallèles à OX et OY.

Par convention, il a été retenu que les angles d'assiette et de gîte sont nuls quand le plan défini par les centres des boules « O », « X » et « Y » est horizontal.

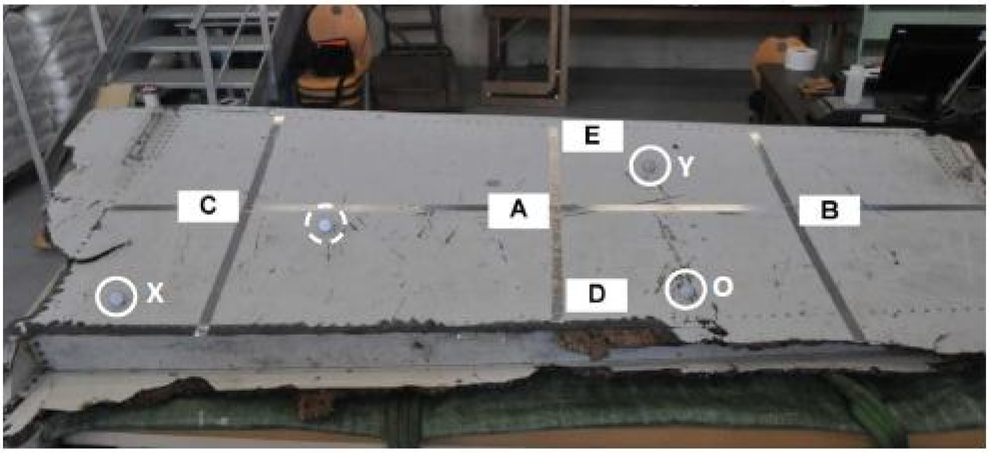

Figure 2 : Position des mires et des points de pose des masses (intrados vers le haut)

Le Tableau 1 regroupe les coordonnées des positions des boules et des masses additionnelles, exprimées dans le repère du fichier IGES fourni par DGA TA.

		Intrados émergé		Extrados émergé	
	Nom	x (mm)	y (mm)	x (mm)	y (mm)
Boules Qualisys	O	782.0	69.0	1754.0	179.5
	X	1935.0	75.0	660.0	174.5
	Y	779.5	544.3	1752.3	528.1
Points d'implantation des masses	A	1031.4	416.9	1385.6	373.1
	B	477.7	397.6	2102.9	434.0
	C	1751	442.0	668.4	312.2
	D	1041.9	117.1	1411.8	83.2
	E	1020.9	716.7	1365.2	600.2

Tableau 1: Positions des marqueurs et des masses additionnelles

3 Comportement

3.1 Reprise d'eau

Pour chacune des attitudes, les mesures se sont déroulées sur une certaine durée, ce qui a permis de constater des variations d'enfoncement et d'attitude entre les premières mesures réalisées sans masse additionnelles et celles réalisées en fin de séance dans les mêmes conditions.

3.1.1 Cas intrados émergé

Dans le cas intrados émergé, après avoir passé trois heures dans l'eau, le flaperon n'a quasiment pas changé d'angle d'assiette et de gîte au cours du temps (Figure 5 et Figure 6). Par contre, il s'est légèrement enfoncé de 2.2 mm (Figure 4), ce qui correspond à un alourdissement d'environ 0.3 kg dont la résultante est voisine du centre de flottaison puisque les angles d'inclinaison ont peu varié.

Figure 3 : Equilibre en surface, intrados émergé

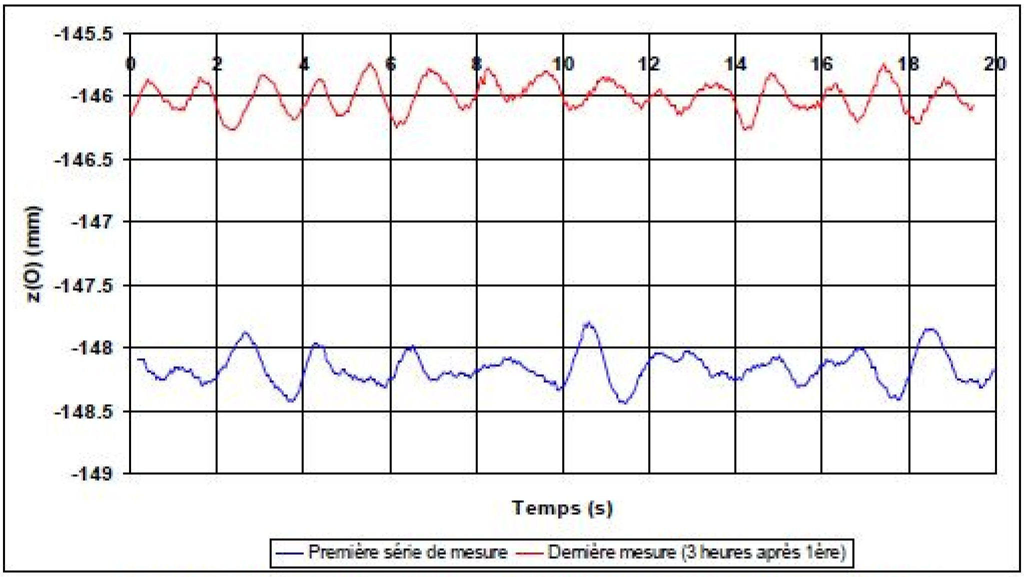

Figure 4 : Flaperon intrados émergé – Prise d'immersion après 3 heures dans l'eau

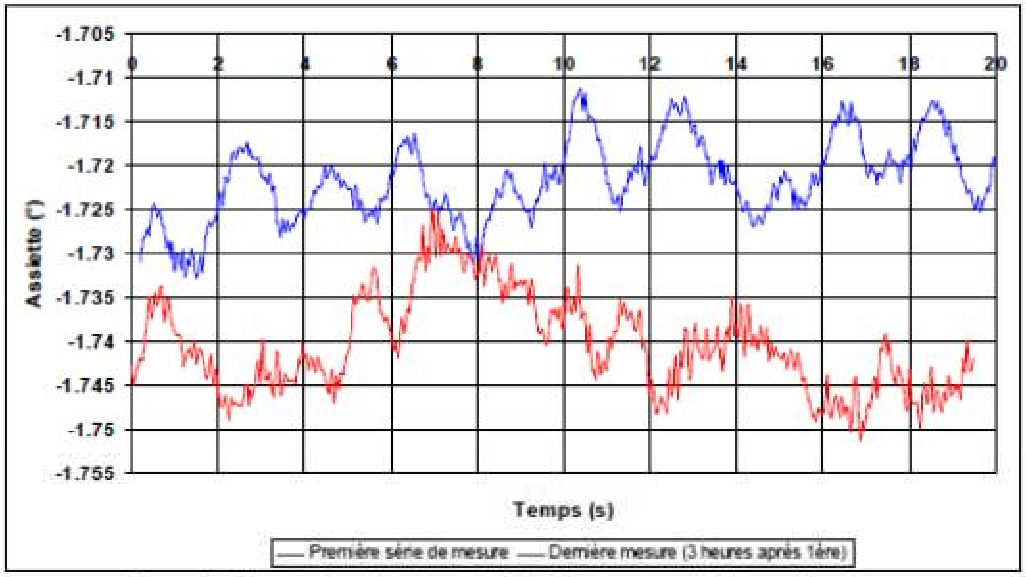

Figure 5 : Flaperon intrados émergé – Prise d'assiette après 3 heures dans l'eau

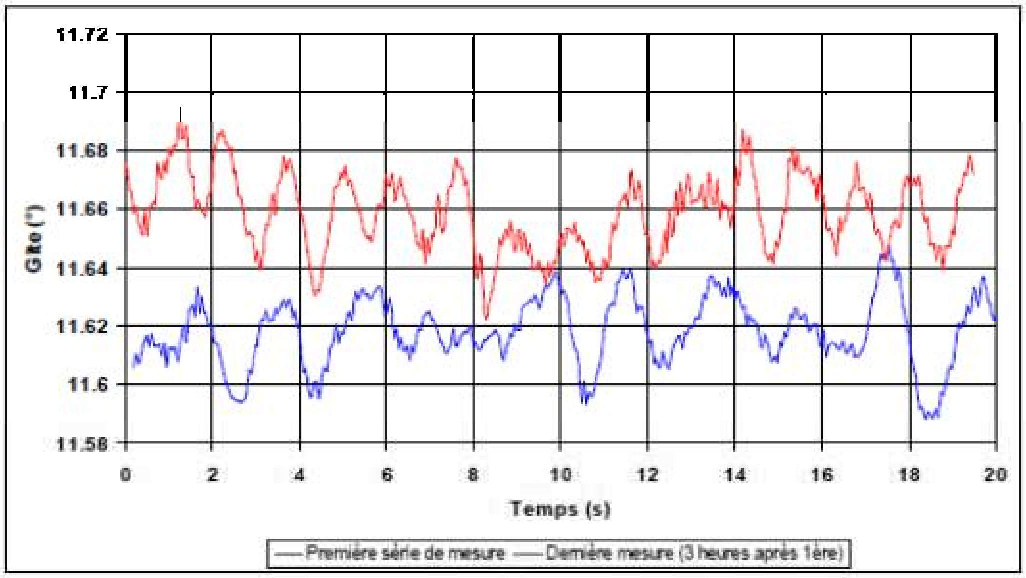

Figure 6 : Flaperon intrados émergé – Prise de gîte après 3 heures dans l'eau

3.1.2 Cas extrados émergé

Posé avec l'extrados vers le haut, le flaperon se stabilise dans une position relativement comparable (Figure 7) à celle de la position intrados émergé.

Figure 7 : Equilibre en surface, extrados vers le haut

Au bout d'une heure trente dans l'eau, le flaperon a pris 0.25° d'assiette, perdu 0.3° de gîte et s'est enfoncée de 3.5 mm au niveau de la boule origine. Cet enfoncement correspond sensiblement à un alourdissement de 0.2 kg dont la résultante se situerait entre la boule « Origine » et le point B de mise en place des masses.

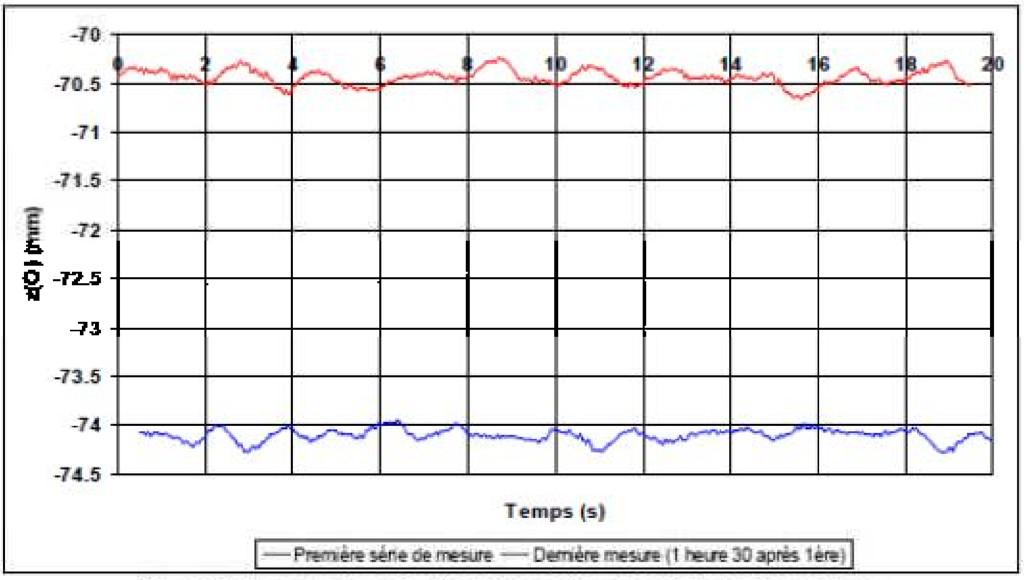

Figure 8 : Extrados émergé – Prise d'immersion après 1 heure 30 dans l'eau

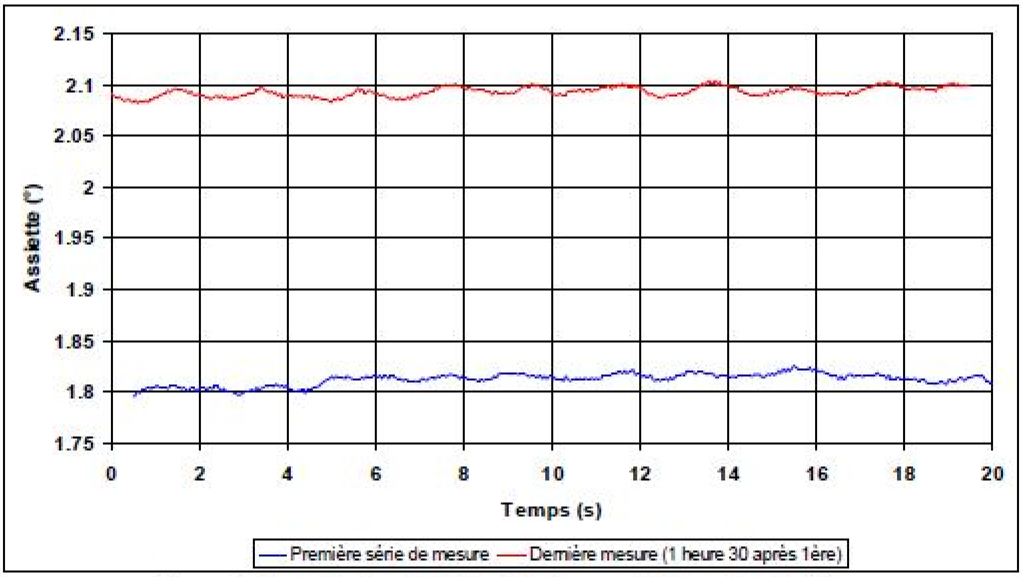

Figure 9 : Extrados émergé – Prise d'assiette après 1 heure 30 dans l'eau

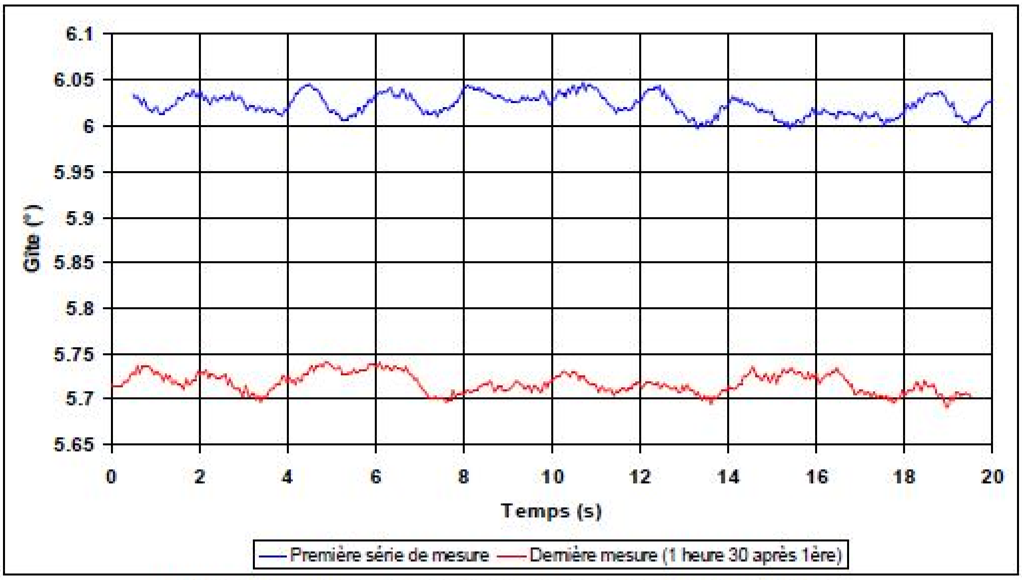

Figure 10 : Extrados émergé – Prise de gite après 1 heure 30 dans l'eau

3.2 Immersion complète

La réserve de flottabilité du flaperon est importante puisque 41 kg de lests supplémentaires ont été nécessaires pour l'immerger totalement. En pratique la réserve de flottabilité est légèrement inférieure à 41/1023.5= 0.040 m^3 puisqu'une partie des lests utilisés se trouvait immergée (Figure 11) lors de cette expérience. En corrigeant de la poussée hydrostatique sur les parties immergées des lests, on déduit que la masse effective pour immerger totalement le flaperon est plus proche de 37 kg.

Figure 11 : Immersion complète, intrados vers le haut

3.3 Sur-enfoncement

Des expériences consistant à lester le flaperon de manière à faire affleurer le bord de fuite à la surface libre, et donc la zone d'implantation des crustacés, ont également été réalisées. Ces expériences menées respectivement pour les configurations intrados émergé et extrados émergé sont illustrées par les Figure 12 et Figure 13.

Figure 12 : Bord de fuite affleurant - intrados émergé

La position des masses utilisées à cette fin a été mesurée à l'aide du système Qualisys® en posant sur le centre de chacune une boule de mesure. Les valeurs obtenues, exprimées dans le repère du fichier CAO, sont résumées dans le Tableau 2.

Configuration flaperon	Masse (kg)	x (mm)	y (mm)
Intrados émergé (Figure 12)	10.0	633	59
	2.0	1544	39
	1.5	77	29
Extrados émergé (Figure 13)	2.5	760	65
	2.5	152	43

Tableau 2: Chargements pour amener le bord de fuite affleurant

Figure 13 : Bord de fuite affleurant - extrados émergé

4 Caractéristiques hydrostatiques

4.1 Définitions

L'annexe 1 résume la nomenclature utilisée pour définir les caractéristiques hydrostatiques.
A partir du fichier CAO transmis par DGA TA, un nouveau fichier a été défini dans lequel des surfaces ont été construites de manière à délimiter un volume fermé excluant les éléments de peau endommagés que l'on voit au niveau du bord de fuite et sur les côtés. La Figure 14 illustre ce volume. On peut, sur cette base, estimer un déplacement V_f, appelé « de forme », et qui correspond au volume immergé délimité par l'enveloppe extérieure : ce qui reviendrait à admettre que toute l'eau emprisonnée dans le flaperon est figée et entraînée dans ses mouvements.

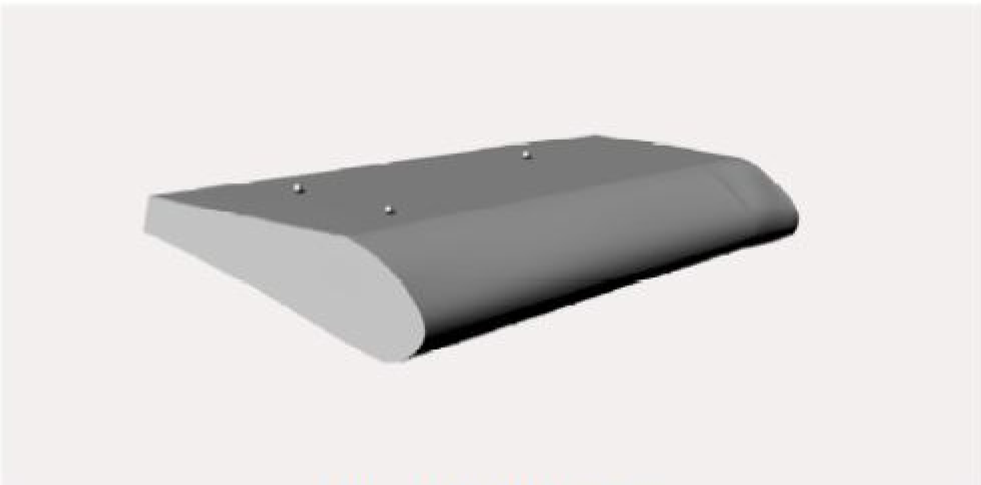

Figure 14 : Vue du volume fermé

Sur la base des relevés réalisés et en utilisant les éléments de CAO, on estime les grandeurs suivantes pour les deux situations d'équilibre :

- Le déplacement de forme V_f,
- Le tirant d'eau maximal,
- Le tirant d'air maximal,
- La surface projetée des œuvres mortes (exposées au vent) dans 2 directions,
- La surface projetée des œuvres vives (exposées à l'eau) dans 2 directions.

On appellera frontale la projection sur un plan perpendiculaire à la direction x et latérale la projection sur un plan perpendiculaire à y. Les valeurs de tirant d'air, tirant d'eau et surface projetées sont basée sur la CAO complète et incluent la contribution des éléments de peau abîmés.

Par analogie avec les études de stabilité des bâtiments de surface et bien que l'objet étudié ne présente pas de plan de symétrie, on caractérise la stabilité du flaperon par les valeurs de hauteurs métacentriques longitudinale et transversale GM_L et GM_T correspondant à des inclinaisons en assiette et gîte (Figure 15).
La raideur en enfoncement est caractérisée par l'enfoncement sans inclinaison par unité d'effort vertical appliqué dZ/dF_Z. Cette raideur peut également se traduire sous forme d'une surface de flottaison effective $A_W = \frac{dF_Z}{\rho dZ}$. Le point d'application d'un effort vertical, ne provoquant pas d'inclinaison, se situe sur la verticale passant par le centre F de cette surface de flottaison effective.

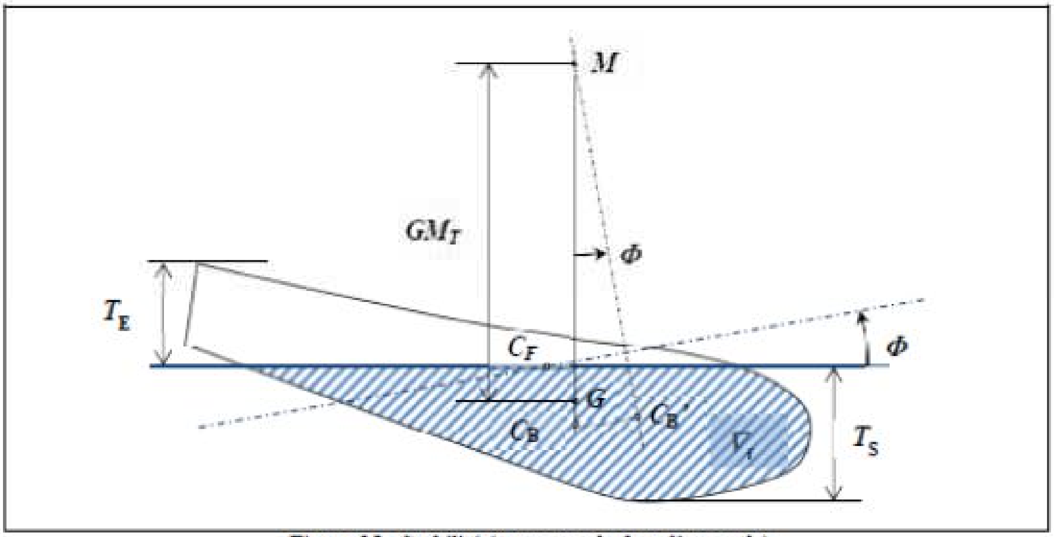

Figure 15 : Stabilité (transversale dans l'exemple)

4.2 Analyse des mesures

Les annexes 2 et 3 restituent les résultats des mesures dans les positions intrados émergé et intrados immergé.
L'annexe 4 détaille la méthode de détermination des hauteurs métacentriques longitudinale et transversale dans ces deux situations. Pour cette détermination, les hauteurs métacentriques

sont rapportées à la masse m du flaperon. Pour des études ultérieures, il peut être intéressant de rapporter ces hauteurs métacentriques au déplacement de forme ∇_f en écrivant :

$$GM_f = GM\frac{m}{\rho\nabla_f}$$

Les Figure 16 et Figure 17 représentent les expériences de flottabilité sur des vues CAO. Sur ces figures sont représentés les positions du centre de la surface de flottaison et du centre de volume de la forme fermée. Les petites marques rouges sur la face émergée du flaperon correspondent aux centres des boules utilisées par le système Qualisys®.

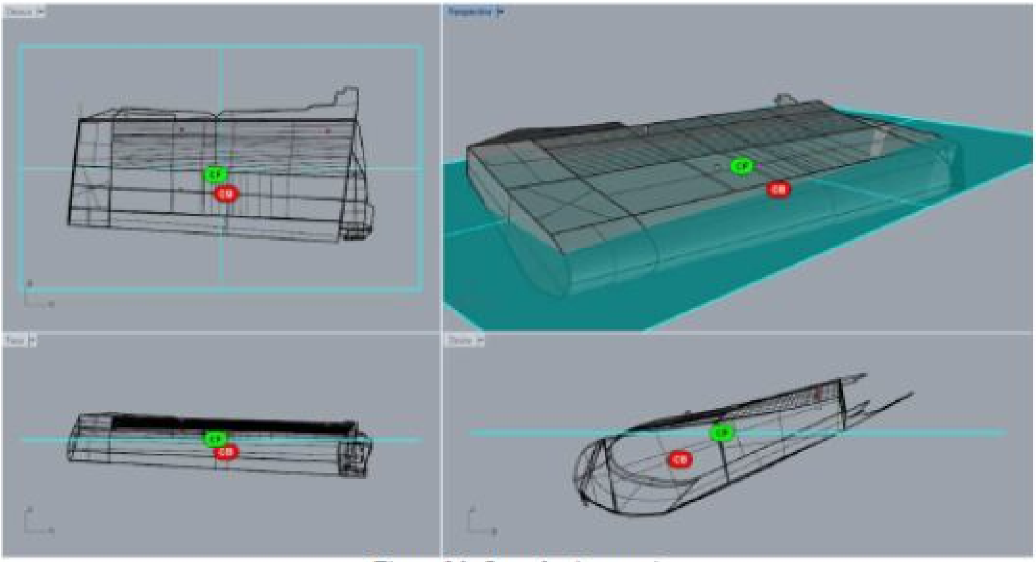

Figure 16 : Intrados immergé

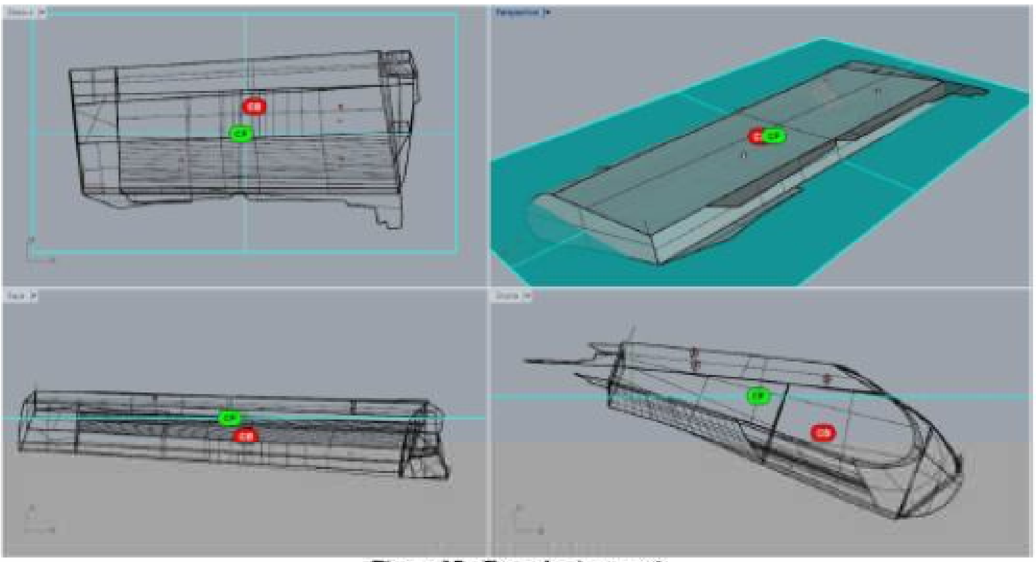

Figure 17 : Extrados immergé

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L'annexe 5 compare, sous des angles de vue très proches, différentes images CAO du flaperon aux photos prises par DGA TA durant les essais.

4.3 Résultats

4.3.1 Surfaces projetées

Les Figure 18 et Figure 19 indiquent les grandes longueurs et les surfaces projetées du Flaperon pour les deux sens de flottaison.

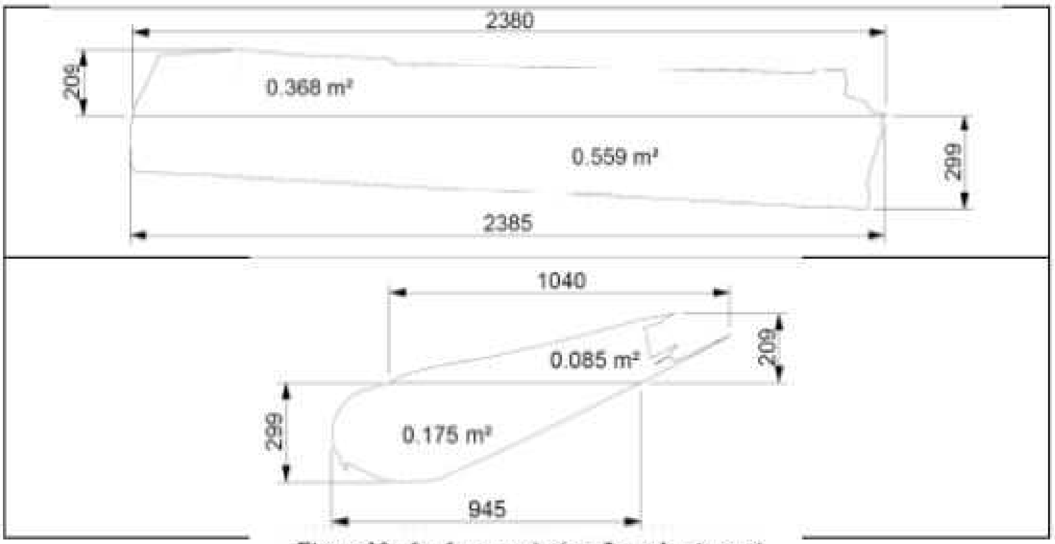

Figure 18 : Surfaces projetées - Intrados émergé

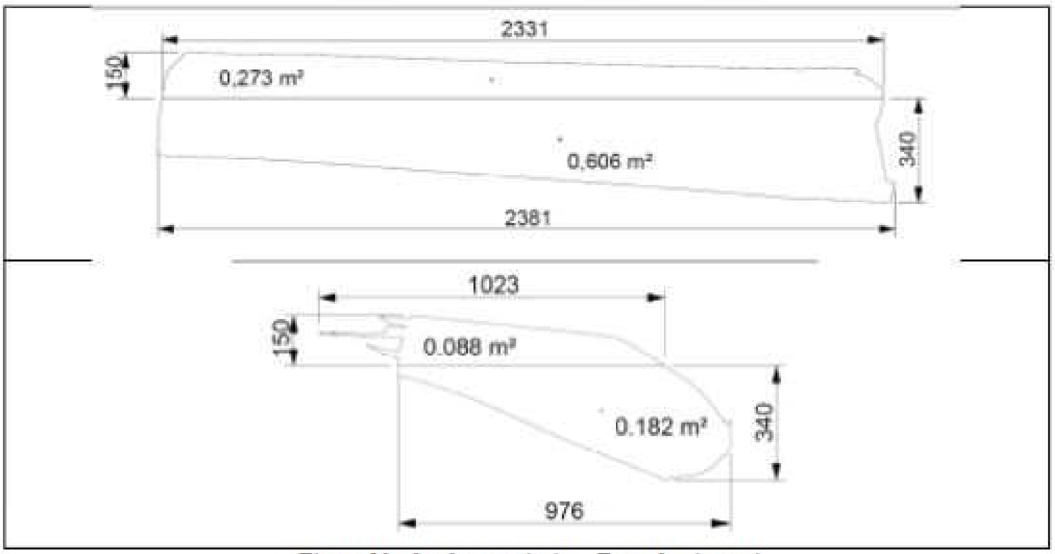

Figure 19 : Surface projetées - Extrados émergé

4.3.2 Synthèse

Le Tableau 3 rassemble les données relatives à l'hydrostatique du flaperon telles qu'elles ont pu être estimées à partir des mesures réalisées par DGA Techniques hydrodynamiques sur le site de Balma du 25 au 28/08/2015 et en utilisant le relevé des formes réalisé par DGA Techniques aéronautiques.

Situation Intrados			Emergé	Immergé
Masse	m	kg	39.7	39.7
Déplacement de forme	V_f	m^3	0.2569	0.2580
Position du centre de volume de forme	x_B	m	1.143	1.163
	y_B	m	0.593	0.583
	z_B	m	0.152	0.110
Surface de flottaison effective	A_W	m^2	0.131	0.178
Position du centre de flottaison effective	x_F	m	1.385	1.085
	y_F	m	0.485	0.396
Hauteur métacentrique longitudinale relative à la masse	GM_L	m	2.011	2.219
Hauteur métacentrique longitudinale relative au déplacement de forme V_f	GM_{Lf}	m	0.304	0.334
Hauteur métacentrique transversale relative à la masse	GM_T	m	0.503	0.206
Hauteur métacentrique transversale relative au déplacement de forme V_f	GM_{Tf}	m	0.076	0.031
Tirant d'eau maximum	T_S	m	0.299	0.340
Surface latérale projetée des œuvres vives	A_{LS}	m^2	0.559	0.606
Surface frontale projetée des œuvres vives	A_{XS}	m^2	0.175	0.182
Tirant d'air maximum	T_E	m	0.209	0.150
Surface latérale projetée des œuvres mortes	A_{LE}	m^2	0.368	0.273
Surface frontale projetée des œuvres mortes	A_{XE}	m^2	0.085	0.088

Tableau 3: Données hydrostatiques

5 Conclusions

En complément d'un premier compte rendu (réf. [b]), le présent rapport détaille les mesures de flottabilité réalisées à dans les locaux de DGA Techniques aéronautiques, à Balma, du 24 au 28 Août 2015. Ces essais montrent, qu'en état, l'élément de flaperon possède une flottabilité assez importante. Pour une masse à sec de 39.7 kg, 37 kg de lests supplémentaires sont nécessaires pour l'immerger totalement. Sa position d'équilibre qui est sensiblement la même que l'intrados soit vers le haut ou vers le bas, est telle que le bord d'attaque est immergé alors que le bord de fuite est légèrement dégagé de la surface.

Pour ces deux attitudes, ce rapport fournit les caractéristiques hydrostatiques et l'estimation de grandeurs géométriques définissant les parties immergées et émergées.

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Références

[a] Lettre de Monsieur François Granger du 03/08/2015 définissant les analyses à mener.

[b] E11374 Pièce n°1 Essai de flottabilités pour DGA TA Compte rendu des essais d'août 2015. N°15-501367 DT/DGA TH/SDT/UP_Perf du 14/09/2015

Annexe 1 : Nomenclature

A_{LE}	Surface latérale projetée des œuvres mortes (Emerged)	m^2
A_{LS}	Surface latérale projetée des œuvres vives (Submerged)	m^2
A_W	Surface de flottaison effective	m^2
A_{XE}	Surface transversale projetée des œuvres mortes (Emerged)	m^2
A_{XS}	Surface latérale projetée des œuvres vives (Submerged)	m^2
C_B	Centre de carène (volume immergé)	
C_F	Centre de flottaison	
G	Centre de gravité	
GM_L	Hauteur métacentrique longitudinale relative à la masse	m
GM_{Lf}	Hauteur métacentrique longitudinale relative au déplacement de forme ∇_f	m
GM_T	Hauteur métacentrique transversale relative à la masse	m
GM_{Tf}	Hauteur métacentrique transversale relative au déplacement de forme ∇_f	m
g	Accélération de la pesanteur	$m\ s^{-2}$
m	Masse	kg
m_i	Masse additionnelle	kg
T_E	Tirant d'air maximal des œuvres mortes	m
T_S	Tirant d'eau maximum des œuvres vives	m
x_F, y_F	Position du centre de flottaison	m
x_B, y_B, z_B	Position du centre de volume (de forme)	m
θ	Angle d'assiette (rotation autour d'un axe parallèle à Oy)	deg
Φ	Angle de gîte (rotation autour d'un axe parallèle à Ox)	deg
ρ	Densité de l'eau	$kg\ m^{-3}$
$\nabla = \frac{m}{\rho}$	Déplacement vrai	m^3
∇_f	Déplacement de forme	m^3
∇_i	Volume immergé d'une masse additionnelle (le cas échéant)	m^3

Annexe 2 : Mesures hydrostatiques du 26/08/2015 - flaperon intrados émergé

Position	Masse (kg)	Z (mm)	Assiette (°)	Gîte (°)
A	0	-148.150	-1.721	11.617
A	1	-141.727	-1.455	11.627
A	2	-135.977	-1.341	11.477
A	3	-130.857	-1.224	11.351
B	0	-148.150	-1.721	11.617
B	1	-139.351	-1.182	11.772
B	2	-132.152	-0.728	11.806
B	3	-126.114	-0.412	11.711
C	0	-148.150	-1.721	11.617
C	1	-143.511	-2.016	11.320
C	2	-140.301	-2.331	10.870
C	3	-136.245	-2.674	10.429
D	0	-148.150	-1.721	11.617
D	1	-138.864	-1.695	10.723
D	2	-128.599	-1.731	9.748
D	3	-117.925	-1.861	8.687
E	0	-148.150	-1.721	11.617
E	1	-144.765	-1.448	12.439
E	2	-145.342	-1.197	13.114
E	3	-146.125	-1.081	13.847

Mesures de hauteur, d'assiette et de gîte :

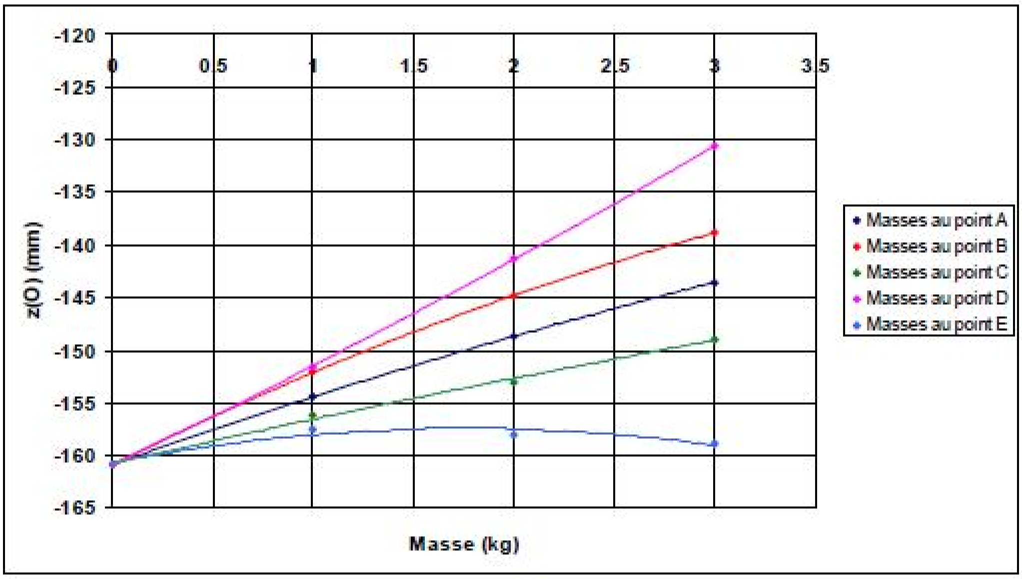

Figure A2-1 : Flaperon intrados émergé – hauteur de la boule « Origine »

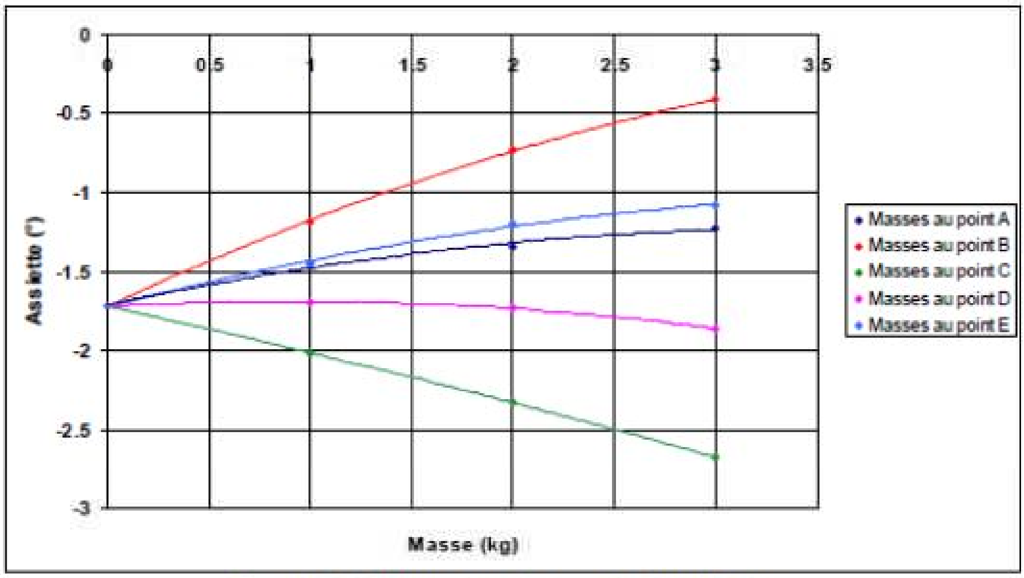

Figure A2-2 : Flaperon intrados émergé – Prise d'assiette

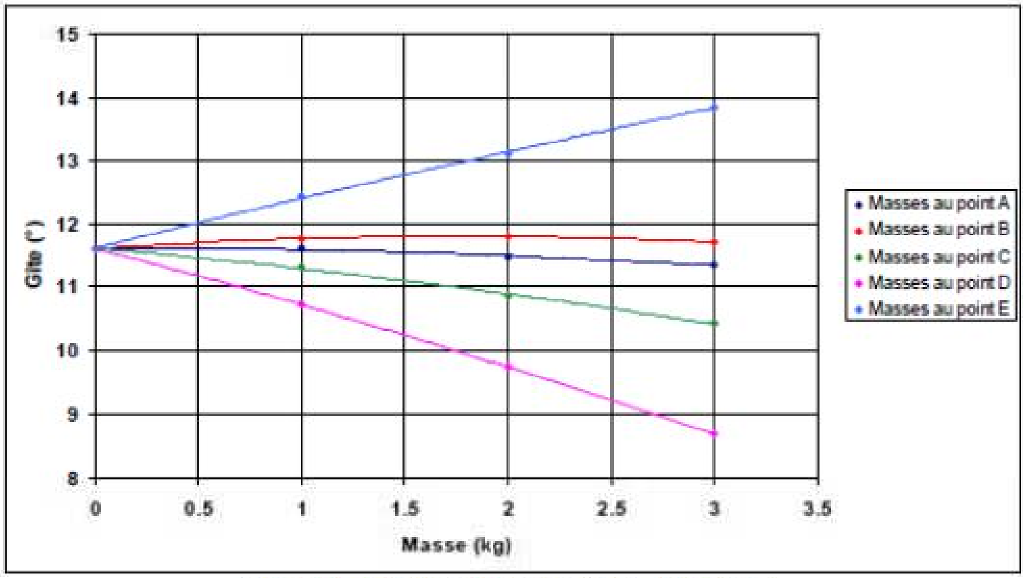

Figure A2-3 : Flaperon intrados émergé – Prise de gîte

Annexe 3 : Mesures hydrostatiques du 27/08/2015 - flaperon extrados émergé

Position	Masse (kg)	Z (mm)	Assiette (°)	Gîte (°)
A	0	-74.100	1.812	6.023
A	1	-66.297	2.027	5.643
A	2	-58.909	2.194	5.267
A	3	-51.507	2.322	4.847
B	0	-74.100	1.812	6.023
B	1	-60.068	2.498	5.171
B	2	-48.157	3.014	4.448
B	3	-39.921	3.487	4.249
C	0	-72.248	1.941	5.842
C	1	-71.578	1.716	5.916
C	2	-71.457	1.334	6.263
C	3	-71.475	0.981	6.379
D	0	-72.248	1.941	5.842
D	1	-52.301	2.557	3.521
D	2	-39.057	2.815	1.890
D	3	-33.118	2.858	0.977
E	0	-70.828	2.058	5.851
E	1	-72.135	1.999	6.770
E	2	-73.030	1.901	7.837
E	3	-74.306	1.858	8.858

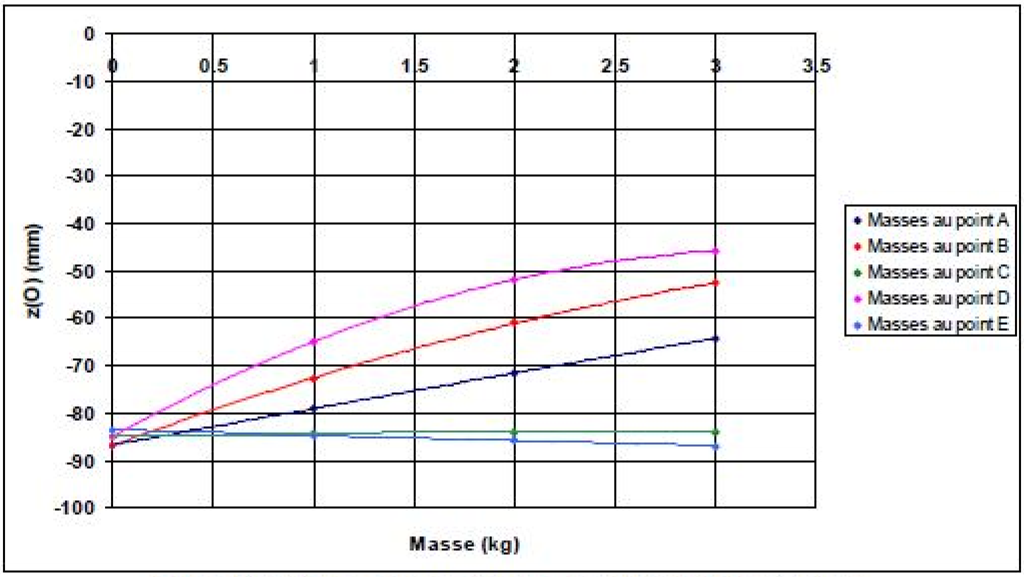

Figure A3-1 : Flaperon extrados émergé – hauteur de la boule « Origine »

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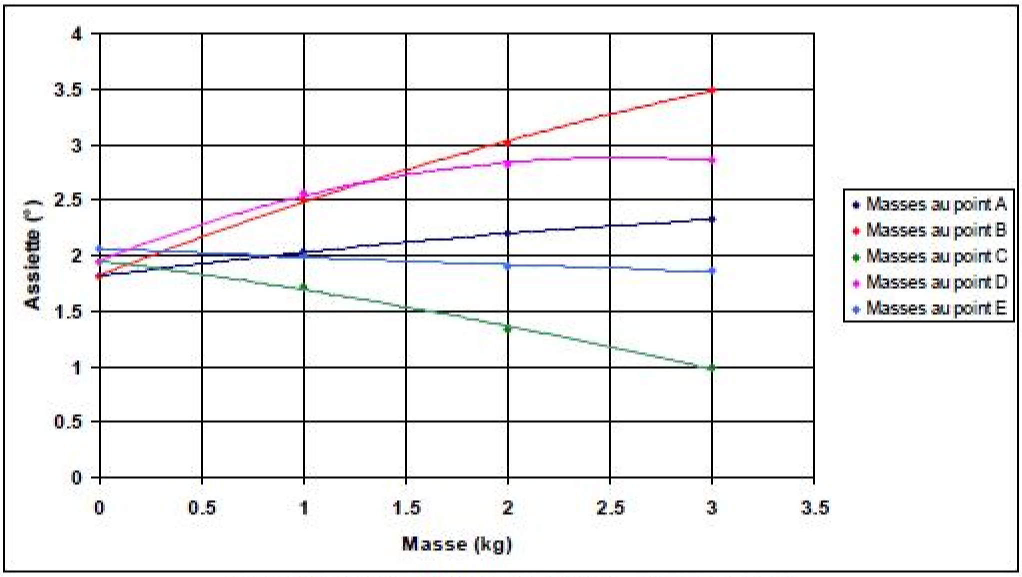

Figure A3-2 : Flaperon extrados émergé – Prise d'assiette

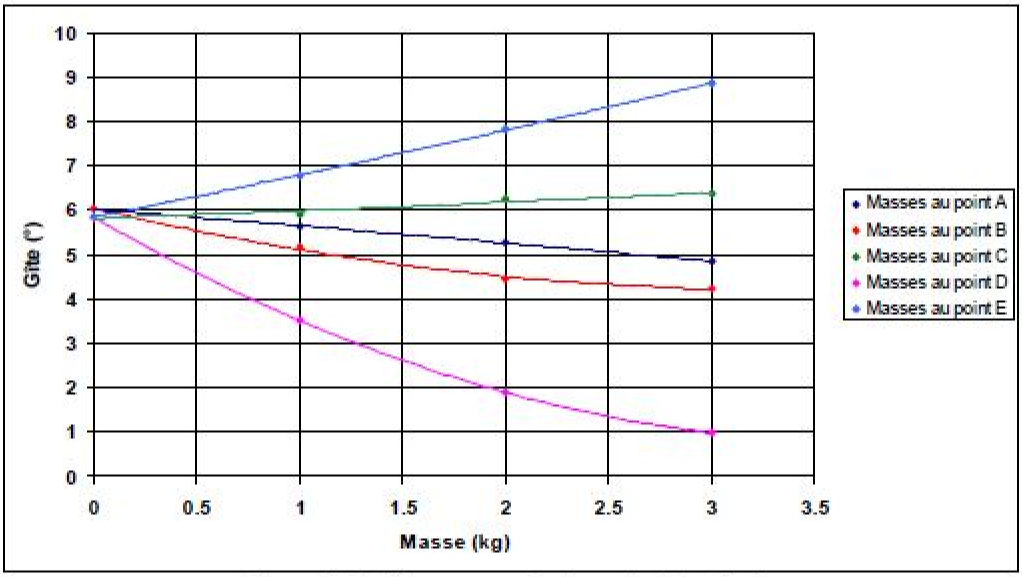

Figure A3-3 : Flaperon extrados émergé – Prise de gîte

Il apparaît sur les mesures de la configuration « extrados émergé » une petite dérive sur les différentes grandeurs relevées en absence de masse. Il semblerait que cette dérive soit liée à des éléments réalisés en textiles (donc pouvant absorber ou relâcher de l'eau) qui ont été plus ou moins immergés lors de la mise en place des différentes masses. Cette hypothèse semble la plus vraisemblable car à partir du moment où les masses ont été retirées du flaperon, ce dernier a commencé à retourner vers sa position originelle. Cette dérive des grandeurs n'est pas apparue sur la configuration « intrados émergé » car les éléments textiles proches de la surface présentaient un volume bien plus faible.

Annexe 4 : Détermination des hauteurs métacentriques

Les valeurs de θ_{ref} et φ_{ref} correspondent aux angles d'assiette et de gîte du flaperon en absence de toute masse.

$$B(m_i, x_i) = -\frac{1}{m}\sum_{i=1}^{n} x_i (m_i - \rho_i \nabla_i)$$

$$A(m_i, y_i) = \frac{1}{m}\sum_{i=1}^{n} y_i (m_i - \rho_i \cdot \nabla_i)$$

Mesures de GM_L et GM_T :

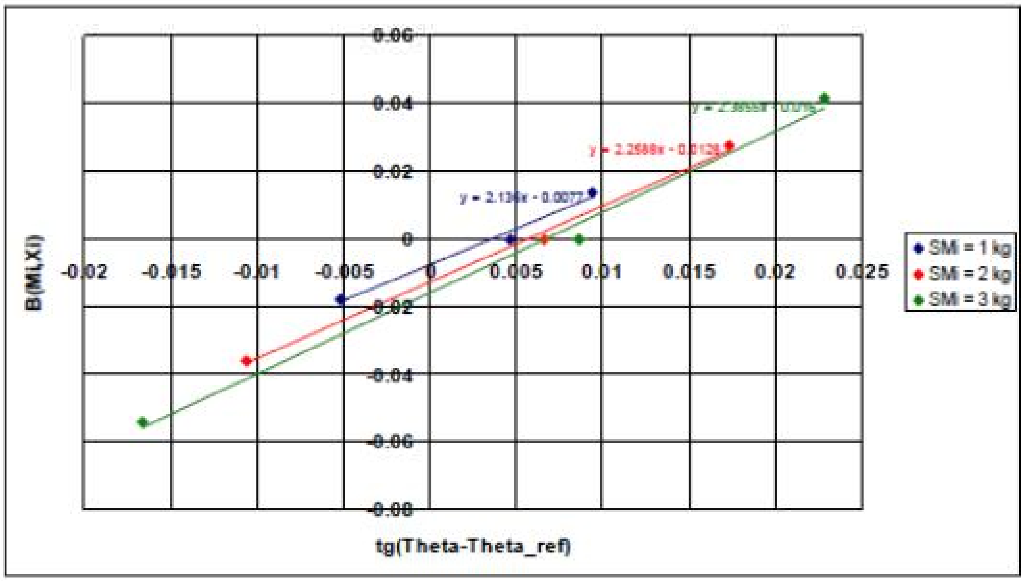

Figure A4-1 : Flaperon intrados émergé – Mesure de GM_L

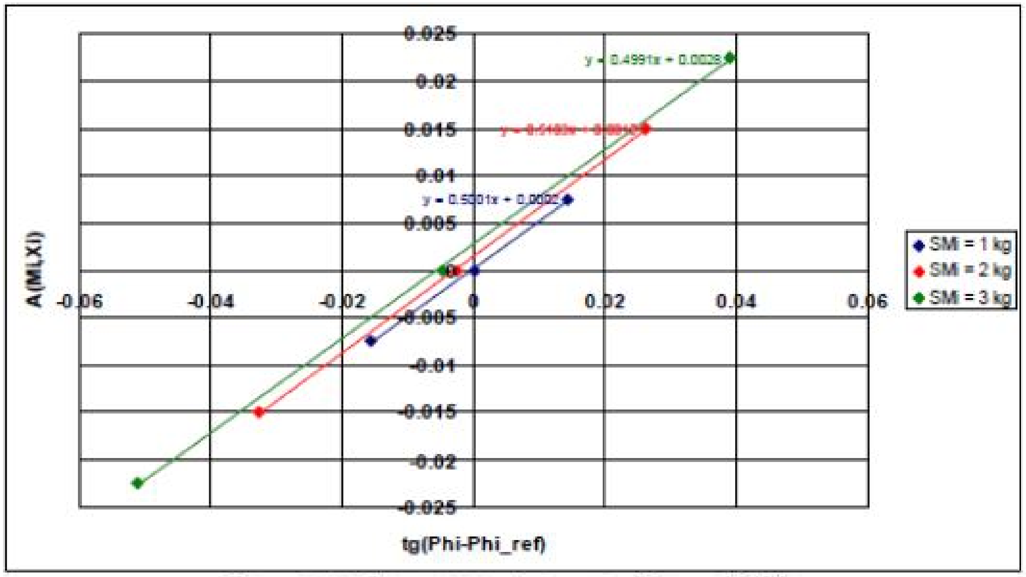

Figure A4-2 : Flaperon intrados émergé – Mesure de GM_T

Masses (kg)	GM_L	GM_T
1	2.136	0.500
2	2.259	0.510
3	2.385	0.499
0	2.011 (*)	0.503 (*)

(*) : ces grandeurs correspondent à des valeurs extrapolées pour une masse nulle

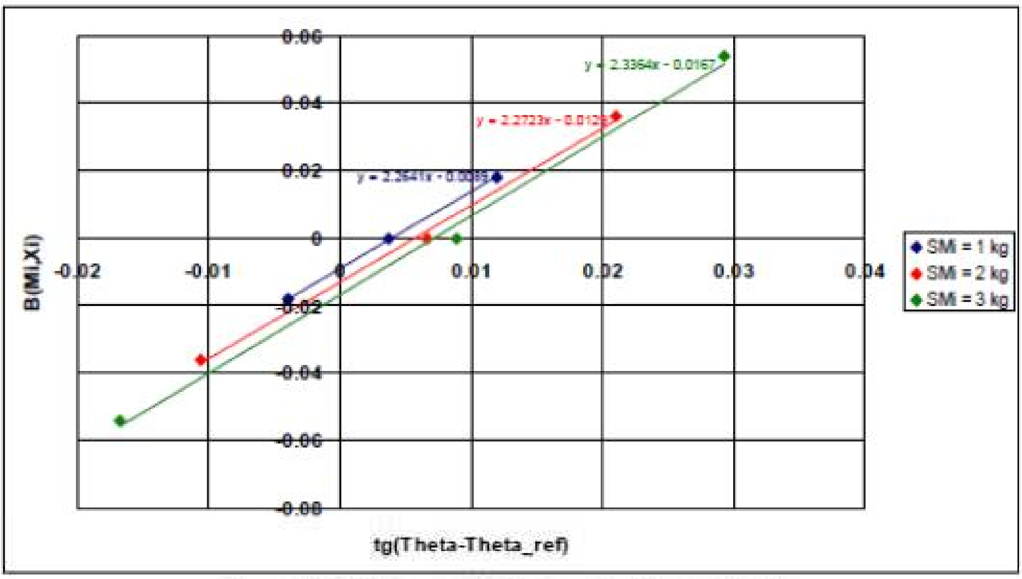

Figure A4-3 : Flaperon extrados émergé – Mesure de GM_L

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Pièce N°2

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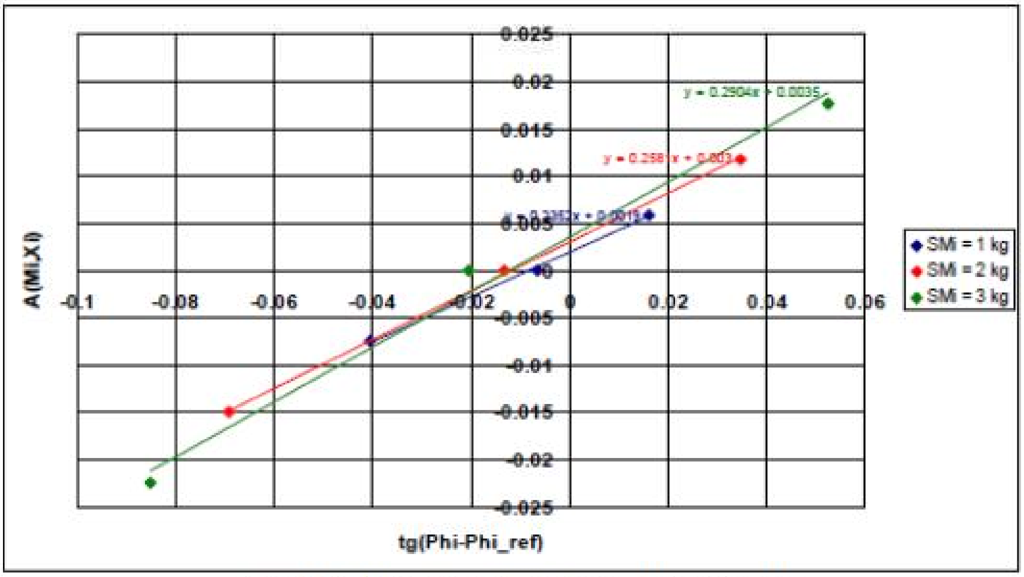

Figure A4-4 : Flaperon extrados émergé – Mesure de GM_T

Masses (kg)	GM_L	GM_T
1	2.264	0.235
2	2.272	0.258
3	2.336	0.290
0	2.219 (*)	0.206 (*)

(*) : Ces grandeurs correspondent à des valeurs extrapolées pour une masse nulle

De ces différentes mesures, il est également possible de déterminer avec une précision satisfaisante la position du centre de flottaison exprimée dans le repère du fichier IGES fourni par DGA Techniques hydrodynamiques :

Configuration flaperon	x (mm)	y (mm)
Intrados émergé	1385	485
Extrados émergé	1085	396

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Pièce N°2

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Annexe 5 : Représentation CAO de la flottaison intrados émergé

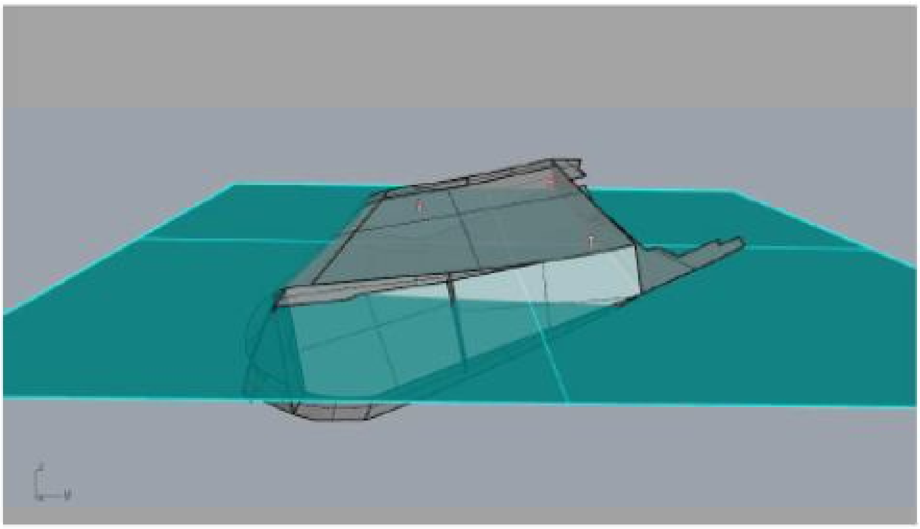

Figure A5-1

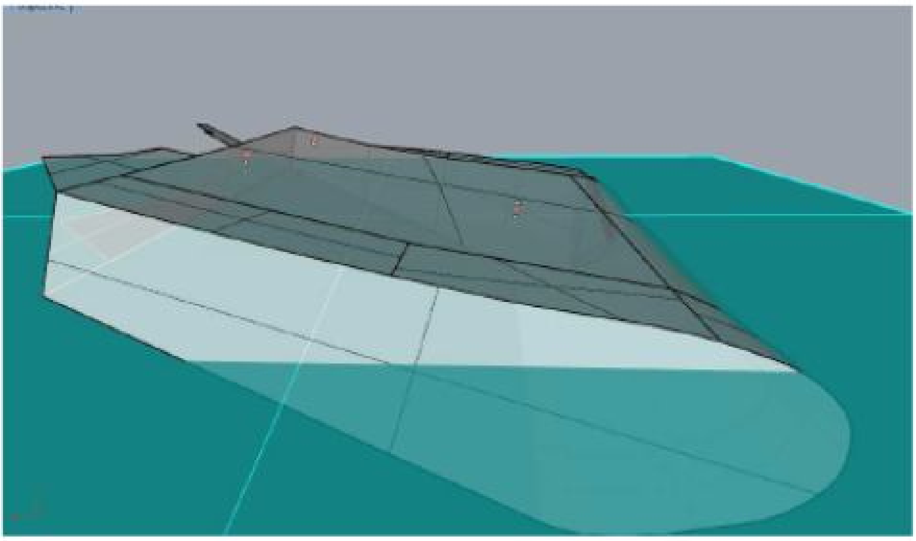

Figure A5-2

DIFFUSION RESTREINTE

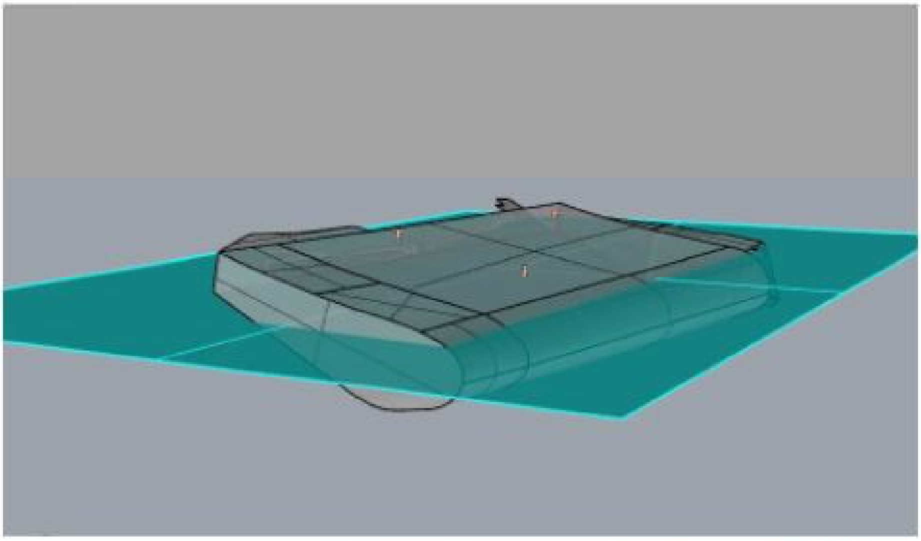

Figure A5-3

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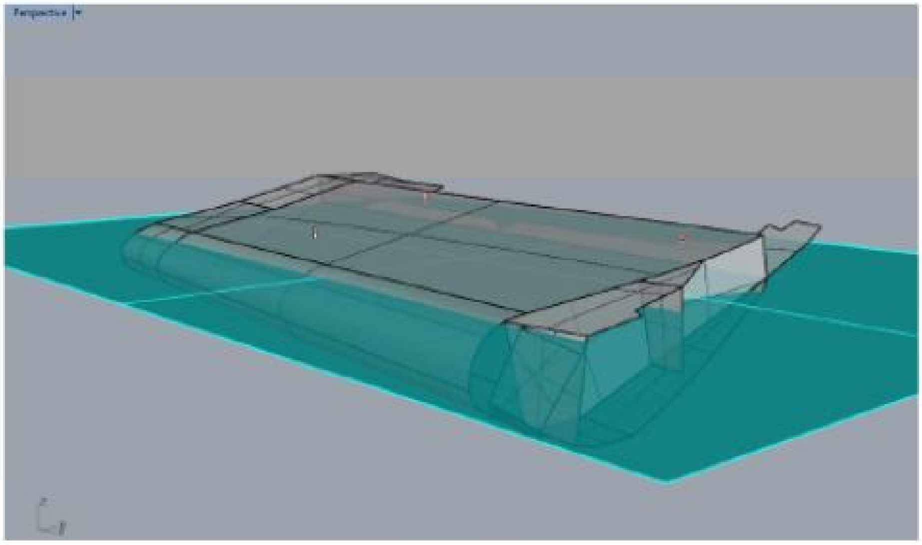


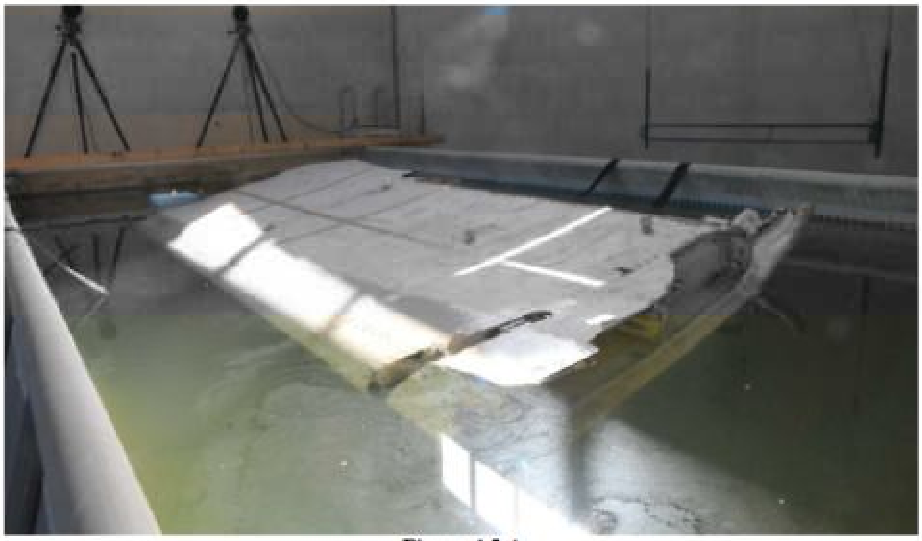


Figure A5-4

DIFFUSION RESTREINTE

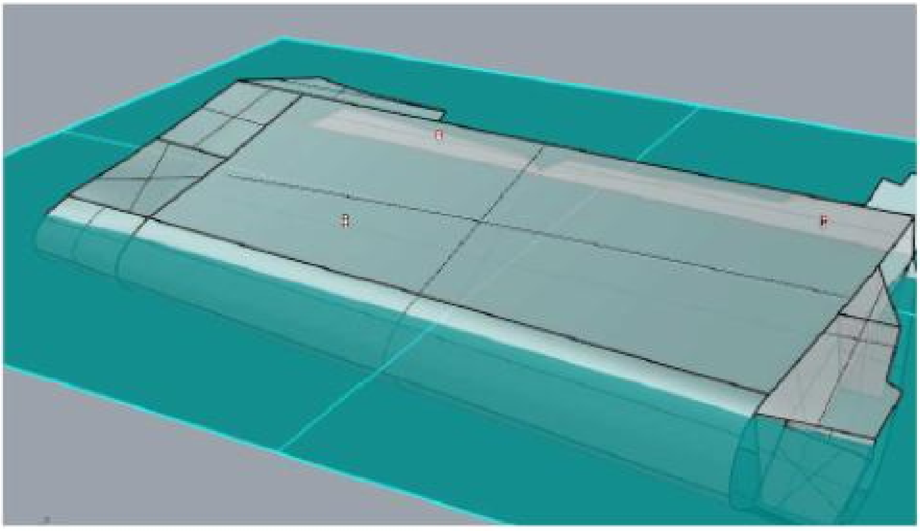
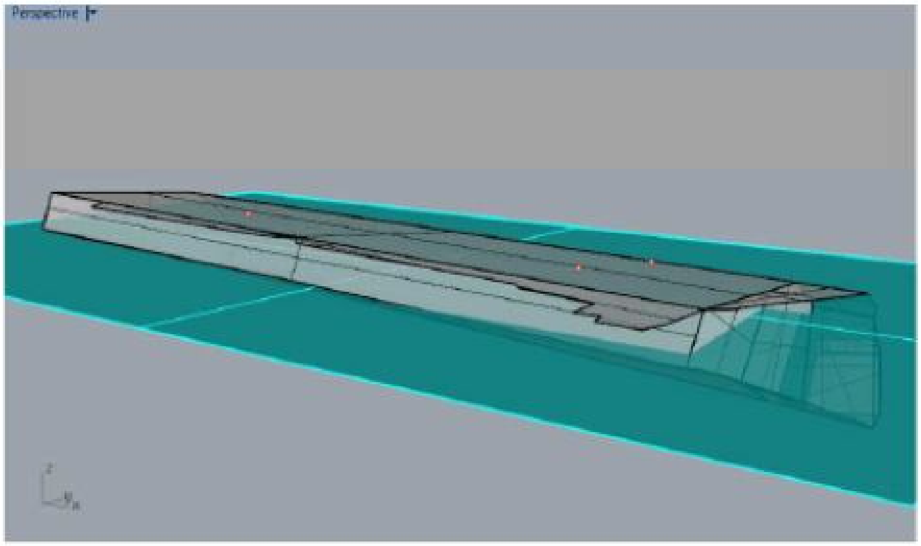


Figure A5-5

Annexe 6 : Représentation CAO de la flottaison extrados émergé



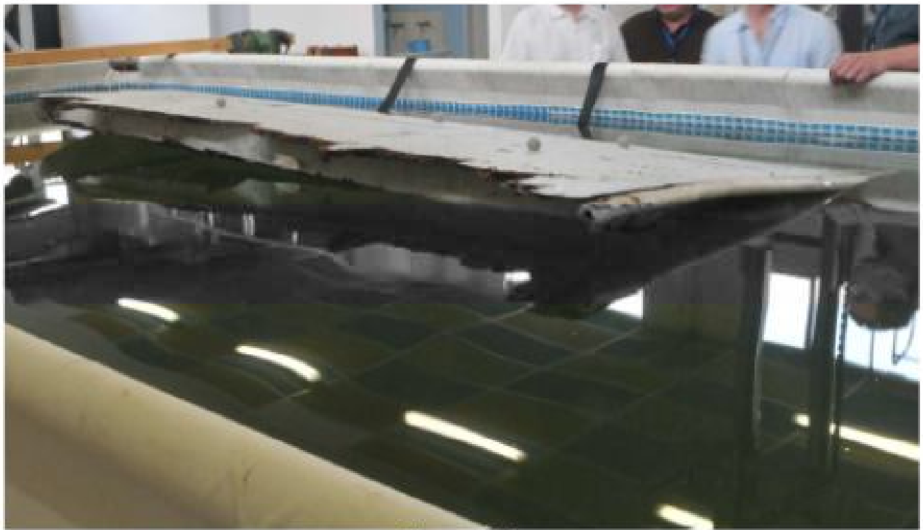


Figure A6-1

DIFFUSION RESTREINTE

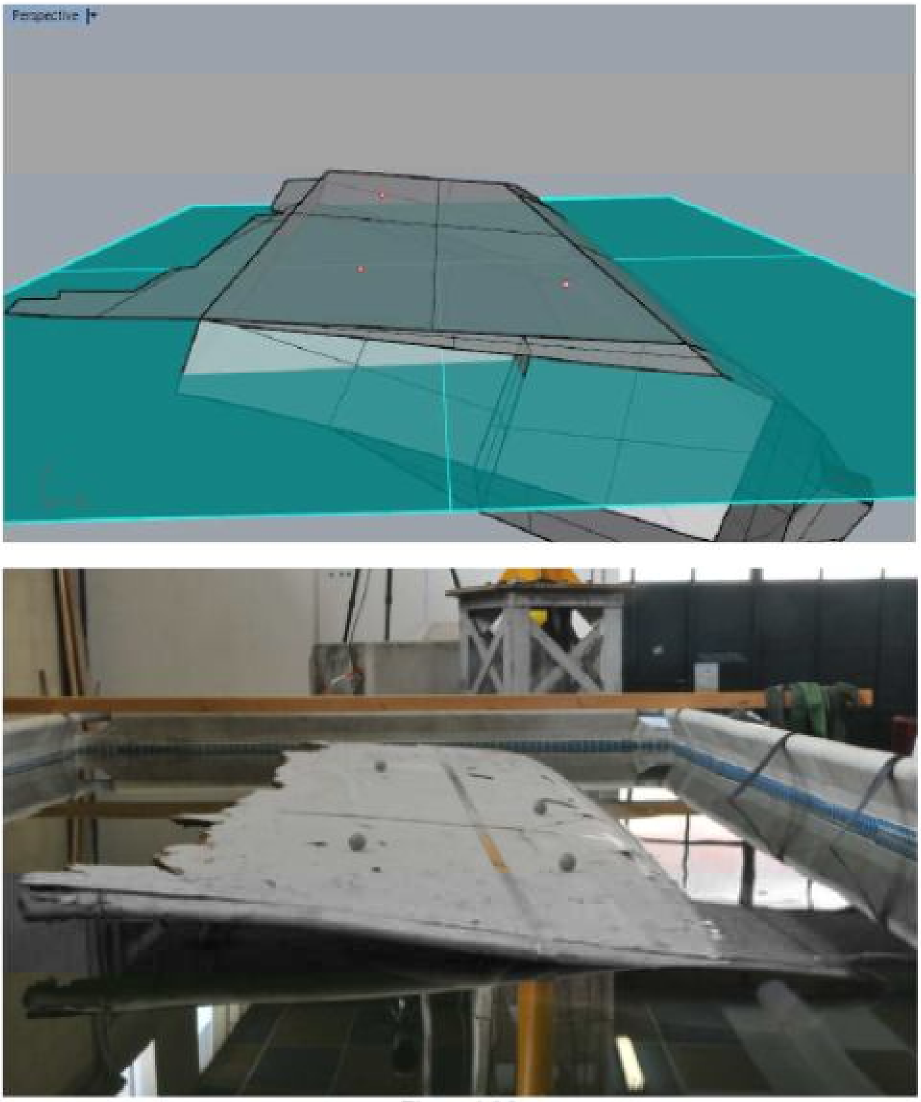


Figure A6-2

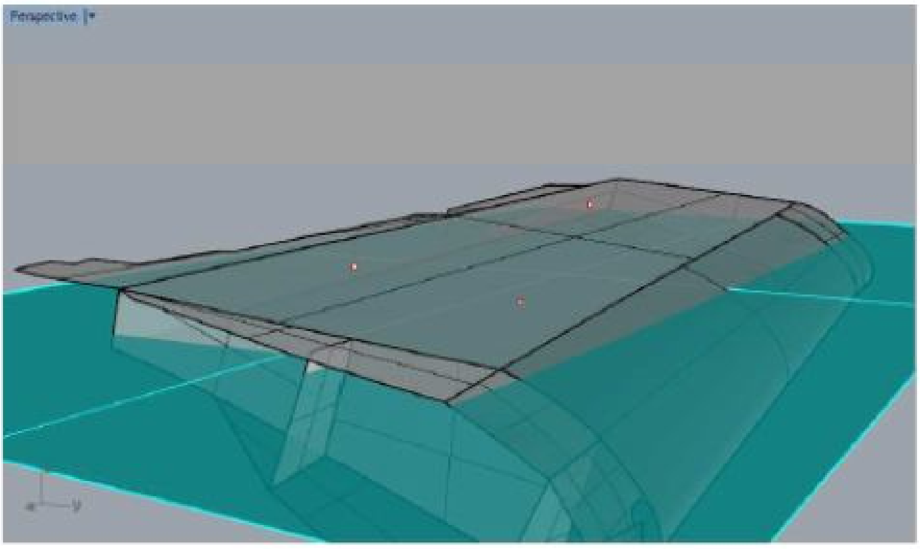


Figure A6-3

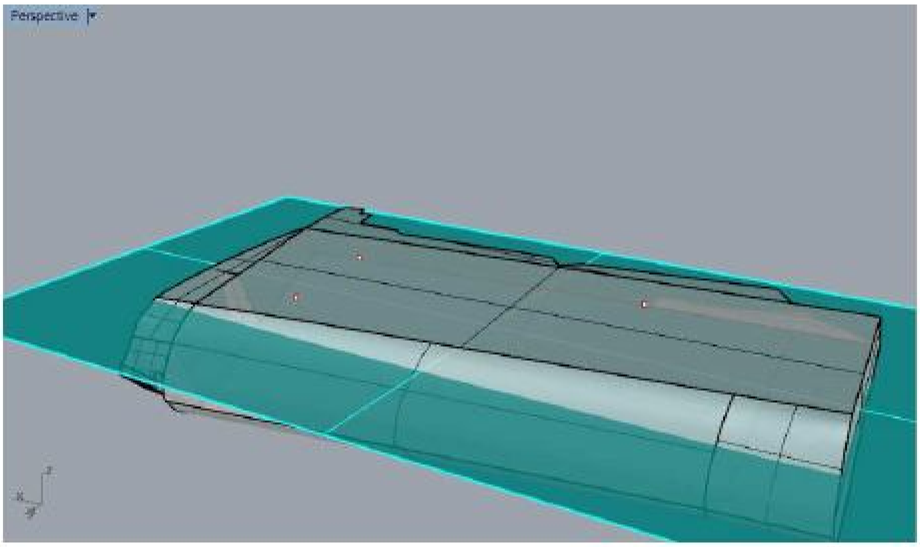


Figure A6-4

Annexe 9 : **Report DGA TH E11374 part 3 – Calculation of the coefficients of dérive**

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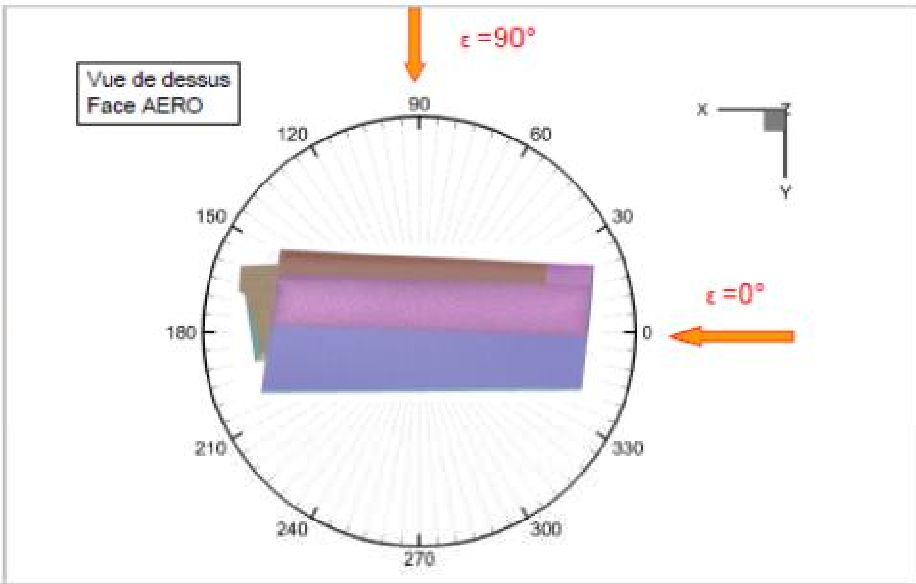

E 11374
ESSAI DE FLOTTABILITE POUR DGA TA

PIECE N° 3
SIMULATIONS DE POLAIRES AERODYNAMIQUES ET HYDRODYNAMIQUES (LOT 2)

Enregistrement : N°16-500560 DT/DGA TH/SDT/UP_PERF du 01/04/2016

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AFFAIRE N°E11374
Pièce N°3

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

Type de rapport

☒Rapport final	☐ Rapport intermédiaire	☐Rapport provisoire

Indice du rapport

Version	Date	Description des pages modifiées ET justification de la modification	Auteur
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AFFAIRE N°E11374
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DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

Résumé

Par l'intermédiaire de DGA Techniques aéronautiques, et dans le cadre d'une expertise judiciaire menée à la demande du Tribunal de grande instance de Paris, DGA Techniques hydrodynamiques a apporté son concours à la caractérisation de l'élément de flaperon trouvé en juillet 2015 à la Réunion. Une seconde étude, objet du présent rapport, est destinée à réaliser des simulations de trainées aérodynamiques et hydrodynamiques de l'élément pour différents gisements et d'en préciser les caractéristiques de trainée.

Les calculs réalisés dans cette étude définissent les polaires aérodynamiques et hydrodynamiques de l'élément de flaperon. Exploités dans un modèle d'évolution temporel, ces résultats permettent d'évaluer les situations d'équilibre et d'estimer les paramètres qui y sont associés.
Sous l'action d'un vent constant et suivant la situation initiale, il peut exister 2 positions s'équilibre stable de dérive pour l'élément : bord de fuite ou bord d'attaque face au vent. L'angle de dérive prend les valeurs de 18° ou 32° à gauche selon le cas avec des vitesses de dérive respectivement égales à 3.29 et 2.76% de la vitesse du vent incident. Les valeurs de ces angles et des rapports de vitesses sont indépendantes de la vitesse du vent.

Type de clients :	DGA (code 1800)
Famille de navires :	Sans Objet
Domaine :	Résistance – propulsion Tenue à la mer
Moyen :	Numérique
Programme :	
Mots clés :	**CFD, flaperon**

AFFAIRE N°E11374
Pièce N°3

DIFFUSION RESTREINTE

DGA Techniques hydrodynamiques

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1 Objet du rapport

Par l'intermédiaire de DGA Techniques aéronautiques, et dans le cadre d'une expertise judiciaire menée à la demande du Tribunal de grande instance de Paris, DGA Techniques hydrodynamiques a apporté son concours à la caractérisation de l'élément de flaperon trouvé en juillet 2015 à la Réunion. Cette étude est destinée à réaliser des simulations de traînées aérodynamiques et hydrodynamiques de l'élément pour différents gisements et d'en préciser les caractéristiques de traînée.

2 Données d'entrée

2.1 Documents à appliquer et de référence

R[1] E11374 Essai de flottabilité pour DGA TA pièce n°1 Compte-rendu des essais d'Août 2015

R[2] E11374 Essai de flottabilité pour DGA TA pièce n°2 Hydrostatique

2.2 Géométrie

La géométrie initiale du flaperon est représentée sur la Figure 1.

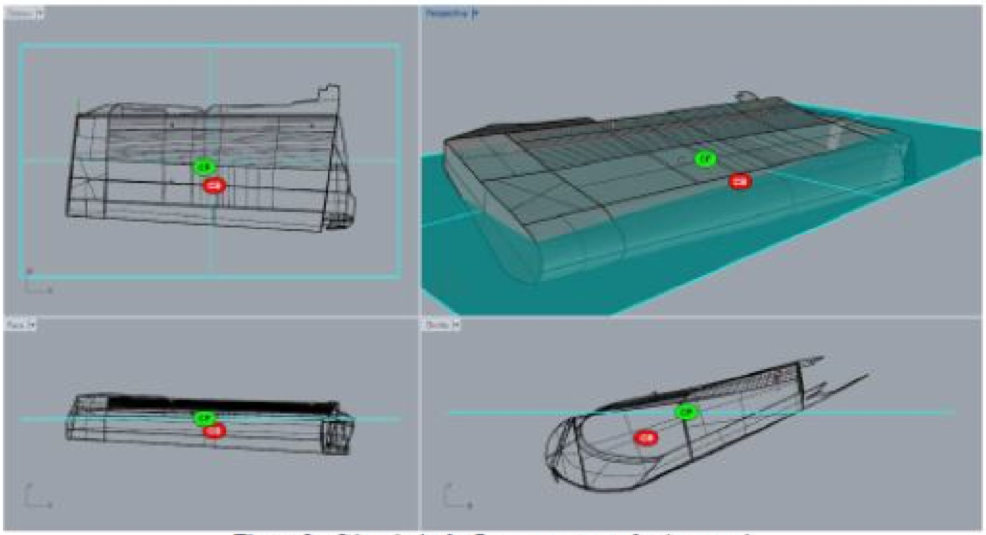

Figure 1 - Géométrie du flaperon – extrados immergé

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2.3 Caractéristiques de la flottaison

Les essais de flottabilité (Lot 1) décrit en R[1-2] ont permis de déterminer les caractéristiques de l'élément en surface pour les configurations intrados immergé et extrados immergé.

La présente étude (Lot 2) se limite à la configuration « extrados immergé », considérée comme étant celle qui a prédominé lors de la dérive de l'objet.

On donne ci-dessous les principales caractéristiques de flottaison de cette configuration (R[2]).

			Extrados immergé
Masse	m	kg	39.7
Déplacement de forme	∇	m^3	0.25690
Position du centre de volume de forme	x_B	m^3	1.14300
	y_B	m	0.59300
	z_B	m	0.15200
Surface latéale projetée des oeuvres vives	A_{LS}	m²	0.5590
Surface frontale projetée des oeuvres vives	A_{XS}	m²	0.1750
Surface latéale projetée des oeuvres mortes	A_{LE}	m²	0.367
Surface frontale projetée des oeuvres mortes	A_{XE}	m²	0.085
Tirant d'eau maximum	T_s	m	0.299
Surface de flottaison effective	A_W	m²	0.1310
Hauteur métacentrique transversale relative au déplacement de forme	GM_{Tf}	m	0.0760

Figure 2 - Caractéristiques utiles de flottaison de la configuration "extrados immergé" (R[2])

3 Calculs

3.1 Maillages

Afin d'être en mesure de réaliser des calculs, la géométrie de l'objet définie à partir de relevés photogramétriques décrits en R[2] a été légèrement modifiée (Figure 3) : les plans fins en extrémité de profil ont été supprimés. Ils ne représentent qu'une surface très faible par rapport à l'élément complet et sont difficilement modélisable numériquement de façon satisfaisante.

Les différents plans minces en côté de profil (Figure 3) ont été joints par des surfaces pour former un volume fermé.

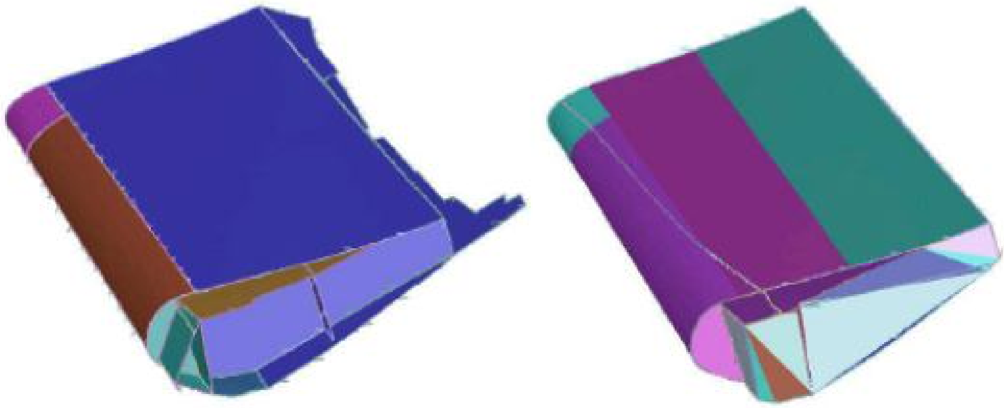

Figure 3 - Modifications de la géométrie du flaperon

Le plan de flottaison est placé selon les résultats des essais (R[2]).

Deux maillages ont été réalisés grâce au mailleur Fluent Meshing version 16 :

- L'un pour les calculs aérodynamiques.
- L'autre pour les calculs hydrodynamiques.

Les domaines de calcul sont parallélépipédiques de dimension 40m*40m*20m, 20m étant la distance dans la direction Z perpendiculaire à la surface libre (Figure 4).

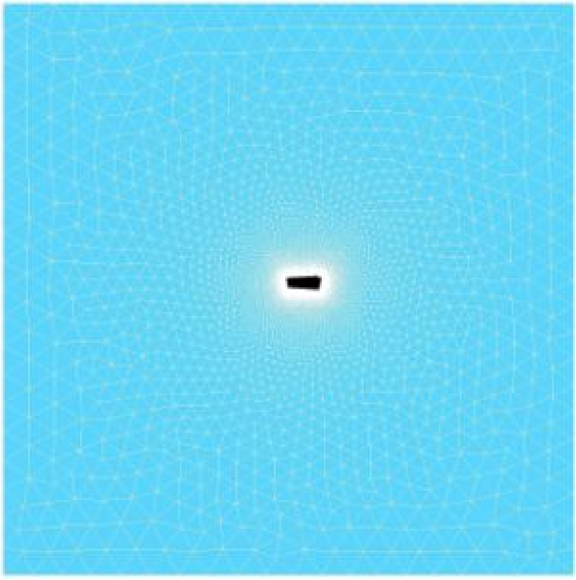

Figure 4 - Domaine de calcul

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Les tailles de mailles surfaciques sur l'objet sont comprises entre 1mm et 8mm.

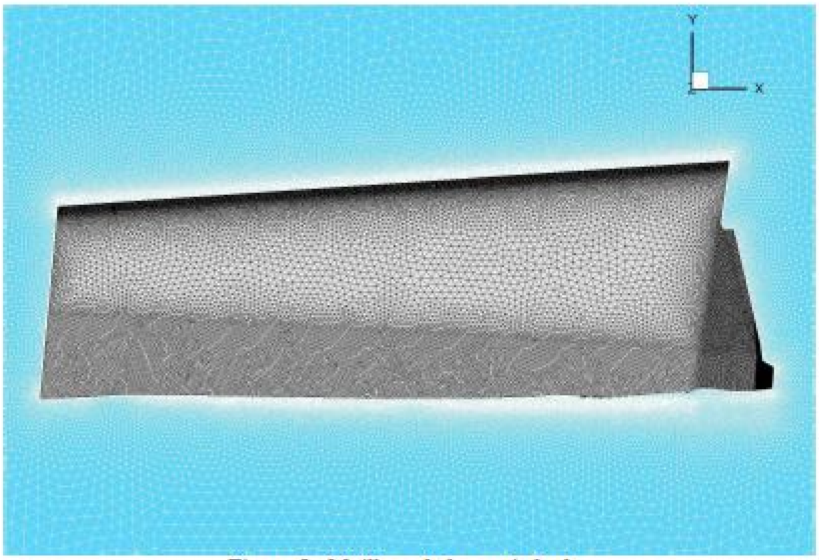


Figure 5 - Maillage de la partie hydro

Les couches limites sont modélisées par 6 couches de cellules prismatiques.

3.2 Conditions de calcul

3.2.1 Conditions limites

La surface libre est représentée par une condition de type symétrie. Les autres bordures extérieures du domaine sont de type « Velocity Inlet », ce qui correspond à une vitesse d'écoulement.

3.2.2 Conditions numériques

Toutes les simulations ont été réalisées à l'aide du solveur RANS Fluent version 13, capable de prendre en compte les deux fluides en présence (air et eau). Le modèle de turbulence k-ε RNG combiné à une loi de paroi de type « Enhanced Wall treatment » est utilisé.

3.2.3 Caractéristiques des fluides

Le fluide *hydrodynamique* est de l'eau de mer aux caractéristiques suivantes :

$\rho = 1026 \quad kg.m^{-3}$

$\mu = 1.5\,10^{-3} \quad kg.m^{-1}.s^{-1}$

Le fluide *aérodynamique* est de l'air aux caractéristiques suivantes :

$\rho = 1.225 \quad kg.m^{-3}$

$\mu = 0.0000156 \quad kg.m^{-1}.s^{-1}$

3.3 Cas de calculs

3.3.1 Définition des angles des polaires

La définition des angles de gisement est représentée sur la Figure 6 pour les calculs aérodynamiques et sur la Figure 7 pour les calculs hydrodynamiques.

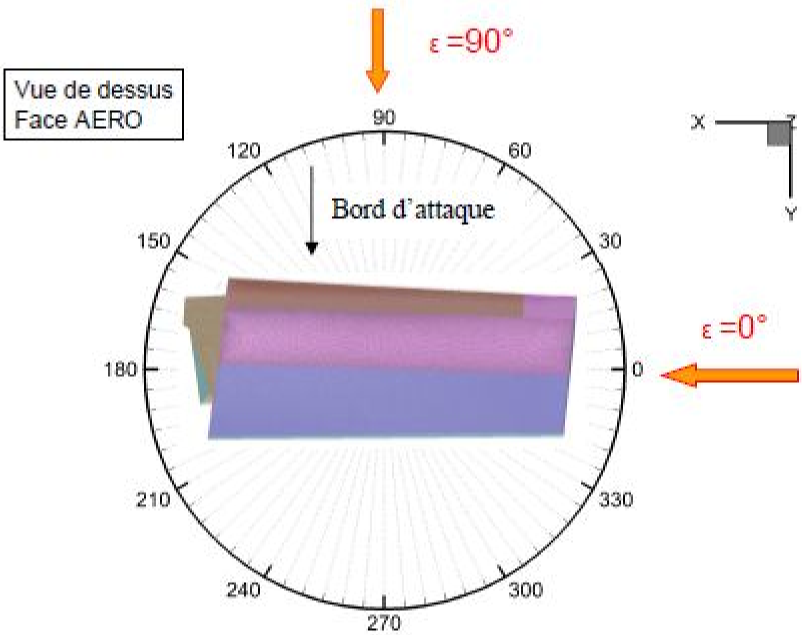


Figure 6 - Orientation de la polaire - côté AERO

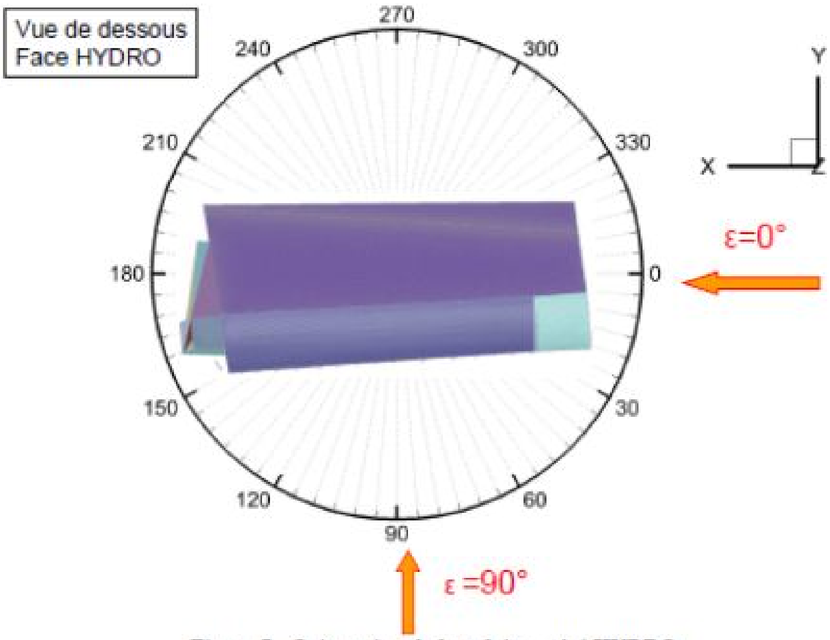


Figure 7 - Orientation de la polaire - côté HYDRO

3.3.2 Calculs aérodynamiques

Les calculs aérodynamiques ont été réalisés avec un vent supposé constant de 10m/s pour des gisements de 0° à 360° par pas de 30°.
Des calculs complémentaires ont été réalisés aux gisements de vent incident de 0° et 60° et pour des vitesses de 5, 15 et 20m/s afin de vérifier la sensibilité des coefficients au nombre de Reynolds.

3.3.3 Calculs hydrodynamiques

La vitesse d'écoulement considérée pour établir la polaire d'efforts hydrodynamiques a été estimée en s'appuyant sur les résultats des calculs aérodynamiques. Pour une vitesse de vent constant de 10m/s avec un gisement de 90° jugé proche de l'équilibre probable et en admettant que les coefficients aérodynamiques et hydrodynamiques sont du même ordre de grandeur, on obtient une vitesse de courant constante en moyenne de 0.24m/s.
Comme pour les calculs aérodynamiques, l'influence du nombre de Reynolds sur les coefficients hydrodynamiques est évaluée par des calculs complémentaires pour des gisements de 0, 60 et 270° et des vitesses de 0.1, 0.3, 0.5, 0.7 et 0.9m/s.

4 Résultats

Les résultats sont exprimés sous formes de coefficients d'efforts C_X, C_Y, C_Z et de moments C_L, C_M et C_N définis par :

$$C_{X,Y,Z} = \frac{F_{x,y,z}}{\frac{1}{2}\rho A_{ref} V^2} \qquad C_{L,M,N} = \frac{M_{X,Y,Z}}{\frac{1}{2}\rho A_{ref} L_{ref} V^2}$$

Où :

- F est l'effort suivant l'axe considéré en N
- M est le moment suivant l'axe considéré autour du centre de volume de forme en N.m
- ρ est la masse volumique du milieu considéré en $kg.m^{-3}$
- A_{ref} une surface de référence en m^2
    - A_{ref} =0.085m² pour l'aéro
    - A_{ref} =0.175m² pour l'hydro
- Lref est une longueur de référence : L_{ref} =2.38m
- V est la vitesse d'écoulement en m/s

4.1 Calculs aérodynamiques

4.1.1 Polaires

On donne dans le tableau ci-dessous les coefficients d'efforts et les coefficients de moments aérodynamiques pour chaque gisement calculé.

Vitesse m/s	Gisement °	Cx -	Cy -	Cz -	Cl -	Cm -	Cn -
10	0	0.78167	-0.03950	2.19328	0.12758	0.82423	-0.04971
10	30	0.67301	0.79458	1.28501	0.12462	0.28039	-0.22866
10	60	0.34634	1.54653	-0.59574	-0.05463	-0.31267	-0.34664
10	90	-0.27981	1.78787	-1.46909	-0.07878	-0.11454	-0.07275
10	120	-0.78700	1.55735	-0.95117	-0.02879	0.19342	0.15263
10	150	-0.47794	1.30169	0.51497	0.10900	-0.00483	0.17546
10	180	-0.49893	0.08758	1.33308	0.12074	-0.32596	0.05243
10	210	-0.49577	-1.77664	5.51933	0.97211	-0.16109	0.02081
10	240	0.06899	-4.65881	12.80746	1.87036	0.24664	0.05986
10	270	0.28884	-4.79033	11.16598	1.38681	-0.08705	0.12536
10	300	0.41509	-4.78351	14.09135	1.94367	1.44793	0.45962
10	330	0.98827	-1.98243	7.13601	1.16976	1.25386	0.21016

Figure 8 - Polaires aérodynamiques

Ces coefficients sont tracés sur les Figure 9 et Figure 10.

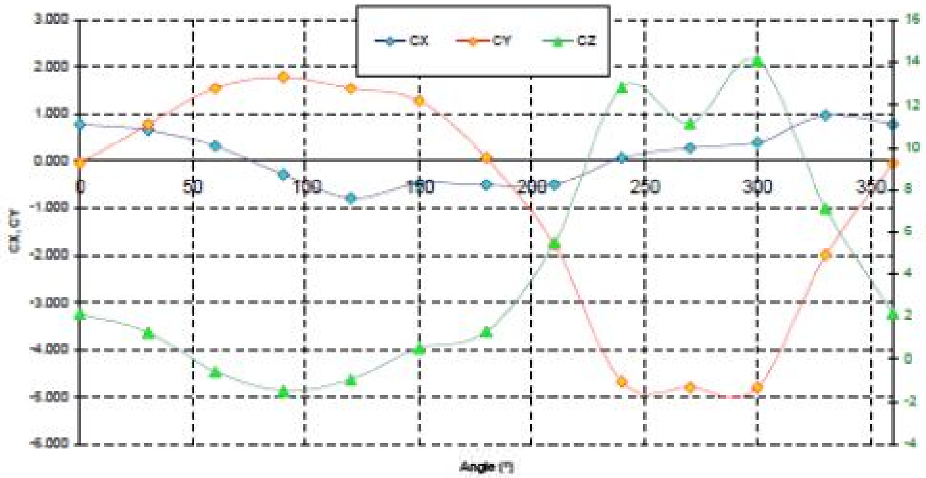


Figure 9 - Polaire de coefficients d'efforts aérodynamiques

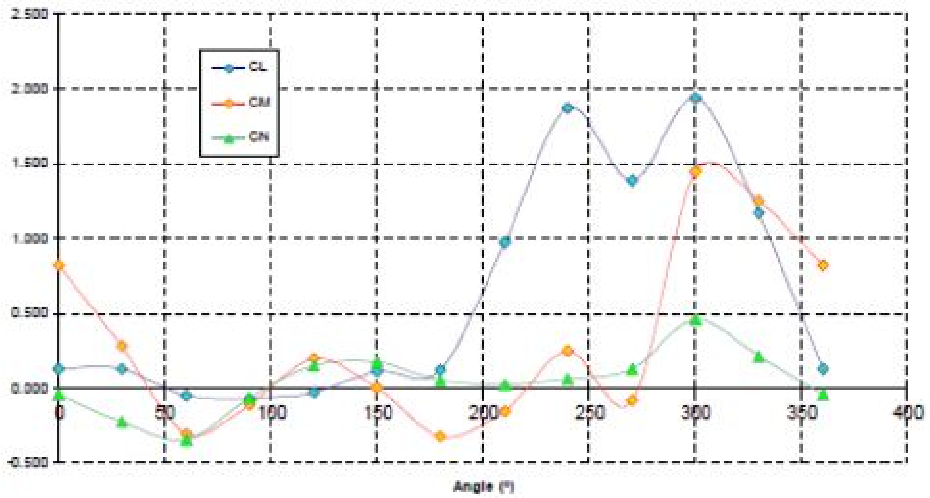


Figure 10 - Polaire de coefficients de moments aérodynamiques

4.1.2 Effets du Reynolds

Le tableau ci-dessous résume les résultats obtenus avec différentes vitesses de vent.

Vitesse m/s	Gisement °	Cx -	Cy -	Cz -	Cl -	Cm -	Cn -
5	0	0.79325	-0.03001	2.29325	0.13928	0.86173	-0.04607
10	0	0.78167	-0.03950	2.19328	0.12758	0.82423	-0.04971
15	0	0.78167	-0.03950	2.19328	0.12758	0.82423	-0.04971
20	0	0.77027	-0.02496	2.21584	0.13285	0.82701	-0.04430
5	60	0.33669	1.56245	-0.62283	-0.05829	-0.29631	-0.34227
10	60	0.34634	1.54653	-0.59574	-0.05463	-0.31267	-0.34664
15	60	0.34582	1.54115	-0.56631	-0.05071	-0.32400	-0.34545
20	60	0.33996	1.53676	-0.55949	-0.04960	-0.32285	-0.34363

Figure 11 - Sensibilité au Reynolds

Pour le cas 0°, correspondant à un écoulement parallèle à l'axe X, on note des variations de C_X inférieures à 3% et de CN inférieures à 8%. Pour le cas 60°, C_X et C_Y ne varient pas de plus de 3%, 2% pour C_N. Dans tous les cas, et dans cette plage de vitesse, les efforts aérodynamiques sont très peu sensibles au nombre de Reynolds.

4.2 Calculs hydrodynamiques

4.2.1 Polaires

Les simulations hydrodynamiques ont été réalisées avec une vitesse de courant constante de 0.24m/s.

Contrairement aux calculs aérodynamiques, les calculs hydrodynamiques font apparaitre des situations pour lesquelles les écoulements sont fortement décollés (Figure 12) conduisant à des fluctuations des efforts. Les calculs ont été réalisés en stationnaires et en instationnaires afin de mieux préciser les valeurs moyennes d'efforts.
Les écarts observés sur les efforts selon les deux approches sont faibles à l'exception du gisement de 150° qui fait apparaître des écarts sensibles sur les coefficients de moment, essentiellement en C_M (Figure 13 et Figure 14).

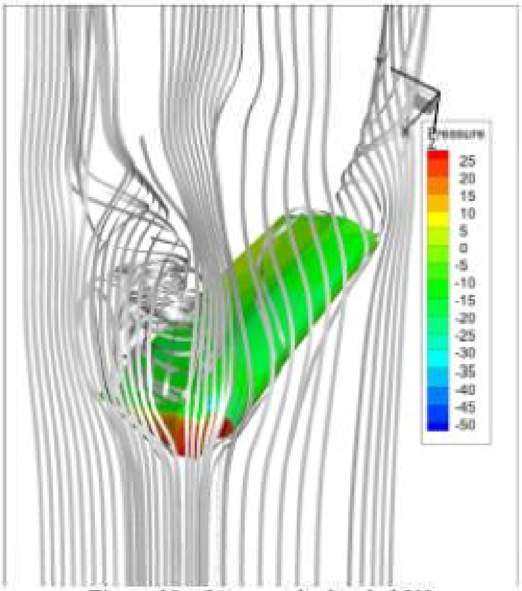


Figure 12 - Gisement hydro de 150°

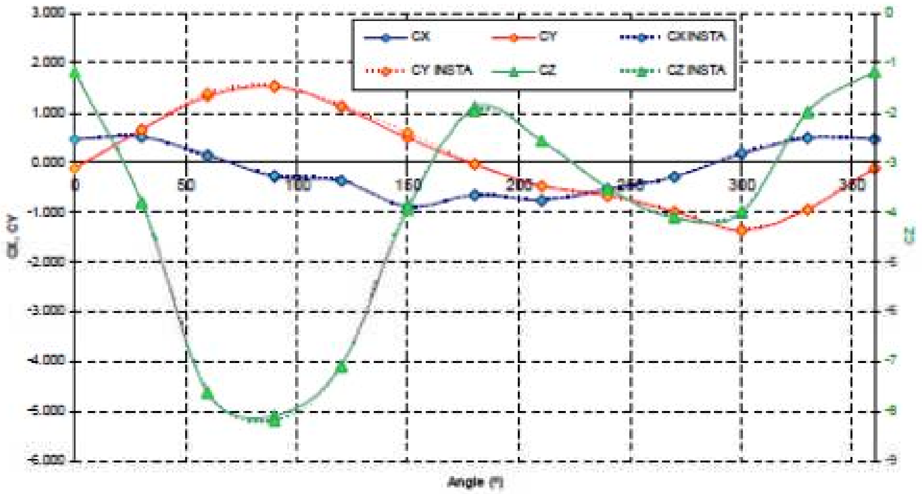


Figure 13- Polaire de coefficients d'efforts hydrodynamiques

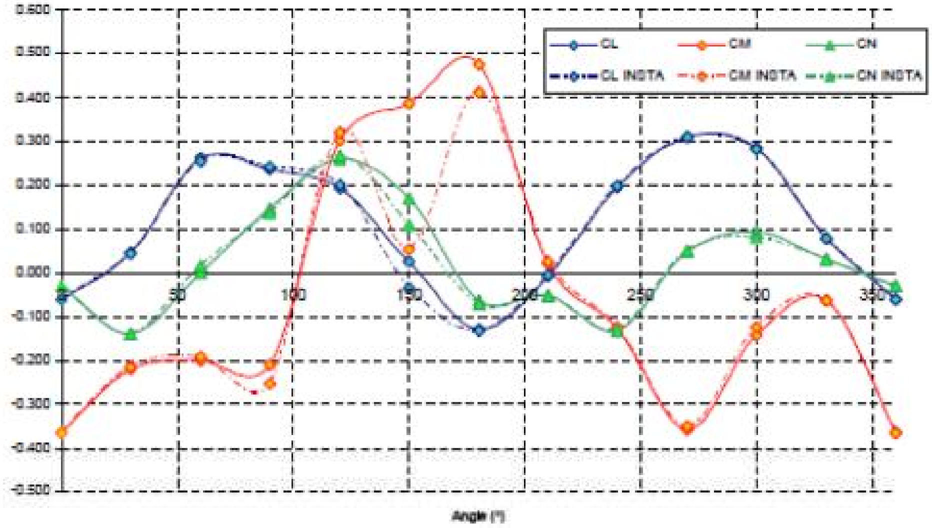


Figure 14 - Polaire de coefficients de moments hydrodynamiques

On retient finalement les valeurs issues des calculs instationnaires, obtenues par la moyenne des efforts calculés aux cours des 100 derniers pas de temps. Le tableau ci-dessous synthétise les résultats sous forme de coefficients. On rappelle que la surface de référence pour exprimer les coefficients hydrodynamiques vaut A_{ref} =0.175m².

Vitesse m/s	Gisement °	Cx -	Cy -	Cz -	Cl -	Cm -	Cn -
0.24	0	0.46195	-0.11746	-1.17047	-0.06060	-0.36546	-0.03018
0.24	30	0.51725	0.67207	-3.81007	0.04423	-0.21517	-0.13872
0.24	60	0.13169	1.37995	-7.62025	0.25470	-0.19269	0.01633
0.24	90	-0.26310	1.53001	-8.20153	0.24235	-0.25245	0.13808
0.24	120	-0.37786	1.13483	-7.11900	0.20071	0.32051	0.26783
0.24	150	-0.91893	0.59084	-3.87954	-0.03459	0.05702	0.10981
0.24	180	-0.65367	-0.03278	-1.96814	-0.13230	0.41156	-0.07154
0.24	210	-0.75599	-0.47812	-2.57085	-0.00574	0.02597	-0.05381
0.24	240	-0.53416	-0.67662	-3.54173	0.19818	-0.12505	-0.12861
0.24	270	-0.28096	-0.98818	-4.10078	0.31051	-0.35039	0.05049
0.24	300	0.18118	-1.35523	-3.96668	0.28278	-0.12457	0.08183
0.24	330	0.49376	-0.94583	-1.99084	0.07996	-0.06201	0.03188

Figure 15 - Polaires hydrodynamiques instationnaires (valeurs moyennes)

4.2.2 Effets du Reynolds

Pour le gisement de 270°, les Figure 16, Figure 17 et Figure 18 représentent les coefficients d'efforts et de moments selon les 3 degrés de liberté. On observe que les coefficients calculés dépensent sensiblement de la vitesse et donc du nombre de Reynolds.
Il faut en revanche constater que cette dépendance est modérée sur la plage 0.24 à 0.5m/s, avec des variations n'excédant pas les 2% sur C_Y et C_N, et 7% sur C_X.

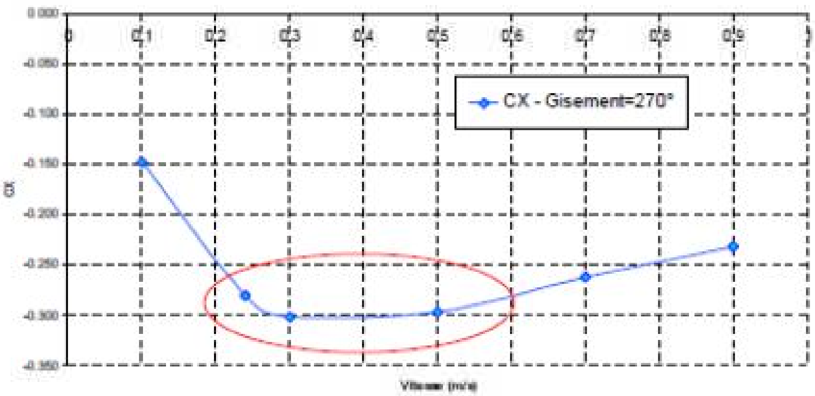


Figure 16 - Effets du Reynolds - Gisement = 270° - CX

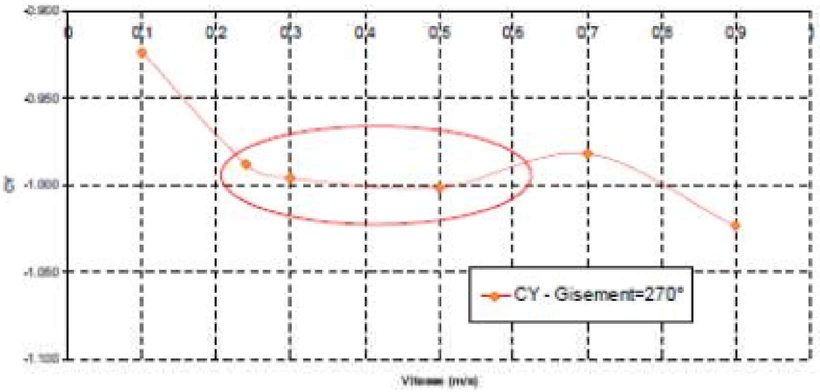


Figure 17- Effets du Reynolds - Gisement = 270° - CY

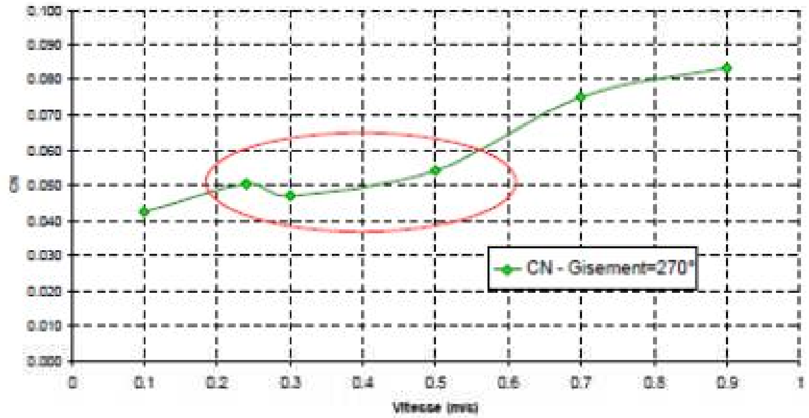


Figure 18- Effets du Reynolds - Gisement = 270° - CN

On donne dans le tableau ci-dessous les coefficients pour chaque vitesse évaluée.

Vitesse m/s	Gisement °	Cx -	Cy -	Cz -	Cl -	Cm -	Cn -
0.1	0	0.48434	-0.12600	-1.12685	-0.06068	-0.33789	-0.03219
0.24	0	0.46613	-0.11898	-1.17656	-0.06153	-0.36357	-0.03122
0.3	0	0.46512	-0.13740	-1.18107	-0.06272	-0.36889	-0.03715
0.5	0	0.46645	-0.13837	-1.16450	-0.05862	-0.37753	-0.03797
0.7	0	0.44529	-0.09513	-1.16129	-0.05763	-0.37380	-0.02070
0.9	0	0.44572	-0.09722	-1.18445	-0.05922	-0.37443	-0.02243
0.1	60	0.06821	1.28456	-7.31784	0.28916	-0.25525	-0.02689
0.24	60	0.15230	1.33288	-7.63038	0.26182	-0.20051	0.00170
0.3	60	0.11544	1.37418	-7.70725	0.24579	-0.18316	0.01484
0.5	60	-0.00246	1.41643	-7.68726	0.22064	-0.22029	0.01954
0.7	60	0.05265	1.43128	-7.69395	0.21007	-0.22184	0.02694
0.9	60	-0.00688	1.49489	-7.84412	0.19803	-0.19516	0.04032
0.1	270	-0.14766	-0.92387	-3.88591	0.30446	-0.28179	0.04250
0.24	270	-0.28096	-0.98818	-4.10078	0.31051	-0.35039	0.05049
0.3	270	-0.30194	-0.99557	-4.17387	0.31341	-0.36414	0.04710
0.5	270	-0.29716	-1.00165	-4.15789	0.31206	-0.35617	0.05411
0.7	270	-0.26235	-0.98187	-3.97791	0.30606	-0.37132	0.07508
0.9	270	-0.23206	-1.02347	-3.65986	0.29177	-0.40639	0.08345

Figure 19 - Effets du Reynolds - hydro

4.3 Dérive de l'objet sous chargement aérodynamique et hydrodynamique

Afin d'évaluer les conditions de dérive de l'élément de flaperon soumis à différentes vitesses de vent, un modèle d'évolution temporelle à 3degrés de liberté (X, Y et N) a été utilisé.
Lors de ces simulations, on admet que la vitesse de dérive est toujours très inférieure à la vitesse du vent, si bien que l'on peut confondre vent réel et vent apparent.

L'ensemble de ce modèle est détaillé en Annexe 1.

On rappelle dans le tableau ci-dessous les résultats en termes de coefficients aérodynamiques et hydrodynamiques. L'angle ε est le gisement par rapport au repère de l'objet.

	AERO			HYDRO		
Angle ε °	C_{XA} (ε) -	C_{YA} (ε) -	C_{NA} (ε) -	C_{XH} (ε) -	C_{YH} (ε) -	C_{NH} (ε) -
0	0.78167	-0.03950	-0.04971	0.46195	-0.11746	-0.03018
30	0.67301	0.79458	-0.22866	0.51725	0.67207	-0.13872
60	0.34634	1.54653	-0.34664	0.13169	1.37995	0.01633
90	-0.27981	1.78787	-0.07275	-0.26310	1.53001	0.13808
120	-0.78700	1.55735	0.15263	-0.37786	1.13483	0.26783
150	-0.47794	1.30169	0.17546	-0.91821	0.59009	0.10891
180	-0.49893	0.08758	0.05243	-0.65367	-0.03278	-0.07154
210	-0.49577	-1.77664	0.02081	-0.75599	-0.47812	-0.05381
240	0.06899	-4.65881	0.05986	-0.53416	-0.67662	-0.12861
270	0.28884	-4.79033	0.12536	-0.28096	-0.98818	0.05049
300	0.41509	-4.78351	0.45962	0.18118	-1.35523	0.08183
330	0.98827	-1.98243	0.21016	0.49376	-0.94583	0.03188

Figure 20- Résumé des simulations

4.3.1 Trajectoire de l'élément pour un vent constant de 10m/s

Pour une vitesse de vent constante de 10m/s, les simulations temporelles ont permis de mettre en évidence 2 situations d'équilibres entre efforts aérodynamiques et hydrodynamiques dépendant de la situation initiale.

Notons β l'angle entre le vecteur vitesse de l'objet et le vecteur vitesse du vent.

Pour un cap initial appartenant à [-3°, -172°], les simulations tendent vers la situation n°1 (Figure 21) , bord de fuite face au vent, caractérisée par :

- dérive δ=+126°
- vitesse u=-0.193 m/s
- vitesse v=-0.266 m/s
- soit une vitesse de V=0.33m/s
- cap de ψ=+144°
- un angle de dérive par rapport au vent de β =18° vers la gauche

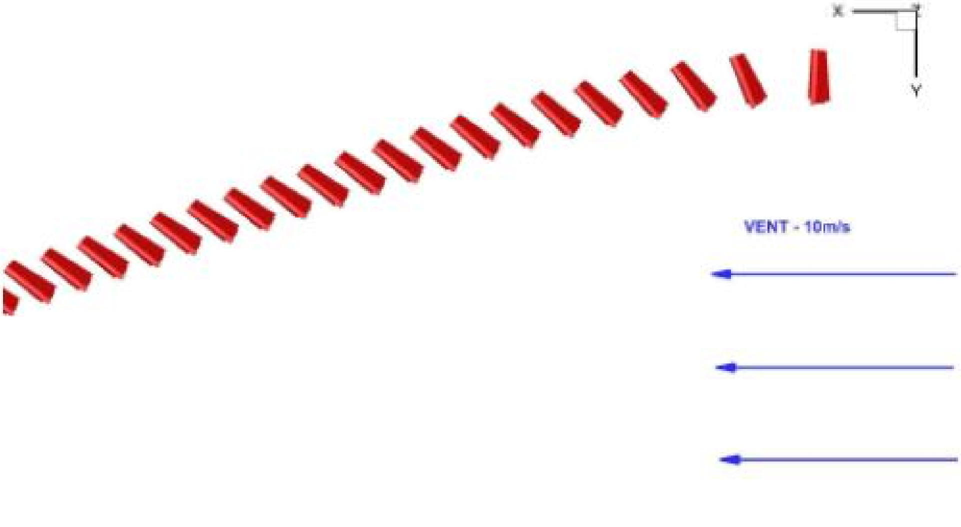


Figure 21 - Trajectoire flaperon - Vent à 10m/s – Situation d'équilibre n°1

Dans les autres cas, les simulations tendent vers la situation n°2 (Figure 22), bord d'attaque face au vent, caractérisée par:

- dérive δ=-118°
- vitesse u=-0.131 m/s
- vitesse v=+0.243 m/s
- soit une vitesse de V=0.27m/s
- cap de ψ=-86°
- un angle de dérive par rapport au vent de β=32° vers la gauche

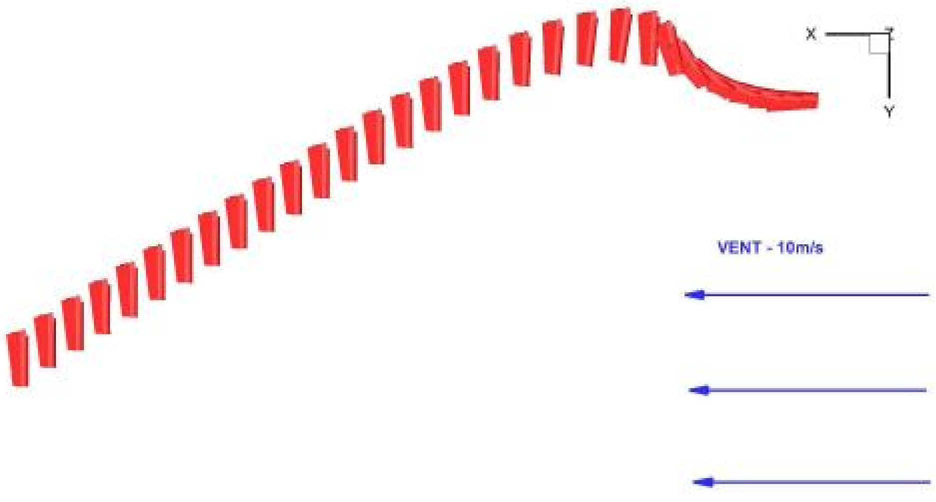


Figure 22 - Trajectoire flaperon - Vent à 10m/s - Situation d'équilibre n°2

4.3.2 Influence de la vitesse du vent

Les simulations d'équilibre ont été reprises pour différentes vitesses de vent (5, 15 et 20m/s). Les 2 situations de dérive sont retrouvées indépendamment de la vitesse du vent. Le tableau ci-dessous indique les valeurs de vitesse de dérive obtenue pour différentes vitesses de vent.

	Equilibre 1		Equilibre 2	
Vitesse m/s	Dérive / vent °	Vitesse dérive m/s	Dérive / vent °	Vitesse dérive m/s
5	18	0.164	32	0.138
10	18	0.32900	32	0.276
15	18	0.49300	32	0.414
20	18	0.658	32	0.552

Figure 23 - Influence de la vitesse du vent sur la dérive

On vérifie que la vitesse relative de l'eau à 0.24m/s retenue est cohérente des vitesses effectivement obtenues. Pour des vitesses de vent comprises entre 5 et 20m/s, les vitesses de dérive par rapport à l'eau restent dans une plage pour laquelle la sensibilité des coefficients au nombre de Reynolds reste modérée (paragraphe 4.1.2).

DIFFUSION RESTREINTE

Compte tenu de la modélisation, la vitesse de dérive est, en régime permanent, une fonction linéaire de la vitesse du vent illustrée sur la Figure 24.

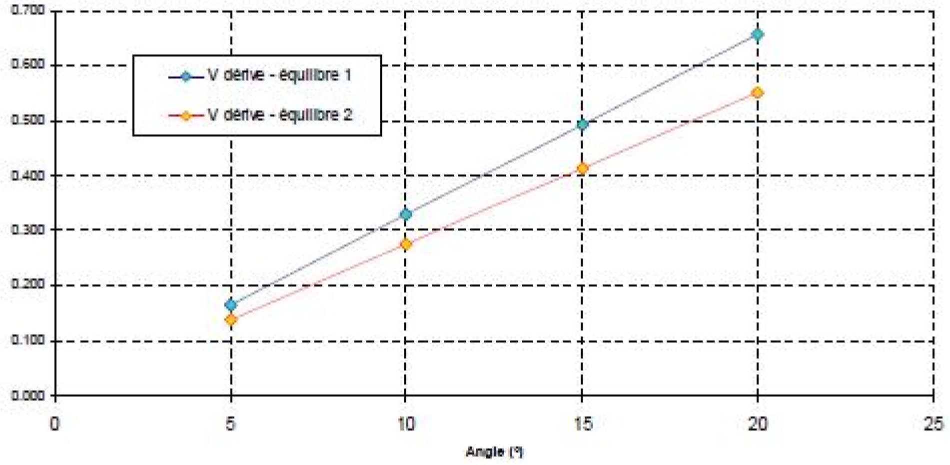


Figure 24- Influence de la vitesse du vent sur la vitesse de dérive

4.3.3 Influence des écoulements sur l'enfoncement et l'inclinaison

On donne ici les résultats en efforts Fz et moments Mx et My cumulés aérodynamiques et hydrodynamiques pour les 2 situations d'équilibres obtenues :

Situation 1 :

- Fz=-10.67 N
- Mx=15.17 N.m
- My=-4.36 N.m
-

Situation 2 :

- Fz=-28.16 N
- Mx=2.5 N.m
- My=-2.95 N.m

Les essais en R[2] ont permis de déterminer la raideur en enfoncement pour la configuration étudiée (extrados immergé), traduite par une surface de flottaison effective : $A_W = \frac{dF_Z}{g\rho dZ} = 0.131 m^2$.

On en déduit la variation d'enfoncement due à un effort Fz selon :

$$dF_z = 0.131.g\rho dZ$$

DIFFUSION RESTREINTE

Les hauteurs métacentriques ayant également été évaluées en R[2], on peut estimer l'angle de roulis induit autour de X selon :

$$\varphi = \arcsin \frac{M_X}{\rho_{eau} \nabla_f g GM_{Tf}}$$

Et l'angle de tangage autour de Y selon :

$$\theta = \arcsin \frac{M_Y}{\rho_{eau} \nabla_f g GM_{Lf}}$$

On obtient ainsi les estimations suivantes :

- Pour la situation 1 :
  - Une variation d'enfoncement de -8 mm (enfoncement de 2% du tirant d'eau)
  - Un angle de gîte de $\varphi = 4.5°$
  - Un angle de tangage de $\theta = 0.3°$
- Pour la situation 2 :
  - Une variation d'enfoncement de -2.1 cm (enfoncement de 7% du tirant d'eau)
  - Un angle de gîte de $\varphi = 0.7°$
  - Un angle de tangage de $\theta = 0.2°$

Ces modifications de comportements induits par le chargement cumulé aérodynamique et hydrodynamique dans les situations d'équilibres obtenues par simulations restent modérées.

5 Conclusion

Les calculs réalisés dans cette étude définissent les polaires aérodynamiques et hydrodynamiques de l'élément de flaperon. Exploités dans un modèle d'évolution temporel, ces résultats permettent d'évaluer les situations d'équilibre et d'estimer les paramètres qui y sont associés.
Sous l'action d'un vent constant et suivant la situation initiale, il peut exister 2 positions d'équilibre stable de dérive pour l'élément : bord de fuite ou bord d'attaque face au vent. L'angle de dérive prend les valeurs de 18° ou 32° à gauche selon le cas avec des vitesses de dérive respectivement égales à 3.29 et 2.76% de la vitesse du vent incident. Les valeurs de ces angles et des rapports de vitesses sont indépendantes de la vitesse du vent.

6 Annexe 1 : Calculs des positions d'équilibre en dérive sous l'action d'un vent constant

6.1 Principe

Les efforts aérodynamiques et hydrodynamiques ont été évalués séparément. Pour estimer les positions et les vitesses de dérive sous l'action du vent on réalise des simulations temporelles.

La dynamique du flaperon sera déterminée grâce à l'application du Principe fondamental de la dynamique au centre de volume de forme <u>**dans le repère mobile associé au flaperon**</u> (XYZ). Les 3 équations correspondantes sont données ci-dessous :

$$m(u'-rv) = \sum F_X$$
$$m(v'+ru) = \sum F_Y$$
$$I_{ZZ} r' = \sum M_Z(\nabla_f) + Kr$$

Où $\sum F_X$ est la somme des efforts sur l'axe X

$\sum F_Y$ est la somme des efforts sur l'axe Y

$\sum M_Z(\nabla_f)$ est la somme des moments autour de l'axe Z exprimée en ∇_f

K est un terme d'amortissement en lacet qui permet de stabiliser la dynamique en rotation. Il a été fixé à $K=-60\ kg.m^2.s^{-1}$

On se limite à 3 degrés de liberté : seuls les translations horizontales (X et Y) et les rotations dans le plan horizontal (autour de Z) sont libres.

6.2 Efforts et moments

On considère les efforts suivants :

1) Les efforts de masse prenant en compte l'eau incluse, c'est-à-dire que $m = \rho_{eau} \nabla_f \approx 264kg$
2) Les efforts inertiels. On estimera l'inertie Izz autour de Z en faisant l'hypothèse que l'objet est un parallélépipède de dimensions X=2.385m, Y=0.945m et Z=0.299m. Ces dimensions correspondent à l'enveloppe de la partie immergée. Ne s'intéressant qu'à la situation d'équilibre finale, Il n'est pas nécessaire d'estimer les inerties avec une grande précision. L'inertie autour de l'axe Z est donc estimée par : $I_{ZZ} = \frac{M}{12}(2.385^2 + 0.945^2) \approx 144kg.m^2$.
3) Les efforts d'amortissement en lacet, estimés arbitrairement (stabilisation).

On néglige les effets de masse ajoutées (ce qui n'est pas rigoureux mais reste acceptable car on ne s'intéresse qu'à l'équilibre stationnaire).

Les efforts et moments aérodynamiques et hydrodynamiques sont ceux obtenus par simulations.

Notons, pour un angle quelconque ε :

$C_{XA}(\varepsilon), C_{YA}(\varepsilon), C_{ZA}(\varepsilon)$ les coefficients d'efforts aérodynamiques issus de la polaire.
$C_{LA}(\varepsilon), C_{MA}(\varepsilon), C_{NA}(\varepsilon)$ les coefficients de moments aérodynamiques issus de la polaire.

$C_{XH}(\varepsilon), C_{YH}(\varepsilon), C_{ZH}(\varepsilon)$ les coefficients d'efforts hydrodynamiques issus de la polaire.
$C_{LH}(\varepsilon), C_{MH}(\varepsilon), C_{NH}(\varepsilon)$ les coefficients de moments hydrodynamiques issus de la polaire.

On rappelle dans le tableau ci-dessous les coefficients obtenus par simulation (voir paragraphe 4.3).

	AERO			HYDRO		
Angle ε °	C_{XA} (ε) -	C_{YA} (ε) -	C_{NA} (ε) -	C_{XH} (ε) -	C_{YH} (ε) -	C_{NH} (ε) -
0	0.78167	-0.03950	-0.04971	0.46195	-0.11746	-0.03018
30	0.67301	0.79458	-0.22866	0.51725	0.67207	-0.13872
60	0.34634	1.54653	-0.34664	0.13169	1.37995	0.01633
90	-0.27981	1.78787	-0.07275	-0.26310	1.53001	0.13808
120	-0.78700	1.55735	0.15263	-0.37786	1.13483	0.26783
150	-0.47794	1.30169	0.17546	-0.91821	0.59009	0.10891
180	-0.49893	0.08758	0.05243	-0.65367	-0.03278	-0.07154
210	-0.49577	-1.77664	0.02081	-0.75599	-0.47812	-0.05381
240	0.06899	-4.65881	0.05986	-0.53416	-0.67662	-0.12861
270	0.28884	-4.79033	0.12536	-0.28096	-0.98818	0.05049
300	0.41509	-4.78351	0.45962	0.18118	-1.35523	0.08183
330	0.98827	-1.98243	0.21016	0.49376	-0.94583	0.03188

Figure 25 - Résumé des simulations aéro et hydro.

Les angles seront conservés entre [0,360°] en utilisant le modulo 360. Par exemple $C_{XA}(\varepsilon)$ devient $C_{XA}(\text{mod}[\varepsilon,360])$.

<u>On définit :</u>

→ $\vec{V}$ le vecteur vitesse du flaperon
→ u la vitesse longitudinale (projection de V sur l'axe X associé au flaperon)
→ v la vitesse transversale (projection de V sur l'axe Y associé au flaperon)
→ r la vitesse de rotation autour de Z
→ ψ le cap du flaperon

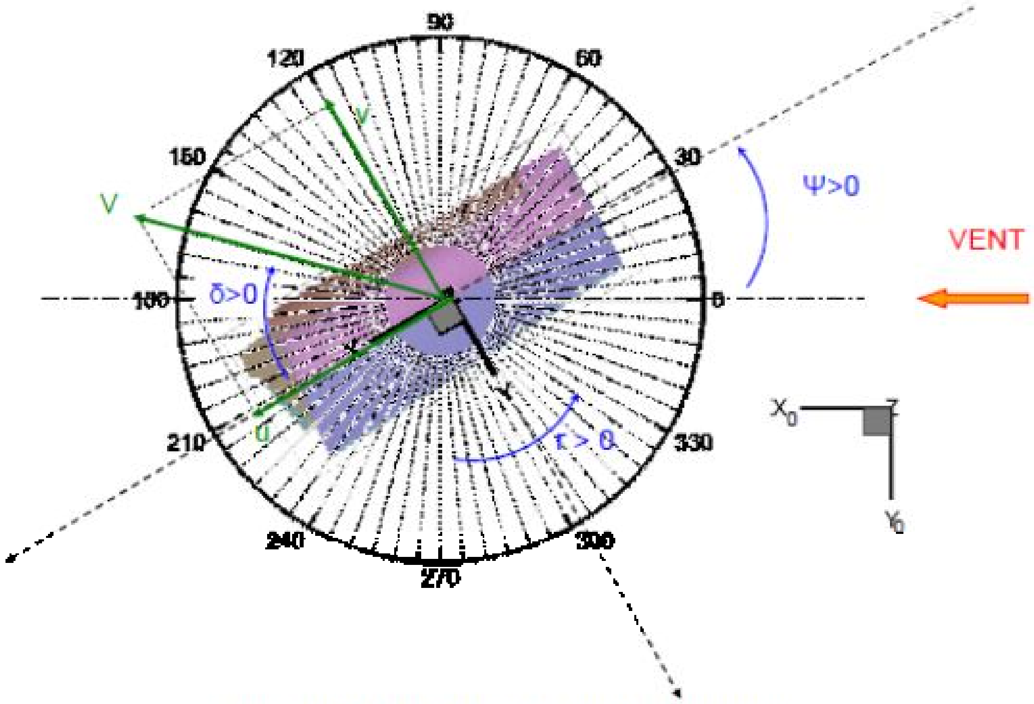


Figure 26 - Définition des repères - simulations temporelles

Les termes d'efforts et de moments aérodynamiques <u>dans le repère mobile associé au flaperon</u> seront calculés à partir du cap ψ du flaperon (voir Figure 26) :

$$F_{XA} = \frac{1}{2}\rho^{air} A^{air}_{ref} V_A^2 . C_{XA}(-\psi) \quad \text{sur X}$$

$$F_{YA} = \frac{1}{2}\rho^{air} A^{air}_{ref} V_A^2 . C_{YA}(-\psi) \quad \text{sur Y}$$

$$M_{XA} = \frac{1}{2}\rho^{air} A^{air}_{ref} L_{ref} V_A^2 . C_{LA}(-\psi) \quad \text{autour de Z}$$

« A » en indice fait référence à une composante aérodynamique
« A^{air}_{ref} » représente la surface de référence aéro
« V_A » est la vitesse du vent
« ψ » est le cap du flaperon

On fera en sorte que $-\psi$ soit toujours compris entre 0° et 360°.

Les termes d'efforts et de moments hydrodynamiques **dans le repère associé au flaperon** seront calculés à partir des polaires hydrodynamiques. On doit ici prendre en compte la dérive δ de l'objet dans l'eau.

La dérive est donnée suivant :

$$\delta = a\tan 2\left(-\frac{v}{u}\right)$$

où « atan2 » est l'arc-tangente signé qui permet de couvrir la plage [-π,+π]

Un coefficient d'effort pour une dérive δ vaut donc par exemple en X : $C_{XH}(\pi+\delta)$

Les termes d'efforts et de moments hydrodynamiques sont donc de la forme

$$F_{XH} = \frac{1}{2}\rho^{eau} A_{ref}^{eau} V^2 . C_{XH}\left[\pi - a\tan 2\left(-\frac{v}{u}\right)\right] \quad \text{sur X}$$

$$F_{YH} = \frac{1}{2}\rho^{eau} A_{ref}^{eau} V^2 C_{YH}\left[\pi - a\tan 2\left(-\frac{v}{u}\right)\right] \quad \text{sur Y}$$

$$M_{XH} = \frac{1}{2}\rho^{eau} A_{ref}^{eau} L_{ref} V^2 . C_{NH}\left[\pi - a\tan 2\left(-\frac{v}{u}\right)\right] \quad \text{autour de Z}$$

« H » en indice fait référence à une composante hydrodynamique
« A_{ref}^{eau} » représente la surface de référence hydro
« V » est la vitesse du flaperon
« ψ » est le cap du flaperon

Etant donnée la faible dépendance des coefficients de traînée au nombre de Reynolds, c'est-à-dire aux vitesses d'écoulements, les coefficients de la Figure 25 sont utilisés pour toutes les vitesses aérodynamiques et hydrodynamiques.

6.3 Simulation temporelle : cap initial $\psi_0 = 10°$ - Equilibre n°1

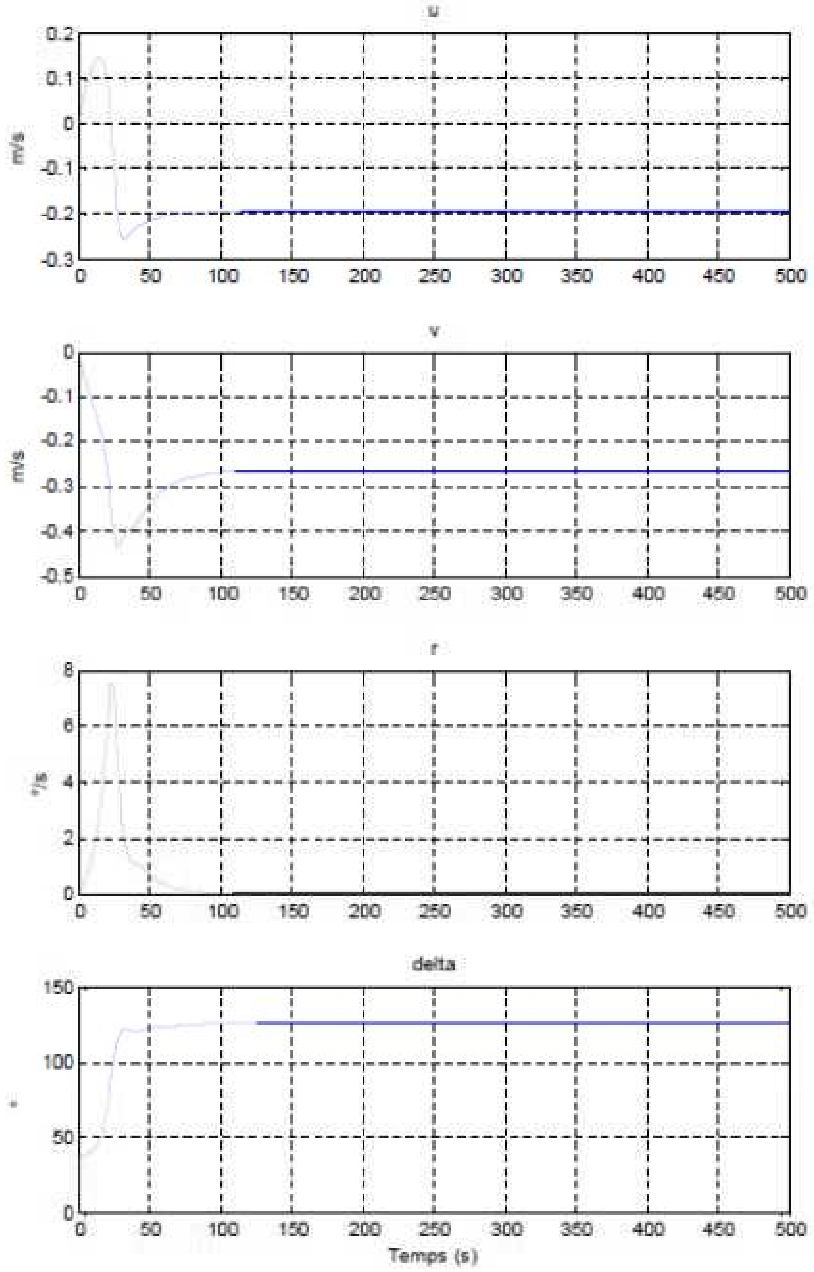


Figure 27 - Vitesses u et v – Vitesse de rotation r – Dérive δ

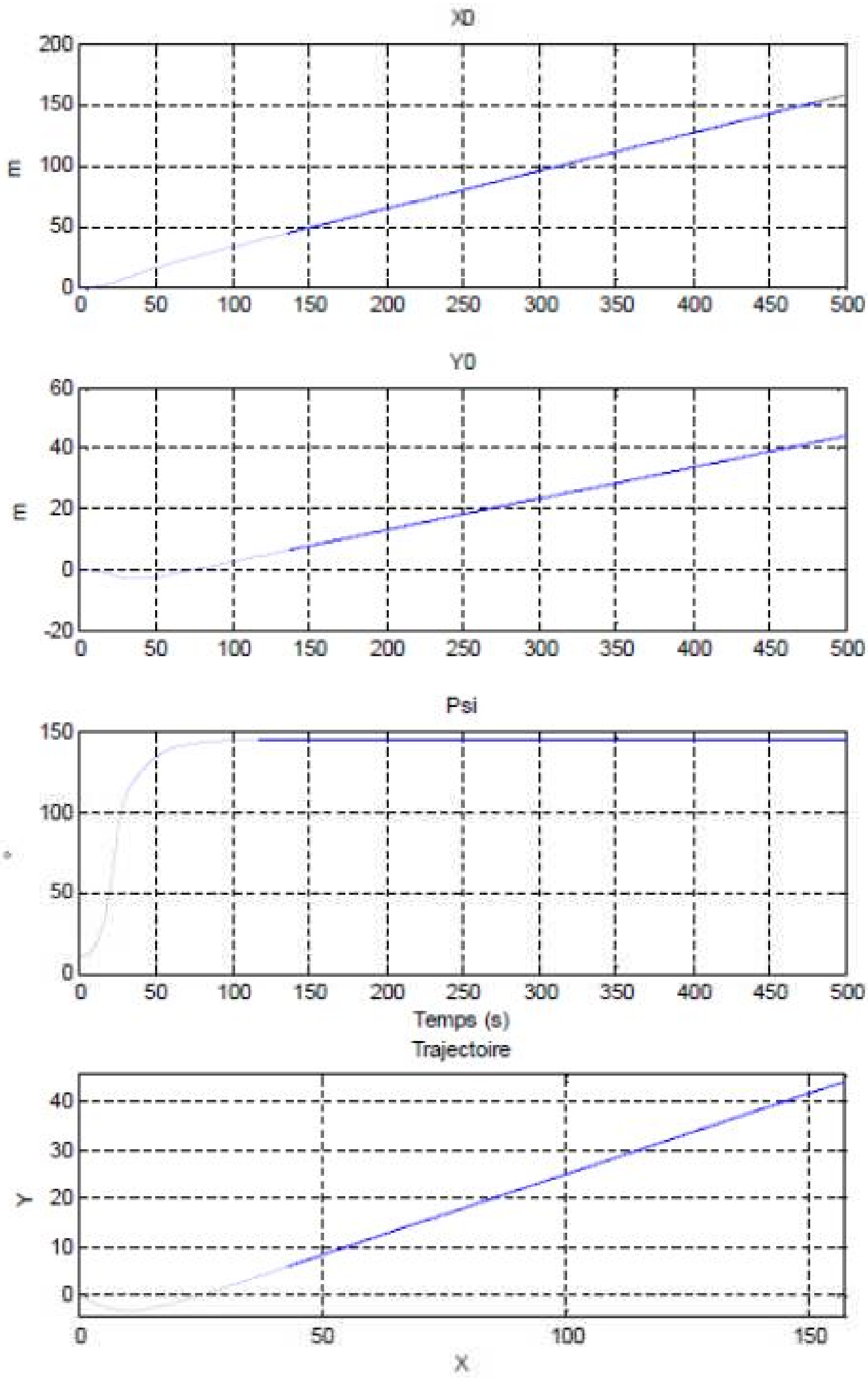


Figure 28 - Positions et cap

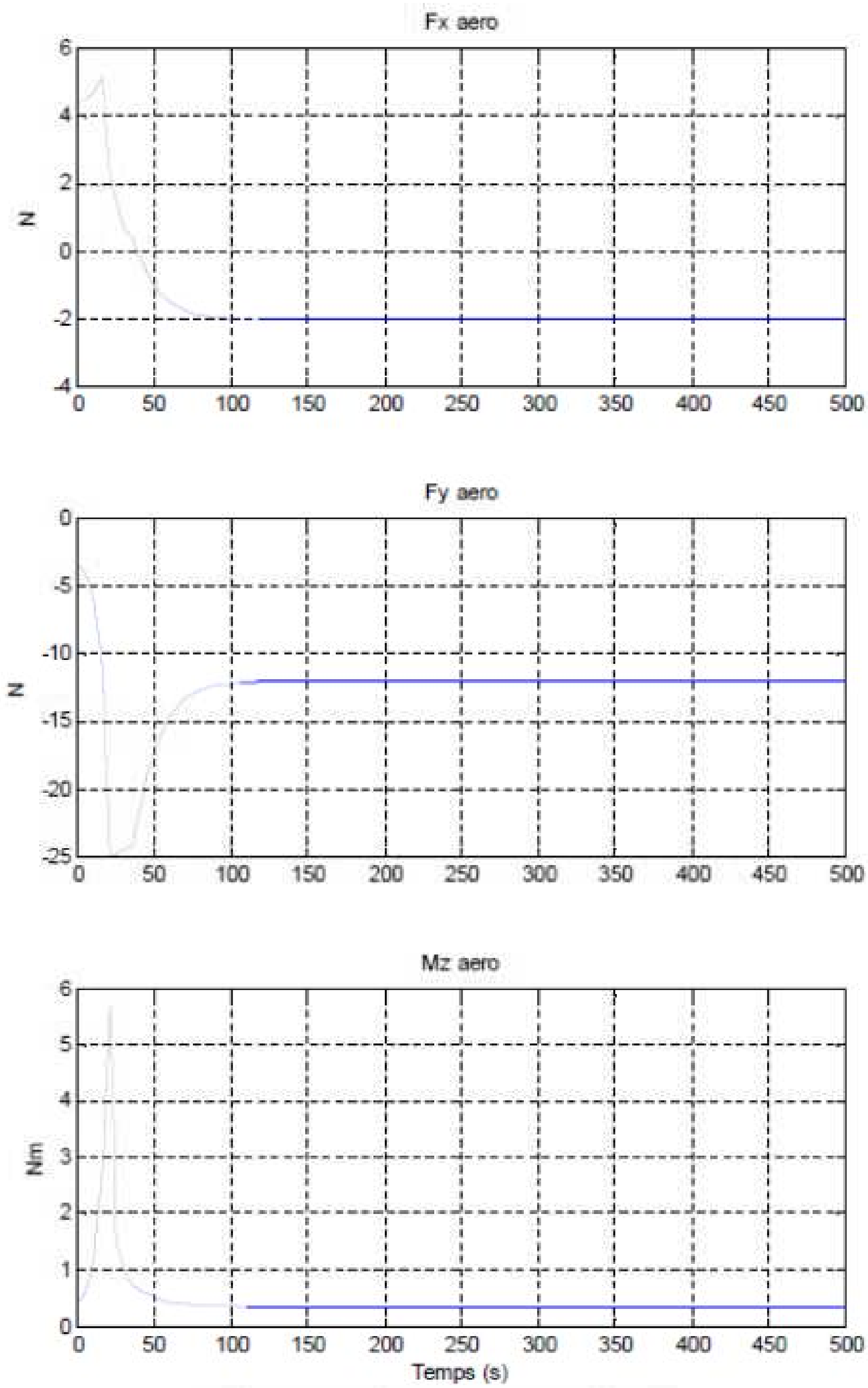


Figure 29 - Efforts et moments aérodynamiques

6.4 Simulation temporelle : cap initial $\psi_0 = 180°$ - Equilibre n°2

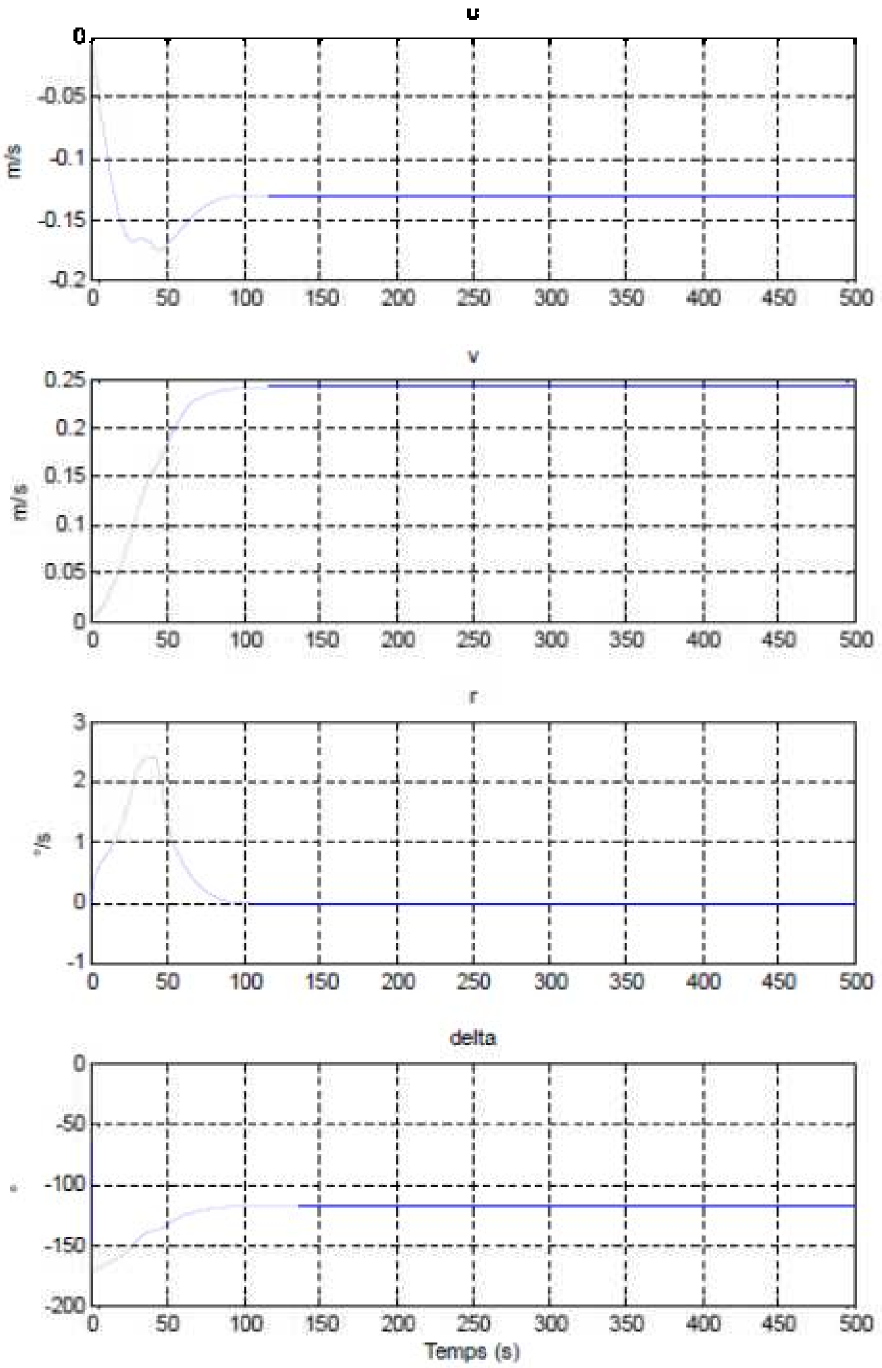


Figure 30 - Vitesses u et v – Vitesse de rotation r – Dérive δ

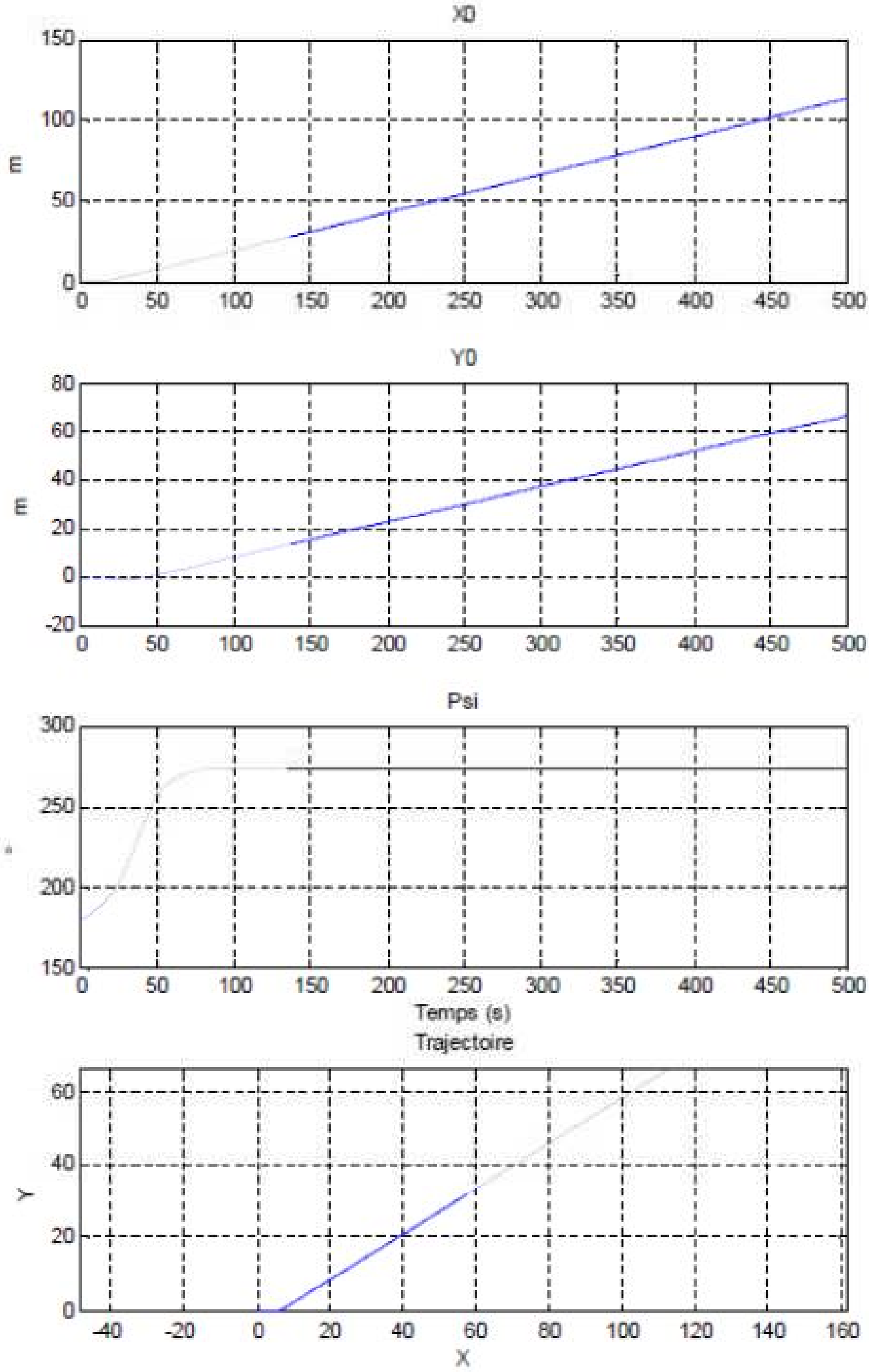


Figure 31 - Positions et cap

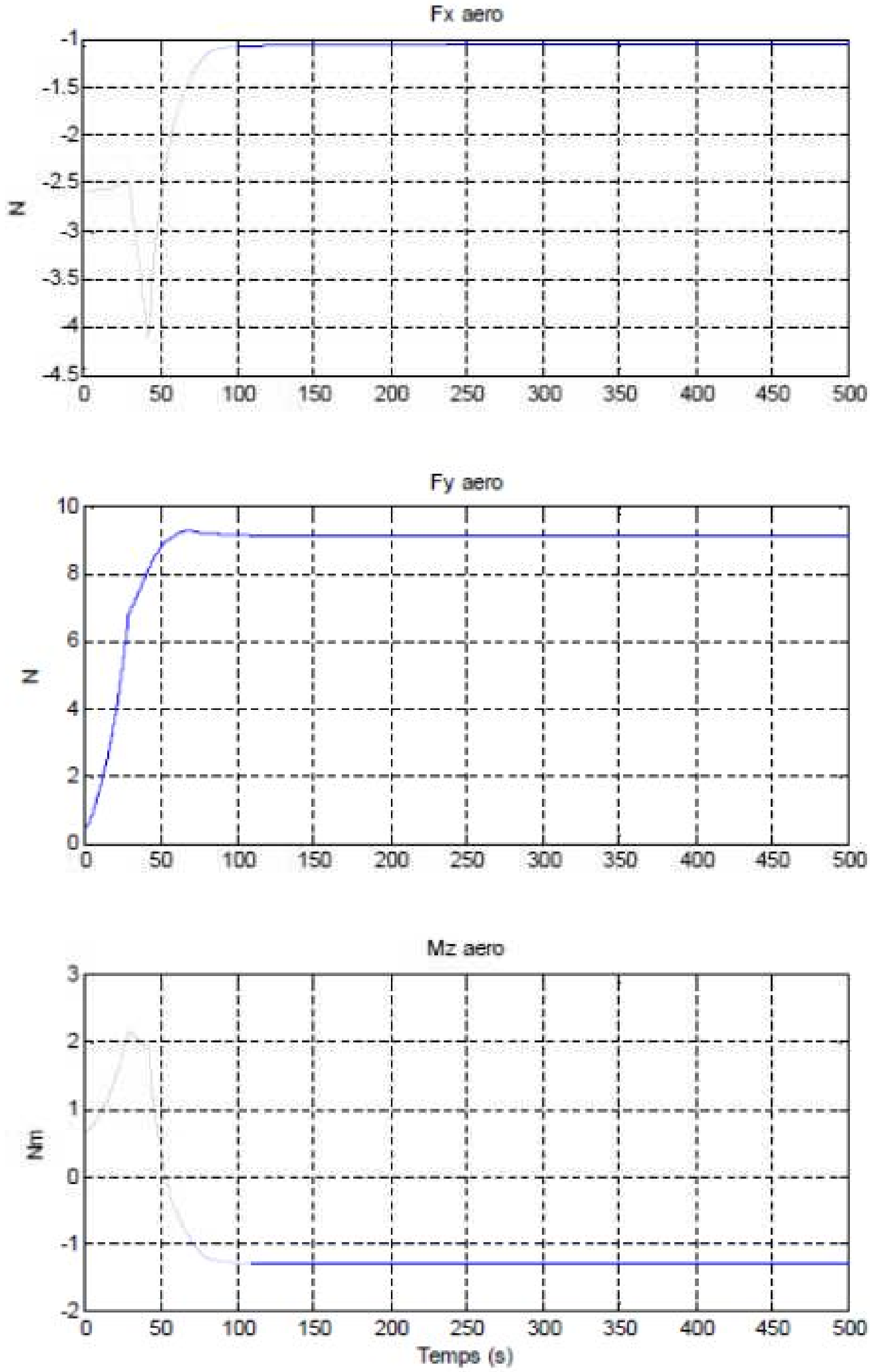


Figure 32 - Efforts et moments aérodynamiques

Annexe 10 : **Report of metrology on the two hinge fittings**

DGA Techniques Aéronautiques
Etablissement de Toulouse
Division « Ingénierie des moyens d'essai »
Section : Mesures en laboratoire
Affectation : IML

RAPPORT DE CONTROLE

N°L-71-2015

DESTINATAIRE(S) : BOTTIN **ENTITE :** MTI

CONTROLE EFFECTUE :

Mesures géométriques sur le flaperon du Boeing 777.

OPERATEURS : AZAM Patrick

DATE DU CONTROLE : 27/10/2015

DATE D'EMISSION : 04/11/2015

L'AGENT TECHNIQUE DE MESURE

Patrick AZAM

FLAPERON

1. OBJET DU CONTROLE

Deux nervures du flaperon.

2. BUT DU CONTROLE

Détecter d'éventuelles torsions sur les chapes de reprises du flaperon.

2. MOYENS UTILISES

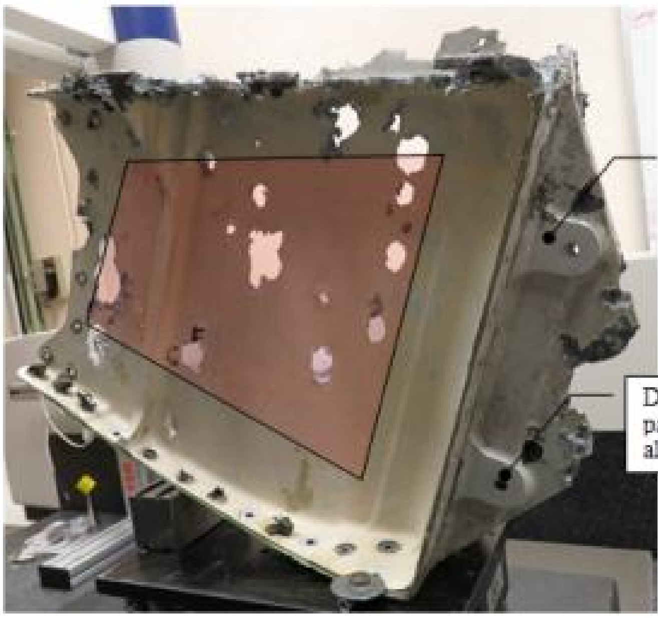
- M.M.T. Contura G2

4. INCERTITUDE DU MOYEN

U = ± 0.002 mm

5. RESULTATS

Pièce I :



Des plans ont été palpés sur les bords des chapes

Des cylindres ont été palpés dans les alésages des axes

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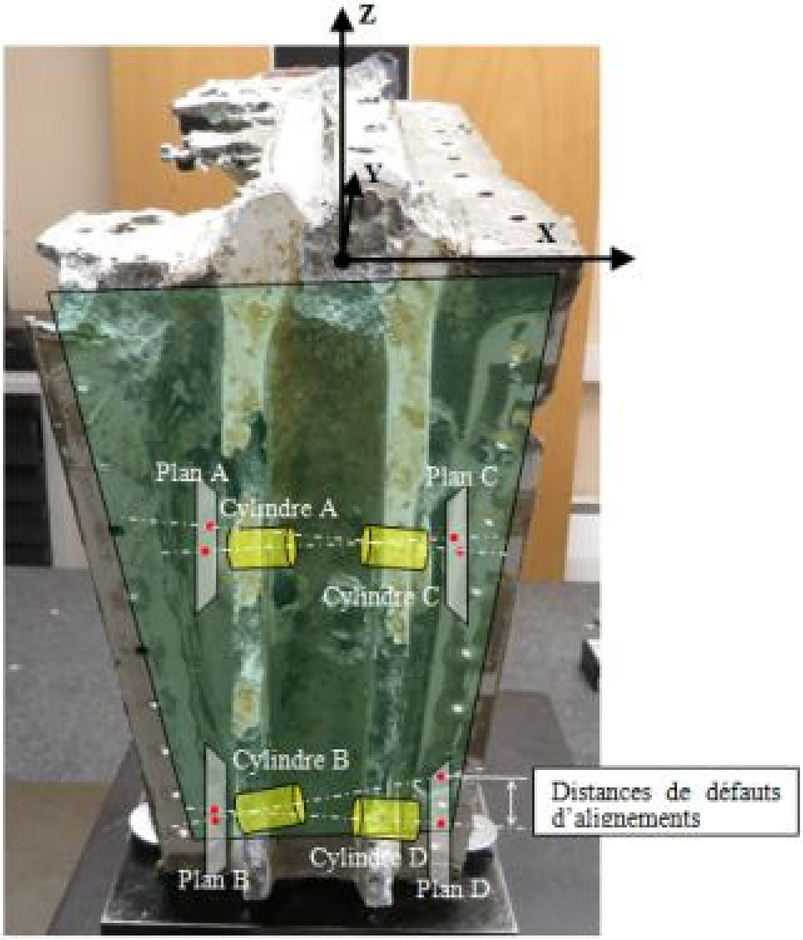


Méthode :

Le référentiel a été construit avec le plan rouge pour l'orientation de l'axe X. L'intersection du plan rouge et du plan vert forme la ligne qui donne l'orientation de l'axe Z autour de l'axe X.

L'orientation des plans et cylindres sont donnés sous forme d'angles dans le référentiel cité ci-dessus pour mettre en valeur les défauts d'alignements des cylindres, les défauts de perpendicularité des cylindres par rapport aux plans et l'orientation des plans dans le référentiel.

Les défauts d'alignements des cylindres sont représentés aussi par la distance des intersections des axes de cylindre avec les plans (points rouges).

Rapport de contrôle n° L-71-2015, page 4/9

Résultats :

Angles de plans :

Angles de la ligne perpendiculaire au plan A dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.2 °

Rotation autour de l'axe Z de X- vers Y : -0.13°

Angles de la ligne perpendiculaire au plan B dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.3 °

Rotation autour de l'axe Z de X- vers Y : -0.14°

Angles de la ligne perpendiculaire au plan C dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.12 °

Rotation autour de l'axe Z de X- vers Y : -0.1°

Angles de la ligne perpendiculaire au plan D dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.16 °

Rotation autour de l'axe Z de X- vers Y : -0.12°

Angles de cylindres :

Angles de l'axe du cylindre A dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.21 °

Rotation autour de l'axe Z de X- vers Y : -0.02°

Angles de l'axe du cylindre B dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.08 °

Rotation autour de l'axe Z de X- vers Y : -0.55°

Angles de l'axe du cylindre C dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.04 °

Rotation autour de l'axe Z de X- vers Y : -0.06°

Rapport de contrôle n° L-71-2015, page 5/9

Angles de l'axe du cylindre D dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.06 °

Rotation autour de l'axe Z de X- vers Y : 0.11°

Distances de défaut d'alignement :

Plan A :

Distance de l'intersection du Cylindre C/plan A et l'intersection du cylindre A/plan A : 0.03 mm

Plan B :

Distance de l'intersection du Cylindre B/plan B et l'intersection du cylindre D/plan B : 0.19 mm

Plan C :

Distance de l'intersection du Cylindre C/plan C et l'intersection du cylindre A/plan C : 0.18 mm

Plan D :

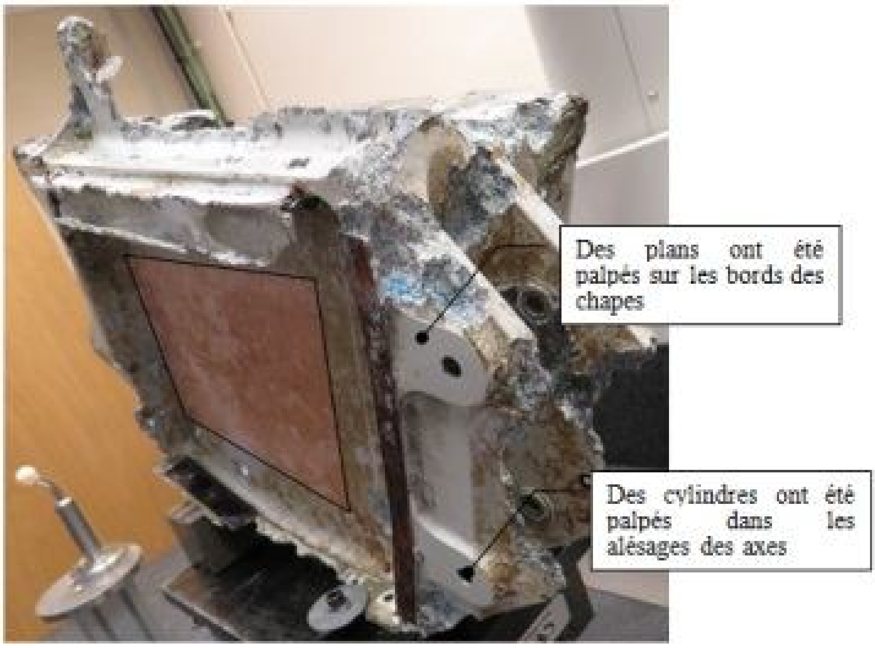
Distance de l'intersection du Cylindre D/plan D et l'intersection du cylindre B/plan D : 0.48 mm

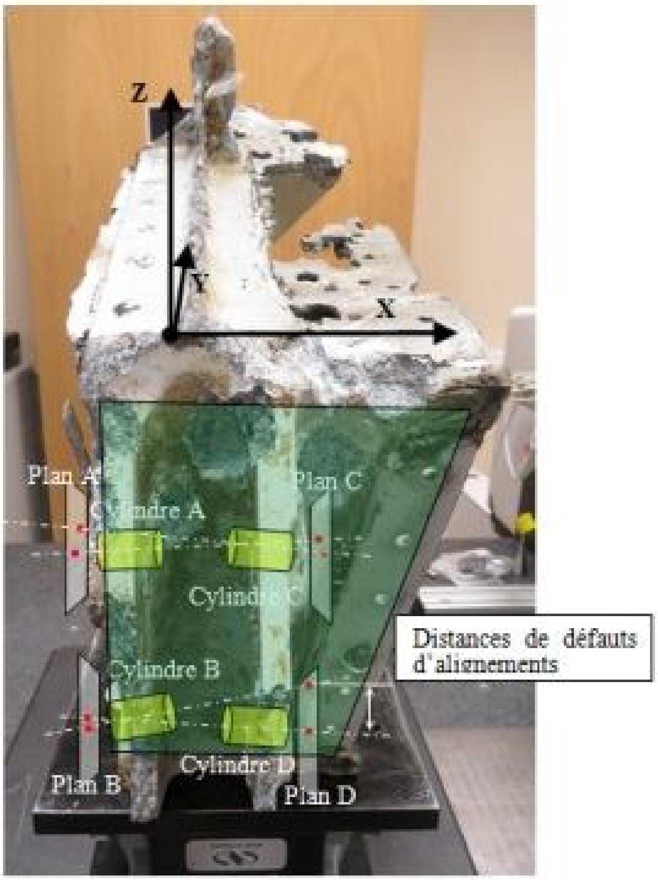
Si l'on accepte que le référentiel soit réaliste (problèmes d'orientations dues aux déformations et à la corrosion du Flaperon), l'ensemble des angles des plans et cylindres, sont pratiquement confondus avec l'axe X.

L'axe du cylindre B a plus d'angle que les autres et donc une plus grande distance entre intersections (plan D). Une répétabilité de mesures a été effectuée sur cet alésage et elle s'avère être bien plus mauvaise que pour les autres surement due à un défaut géométrique du cylindre (corrosion, déformation). Il en découle une incertitude de mesure plus élargie.

Rapport de contrôle n° L-71-2015, page 6/9

Pièce II :





Méthode :

Le référentiel a été construit avec le plan rouge pour l'orientation de l'axe X. L'intersection du plan rouge et du plan vert forme la ligne qui donne l'orientation de l'axe Z autour de l'axe X.

L'orientation des plans et cylindres sont donnés sous forme d'angles dans le référentiel cité ci-dessus pour mettre en valeur les défauts d'alignements des cylindres, les défauts de perpendicularité des cylindres par rapport aux plans et l'orientation des plans dans le référentiel.

Les défauts d'alignements des cylindres sont représentés aussi par la distance des intersections des axes de cylindre avec les plans (points rouges).

Résultats :

Angles de plans :

Angles de la ligne perpendiculaire au plan A dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.08°

Rotation autour de l'axe Z de X- vers Y : -0.04°

Angles de la ligne perpendiculaire au plan B dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.15 °

Rotation autour de l'axe Z de X- vers Y : 0.02°

Angles de la ligne perpendiculaire au plan C dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.03 °

Rotation autour de l'axe Z de X- vers Y : -0.02°

Angles de la ligne perpendiculaire au plan D dans le référentiel pièce :

Rotation autour de l'axe Y de X- vers Z : 0.09 °

Rotation autour de l'axe Z de X- vers Y : -0.06°

Rapport de contrôle n° L-71-2015, page 8/9

<u>Angles de cylindres :</u>

<u>Angles de l'axe du cylindre A dans le référentiel pièce :</u>

Rotation autour de l'axe Y de X- vers Z : 0.19 °

Rotation autour de l'axe Z de X- vers Y : -0.18°

<u>Angles de l'axe du cylindre B dans le référentiel pièce :</u>

Rotation autour de l'axe Y de X- vers Z : 0.17 °

Rotation autour de l'axe Z de X- vers Y : -0.21°

<u>Angles de l'axe du cylindre C dans le référentiel pièce :</u>

Rotation autour de l'axe Y de X- vers Z : -0.07 °

Rotation autour de l'axe Z de X- vers Y : -0.04°

<u>Angles de l'axe du cylindre D dans le référentiel pièce :</u>

Rotation autour de l'axe Y de X- vers Z : -0.06 °

Rotation autour de l'axe Z de X- vers Y : -0.12°

<u>Distances de défaut d'alignement :</u>

<u>Plan A :</u>

Distance de l'intersection du Cylindre A/plan A et l'intersection du cylindre C/plan A : 0.31 mm

<u>Plan B :</u>

Distance de l'intersection du Cylindre B/plan B et l'intersection du cylindre D/plan B : 0.20 mm

<u>Plan C :</u>

Distance de l'intersection du Cylindre C/plan C et l'intersection du cylindre A/plan C : 0.05 mm

<u>Plan D :</u>

Distance de l'intersection du Cylindre D/plan D et l'intersection du cylindre B/plan D : 0.06 mm

Si l'on accepte que le référentiel soit réaliste (problèmes d'orientations dues aux déformations et à la corrosion du Flaperon), l'ensemble des angles des plans et cylindres, sont pratiquement confondus avec l'axe X.

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Les résultats des angles des axes des cylindres et les distances entre intersections semblent corrects mais sont peu crédibles en rapport avec la mauvaise répétabilité des mesures des alésages, due à un défaut géométrique du cylindre (corrosion, déformation). Il en découle une incertitude de mesure plus élargie. Seul le cylindre B a une bonne répétabilité. Mieux vaut se retourner sur les résultats angulaires des plans.

Annexe 11 : **Vérification of the compliance matière of the hinge fittings**

MTA	Fiche d'analyses	N°:6-16	1/3

OT	*P1501516001003*
Demandeur	*S. BEN RHOUMA*
Programme	
Activité	

Travaux demandés objectif, contexte

Bonjour,
Analyse chimique élémentaire par fluorescence X de la ferrure du flaperon Boeing dans le cadre de l'enquête sur le MH370.
L'objectif est de déterminer la nuance du flaperon sans trop de détérioration.
Le flaperon est en alliage d'aluminium.
Merci d'avance
Cordialement,

Documents d'entrées	***Document de sortie***	
		Rapport simplifié
		Rapport d'essai et/ou d'expertise
	X	*Fiche d'analyses MTA + compte rendu*

Spécimen, nature (état de surface), origine…	*Flaperon Boeing* *Alliage d'aluminium*
Nombre de spécimens/ date mise à disposition :	*1 ou 2*
Précautions particulières (échantillon, personnel)	

Prévision		Responsable prestation MTA	Demandeur	**Réalisation**	Responsable prestation MTA	Garant technique MTA
Nombre d'heures	2	Nom : DESSORS Date :13/05/16 [signature]	Nom : BEN RHOUMA Date : 13/05/16	2	Nom : DESSORS Date : 13/05/16 [signature]	Nom : Hakenholz Date :2/06/2016 [signature]
Fournitures						
Début des travaux	17/5/2016			17/5/2016		
Fin des travaux	19/5/2016			19/5/2016		

NOTA : informations italiques remplies avec le demandeur par le responsable version : 02/2015

MTA	Fiche d'analyses	N°:6-16	2/3

Analyse	Mode opératoire	Devis (H)	Réalisé (H)	Responsable de l'analyse
FX		2	2	

Fin de réalisation des analyses :

Ecarts	Validation (par le responsable de la prestation)
RAS	[signature]

Traitements/ destination des spécimens et reliquats après analyse	
~~Destruction~~	Date de reprise spécimens et prélèvements par le demandeur : 17/5/2016
~~Stockage local~~	
Retour au demandeur	

NOTA : Zone grisée remplie avec le demandeur, zone blanche par MTA version : 02/2015

MTA	Fiche d'analyses	N°:6-16	3/3

1. GÉNÉRALITÉS

Il s'agit de déterminer la nuance de la ferrure du Flaperon Boeing, dans le cadre de l'enquête du MH370.

Afin d'endommager le moins possible la pièce, il a été choisi d'effectuer une analyse par fluorescence X.

2. RESULTATS DE L'ANALYSE

2.1. CONDITIONS OPERATOIRES

Les analyses ont été réalisées par spectrométrie de fluorescence des rayons X, au moyen du pistolet Thermo NITON XLt3, ceci afin d'identifier les principaux éléments présents.

Ces analyses réalisées avec le mode « Alliages » demeurent semi-quantitatives. En effet, tous les éléments ne sont pas détectés par l'appareil (éléments légers : gaz, C, S…) ou non dosables car non prévus dans l'étalonnage du spectromètre (Br…).

3 mesures ont été réalisées, sur des zones où le revêtement a été enlevé au préalable.
Chaque mesure a été réalisée sur 30 secondes.

2.2. RESULTATS DE L'ANALYSE

Tableau de résultats (en %) :

Alliage proposé	Echantillon	Zr	Zn	Cu	Fe	Al	Si	Mg
	ferrure flaperon	0,10	6,2	2,4	0,09	89	0,14	1,9

3. SYNTHESE ET CONCLUSIONS

Au vu des résultats obtenus l'alliage constitutif de l'élément analysé est proche de la nuance des aluminium de la série 7050 (suivant la norme NF EN 573-3), aux incertitudes de mesure près. On rappelle néanmoins que cette analyse est semi-quantitative et non destructive. Une analyse volumique quantitative par dissolution et analyse spectrométrique permettrait d'affirmer la nuance donnée ici à titre indicatif.

Annexe 12 : **Questions posées à Boeing**

The encadrés verts correspondent to the parts fournis détaillés in appendix 10. The encadrés rouges correspondent à une réponse partlle (see appendix 10). Tout part non encadré n'a pas fait l'objet of réponse. The plans détaillés of the part n'ont donc pas été fournis this qui ne permet pas of perform the travaux of calculations of the poste 5.

BORDES Christophe IPETA

De:	Koenig Alain <alain.koenig@gendarmerie.interieur.gouv.fr>
Envoyé:	jeudi 11 février 2016 10:36
À:	juliabenke@bredinprat.com
Cc:	GAUDINO Alain; ROBINSON Emmanuelle; RAMET Carole; "Molé Philippe CNE (DLASSA SRTA PARIS-CHARLES-DE-GAULLE)"; Delannoy Simon-Pierre LCL (SRTA PARIS-CHARLES-DE-GAULLE); paul.chaudanson@gendarmerie.interieur.gouv.fr > > "Chaudanson Paul LCL (SRTA PARIS-CHARLES-DE-GAULLE)"; BORDES Christophe IPETA; Touquet Alain GND (DLASSA SRTA PARIS-CHARLES-DE-GAULLE); fr grangier
Objet:	Demande de renseignements auprès de la société Boeing / SRTA PARIS CDG
Pièces jointes:	alain_koenig.vcf

Bonjour maitre

Faisant suite à notre entretien téléphonique et conformément aux besoins de l'enquête en cours et aux instructions reçues, nous sollicitons votre intervention auprès de la société Boeing.
Vous trouverez ci-après les questions en langues anglaise et française à transmettre à celle-ci.

En anglais :

Part number of the right hand side flaperon fitted on the B777 registered 9M-MRO.

The following data related to this part number :

Kinematic of the flaperon itself, with the max extended position and the non-extended position.

Drawings and schemes of the immediate environment of the flaperon (fittings, actuators, other flap linked or in contact to the flaperon...), the aim is there to understand the use of the flaperon, its kinematic linked to its environment, the types of stress in the different parts and the load paths.

Neighborhood of the flaperon so as to check if the findings on the flaperon such as bumps on the leading edge could be due to an impact on that parts.

Drawings of the flaperon part with structure detail design, panels composition (lay-up of composite, type of honeycomb, materials of the fitting) and materials properties. Load cases on the flaperon in normal use (Limit load cases in extreme positions might be enough) and location of the fuse area (strength of that fuse area would be valuable). These data are necessary to perform calculations that will be compared to scenarios of failure coming from the fractographic analyses.

The concessions on the part if any since we found repairs that are not on the data provided by Malaysia Airlines.

In french :

Le numéro d'identification du flaperon droit monté sur le Boeing 777 immatriculé 9M-MRO.

1

Les données suivantes en lien avec ce numéro d'identification :

Cinématique du flaperon avec ses positions extrêmes (mouvement du flaperon d'une position vers l'autre).

Plans et schémas de l'environnement immédiat du flaperon (ferrures, actionneurs, autres commandes de vols liées ou au contact du flaperon...). Le but est ici de comprendre l'utilisation du flaperon, sa cinématique en lien ou non avec son environnement, le type de contraintes vues par les différentes pièces le constituant et les chemins d'efforts privilégiés, i.e. quels sont les éléments prépondérants pour la tenue structurale du flaperon.

Voisinage du flaperon pour vérifier que les dommages que nous avons constatés tels que les enfoncements sur le bord d'attaque sont dus à un impact sur une ou plusieurs de ces pièces.

Plan du flaperon contenant les détails de composition de sa structure (drapage des peaux composites, type de nid d'abeille, matériaux des ferrures) et les propriétés de chaque matériau. Cas de charge appliqués au flaperon en utilisation normale et localisation des éléments fusibles ainsi que leur tenue. Ces données permettront de réaliser des calculs qui seront ensuite comparés aux scénarios de rupture identifiés lors des analyses fractographiques.

Dérogations présentes sur la pièce s'il y en avait dans la mesure où nous avons trouvé des réparations non enregistrées par Malaysia Airlines.

Vous remerciant d'avance de l'intérêt que vous porterez à notre requête.

Bien cordialement

Alain Koenig

--

ADC Alain KOENIG
Enquêteur à la Division de Lutte contre les Atteintes à la Sécurité et à la Sûreté Aériennes
—o—O—o—
Detective in charge
Criminal Investigations Department
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alain.koenig@gendarmerie.interieur.gouv.fr

Annexe 13 : **Réponses of Boeing**

- Réponse of the cabinet d'avocat by mail with two parts jointes -

BORDES Christophe IPETA

De:	Koenig Alain <alain.koenig@gendarmerie.interieur.gouv.fr>
Envoyé:	vendredi 18 mars 2016 15:00
À:	GAUDINO Alain; ROBINSON Emmanuelle; RAMET Carole; PARIS-MULLER Gaelle; Delannoy Simon-Pierre LCL (SRTA PARIS-CHARLES-DE-GAULLE); paul.chaudanson@gendarmerie.interieur.gouv.fr >> "Chaudanson Paul LCL (SRTA PARIS-CHARLES-DE-GAULLE)"; "Molé Philippe CNE (DLASSA SRTA PARIS-CHARLES-DE-GAULLE)"; Chailloux Fabrice ADJ (DLASSA SRTA PARIS-CHARLES-DE-GAULLE); Touquet Alain GND (DLASSA SRTA PARIS-CHARLES-DE-GAULLE); BORDES Christophe IPETA; fr grangier
Objet:	Affaire BOEING/MH370
Pièces jointes:	18.03.2016 - Réponse de Boeing aux demandes relatives au vol Malaysia Airlines 370.docx; 777 Flaperon.pptx; avertissement.txt; alain_koenig.vcf

Bonjour mesdames et messieurs

Voici la réponse de Boeing, via le cabinet d'avocat Bredin et Prat, qui nous est parvenue ce jour.
Bonne lecture

Bien cordialement

Alain KOENIG

-------- Message original --------
Sujet:[Internet] RE: [Internet] RE: [Internet] Re: Affaire BOEING/MH370
Date : Fri, 18 Mar 2016 13:44:23 +0000
De :BENKE Julia <JuliaBENKE@bredinprat.com>
Pour :'Koenig Alain' <alain.koenig@gendarmerie.interieur.gouv.fr>
Copie à :DEZEUZE Eric <ericdezeuze@bredinprat.com>

Cher Monsieur,

Comme discutÃ© ce matin par tÃ©lÃ©phone, vous trouverez ci-joint la rÃ©ponse de Boeing Ã vos demandes du 11 fÃ©vrier dernier. Comme Ã©voquÃ©, la rÃ©ponse en anglais est accompagnÃ©e dâ€™une traduction en franÃ§ais.
Vous trouverez Ã©galement ci-joint les schÃ©mas du flaperon et de son environnement.

Bien Ã vous,

Julia BENKE

1

- Eléments of réponse in the première part jointe -

18 mars 2016

Réponse de Boeing aux demandes relatives au vol Malaysia Airlines 370

The specific makeup of the composite portions of the 777 flaperon is proprietary, confidential information. Speaking generally though, the composite portions of the skins, spars, and ribs in the flaperon are fabricated from Epoxy impregnated Standard Modulus (average modulus 32-35 MSI, and 540KSI minimum average strength) carbon fiber fabric, style 3K-70-PW. The resin content is 40% by weight and the cure temperature is 350°F.

With respect to the requests for kinematics and the surrounding parts, Boeing has prepared a PowerPoint presentation that contains images depicting the flaperon and some of the surrounding components. Some of these images depict the flaperon at different points in its range of motion. See *777 Flaperon.ppt.*

Finally, Boeing is unaware of any repairs that may have been made by Malaysia Airlines during its operation of the aircraft. Boeing therefore does not have any information responsive to the last category of request.

***

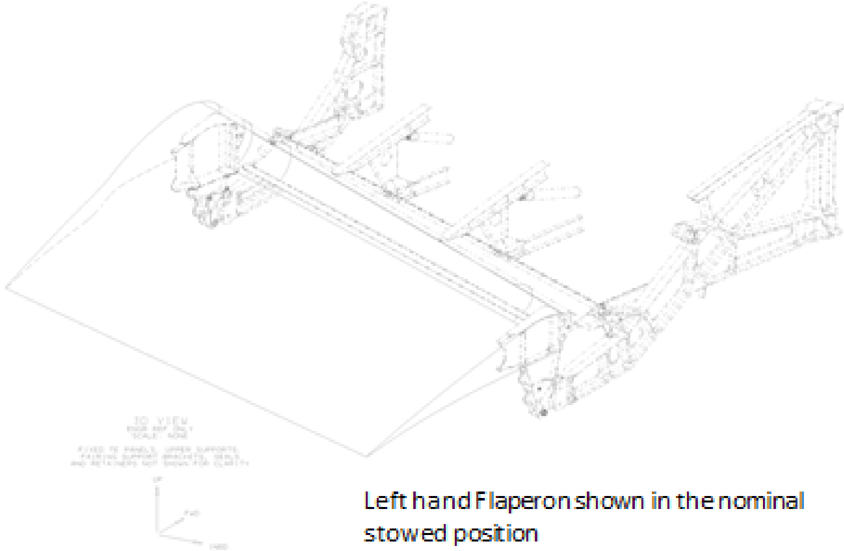
Les éléments relatifs à la composition précise des parties composites du flaperon 777 constituent des renseignement commerciaux confidentiels. Toutefois, de manière générale, les parties composites des peaux (revêtements), longerons et nervures du flaperon sont fabriquées à partir de Standard Modulus imprégné d'Epoxy (modulus moyen 32-35 MSI, et 540KSI force moyenne minimum), tissu de fibre de carbone, style 3K-70-PW. La teneur en résine est de 40% en poids et la température de cuisson est de 350°F.

S'agissant des demandes relatives aux cinématiques et parties environnantes, Boeing a préparé un document Powerpoint qui contient les schémas représentant le flaperon ainsi que certains éléments environnants. Certains schémas représentent le flaperon à différents moments de son amplitude de mouvements. Voir le document Powerpoint « 777 flaperon » ci-joint.

Enfin, Boeing n'a connaissance d'aucune réparation qui aurait pu être faite par Malaysia Airlines au cours de son exploitation de l'avion. Par conséquent, Boeing n'a malheureusement aucune information en réponse à la dernière question à ce sujet.

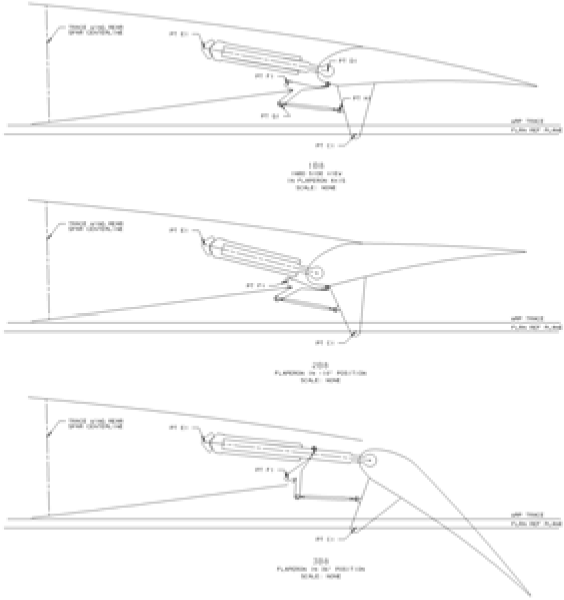
- Eléments of réponse in the deuxième part jointe -

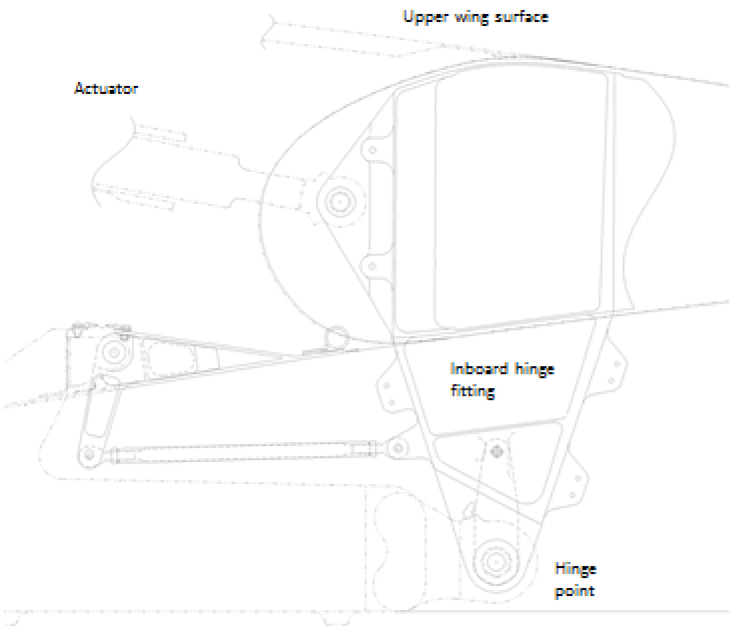
777 Flaperon

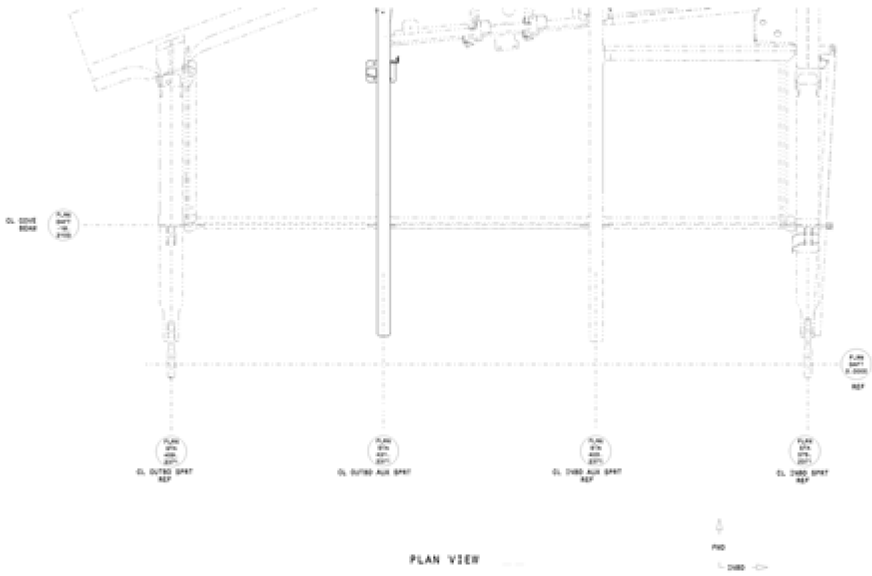


Left hand Flaperon shown in the nominal stowed position

Flaperon range of motion. Upper section cut through the inboard actuator rib in the stowed position. Middle cut with flaperon full trailing edge up. Lower cut with flaperon full trailing edge down.







Left Wing upper fixed panel support structure forward of flaperon. Right hand opposite.

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MINISTÈRE
DE LA DÉFENSE

DGA Techniques aéronautiques

EXAMINATION REPORT

EXAMINATION REPORT

N° 16-DGATA-MTI-P1501516001002-DR-F-Â

This document is a courtesy translation of the original examination report issued by the French DGA/TA and, as requested by the French judicial authorities. As accurate as this translation may be, the original text in French is the work of reference

DGA

DIRECTION GÉNÉRALE DE L'ARMEMENT

RESTRICTED
CIRCULATION

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DGA Technical aéronautiques

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MINISTÈRE DE LA DÉFENSE

EXAMINATION REPORT

REPORT

N° 16-DGATA-MTI-P1501516001002-DR-F-Â

	N/A	Visa	Date	Post (Entity)
Author				Head of Department of « Investigations following incidents or accidents »
Technical Check				Head of the division « Materials and Technologies »
Approval				Head of the division « Materials and Technologies »

PAGE SANS TEXTE

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MINISTÈRE DE LA DÉFENSE

DIRECTION GÉNÉRALE OF L'ARMEMENT

DGA Technical aéronautiques

REPORT	
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Métiers	**Pôles**
7 - Matériaux, Ateliers et Bureaux d'études	7 - Matériaux, composants, maîtrise risques environnementaux

Prestation étatique : Oui ☐ Non ☒	Report joint in Indigo : Oui ☐ Non ☒

Summary :

Following the discovery on 29/07/2015 on a beach on the island of la Réunion of a part from the flight controls (a flaperon), the Tribunal of Grande Instance of Paris (TGI Paris) requested assistance from the DGA techniques aéronautiques (DGA TA) in order to perform examinations on this part.

The part arrived on site on 01/08/2015 and was placed in the Hall 42, which was secure. The seals were broken on 05/08/2015 in the presence of members of the judicial investigation and of the technical investigation.

In the light of the parts available, all of the examinations that could be undertaken on that day were performed. This report is thus intended to present the results from them.

- SUMMARY (continued) -

- SUMMARY -

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1. BACKGROUND

Following the discovery on 29/07/2015 on a beach on the island of La Réunion of a part from the flight controls (a flaperon), the Tribunal of Grande Instance of Paris (TGI Paris) requested assistance from the DGA techniques aéronautiques (DGA TA) in order to perform examinations on this part.

The part arrived on site on 01/08/2015 and was placed in Hall 42, which was secure. The seals were broken on 05/08/2015 in the presence of members of the judicial investigation and of the technical investigation.

In the light of the parts available, all of the examinations that could be undertaken on that day were performed. This report is thus intended to present the results from them.

2. HISTORY OF DOCUMENT

Version	Date	Type
A	26/07/2016	Initial Document

3. REFERENCE DOCUMENTS

1. Ordinance of expert commission (appendix 1),
2. Oath taken by expert not registered on a list of experts (appendix 2),
3. Technical proposal n°15-DGATA-MTI-P1501516001-A,
4. MMM 57-63-05 : COMPONENT MAINTENANCE MANUAL WITH ILLUSTRATED PARTS LIST - WING TRAILING EDGE FLAPERON ASSEMBLY,
5. Repairs to the flaperon seal retainers (joint mouldings), Malaysia Airliness Engineering note n° 77 IN- 57 - 20215 issue A (appendix 3).
6. Boeing responses (mail, word and powerpoint documents in appendix 13),

4. OBJECTIVES OF EXAMINATION

The objectives of the examination are detailed in the expert commission ordinance (reference 1) and in the technical proposal (reference 3) which details the requirement, which were to:

- determine if the part belonged to aircraft 9M-MRO which was performing flight MH370 on 8 March 2014,
- identify the damage and the fracture zones on the part,
- determine the buoyancy characteristics of the part,
- analyze the most significant zones in order to determine the fracture mode,
- make calculations on the broken parts, where possible (depending on the observations and of the data available).

5. PROGRESS OF THE EXAMINATION

It is useful to detail here the progress of the examination, whose various sections are then detailed item by item:

- Arrival of the part on 01/08/2015,
- Breaking of the seals on 05 August 2015, search for elements to identify various elements of the part (number, paint samples, repair), the decision was taken not to turn over the flaperon until the crustaceans expert had taken samples,
- On 06 August 2015, new search for numbers with boroscope, characterisation of defects with Boeing, 3D measurements of flaperon,
- On 09 August 2015, visit by Doctor Poupin who took the samples of the crustaceans,
- While waiting for confirmation that this flaperon belonged to aircraft 9M-MRO, work on the paints and on the repair continued through August and the buoyancy test was prepared (sample of the crustaceans, weighing, 3D measurements aimed at the construction of a model of the outside shape…),
- From 24 to 28 August 2015, performance of buoyancy tests with DGA TH,
- On 03 September 2015, confirmation by the Paris Public Prosecutor's office that the flaperon did in fact belong to aircraft 9M-MRO,
- On 16 September 2015, visit by M. Daniel of Météo France for calculations of retro-drift, M. Daniel joined up with DGA TH in order to check that the buoyancy tests had made it possible to adequately characterize the part for the purpose of these retro-drift calculations,
- On 05 Octobre 2015, validation of change to examination phase requiring dismantling and cutting for micrographic and fractographic examinations,
- From 14 to 18 December 2015, meeting in Malaysia in the context of the request for international criminal assistance, presentation of the results to the Malaysian safety investigation and to the judicial investigation drawing attention to the absence data from Boeing,
- At the start of 2016, organisation of a visit to chez Air France Industries in order to observe a flaperon in the airplane aboutment (visit on 2 March 2016). In parallel, request for information via Boeing's lawyers (partial answer only supplied on 18 March 2016),
- Organisation of a visit by the victims' families on 23 June 2016.

6. SECTION 1: IDENTIFICATION OF THE PART

The objective of section 1 was to get information that made it possible to identify the part and to check that it did in fact belong to aircraft 9M-MRO that undertook flight MH370 on 8 March 2014.

When the crate was opened, it was noted that the identification plate was missing (see plate n°1). It was then decided to :

- sample a piece of the paint that seemed to be a touch-up for analysis (see plate 2),
- check the presence of a temporary repair which had not been replaced, according to Malaysia Airliness (see plate n°3 and appendix 3 for the plan),
- undertake an boroscope search for the numbers identifying the various parts that make up the flaperon.

The boroscope inspection initially made it possible to find numbers on the panels in the area of the leading edge:

- 557 CB,
- 657 BB,
- 657 AT,
- 657 DB,
- 657 CT.

These numbers, photos of which are shown in plate n°4, correspond to those used to identify the Boeing 777 flaperon leading edge panels, these being the same as on any Boeing 777.

Passing through a hole made by corrosion, an boroscope inspection inside the box section was made. This made it possible to read off several serial and part numbers (see plate n°5). These references were provided to the Judge and to the Judicial Expert in order to determine, with the manufacturer CASA, if the part belonged to aircraft 9M-MRO from flight MH370.

According to information supplied by Boeing during the day on 06/08/2015, the correspondence between the basic parts (numbers found) and the assembled part (flaperon number) is only kept for 7 years, in theory. Thus, while waiting for the confirmation of identification by CASA the parts likely to belong to this part such as the repairs or paint touch-ups were subjected to physico-chemicals analyses in order to characterize them and to compare them to the parts supplied by the airline. The following examinations were thus performed by DGA-TA:

- paint samples from lower and upper surfaces were taken, analyzed and compared to the sample from the zone that seemed to have been touched-up (results in appendix 4),
- work to inspect the presence of a repair and specifically the characterisation of the zone that was supposed to have been repaired was continued (see plate n°3 and appendix 5 for the material and paint results).

On 03 September 2015, the Paris Public Prosecutor's office confirmed that the flaperon did in fact come from 9M-MRO, the above-mentioned no longer being useful for identification of the part and were thus not continued.

7. SECTION 2: OBSERVATION OF THE PART

The objective of section 2 was to characterize the part and the defects (fractures, damage…) that it had.

7.1. OVERVIEW

This paragraph will list different types of damage noted. In order not to dissociate the overview from the detailed examination, all of the parts with significant damage, i.e. which could explain the separation of the flaperon, is covered in section 4.

The flaperon had the following damage (those examined in section 4 are in **bold** type):

- **the inboard and outboard hinge fittings were fractured in two places** :
  - at the level of the leading edge,
  - on the lower surface of the flaperon.
- the fracture surfaces on the hinge fittings were highly corroded,
- the ribs at the edge of the flaperon show, in their metallic area, holes due to corrosion,
- **the leading edge showed dents and cracks**,
- **the trailing edge was generally broken**,
- **the lower and upper surface panels showed localised dents and the upper surface had a large crack**,
- the mounting attachment zones on each side of the flaperon were damaged or broken off.

In addition the flaperon was covered with a colony of crustaceans.

7.2. METROLOGICAL CONTROL OF THE FLAPERON

A metrological and morphological control of the flaperon was undertaken in order to determine the position and the extent of the damage noted. This included taking photos and making measurements (3D for example).

All of the metrological characteristics of the part as well as the damage and fracture zones were noted.

The first measurement on 06 August 2015, presented in appendix 6, only related to the upper surface and the ribs to prevent any manipulation of the part that could be damaging for the biological examination. It showed the absence of any significant distortion of the flaperon as can be seen in the illustration below.

The 3D measurement shows that the three lines measured remained aligned on the upper surface and appear to be together seen from the side, indicating the absence significant distortion on the part

ron -

Other 3D measurements of the part were undertaken to prepare for the buoyancy test .

7.3. CRUSTACEANS

On its arrival, the flaperon was covered with a colony of crustaceans. On 5 August 2015, it was decided by the Judicial Expert not to perform any examination before these crustaceans were seen by an expert in marine biology.

This expert, Doctor Poupin, came to the DGA TA on 9 August 2015 to examine the crustaceans and take some samples for analysis. The objective was to deduce, based on the size of the crustaceans, their age and origin. In addition, siting of the crustaceans could make it possible to determine the position of the flaperon while it drifted across the sea.

To be able to continue the examinations, the upper surface and the inboard and outboard sides of the flaperon were mapped in order to determine the zones where the crustaceans were found. Each of these zones is represented on plates 8 to 13. It should be noted that there was only one crustacean present inside flaperon. The crustaceans were mainly positioned on the upper surface of the part, which led us to believe that the flaperon drifted with the upper surface immersed, on the surface of the water a priori considering their positing, as indicated by Dr. Poupin.

Then the crustaceans were sampled by zones, weighed and put into a freezer while waiting to be placed under seal and taken to the CNRS at Gif on Yvette on 24 November 2015. The total weight of the crustaceans sampled at that time was 468.3 grams. This weight did not represent that the total weight of the crustaceans since some had been taken by Dr Poupin for his analyses.

A table summarizing the samples and the weights of the crustaceans by zone can be found in plate n°14.

7.4. X-RAY FLAPERON

X-rays of the flaperon were made in order to check the presence or absence of metallic elements inside the box section formed by the two spars and the ribs.

Plate n°15 shows the local x-ray and the zones referenced 1 to 12 on the flaperon for the x-rays. The surface of the flaperon was about 2.42m^2. Plate 16 contains the relevant photos.

The lightest zones on the x-rays corresponded to salt deposits following the penetration by sea salt into the cracks in the composite panel (see §9.1 for the detail of the flaperon's structure).

The total of the surfaces bleached by the salt (slat water penetration) in the composite was approximately 0.153m^2 (see plate n°17). The thickness of the honeycomb was about 0.02m. The maximum volume of water contained would thus have been 0.00306m^3, that's to say 3.1 kg taking into account volume weight of ocean water of 1025 kg/m^3.

An boroscope inspection was made in a suspect zone (shining mark on the x-ray), the examination showed the presence of a crustacean inside the flaperon.

No traces of metallic shards was found during the examinations.

7.5. WEIGHT, DIMENSIONS OF FLAPERON AND 3D MEASUREMENTS

The flaperon was weighed, its weight being 40 kg (see plate n°18).

The dimensions and the approximate position of the centre of gravity in line with the lower surface (position not referenced in the thickness) of the flaperon are in plate n°19.

Measurements of the flaperon were undertaken for the buoyancy tests in order to supply the DGA TH with a model of the outer envelope. The dimensions of this model shown in plate 20 differ slightly from those measured in plate 19 since it did not include the joints and only slight approximations were made. The important thing being the outer volume of the part, this was not prejudicial.

8. SECTION 3: BUOYANCY TEST

The objective of this section was to determine the part's buoyancy characteristics. In order to avoid any chemical reactions that could prejudice the examinations to follow, as well as to be representative of the Indian Ocean, the test had to be performed in salt water. The fracture surfaces were protected with a varnish so as to avoid worsening the corrosion.

The test was performed by DGA TH with the support of DGA TA in salt water pool situated on the DGA TA's premises. The measurements made by DGA TH made it possible to determine the buoyancy characteristics of the par, that's to say:

- the surface attitude at rest and thus the corresponding air draft,
- the linear and angular stiffness for this attitude.

The test was performed in both possible floating positions for the part (see plates n°21 to 23). The holes made by the corrosion on the hinge fittings were blocked in order to check their possible influence on the buoyancy. It was shown that with or without these, the balance position was identical.

The tests performed showed that in that, the buoyancy was quite high. The position with the upper surface immersed seemed more stable, which is consistent with a significant presence of crustaceans on the upper surface. However, the waterline noted did not correspond to that suggested by the zones where the crustaceans were located, that's to say on the water, while the trailing edge was significantly out of the water.

In order to evaluate the conditions in which the buoyancy in this position would have been possible, the flaperon was weighted to make the waterline coincide with that defined by the presence of the crustaceans. The effective weight (real weight of 40kg minus the buoyant upthrust) to completely immerse the flaperon was 37 kg distributed across the lower surface.

By adding weights only at the level of the trailing edge, the following results were obtained:

- lower surface upwards, it was necessary to add 13.5 kg along the trailing edge,
- when the upper surface was placed upwards, only 5 kg was required.

Taking into account the x-rays made (see §7.4), absorption of about 3.1 kg of water in the honeycomb structure of the panels is not sufficient to explain this gap. Equally, the small amount of residual trailing edge structure did not make it possible to absorb sufficient water to cause the flaperon to tip over towards the rear.

The detailed results of this test are in the reports n°E611374 parts 1 and 2 written by DGA-TH. (see appendices 7 and 8).

In addition, DGA TH also made calculations of drift coefficients that were used by Météo France for the retro-drift calculations for the flaperon. The report on this work, numbered E611374 part 3, is in appendix 9.

9. FLAPERON COMPOSITION AND ENVIRONMENT

This chapter details the composition of the flaperon and its environment. These data are useful in understanding the various examinations as well as the conclusions.

9.1. FLAPERON COMPOSITION

Although we had not received the exact plans of the flaperon, the various parts at our disposal as well as the observations performed made it possible to detail the composition of this flight control surface.

The structure of the flaperon is hybrid as it contains metallic parts, in particular the hinge fittings, assembled with the parts in organic matrix composite materials, which will subsequently be referred to as composite materials.

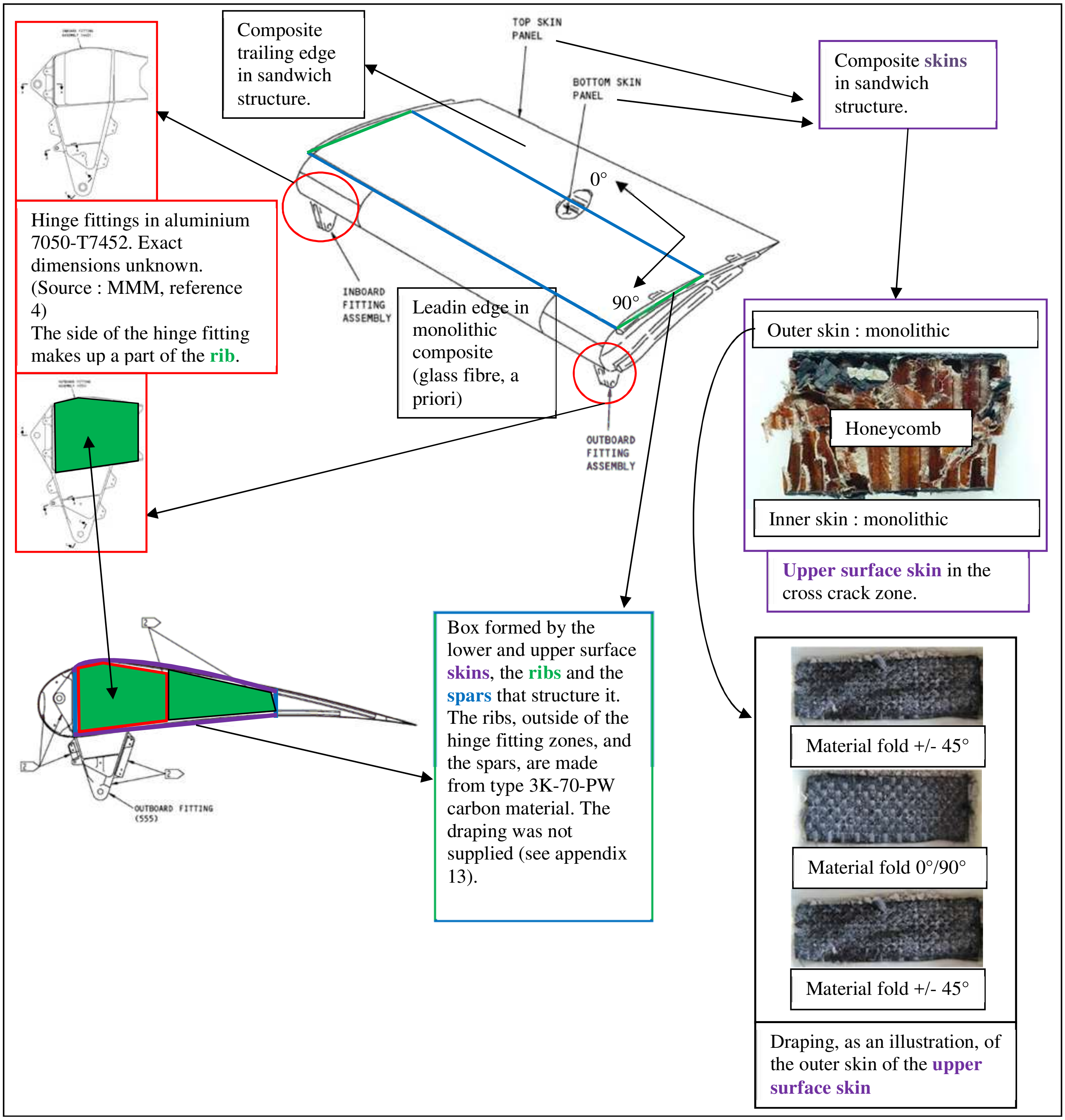
In order to avoid any confusion there follows a short definition of what a composite structure can be, with examples linked to the flaperon :

A composite structure is made up of two basic parts: fibres and resin. When the fibres are pre-assembled in folds, they are laid out according to a draping plan with some resin. Cooking then takes place and the part is then formed. Unlike a metallic part, the material really only exists once it is assembled according to the plan for the part and then cooked. Thus, it is inseparable from the part that it constitutes as it does not pre-exist and its mechanical characteristics depend on its plan.

There are two main types of composite structure on fixed-wing aircraft:

- *monolithic structures containing only fibres and resin (the leading edge of the flaperon is made this way),*
- *sandwich structures which include two monolithic skins in the middle of which is glued a third component such as in the case of the flaperon skins where a honeycomb is found.*

The following diagram details the parts at our disposal and those that we observed.



- Composition of the flaperon -

The two hinge fittings connect with the structure of the wing. The flaperon's resistance is in itself ensured by the box formed by the 2 spars, the two ribs and the skin. The leading edge and the trailing edge are subject to lower stress and mainly have an aerodynamic role.

9.2. CONNECTIONS WITH THE WING

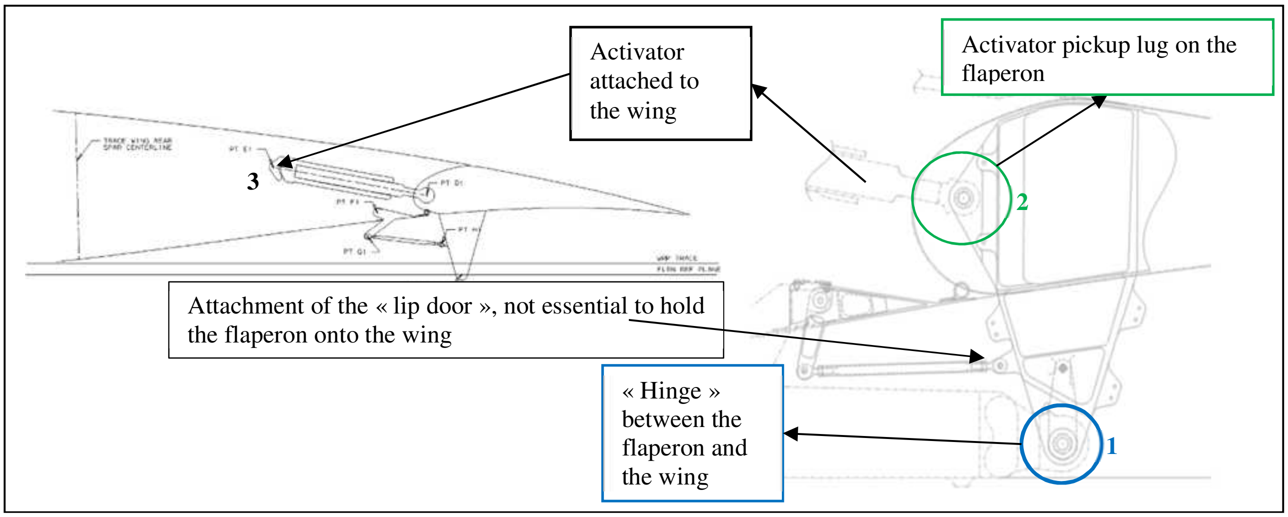
The hinge fittings located on the aeroplane and on the flaperon are those parts that ensure attachment of the latter to the aeroplane. The other attachment parts visible on the diagrams constitute secondary load paths.

The two hinge fittings on the flaperon side have two lugs:

- The one at the level of the leading edge that picks up loads from the actuator,
- The one located in the lower part is directly linked to the wing by an hinge point that serves as the hinges around which it pivots. The lower part of the hinge fitting seems to be designed to pick up forward-aft axial loads (logical given the function of the flaperon) and its bearing of lateral loads, i.e. in the direction of the flaperon span, seems limited.

On the aeroplane side, the same number of lugs is found, one attached to the other end of the activator and the other directly opposite the lower flaperon lug. The image below shows this attachment system for the inboard hinge fitting.

All of the links, which should allow rotational movement, are ensured by of the hinge points passing through the lugs.



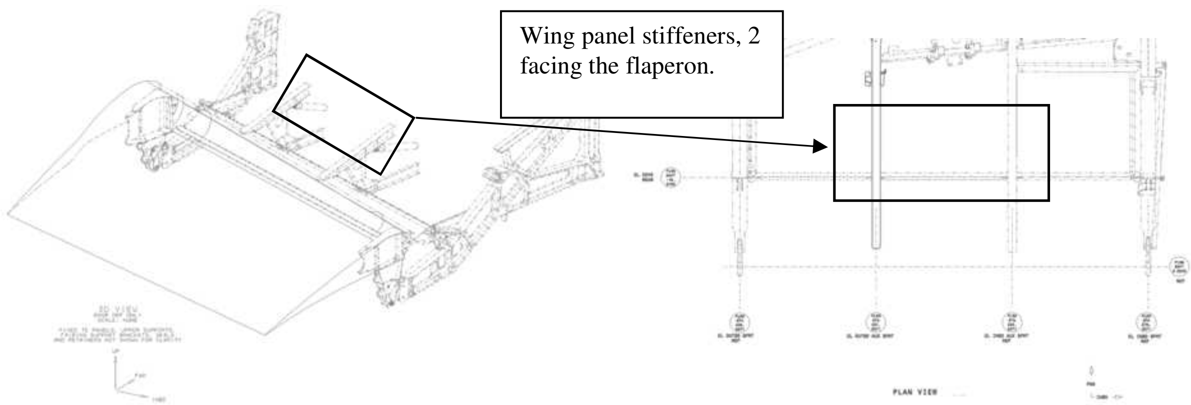
- Flaperon attachments -

The number of critical flaperon attachment points can thus be reduced to three on each side (see diagram above) since the lower wing lugs and flaperon constitute a hinge by being attached to a single hinge point. The loss of one of these attachment points is likely to lead to the separation of the flaperon by causing a possible chain-reaction fracture of the other attachment points.

It should be noted that, according to Boeing (meeting on 06 August 2015), the loss of a flaperon does not prevent the flight being continues and that some of its parts are even « fuses ». These "fuse" zones on the flaperon were not provided by Boeing (see appendix 12).

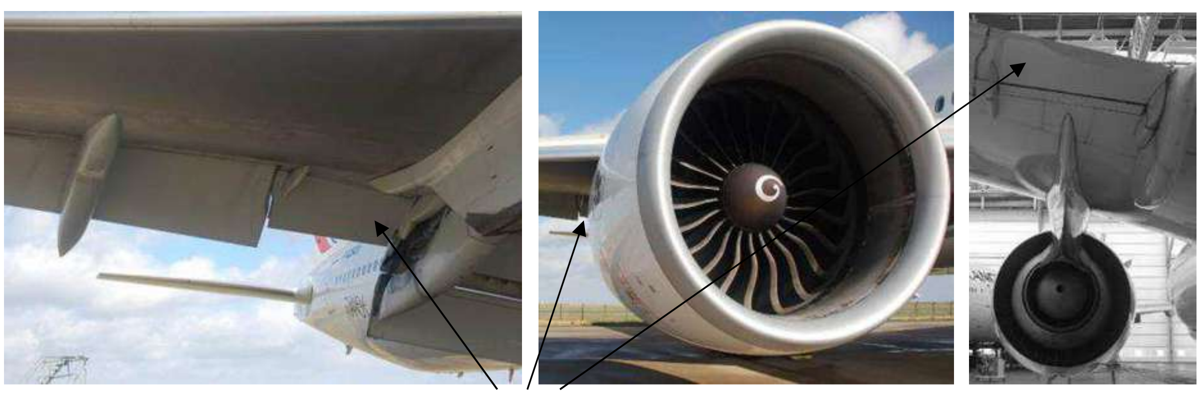
9.3. FLAPERON ENVIRONMENT

The parts supplied by Boeing, in addition to the visit to a Boeing 777, made it possible to define the flaperon's environment which might explain some of the damage noted. The image below shows the flaperon in the retracted position as well as the parts of structure facing it.



- Flaperon in retracted position, wing parts nearby -

The flaperon is surrounded by other flight control surfaces. Profile continuity between these parts and the flaperon explains why the latter is thicker outboard than inboard. Finally, it should be noted that the flaperon that we received is completely hidden by the engine when seen from the front of the aeroplane. The following images show the flaperon in the aeroplane environment.



- Flaperon fitted on aeroplane -

10. SECTION 4: TECHNICAL LABORATORY ANALYSES

The fracture zones and the damage identified in section 2, judged to be interesting in determining the phenomenon that caused the separation of the flaperon from the aircraft, were analyzed so as to determine the cause of the damage, the type of fracture and possibly the direction of loads, given the work planned in section 5.

The analyses are presented in two sub-sections, one relating to the metallic parts which, with the exception of the ribs, means the links with the wing, the other on the parts made of composite materials, thus the structure of the flaperon itself.

When it was possible, a materials compliance analysis was also undertaken.

10.1. METALLIC PARTS – LINKS WITH THE WING

Initially, it should be stated here that the level of corrosion of the various fracture surfaces of the metallic parts ma de it impossible to undertake a Scanning Electron Microscope (SEM) examination. In fact, this initial condition made it impossible to reach the level of preparation required to undertake the appropriate observations. It was thus not possible to confirm the observations made by the macrographic examinations with the micro-fractographic examinations.

10.1.1. OUTBOARD HINGE FITTING AND NEARBY ELEMENTS

Plate n°24 shows the two fractures on the outboard flaperon hinge fitting (lower surface and leading edge sides after disassembly of the panel).

Plate n°25 shows the direction of the distortions and the tears at the level of the ribs near to the fracture on the leading edge side and plate n°26 shows the direction of the distortions on the parts located behind the hinge fitting.

Visual examinations showed that the loads causing the distortions were oriented from inboard towards outboard, which is particularly notable at the level of the leading edge ribs.

In order to perform a metrological inspection on the hinge fitting, the latter was dismantled (see plate n°27). The fracture surfaces on the leading edge side and lower surface are shown in plates n°28 to 30. All of the fractures were of static-type morphology and were highly oxidized.

The hinge fitting side had numerous oxidized holes due to exposure to sea water.

10.1.2. INBOARD HINGE FITTING AND NEARBY ELEMENTS

Plate n°31 showed the inboard hinge fitting after removal of the leading edge panel, and shows, after disassembly of the seal retainer, that a repair had been made. This repair could not be identified. A priori it was not in the in the Malysia Airlines aeroplane log as it was not mentioned as a means of identifying the part and Boeing did not indicate that the flaperon had any variance (see appendix 10). It thus seems possible that this repair, which can be considered as minor, was not recorded.

Plate n°32 shows general view of the fractures on the lower surface side and leading edge of the inboard hinge fitting.

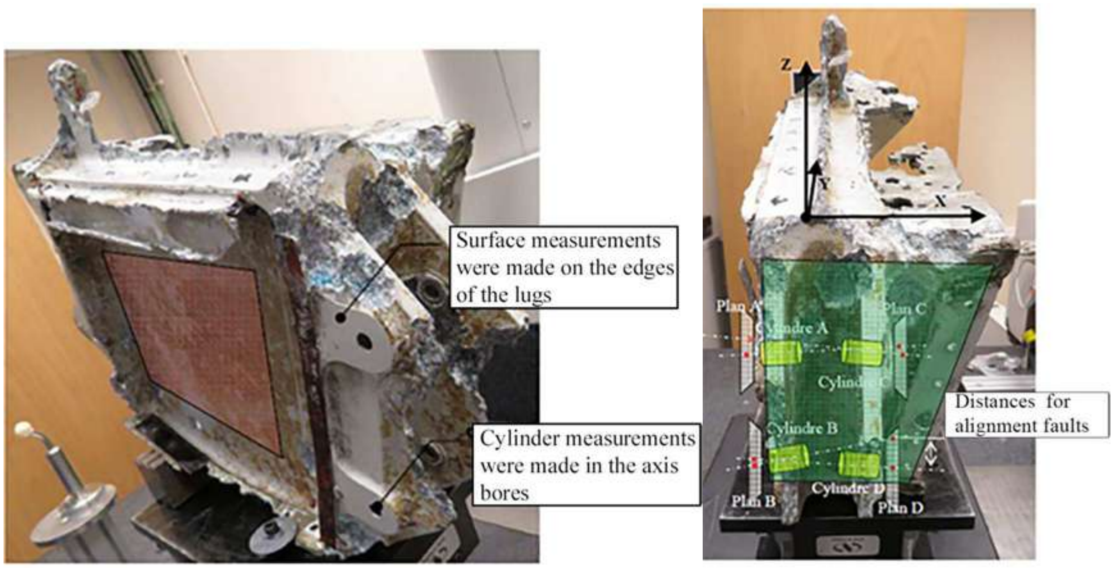
Plate n°33 shows the fracture on the leading edge side, the distortions of the rib next to the lug, as well as those on the upper surface panel. The examinations showed that the loads were oriented inboard towards outboard.

Plates n°34 and 35 had fractures on the lower surface side of the hinge fitting and at the level of cover attachment. The latter had no particular distortion that could be examined and its fracture surface was highly oxidized.

The inboard hinge fitting was disassembled for a metrological inspection (see plate n°36). Plates n°37 to 39 show the inboard hinge fitting fractures after disassembly. All of the fractures were of static-type morphology and were highly oxidized.

10.1.3. METROLOGY OF THE OUTBOARD AND INBOARD HINGE FITTINGS

In the absence of any plans of the hinge fittings and for the purpose of measuring possible overall distortion of the latter, references were made by the metrology department based on non-distorted parts, as illustrated below, on the inboard hinge fitting. The distortions were thus measured against these references and not against the plans of the part. The complete metrology report is in appendix n°10.



- Creation of references for the measurements and measurements on the inboard hinge fitting -

Plate n°40 shows a slight distortion of the outboard hinge fitting towards the outside of the aeroplane.

The inboard hinge fitting also shows minor distortion towards the outboard hinge fitting (outside of the aeroplane, see plate n°41).

10.1.4. MATERIAL COMPLIANCE OF THE HINGE FITTINGS

A metallurgical inspection (chemical analysis, measurement of conductivity and hardness tests) was performed on one of the hinge fittings without damaging it in order to check its compliance against the MMM specifications (reference 4). The metallurgical analyses required slight polishing of the surface of the hinge fitting.

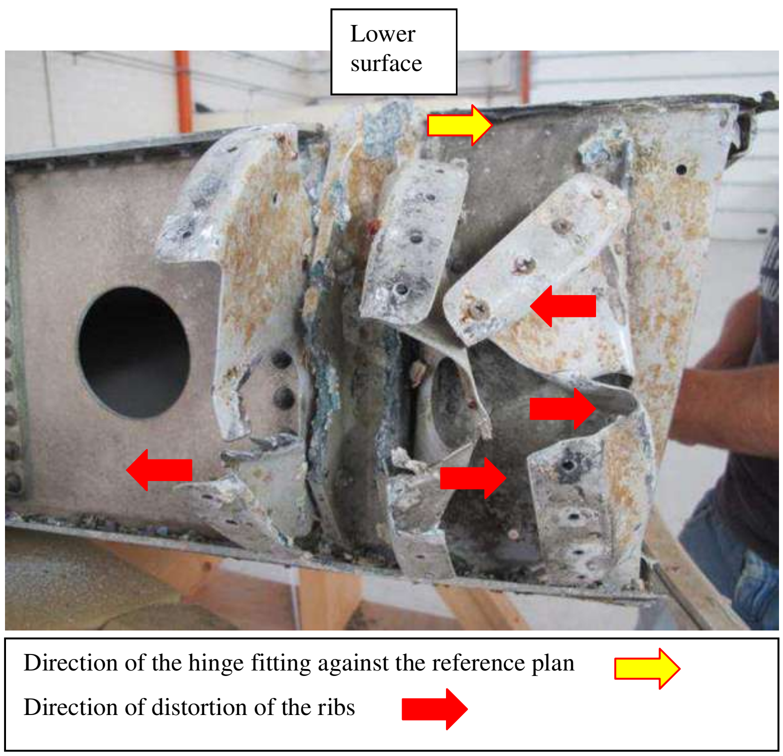
The MMM indicates hinge fittings with type 7050 aluminium of T7451 grade. The chemical composition of the hinge fitting analyzed (see appendix n°11) as well as the other examinations performed produced of results in accordance with this specification: XXX

- The grade of aluminium corresponds to that of a type 7050 alloy,
- The values for conductivity (**23.25** MS/m on average) and Brinell hardness (**162** HB2.5/62.5 on average) corresponded to 7050 alloy of T73651 grade according to IGC 04.02.110B. The T73651 metallurgical grade (European standard) is equivalent to metallurgical grade T7451 (American standard).

10.1.5. DAMAGE NOTED ON THE LEADING EDGE RIBS

In addition to the hinge fittings, it was useful to contrast the supposed distortion direction with what was observed on the nearby parts, in particular at the level of the leading edge.

Plate n°42 summarizes the direction of the distortions of the hinge fittings with those noted on the ribs close to the hinge fittings. All of these distortions were correlated and were going in the inboard – outboard direction. The image below shows an example of these observations for the outboard side.



- Distortions of the outboard hinge fitting and of the leading-edge ribs

The leading edge ribs were bent and in places seemed to have been torn by another part. After the visit made to an aircraft, it appeared that the hinge point that allowed the return of the activator at the level of the hinge fitting could be the cause of the tears of the while the ribs could have pressed on the shaft or the body of the activator, which would explain the form of the folds (see plate 43).

10.1.6. CONCLUSION ON METALLIC PARTS

The examinations performed showed that :

- the separation of the flaperon from the aeroplane occurred on the flaperon side with :
  - the activator return lugs being broken,
  - the lower parts of each hinge fitting at the level of the lower surface being broken,
- all of the fracture surfaces were a one hundred percent static morphological type, but it was not possible to confirm that using the SEM due to the high level of oxidization,
- the damage noted on the ribs seemed to be linked to the hinge point attachments to the activators as well as to the shaft or body of these activators,
- the slight distortions measured on the hinge fittings and the distortions of the ribs were all oriented in the direction, inboard towards outboard,
- the materials inspected on the hinge fittings was in compliance with the information in the MMM (reference 4).

10.2. COMPOSITE MATERIAL PARTS – STRUCTURE OF THE FLAPERON

Before any other considerations, it should be noted here the most significant oservation the on the parts made of composite materials was that performed macroscopically In fact, the make-up of the material, with fibre folds oriented in different directions according to a draping plan, meant that analysis of the fracture surfaces at the microscopic level could sometimes be complicated or even made contradictory since each fold, due to its orientation, was not loaded in the same manner as another. In addition, the observations performed here were sometimes only able to be performed on small thicknesses because of the pollution, thus in some cases only representing one fold, thus only one orientation. Nevertheless, the microfractographic observations confirmed in the vast majority of cases those of the macroscopic observations.

10.2.1. OVERVIEW

Comparison with an undamaged flaperon showed that the part behind the rear spar was missing (see plate 44). The missing part represented about 1/3 of its original surface.

10.2.2. LEADING EDGE

The leading edge had several areas of damage :

- dents and tears at the level of the removable access doors, in particular on the outboard side,
- four vertical impacts in the central zone.

A small part of the access door on the inboard side was missing. On the outboard side, the access door made of several parts was broken and had a tear indicating indicating being hit by another part. (see plate 45).

The leading edge had four vertical impacts that suggested interaction with a part directly next to the flaperon (see plate 46). The fact that the leading edge was not destroyed equally suggests a secondary impact, i.e. after that which caused the separation of the flaperon.

In the absence of any precise data being supplied by Boeing, it was decided to check on a Boeing 777 if the nearby structure could explain these marks. This was not the case. The data supplied by Boeing a posteriori confirmed the absence of a part directly next to the flaperon that may have caused an impact that would leave these four marks with spacing observed (see plate 47).

10.2.3. LOWER SURFACE

10.2.3.1. VISUAL OBSERVATION

The observations made on the lower surface with it oriented upwards.

The lower surface of the flaperon had several dents (see plate 48).

The fracture on the trailing edge consisted of two distinct parts. The first two-thirds were straight and the fracture followed the rear spar (coming from the outside of the aeroplane towards the inside). The last third was not straight and had a more uneven surface (see plate 49).

10.2.3.1. OBSERVATION OF THE IRREGULAR TRAILING EDGE FRACTURE

Observation of the irregular part showed a smooth fracture, without protruding fibres, characteristic of a compression fracture (see plate 49).

A piece of composite was sampled (see plate 50) at the level of the irregular trailing edge fracture, then observed with the FEG-SEM. This piece consisted of an inner skin, honeycomb and an outer skin. Both skins were examined.

The inner skin fracture consisted of both the parts characteristic compression (fibres in the same fracture plane; steps) and of the parts characteristic traction (radiating fibres on the fracture surfaces, various fibre fracture planes). However, observation of all of the fracture surfaces showed that the compression zones seemed to be in the majority.

The fracture of the outer skin also exhibited compression and traction. But, in this case, observation of all of the fracture surfaces showed that the traction zones seemed to be in the majority.

Taking into account the macroscopic and microscopic observations, the irregular trailing edge fracture seemed to have occurred in bending, from the lower surface towards upper surface.

10.2.3.2. STRAIGHT TRAILING EDGE FRACTURE

Observation of the straight fracture (see plate 51) brought to light the irregularity of the fracture in the upper layers of composite and the regularity of the fracture of the lower layers of composite, with no protruding fibres. The upper layers thus seemed to have failed in traction around of the attachments (peeling) and the lower layers in compression. Observation of this straight fracture also showed the material to be oriented towards the bottom (lower surface oriented upwards).

A piece of composite was sampled (see plate 52) at the level of the straight trailing edge fracture, then observed under the FEG-SEM.

Observation of the fracture on the intermediate folds indicated that the compression zones seemed to be in a majority, even if there were some zones of traction present.

It was the same for the fracture on the inner folds: there were some zones of traction present, however compression zones seemed to be in a majority.

Taking into account the macroscopic and microscopic observations, the straight trailing edge fracture seemed to have occurred in bending, from the lower surface towards upper surface.

10.2.4. UPPER SURFACE

10.2.4.1. VISUAL OBSERVATION

The observations were made with the upper surface oriented upwards.

The top of the upper surface of the flaperon had several dents (see plate 53), several impact marks and a crack several centimetres long.

The trailing edge was broken. The fracture was regular, with no protruding fibres (see plate 54).

The impact at the end of the crack as well as a part of the crack were extruding (see plate 56). The damage observed indicated the presence of a « high energy » event.

10.2.4.2. TRAILING EDGE FRACTURE

Taking into account the regular appearance of the fracture with no protruding fibres, there was likely some compression present (see plate 54). Further, observation of the fracture also showed the material to be oriented towards the bottom (lower surface oriented upwards).

A piece of composite was sampled (see plate 55), then observed with the FEG-SEM. This piece consisted of an inner skin, honeycomb and an outer skin. Both skins were examined.

Observation of the fracture of the inner skin showed the presence of traction. However, many of the zones were not observable, as they were highly polluted: it was thus impossible to state categorically that there was no compression.

Observation of the fracture of the outer skin indicated that the traction seemed to be in a majority, even if there were some zones of compression present.

The macroscopic observations indicated at first sight compression loading on this zone, even some bending towards the outside, i.e. lower surface towards upper surface, due to various folds of enshrouding matter observed. This was not confirmed by SEM observations. In fact, under pure bending load from the lower surface towards the upper surface, it was expected to find mainly traction on the inner skin and compression on the outer skin. The following sections may explain this inconsistency:

- the loading was not oriented in a uniform manner which, on a composite part with various fold orientations, made correlations even more complex,
- the zones observables with the SEM were small due to the pollution and made it impossible to confirm compression as the principal mode in the outer skin with any certainty,
- this fracture could be the consequence of the preliminary trailing edge fracture on the lower surface.

10.2.4.3. UNPIERCED CRACK

A piece of composite was sampled at the level of the crack, in a part where the latter was not pierced (see plate 57): only the outer skin was broken and was thus observed.

Macroscopically, the outer skin seemed to have broken in bending. Microscopically, it seemed that the closer the observations were made to the paint, the more traction seemed to be in the majority. And, the closer the observations were performed to the honeycomb, the more compression seemed to be in the majority.

The fracture at the level of the unpierced crack was thus in bending, probably due to skin bowing.

In this zone, a calcination test was performed so as to establish the orientation of the folds of the outer skin of the box. The results are presented in plate 58.

10.2.4.4. PIERCED CRACK

A piece of composite was sampled at the level of the crack, in a part where the latter was pierced (see plate 59). This piece consisted of an outer skin, of honeycomb and an inner skin. At the level of the outer skin, material orientation towards the bottom was observed. It thus seems that a part from outside the flaperon pierced or dented this zone (part of the aeroplane, water penetration?).

Observation on the FEG-SEM (see plate 60) of the fractures on the outer skin and on the inner skin showed that on the usable zones (very polluted fracture surfaces), traction seemed to be in the majority, even if there was some compression present.

The low usable thickness made it impossible to conclude that there was a simple traction fracture, though a fracture resembling traction could be a consequence of a shearing load given the draping observed in this zone.

10.2.5. SUMMARY OF THE EXAMINATIONS

It appears that the flaperon lost nearly one third of its surface behind the rear spar. The observations were performed with the upper surface upwards (see plate 61).

- Leading edge

The access door on the inboard side was partially broken off. On the outboard side, note dents and tear were noted, suggesting contact with one or more nearby parts.

In its central part, the leading edge had inexplicable dents and vertical cracks.

- Lower surface(trailing edge)

At the level of the fracture of the trailing edge, the material was oriented upwards. The straight trailing edge fracture was linked to bending loads. The irregular trailing edge fracture was from bending: mainly traction on the outside and compression on the inside.

- Upper surface(crack and trailing edge)

The upper surface had some dents, impacts, of which one was salient and a crack with one salientpart.

The trailing edge fracture was uneven but was locally clean with no protruding fibres which, combined with material orientation upwards, suggested bending. However, microscopic examinations indicated mainly fractures in traction in this zone. This fracture of the trailing edge side upper surface could have occurred after that on the lower surface, which would explain its uneven character.

In its non-salient part, the fracture at the level of the crack occurred in bending: traction mainly on the paint side and compression mainly on the honeycomb. This leads to the assumption of bowing.

In its salient part, the fracture at the level of the crack seemed to have occurred in traction. The material was oriented downwards in this zone, which suggests possible penetration by a part from outside the flaperon, which then fell out, or damage linked to water ingestion.

10.3. CONCLUSION – SEPARATION AND DAMAGE SCENARIO

Concerning the dents, it is likely that some 'objects' struck the the flaperon forcibly.

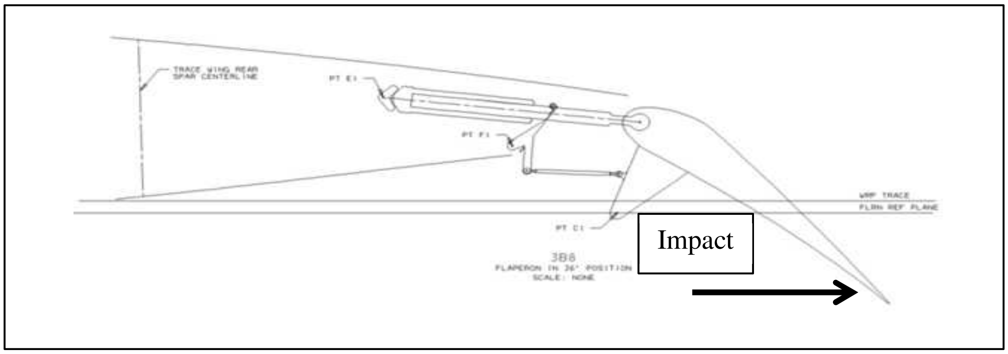
The perforations observed were likely due to the presence of salient parts on these 'objects'.

On the base of the observations and examinations performed, it is possible to **hypothesize** a scenario that could have led to the separation and to the damage noted on the flaperon.

First of all, it appears possible to exclude in-flight loss of the flaperon since its weight is concentrated forwards, which would a priori lead to a fall with the leading edge forwards and the probable destruction of the latter. The damage to the trailing edge would also likely be different. A simulation of a flaperon fall with an initial speed corresponding to that of an aeroplane in flight would enable this to be definitively eliminated.

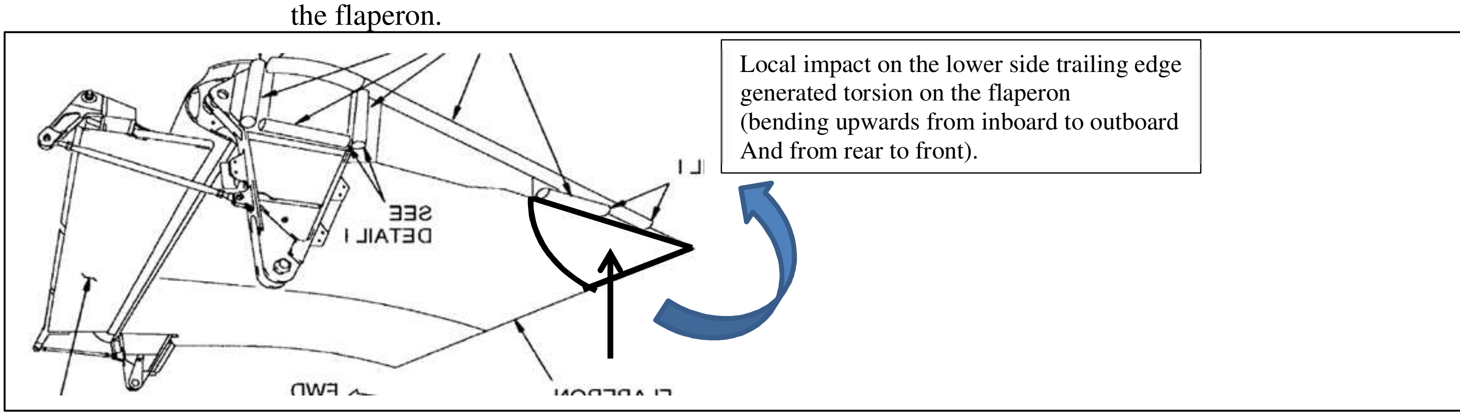
The hypothesis for a separation and damage scenario would be as follows:

1. Considering an impact with water as likely, and considering the damage observed, it seems that the flaperon must have been deflected at the time of the impact,



- Presumed position of the flaperon on impact -

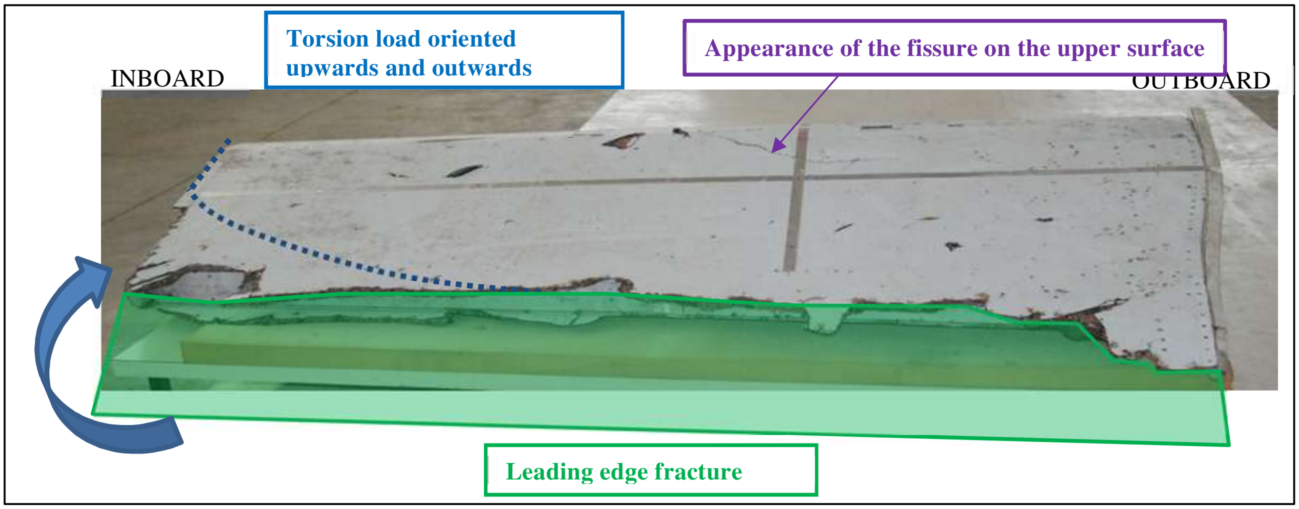
2. The damage being greater on the trailing edge on the inboard side, notably on the lower surface side, it appears that the contact occurred first in this zone. The loads generated, pushing from the lower surface towards the upper surface locally (unlike uniform aerodynamic loading), resulted in a bending load from the rear towards the front as well as of inboard towards outboard. This caused torsion on the flaperon.



- Impact point and torsion loading on the flaperon -

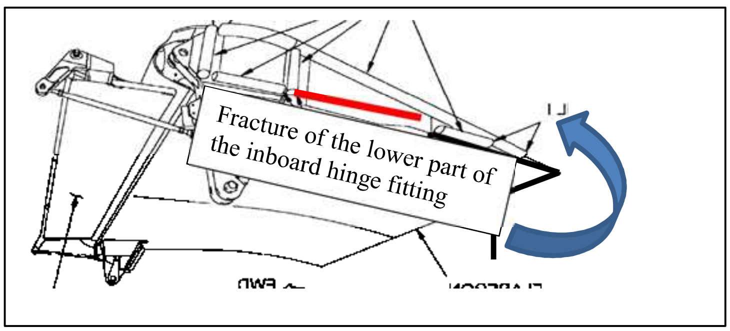
3. This contact led to the dispappearance of a large part of the trailing edge, behind the rear spar (trailing edge bending upwards). The crack observed on the upper surface could be a consequence of the loads linked with the torsion that would

have generated bowing near the forward spar and a shearing fracture in more in the centre of the flaperon.



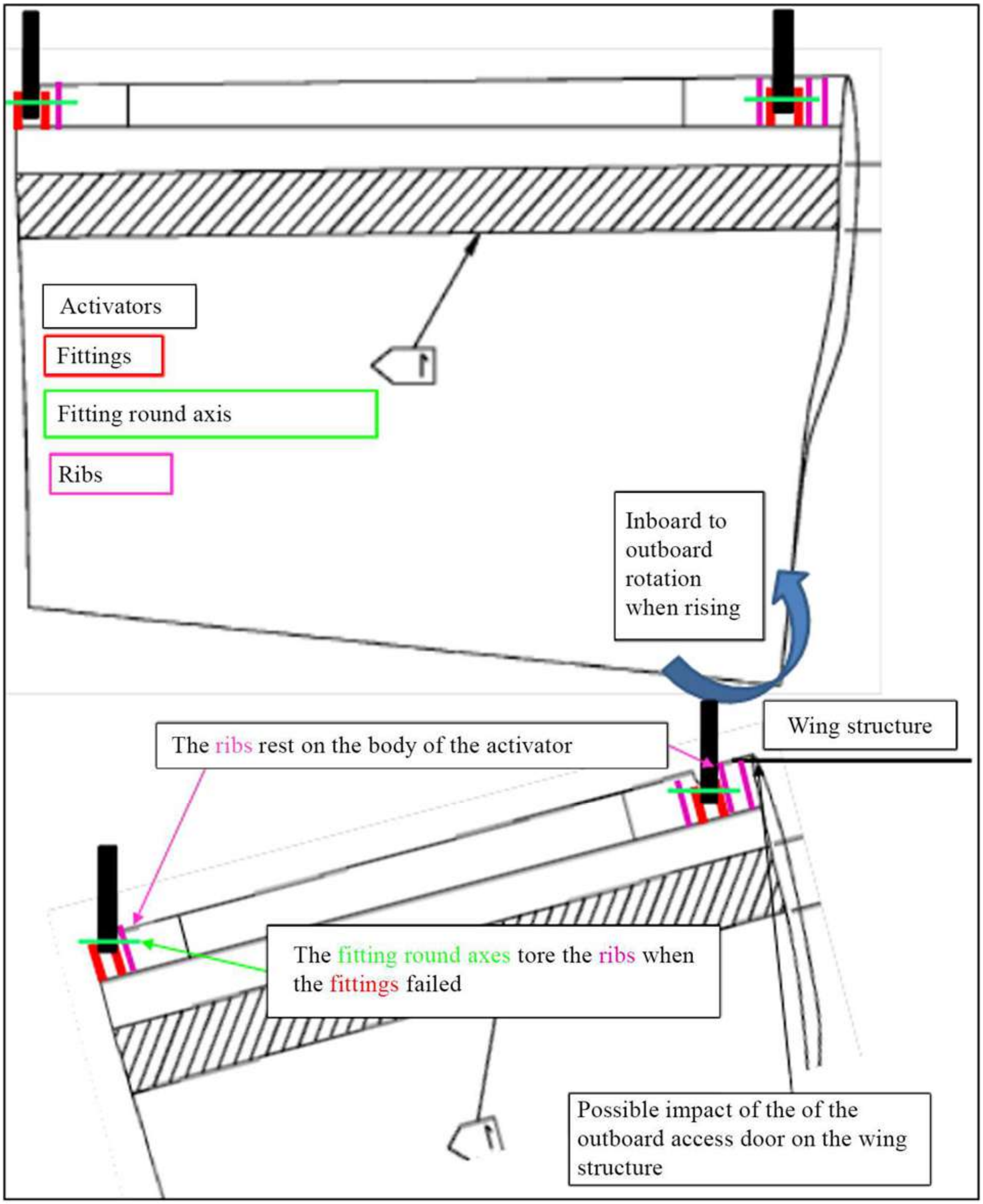
- Fracture of the trailing edge and appearance of the crack on the upper surface-

4. Almost simultaneously, this torsion from inboard towards outboard and from the rear to the front broke off the lower part of the inboard hinge fitting, not designed for this type of load.



- Fracture of the lower part of the inboard hinge fitting -

5. The flaperon pivoted from the inside towards the outside around the outboard hinge fitting (anticlockwise direction). This caused the fracture of the lower part of the outboard hinge fitting as well crushing the fairing of leading edge and pushing the of leading edge ribs onto the actuating cylinders, which would explain their being crushed. The inboard then the outboard lugs, which the activators are attached to, broke off and the flaperon detached. The moment when the fracture of the lugs occurred during this sequence is not clearly definable, in particular the fracture of the inboard lug before that of the lower part of the outboard hinge fitting.



- Ribs and lugs fracture damage sequence: separation of the flaperon -

Beyond the possible in-flight loss, which is not entirely excluded, this scenario can only be considered as a hypothesis since:

- no available parts allowed us to perform the work in section 5 that could corroborate this,
- the flaperon is aft of the engine which leaves some doubt as to its loading during aeroplane impact with the water,
- the phenomena at issue are highly dynamic and thus difficult to exploit.

11. SECTION 5: CALCULATIONS AND SIMULATIONS

As stated above, the parts available to us did not make it possible to perform work planned for this section (see appendix 12 for the missing parts).

12. CONCLUSIONS

The identification numbers of the flaperon components found thanks to the boroscope inspection allowed the manufacturer of the part to confirm to the Judge and to the Judicial Expert that the part did indeed belong to the Malaysia Airliness aeroplane registered 9M-MRO of (communication by the prosecutor's office on 3 September 2015).

Before any destructive tests, the part was examined in its entirety. Its characteristics were recorded. Damage to it, as well as the colony of crustaceans on it, was mapped.

A buoyancy test was performed by DGA TH in the premises of the DGA TA and allowed flaperon bouyancy to be characterized.

The significant damage was appraised for the purpose of determining a scenario for separation of the part from the aeroplane. In the absence of data from Boeing, and despite the deterioration of some fracture surfaces, a hypothesis was nevertheless formulated: taking into account the results of the examinations, it appears that the flaperon impacted the water while still attached to the aeroplane and that at the time of the impact it was deflected. A fall simulation for the flaperon with an initial speed corresponding to that of an aeroplane in flight could definitively exclude the loss of the latter in flight.

The little data supplied by Boeing did not enable the examination to be progressed by making calculations that would have made it possible to confirm or reject the proposed hypothesis.

- PLATES -

PAGE SANS TEXTE

Planche 1 : **Photos of presentation of the flaperon received for examination**

Leading edge

Trailing edge

Missing identification plate

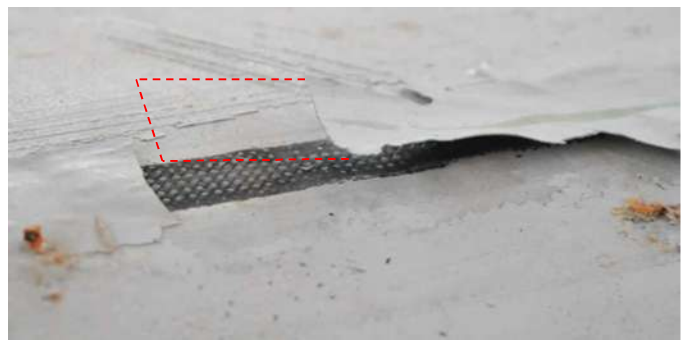
Inboard side

Outboard side

Planche 2 : **Paint sample in a zone that appeared to have been touched up**

Cut

Paint sample

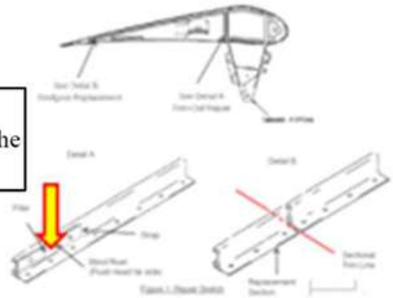


Piece of paint sampled

Sampling to search for explosive residues

Planche 3 : **Check on the presumed repair made by Malaysia Airlines**

Addition of a riveted piece on the back of the joint



Repair on the joint moulding

Repair on the joint moulding

Removal of joint

Cutting off joint moulding to check repair

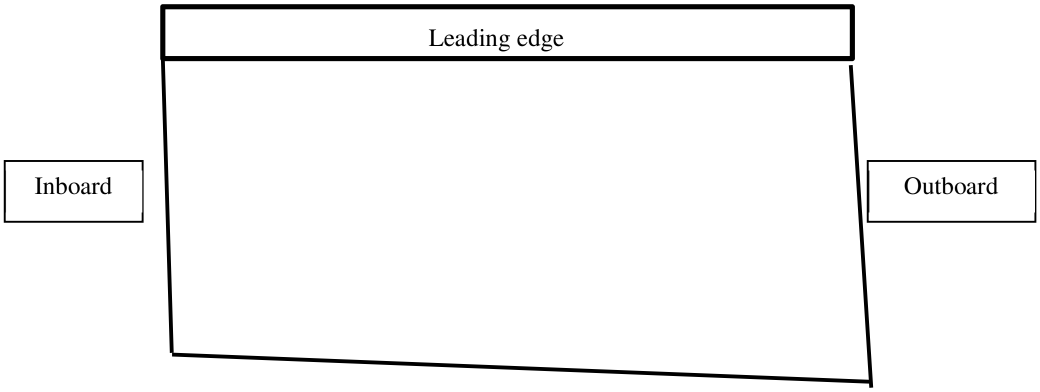
No repair on joint moulding

Joint moulding (see from behind)

View of area after cutoff

This repair is a minor and temporary repair and that should be replaced by a modification (according to ref. 6 in appendix 11). It thus seems probable that application of the modification was not recorded.

Planche 4 : **Boroscope inspection – leading edge**

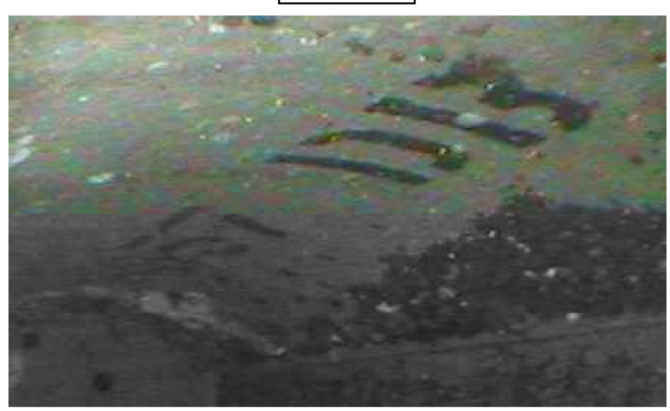


Numbers on the leading edge access panels

557 CB

657 BB

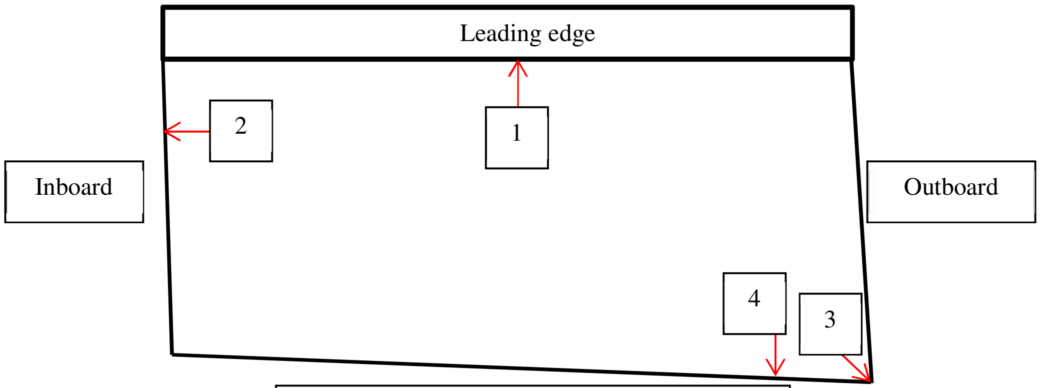
657 AT



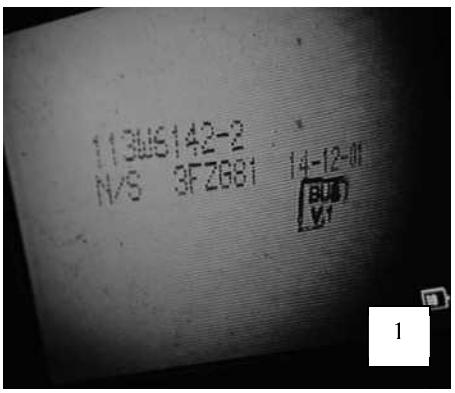
657 DB

657 CT

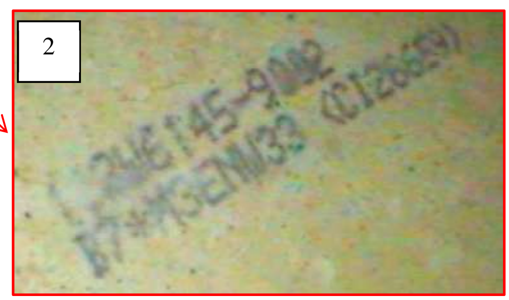
Planche 5 : **Boroscope inspection - box**



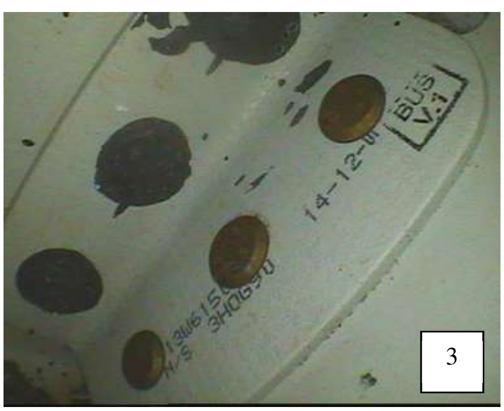
Position of references noted



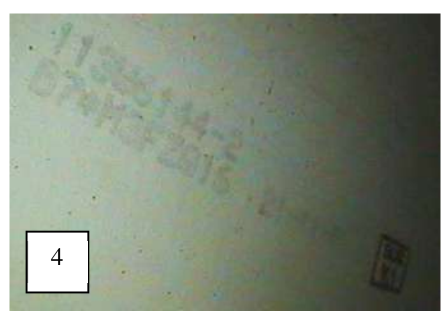
Reference n°1 on forward spar



Reference n°2 on inboard side



Reference n°3 on the bracket between the outboard side and the aft spar

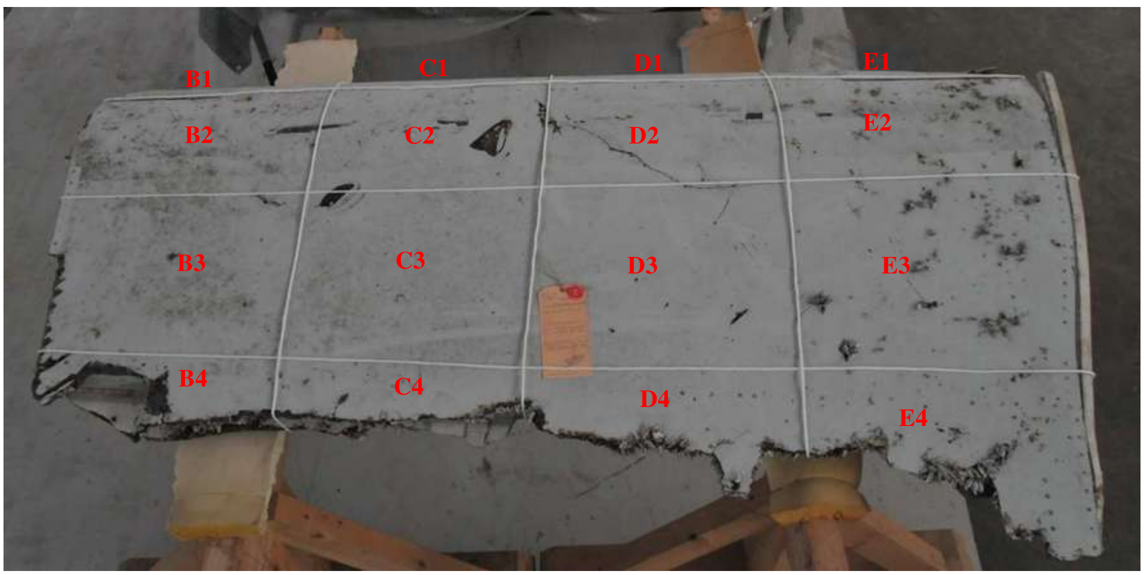


Reference n°4 on the aft spar

LOCALISATION OF THE CRUSTACEANS AND SAMPLES

Planche 6 : **References of the zones on the flaperon**

Leading edge



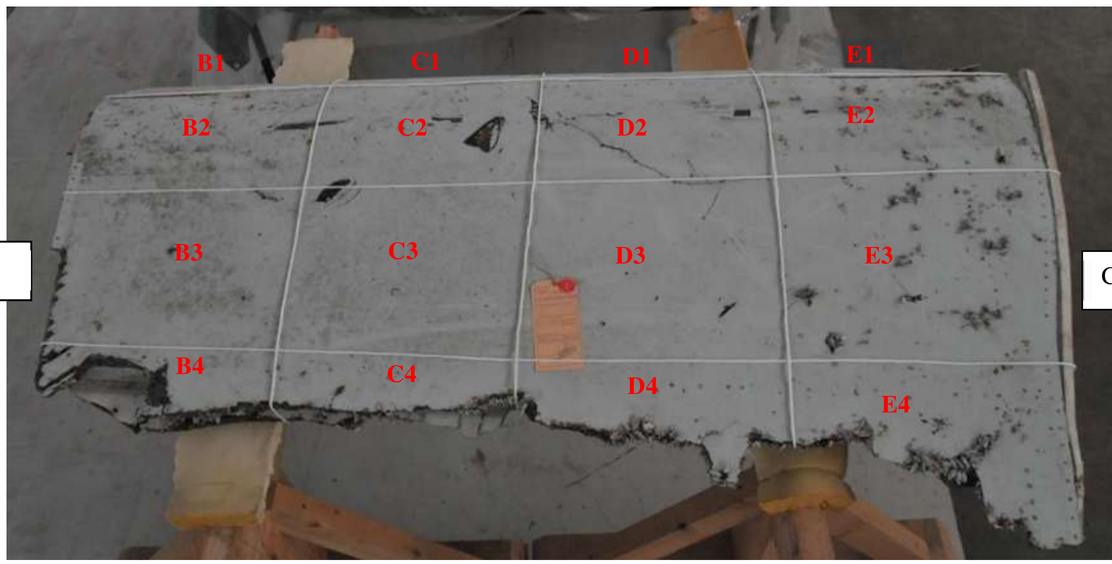
Upper surface side

Trailing edge

Planche 7 : **Rferences of the zones on the flaperon**

Side A

Côté A



Côté F

Upper surface

Side F

Planche 8 : **Detail of zones A on the flaperon**

Side A

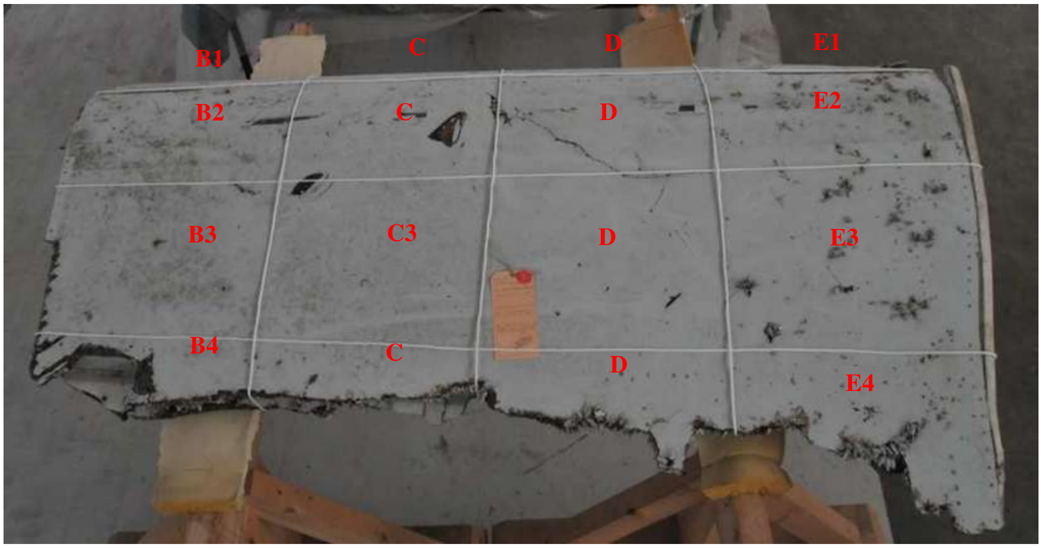
Zone A1

Zone A2

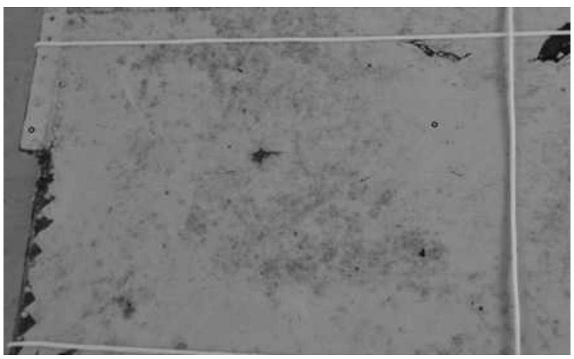
Zone A3

Zone A4

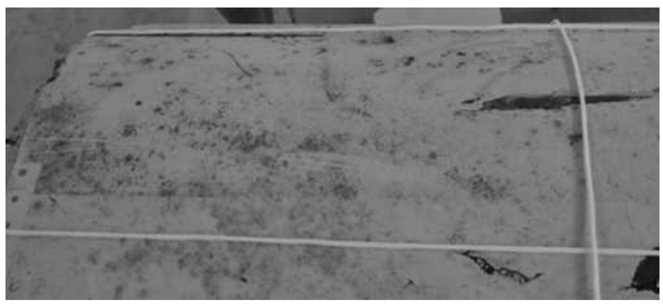
Planche 9 : **Detail of the zones B on the flaperon**



Zone B1



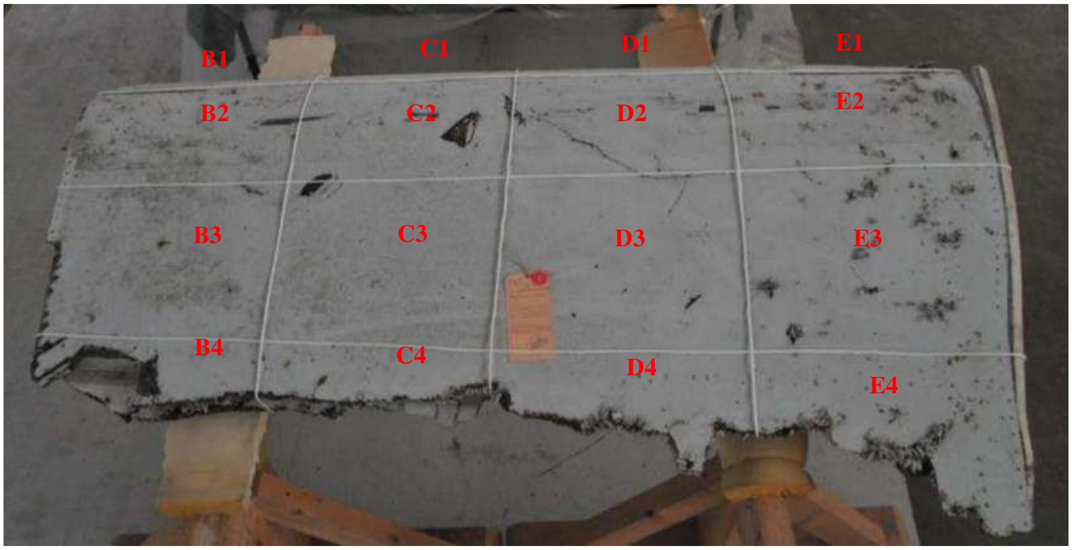
Zone B3



Zone B2

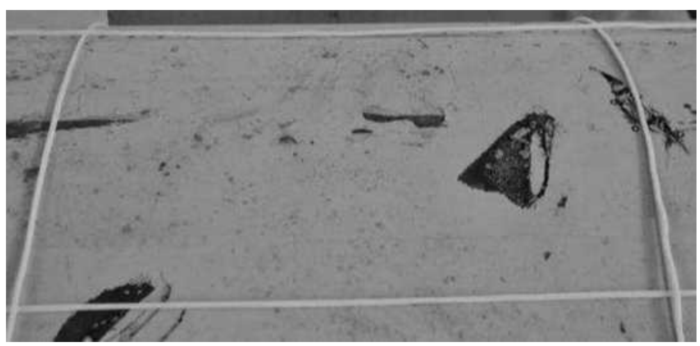
Zone B4

Planche 10 : **Detail of the zones C on the flaperon**



Zone C1

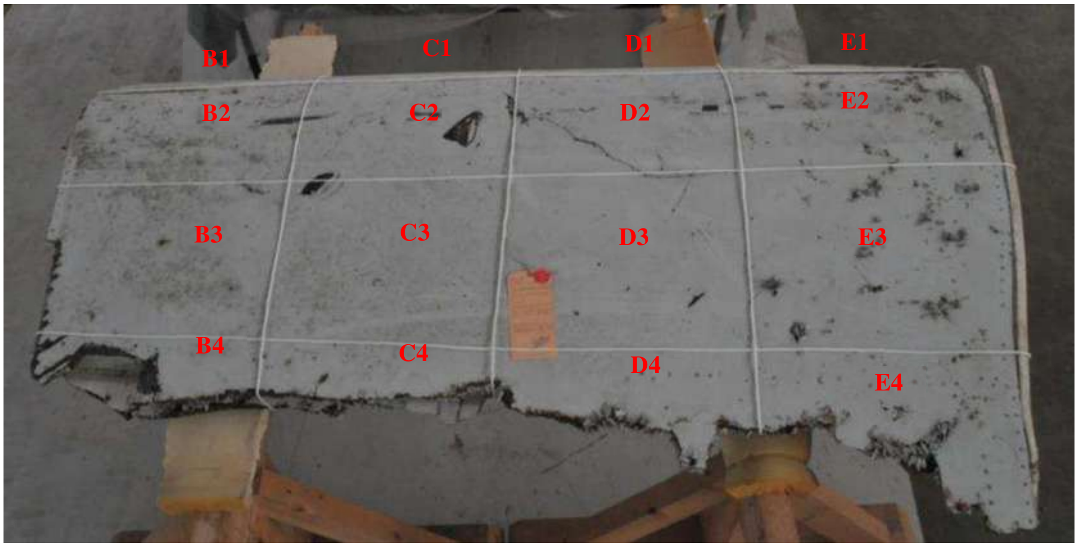
Zone C3



Zone C2

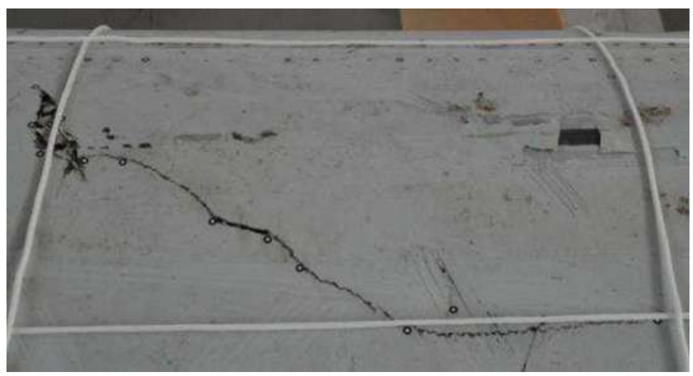
Zone C4

Planche 11 : **Detail of the zones D on the flaperon**



Zone D1

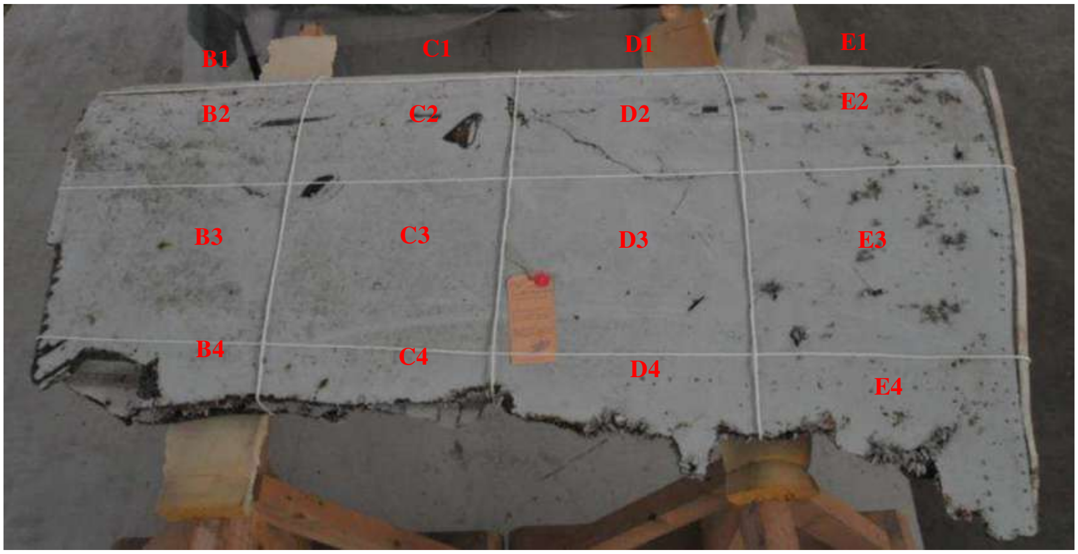
Zone D3



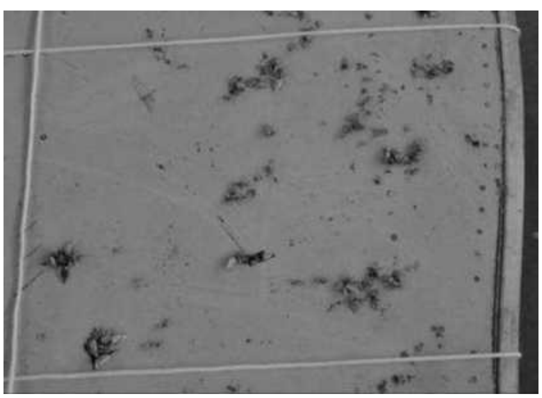
Zone D2

Zone D4

Plate 12: Detail of zones E on the flaperon



Zone E1

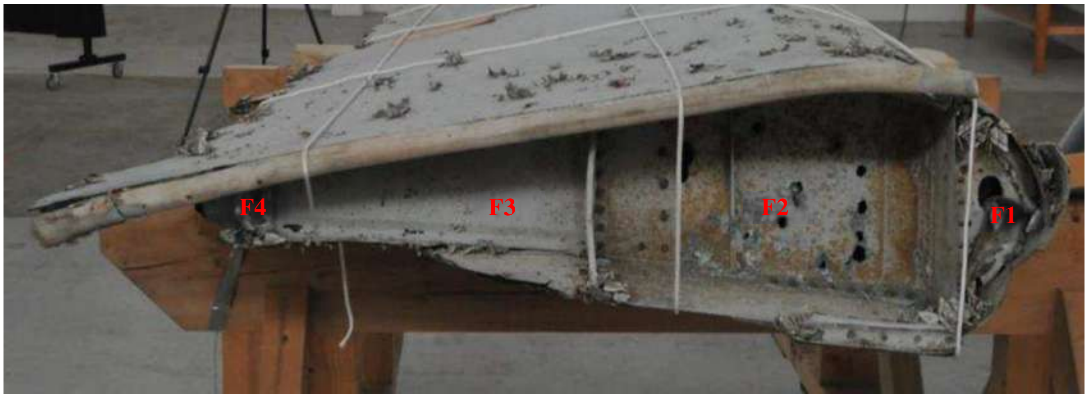


Zone E3

Zone E2

Zone E4

Planche 12 : **Detail of zones F on the flaperon**



Zone F2

Zone F1

Zone F4

Zone F3

Planche 13 : **Weights of the crustaceans sampled by zone**

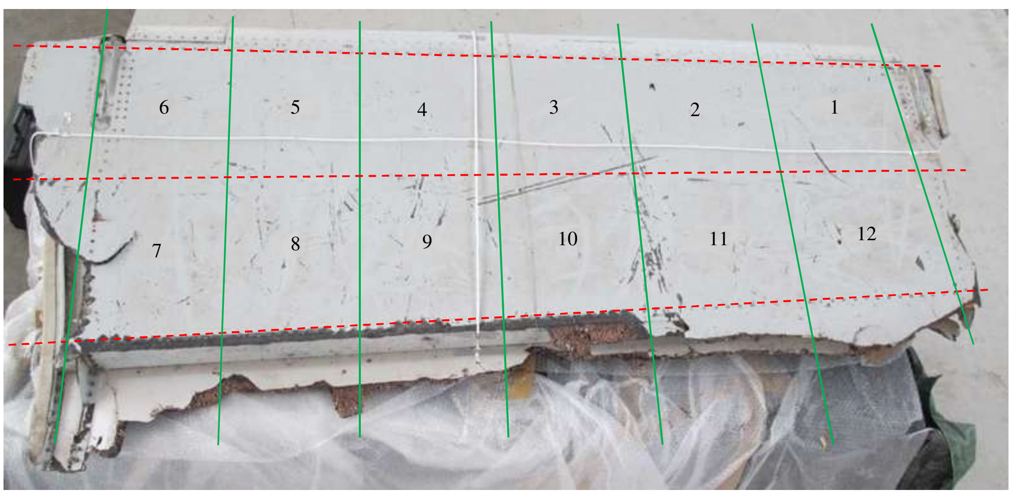
Zone identified	Weight of crustacean sampled in gr	observations
A1	16	Sampled by DGA TA
A2	36	Sampled by DGA TA
A3	12,6	Sampled by DGA TA
A4	0	
B1	?	Sampled by expert crustacean
B2	?	Sampled by the SR
B3	0	
B4 upper surface B4 lower surface	9.6 14,9	Sampled by DGA TA
C1	0	
C2	5	Sampled by DGA TA
C3	0	
C4 upper surface C4 lower surface	17,1 18,3	Sampled by DGA TA
D1	0	
D2	0	
D3	0	
D4 upper surface D4 lower surface	39,9+ ? 28,2+ ?	Sampled by DGA TA and expert crustacean
E1	35,4	Sampled by DGA TA
E2	13,2	Sampled by DGA TA
E3	20,5+ ?.	Sampled by DGA TA and expert crustacean
E4 upper surface E4 lower surface	47,9+ ? 29,4+ ?	Sampled by DGA TA and expert crustacean
F1	43,7	Sampled by DGA TA
F2	45,2	Sampled by DGA TA
F3	32,3	Sampled by DGA TA
F4	12,7	Sampled by DGA TA

Total weight sampled by DGA TA and sent to Gif sur Yvette : 468.3 grams.

X-RAYS OF THE FLAPERON

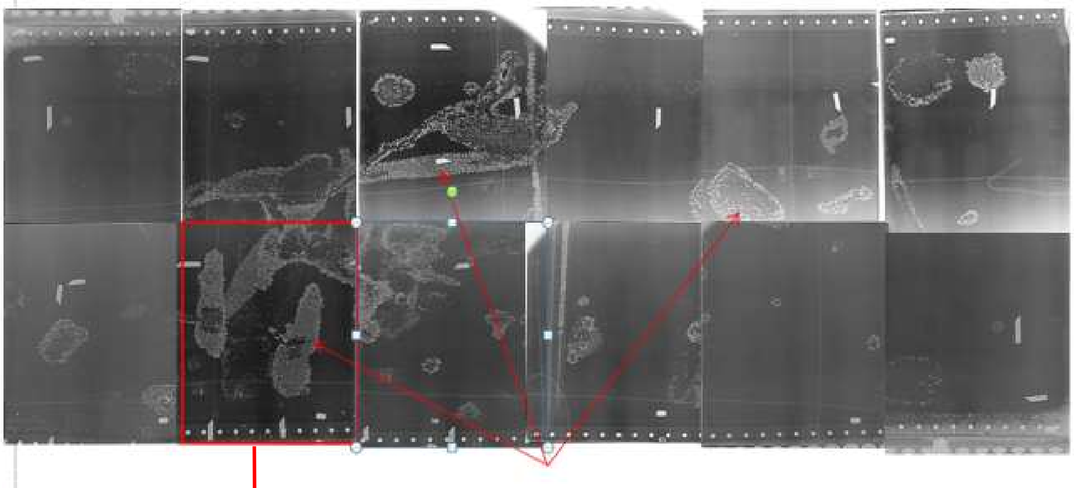
Planche 14 : **X-raysof the flaperon – localisation of the zones x-rayed**

RX x-ray area

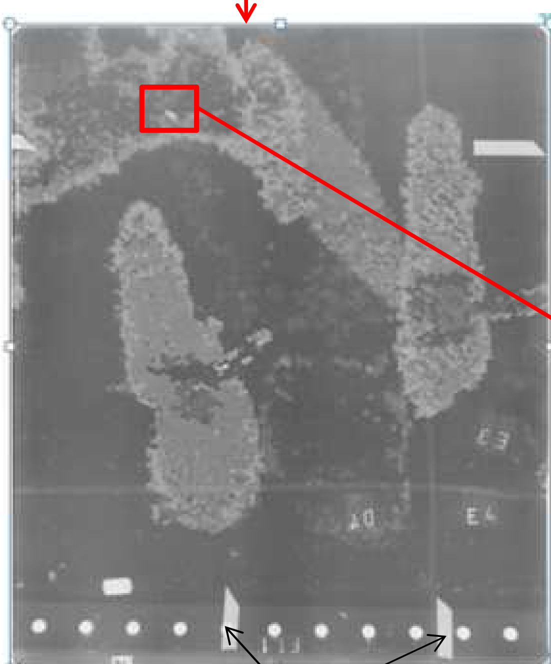


X-ray zones

Planche 15 : **X-rays of the flaperon**



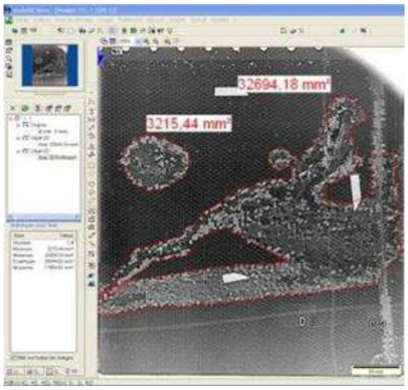
The lightest zones correspond to salt deposits following sea water penetration in the cracked composite



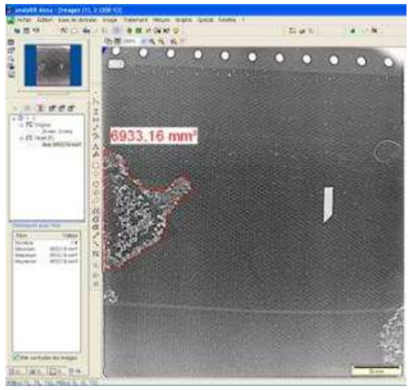
Boroscope of the zone: presence of a crustacean inside the flaperon

Adhesive strip for reference

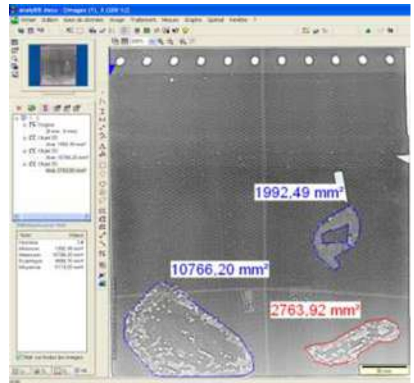
Planche 16 : **Area of the zones covered in salt**



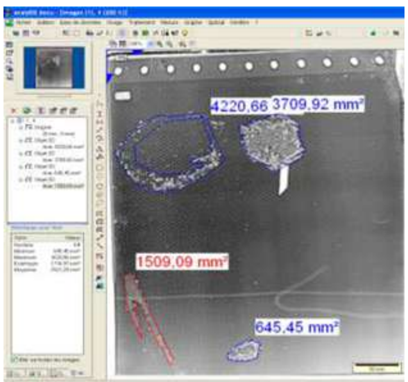
35909,62 mm^2



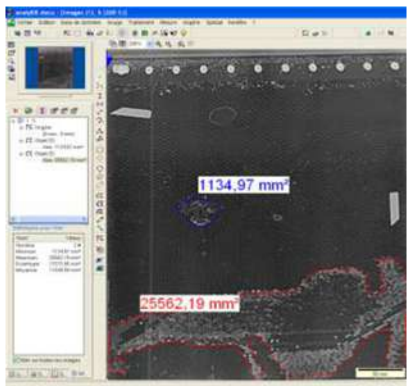
6933,16 mm^2



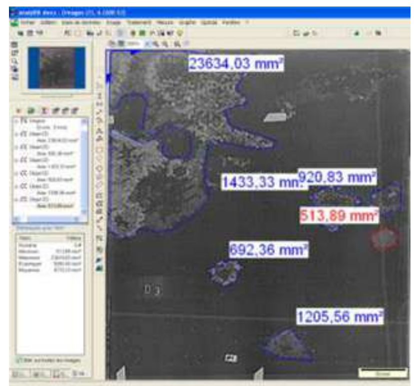
15522,61 mm^2



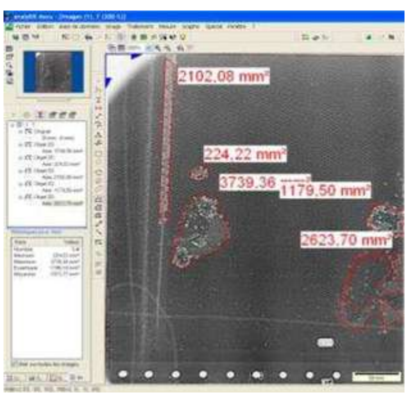
10085,12 mm^2



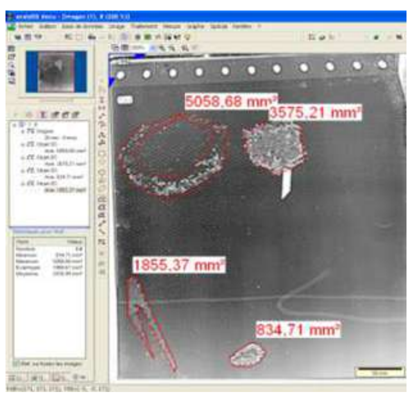
26697,16 mm^2



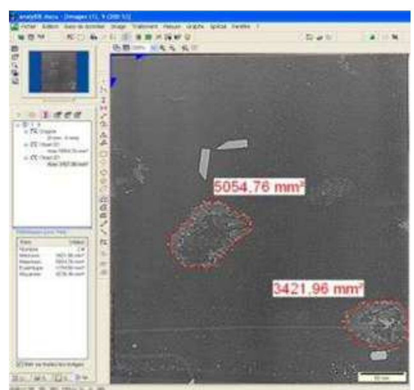
28400 mm^2



9868,86 mm^2



11323,97 mm^2



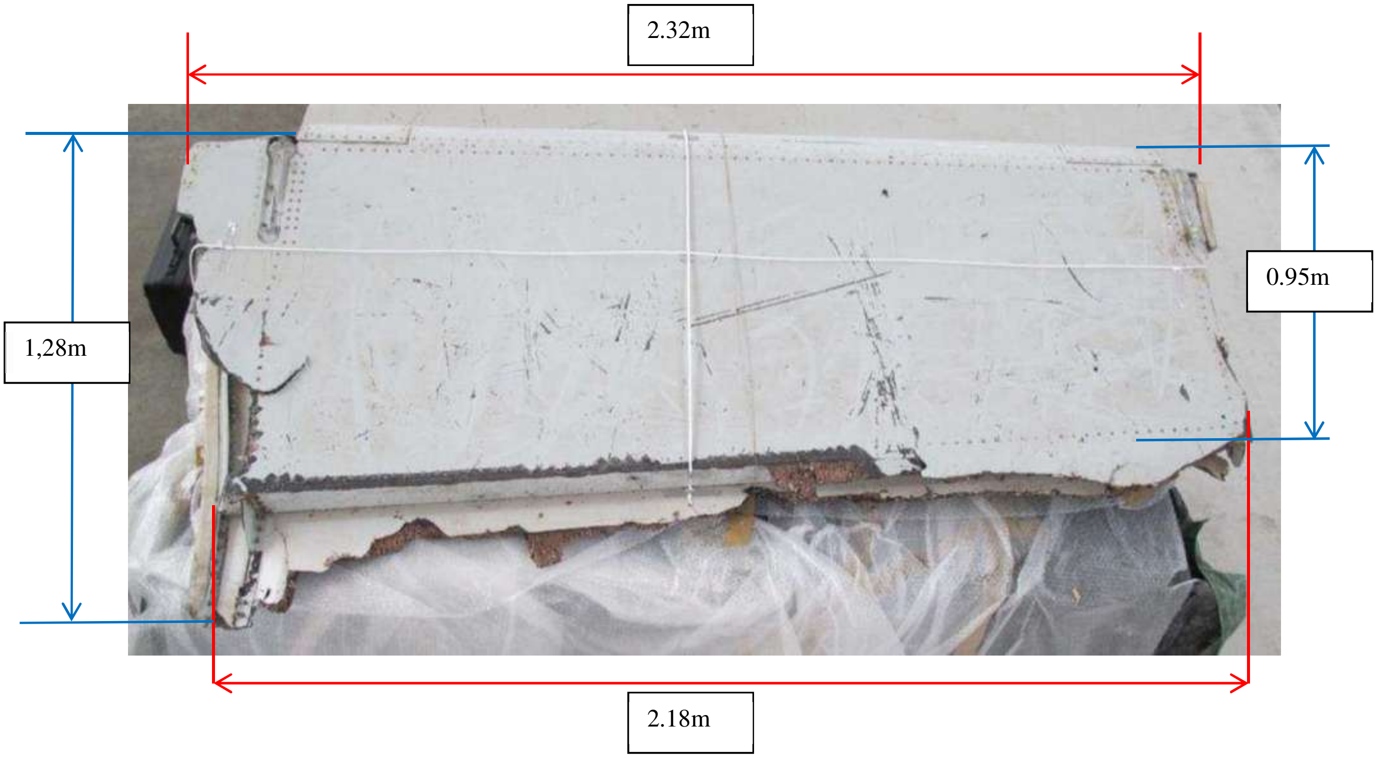
8476,72 mm^2

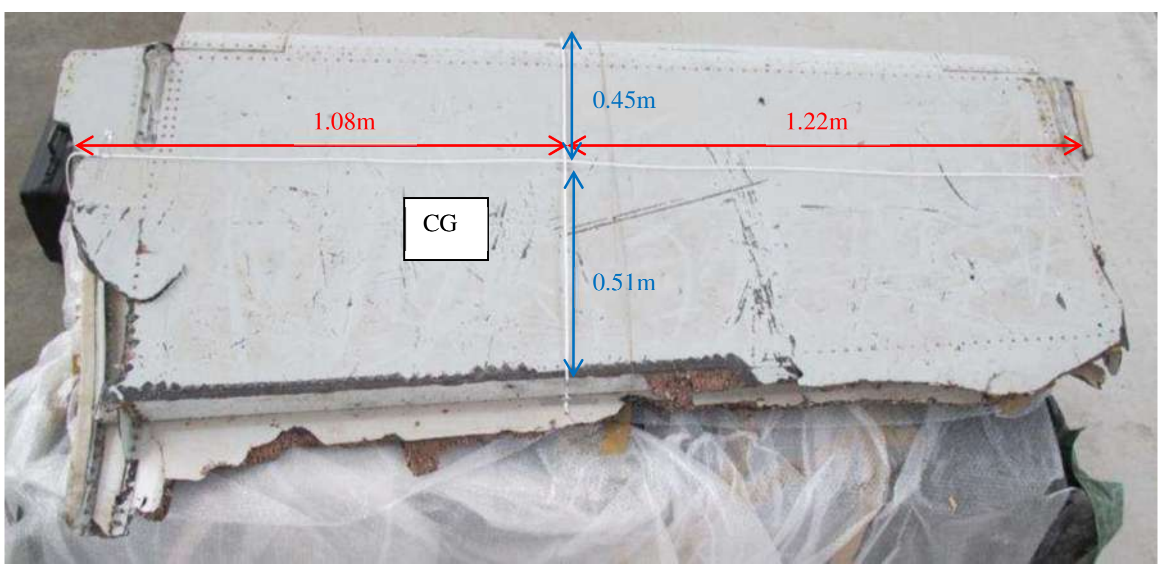
Total area = 153217 mm^{2,} (0.153 m$^{2)}$

PHYSICAL CHARACTERISTICS OF THE FLAPERON

Planche 17 : **Weight of the flaperon**

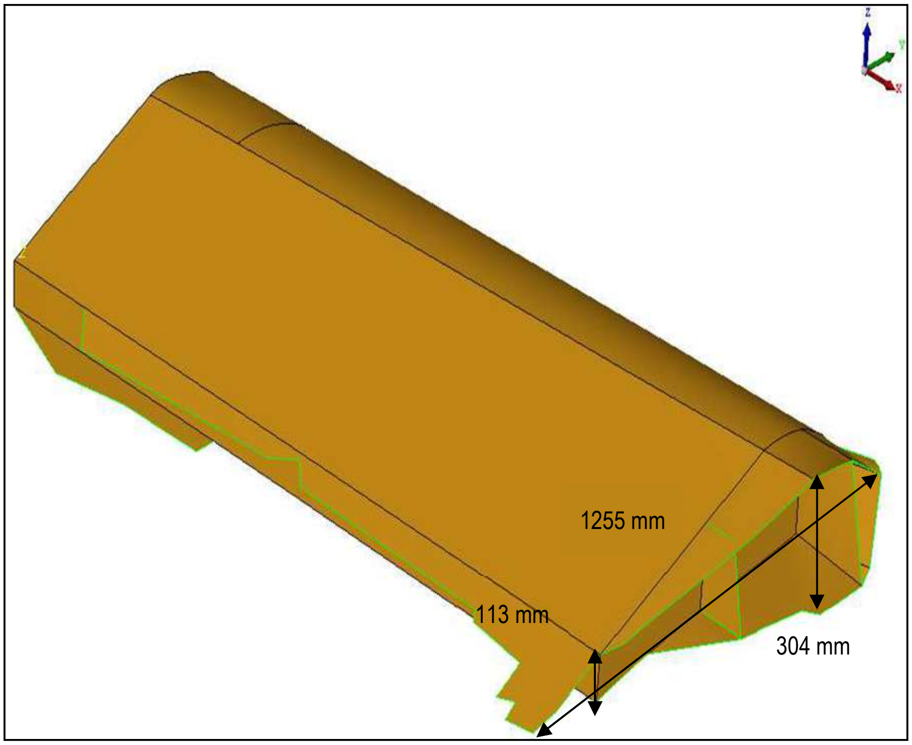
Planche 18 : **Dimensions and position of the centre of gravity lower surface side**

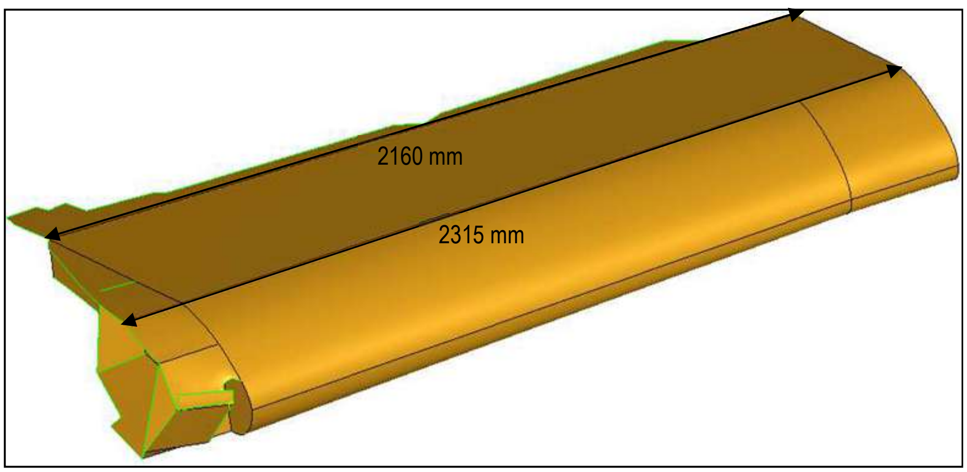




Position of centre de gravity on the lower surface side

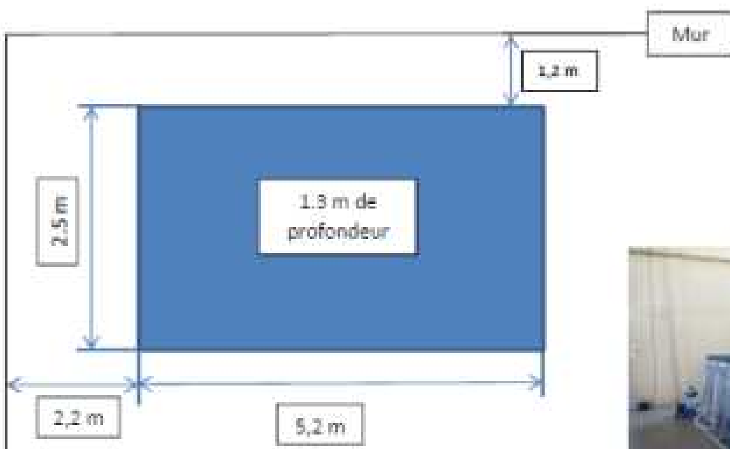
Planche 19 : **3D model of the flaperon**





BUOYANCY TEST

Planche 20 : **Buoyancy test**



Piscine pleine d'eau salée à 4% et une température de 20°C.

Au environ de 1,1 m d'eau.

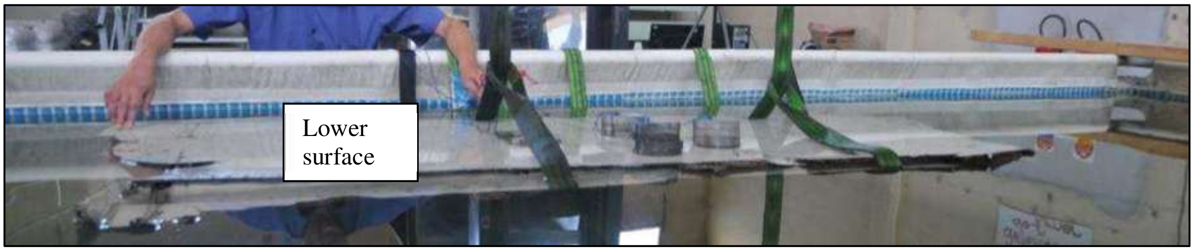
Planche 21 : **Buoyancy test**

DGA TH cameras around the pool

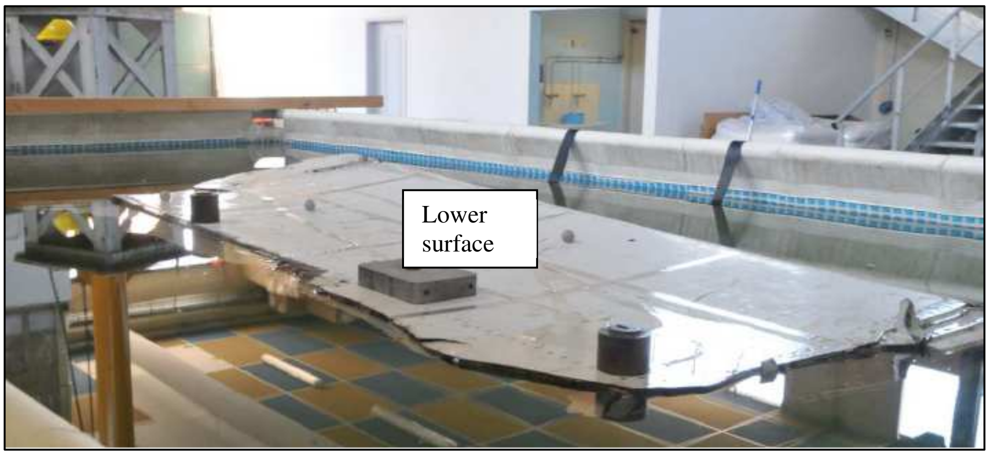
Flaperon in the pool

Positioning the flaperon in the pool

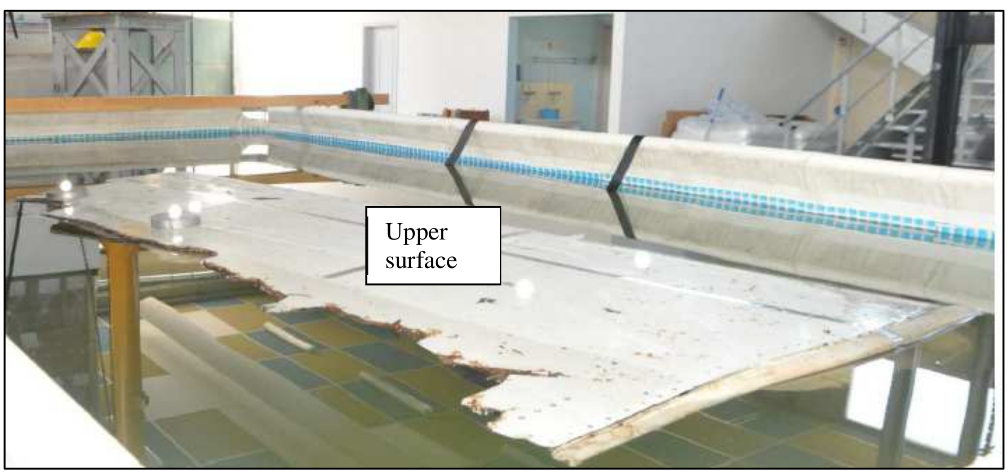
Planche 22 : **Buoyancy test**



The effective weight to immerse the flaperon completely was 37 kg (41kg –Archimedes buoyancy on weights).



The added weight, which did not touch the water and was thus effective, to immerse the lower surface trailing edge upwards was 13.5 kg.

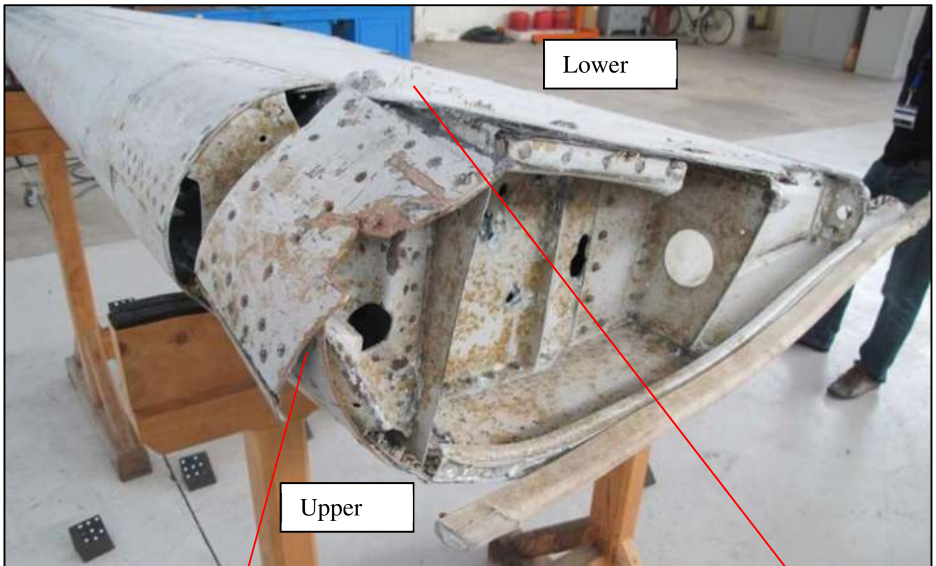


The added weight, which did not touch the water and was thus effective, to immerse the upper surface trailing edge upwards was 5 kg

EXAMINATIONS OF THE METALLIC ELEMENTS

EXAMINATIONS OF OUTBOARD HINGE FITTING AND NEARBY ELEMENTS

Planche 23 : **Hinge fitting on the outboard side**

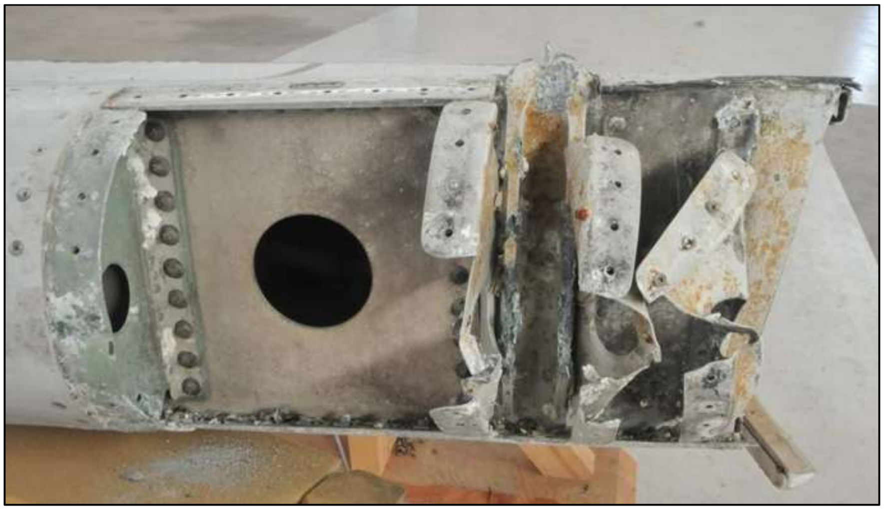


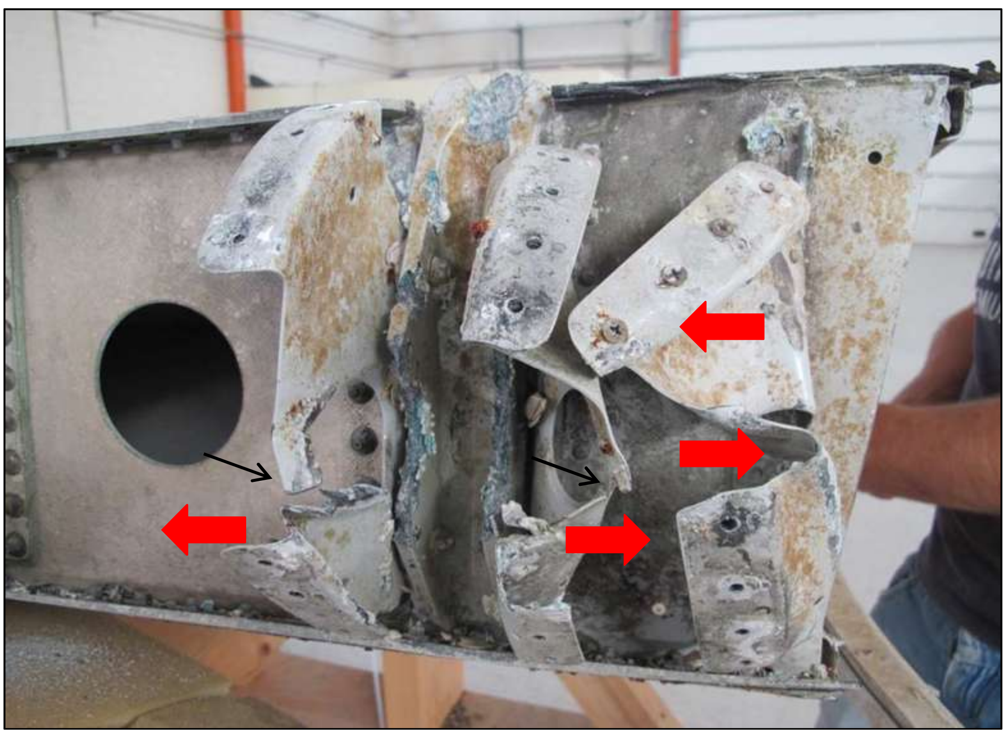
Disassembly of leading edge panel

Lower surface fracture

Leading edge fracture

Planche 24 : **Hinge fitting on the outboard side**





Direction of distortions on rib tears

Planche 25 : **Elements located aft of the outboard hinge fitting**

Direction of distortions

Planche 26 : **View of the flaperon after disassembly of the outboard hinge fitting**

Planche 27 : **Outboard hinge fitting disassembled**

Outboard hinge fitting dissassembled

Leading edge fracture

Lower surface fracture

Planche 28 : **Lower surface outboard side hinge fitting fracture**

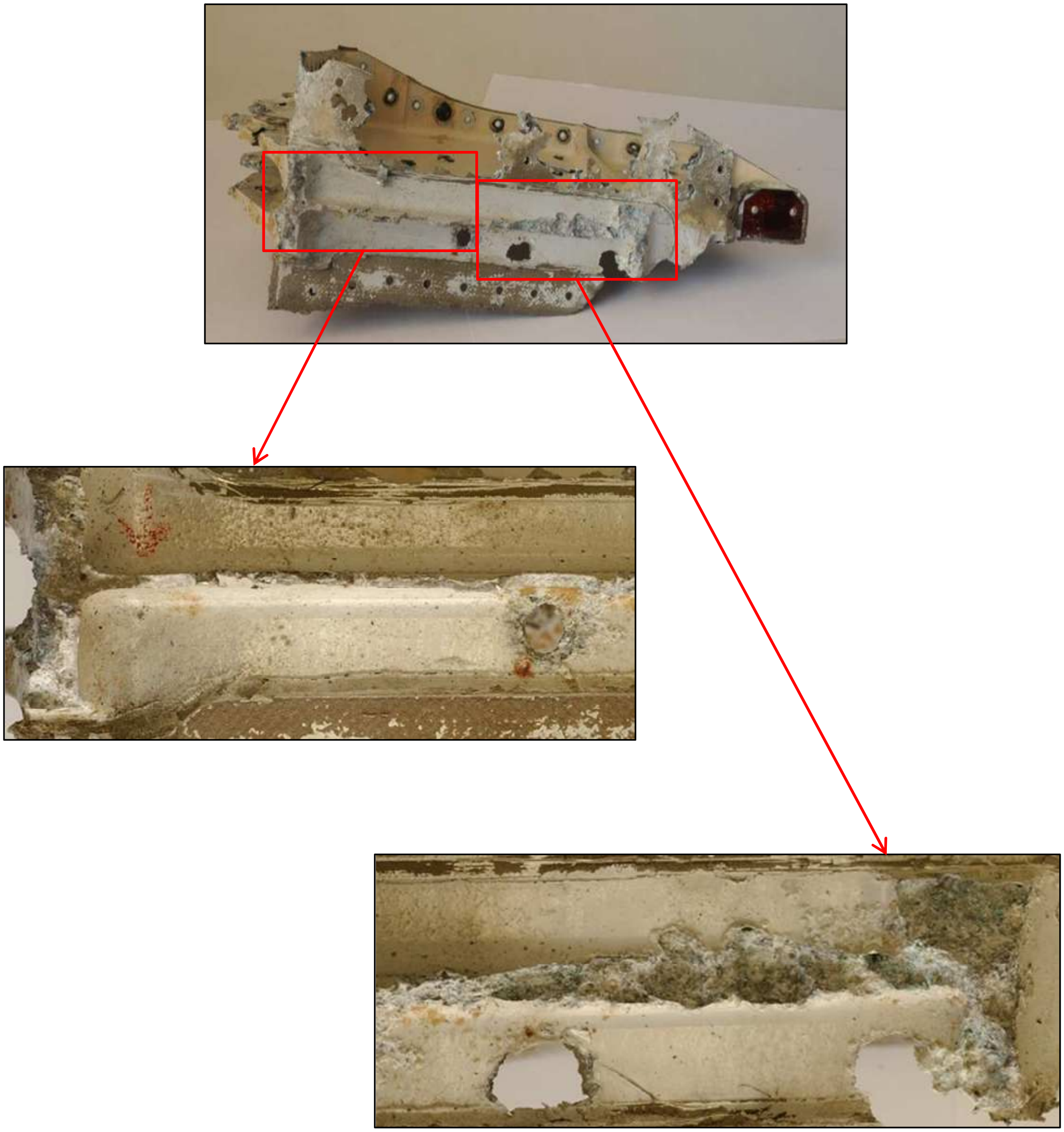
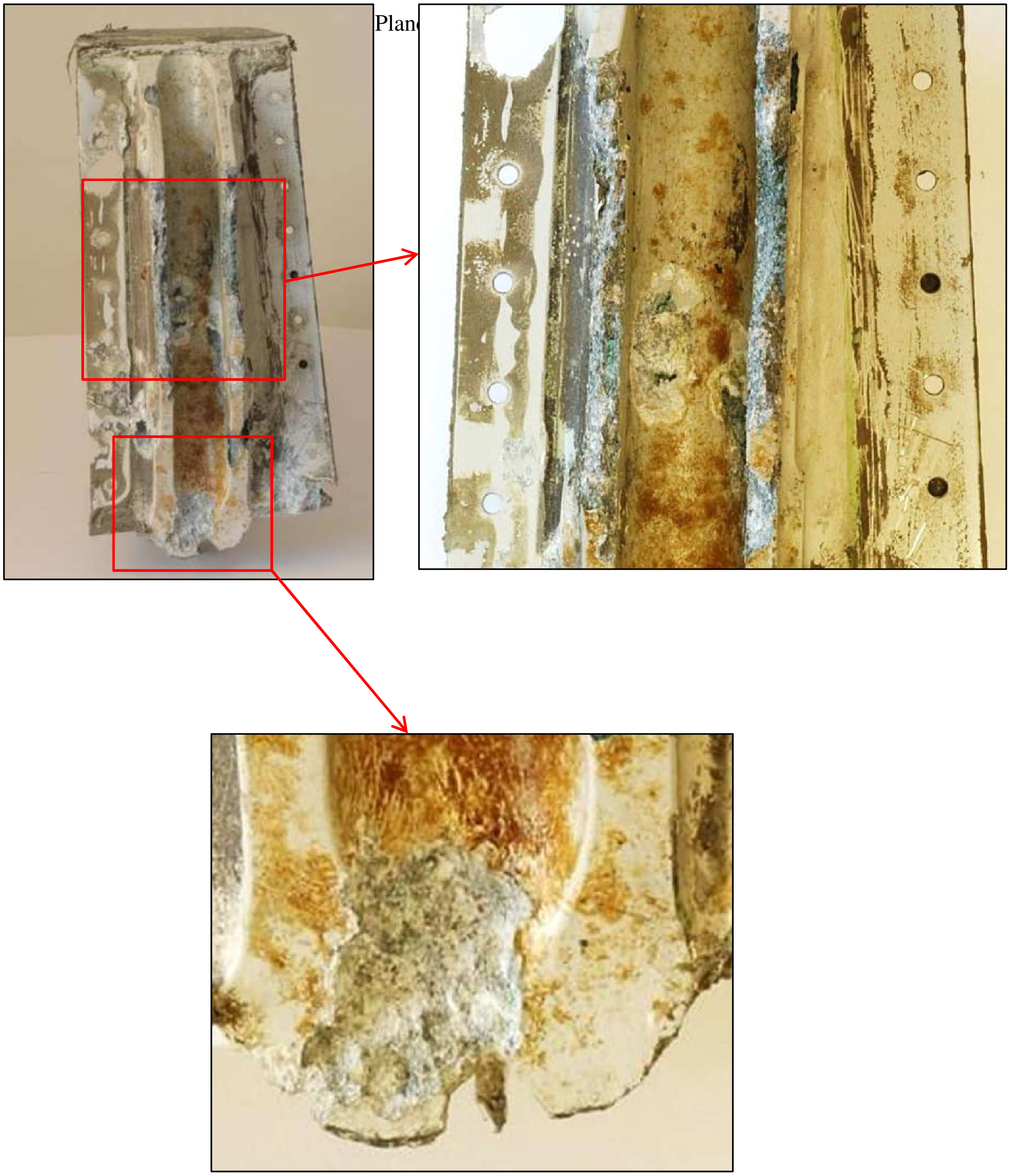


Planche 29 : **Leading edge outboard side hinge fitting fracture**



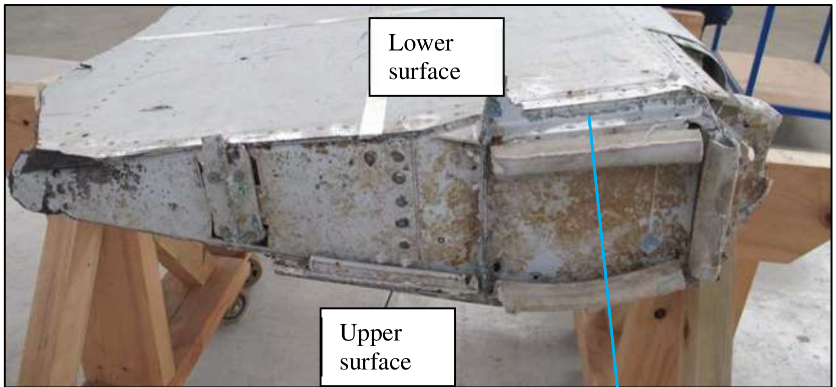
EXAMINATIONS OF INBOARD HINGE FITTING AND NEARBYELEMENTS

Planche 31 : **Inboard hinge fitting**

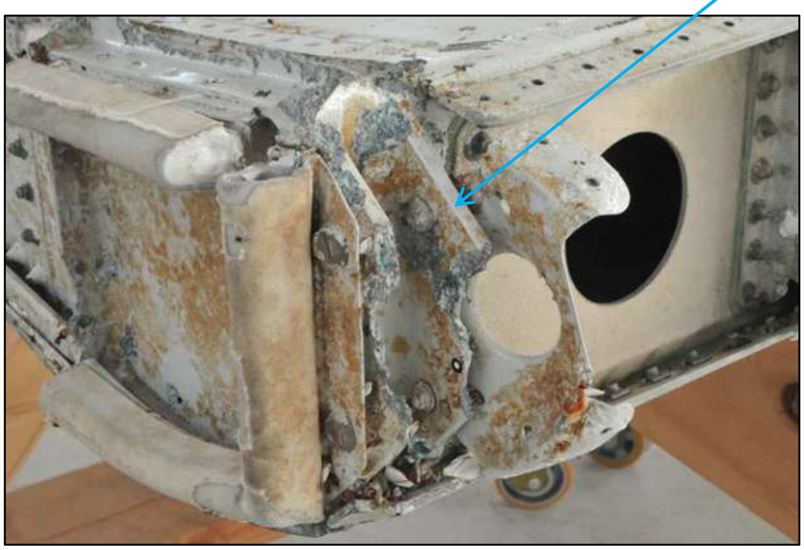
Disassembly of leading edge panel

Repair: disassembly of seal retainer

Planche 32 : **Inboard hinge fitting**

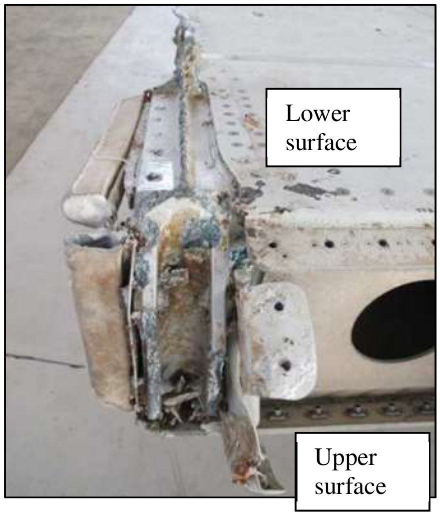


Lower surface side hinge fitting fracture



Leading edge side hinge fitting fracture

Planche 33 : **Inboard hinge fitting**



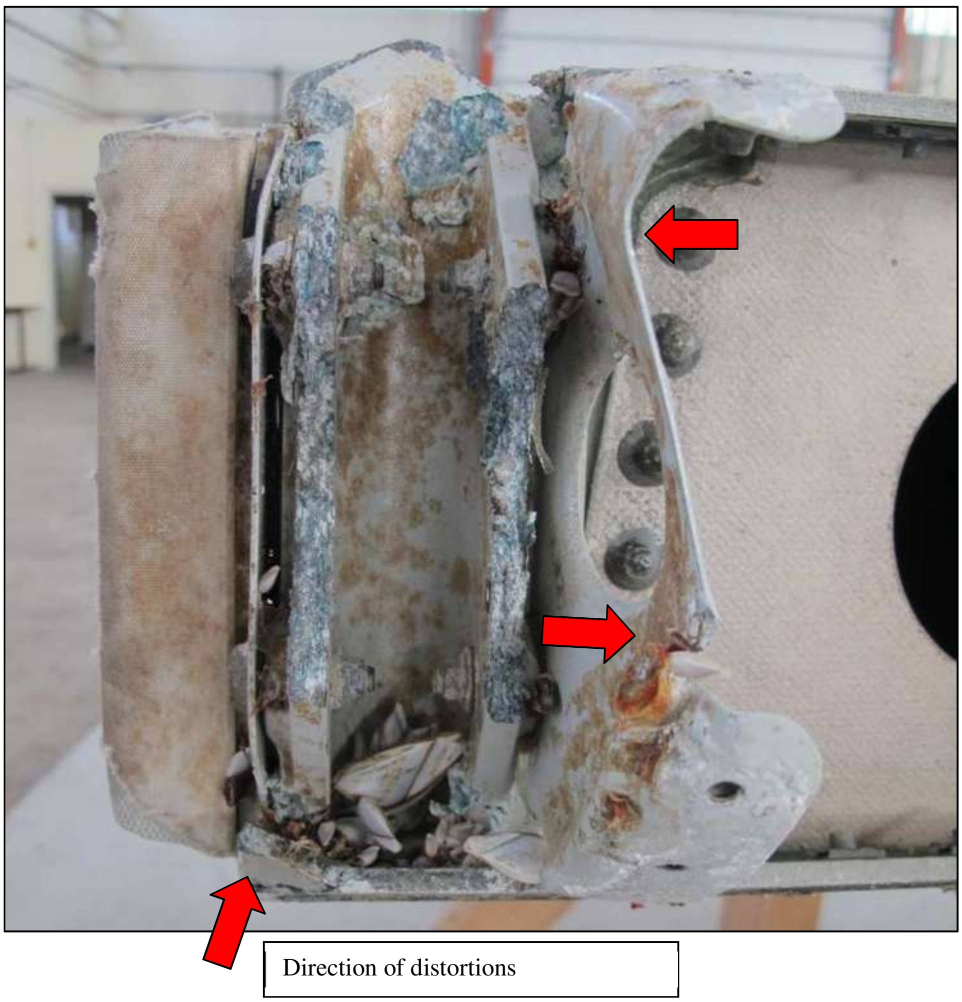
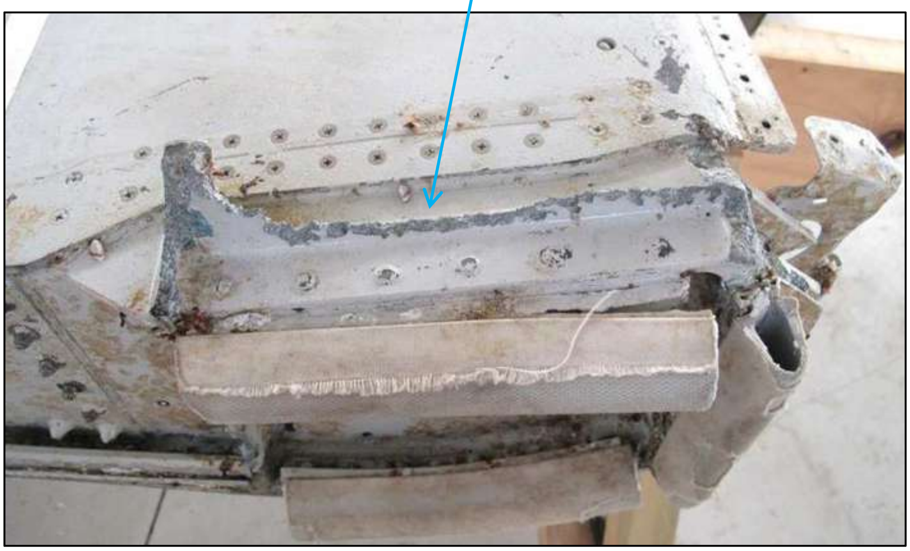
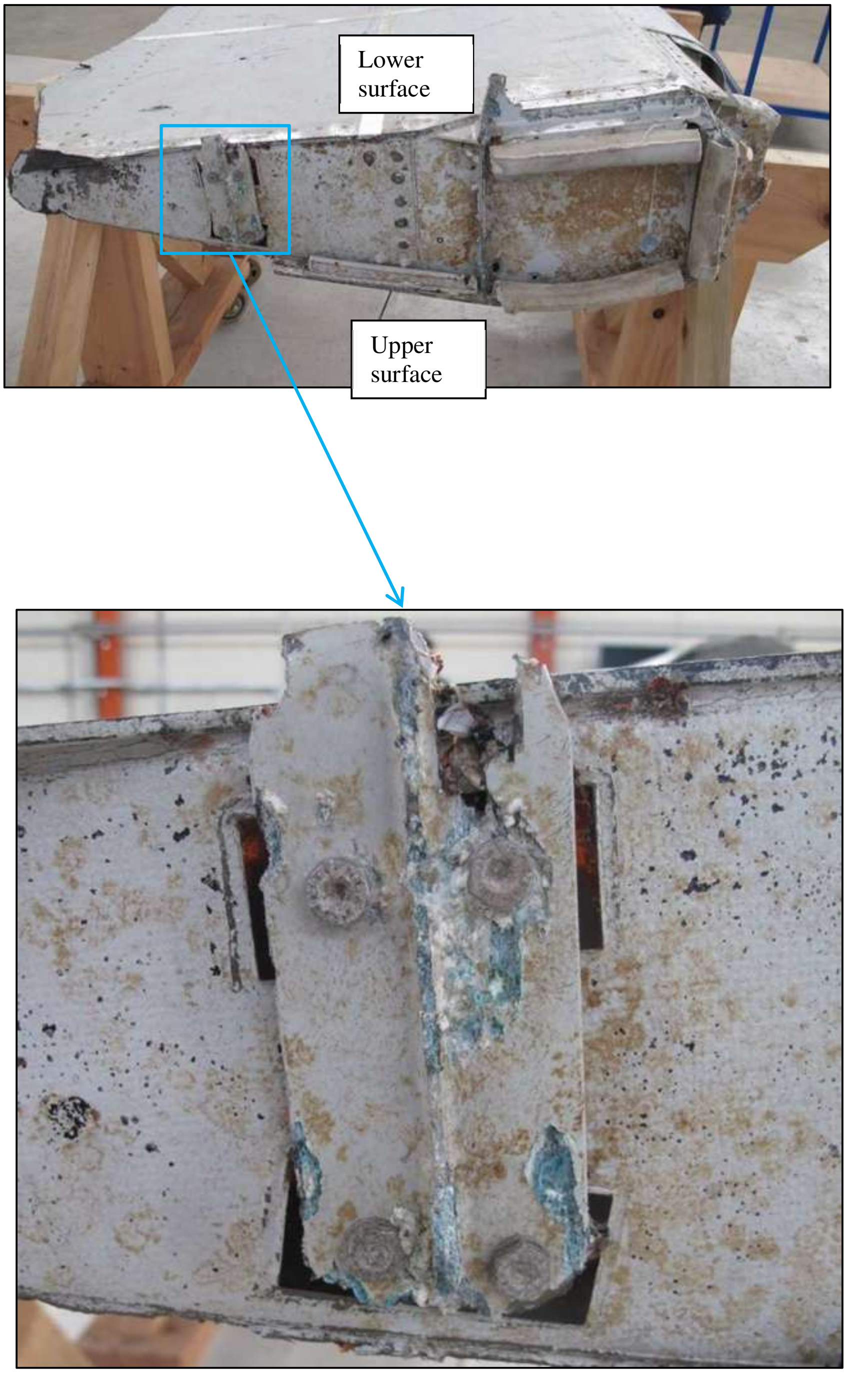


Planche 34 : **Inboard hinge fitting**



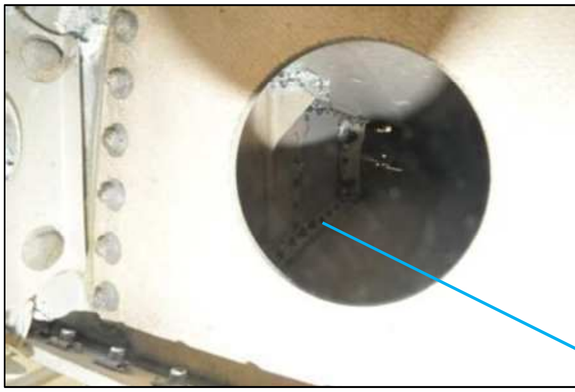
Lower surface side hinge fitting fracture

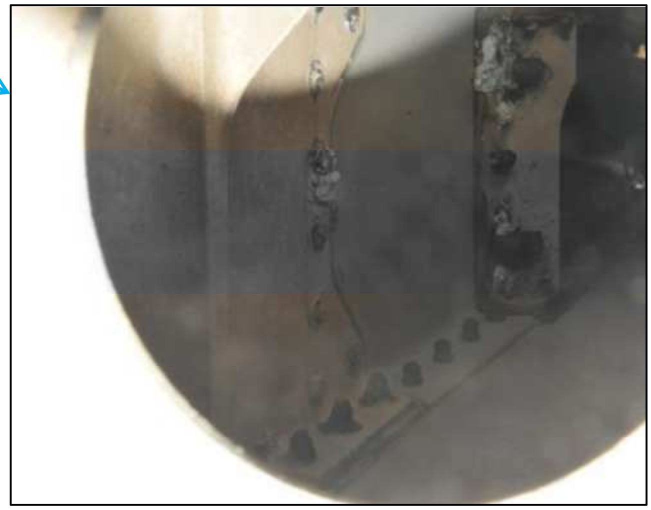
Planche 35 : **Cowling attacment on the inboard side**



Attachment fracture

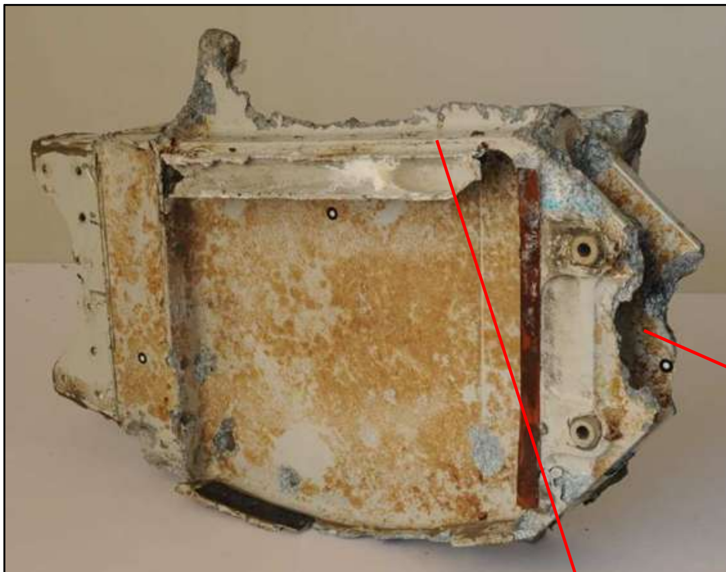
Planche 36 : **Flaperon after disassembly of the hinge fitting on the inboard side**



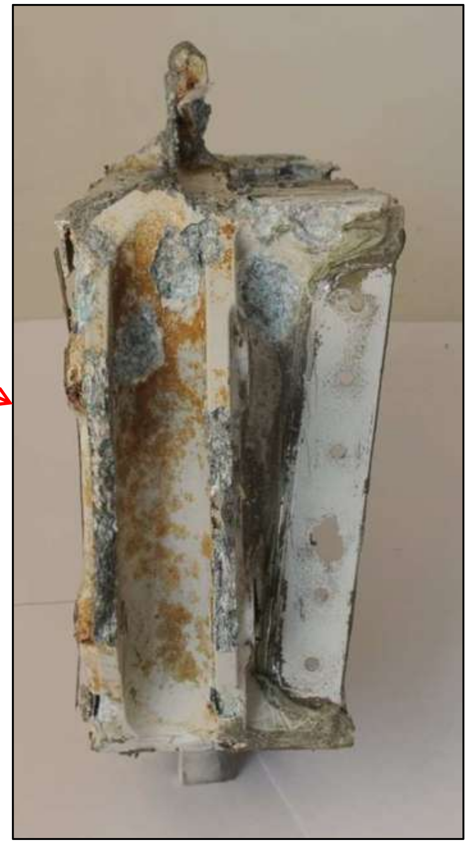


Lower surface side hinge fitting fracture

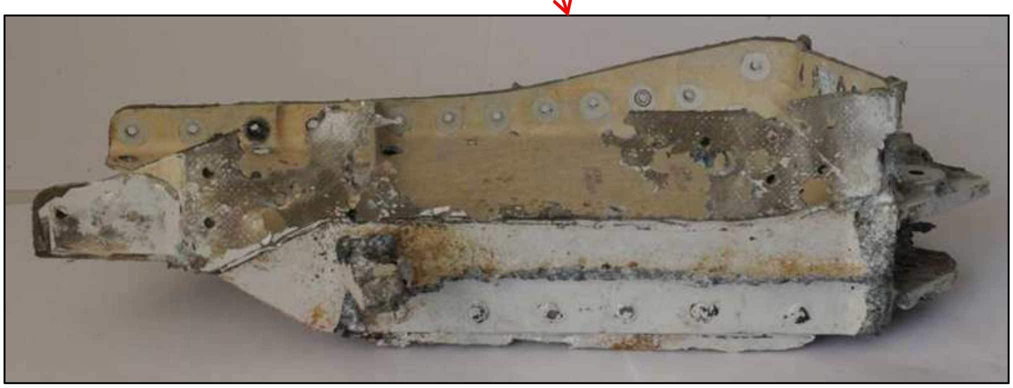
Planche 37 : **Inboard hinge fitting disassembled**



Inboard hinge fitting disassembled



Leading edge fracture



Lower surface fracture

Planche 38 : **Lower surface side inboard hinge fitting fracture**

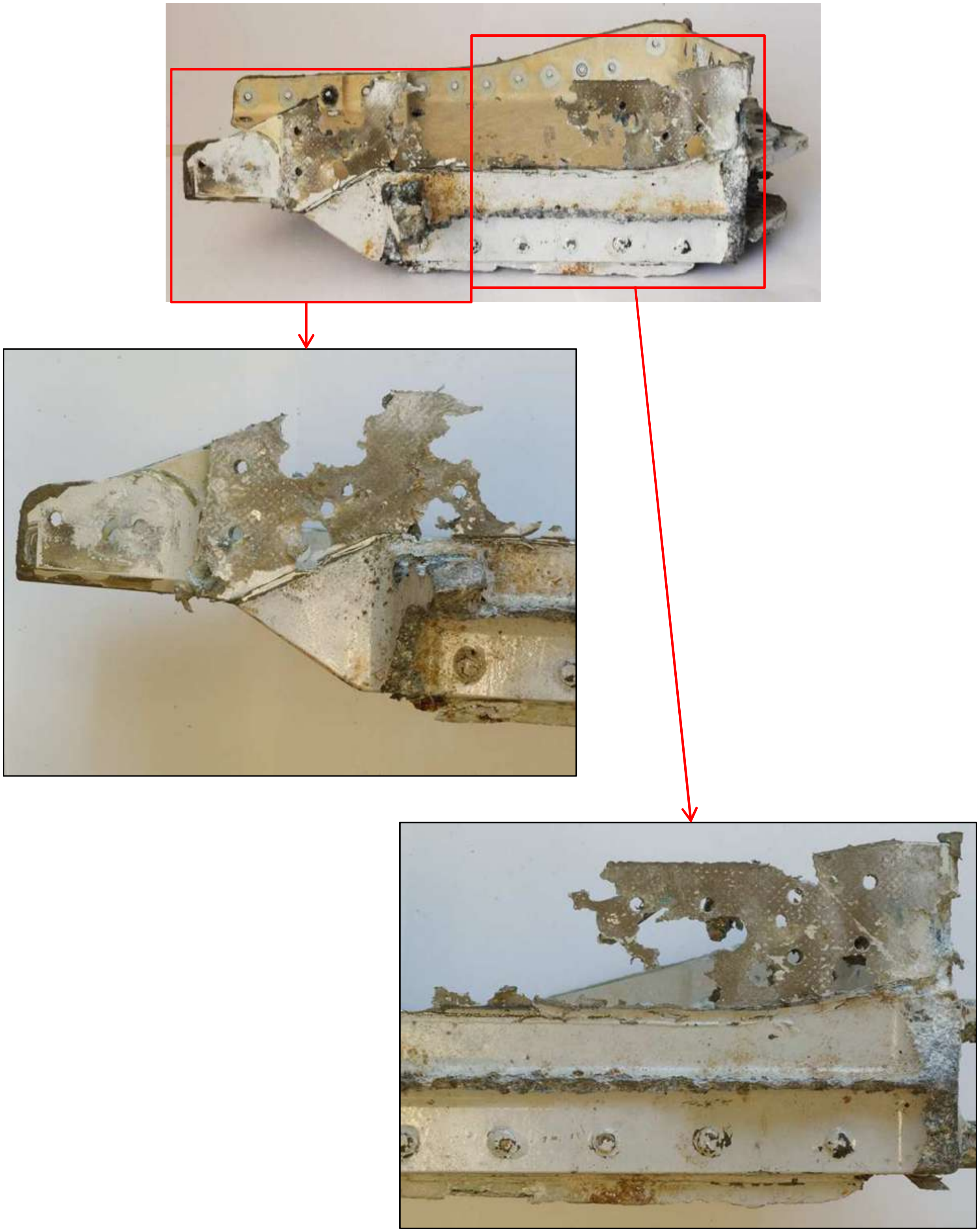
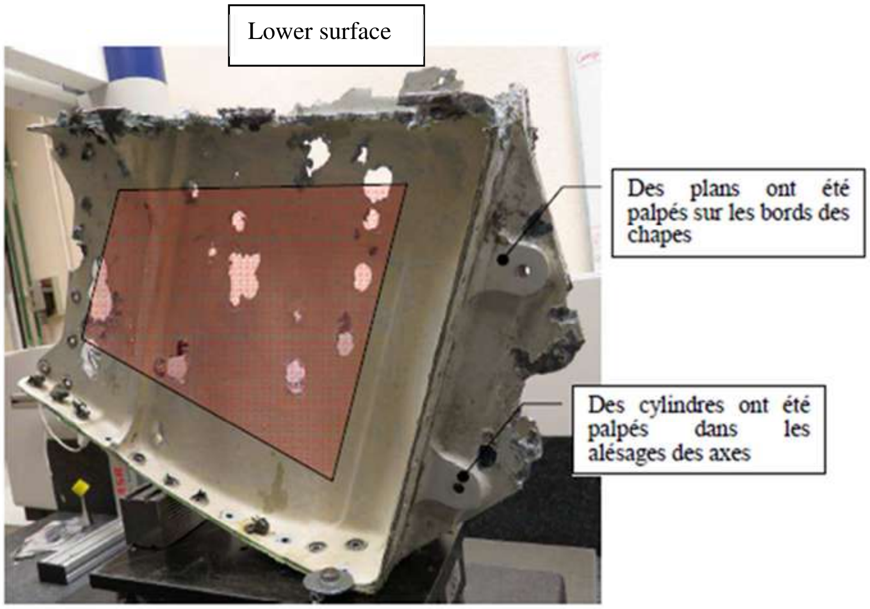


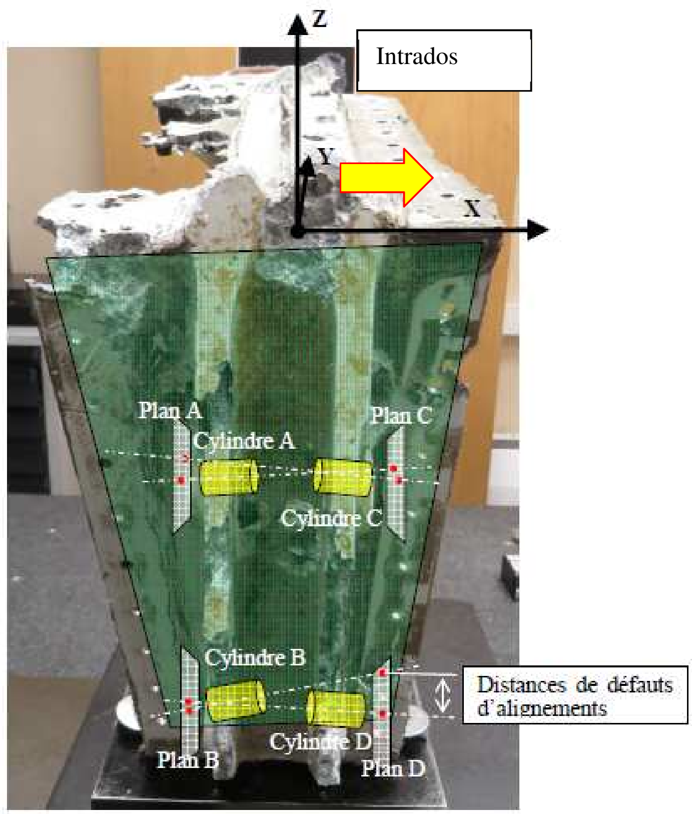
Planche 39 : **Leading edge side inboard hinge fitting fracture**

Planche 40 :

DIRECTION OF DISTORTIONS AND TEARS ON METALLIC PARTS

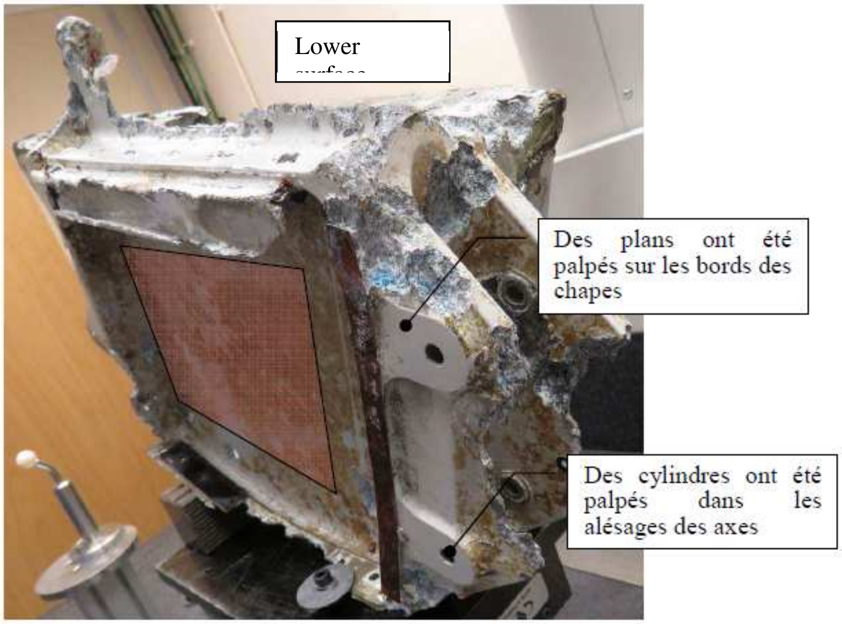
Planche 41 : **Metrology of the outboard hinge fitting**

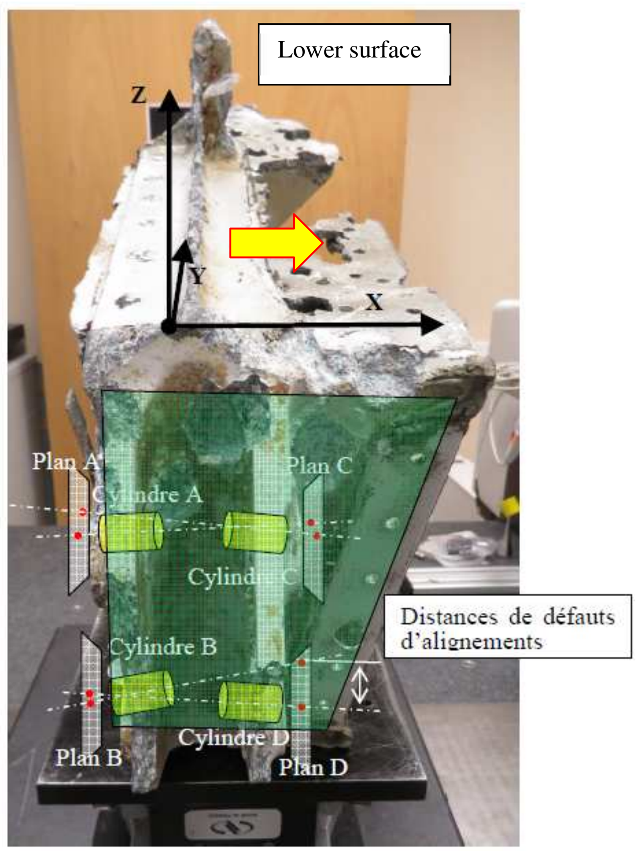




Orientation of hinge fitting in relation to reference plan

Planche 42 : **Metrology of the inboard hinge fitting**



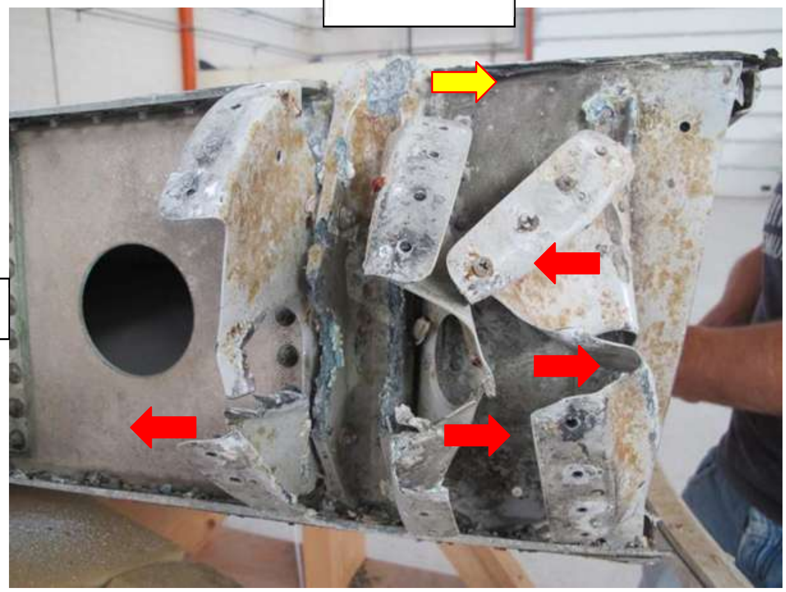


Orientation of hinge fitting in relation to reference plan

Planche 43 : **Summary of the distortions and fractures of the leading edge hinge fittings and ribs**

Lower surface

Outboard hinge fitting



Orientation of hinge fitting in relation to reference plan

Direction of distortions

Lower surface

Inboard hinge fitting

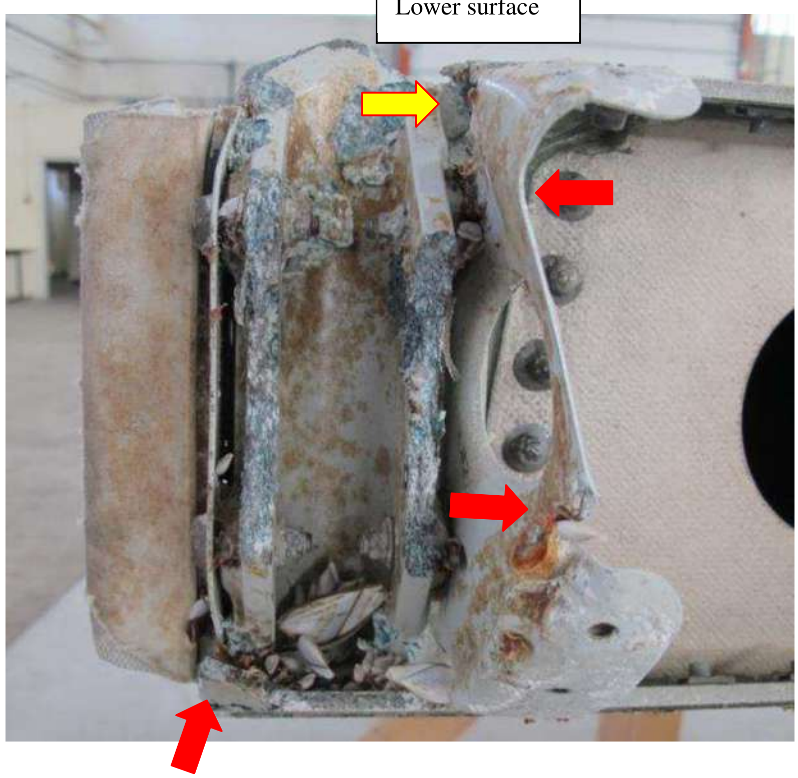
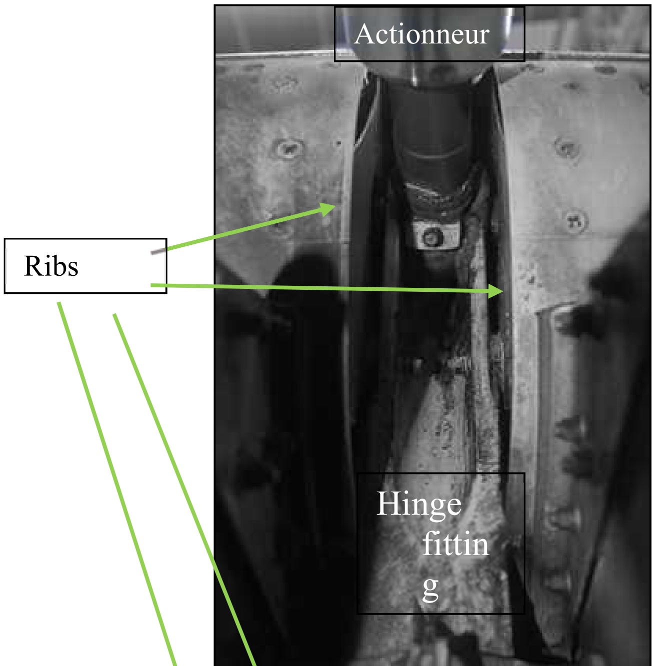
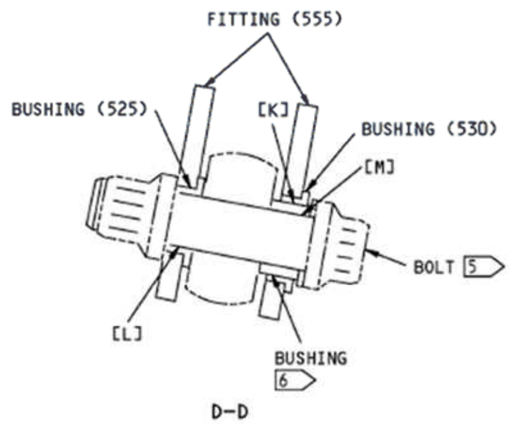
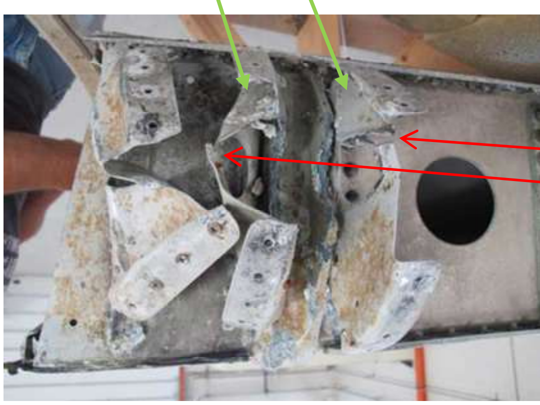


Planche 44 : **Possible explanation of the distortions and fractures of the outboard side leading edge ribs**





Configuration of the activator (outboard)



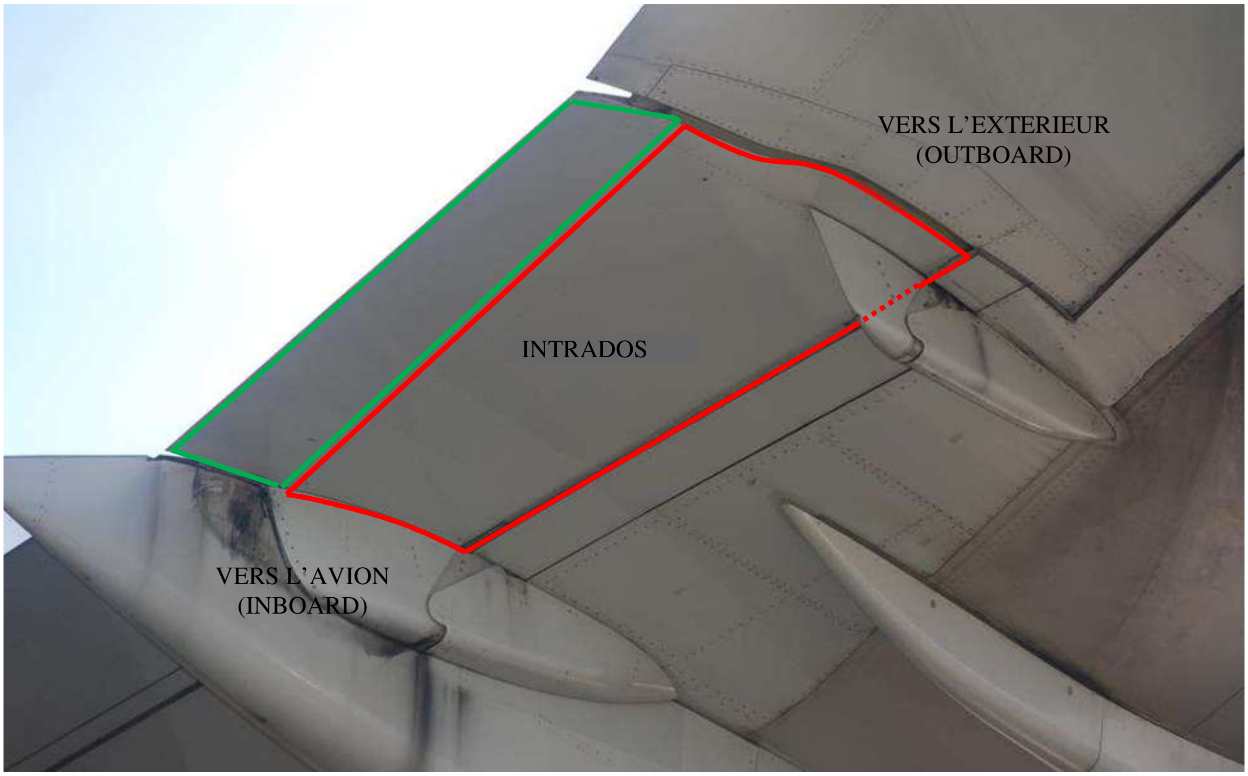
Note: photo turned around to present all the elements with the same orientation

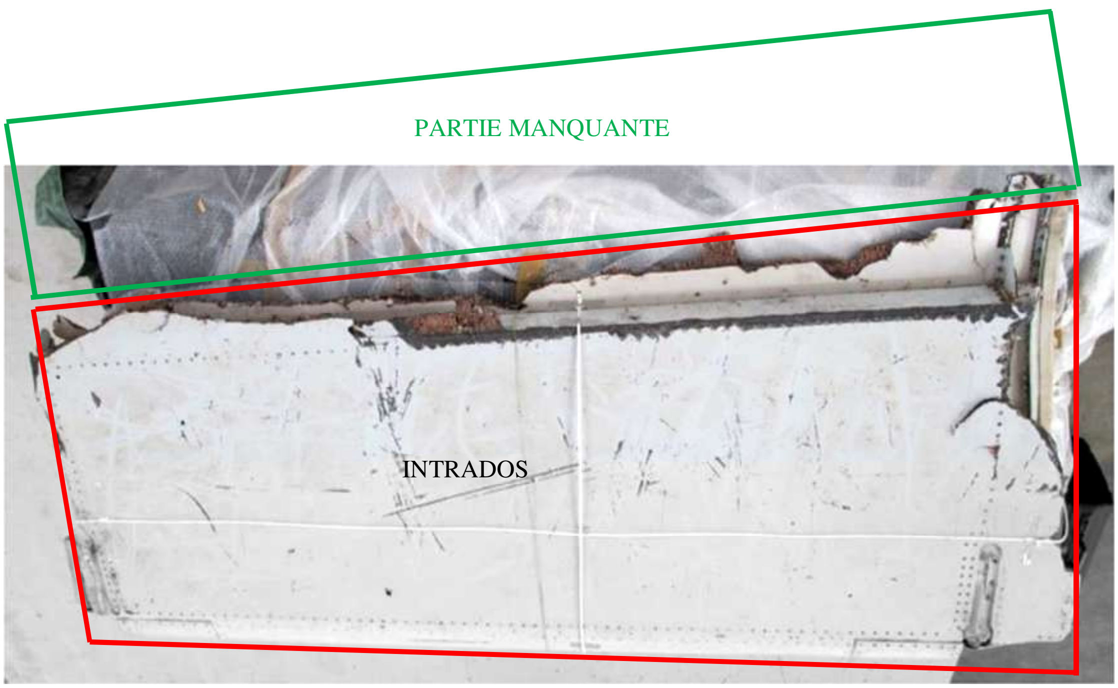
Activator hinge point pin and other attachments

The damage to the ribs, especially the tearssemmed to be due to the activator hinge point pin tips.
The form of the folds leads one to believe that the ribs pushed onto the body of the activator during an overall rotational movement of the flaperon from the inside towards the outside.
This explanation is applicable to the inboard rib side.

EXAMINATIONS OF COMPOSITE MATERIAL PARTS

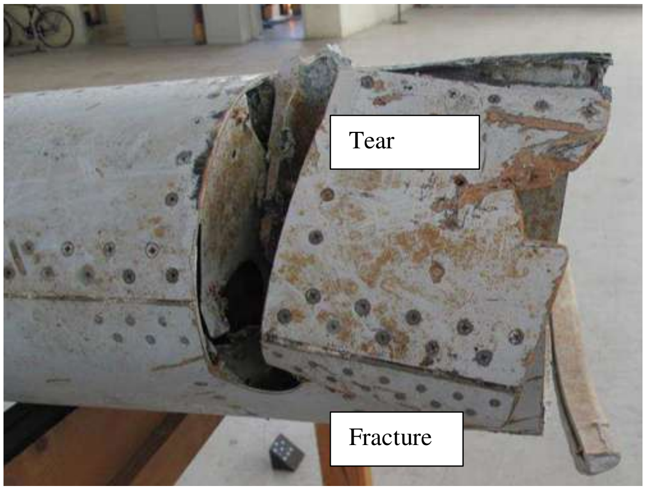
Planche 45 : **Comparison between a complete flaperon and the flaperon from MH 370**

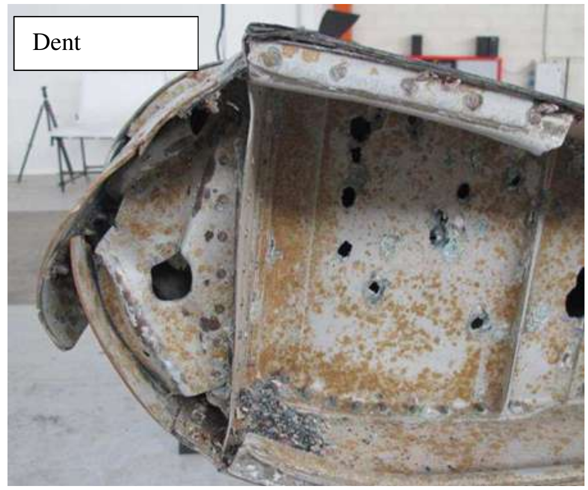




DAMAGE ON THE LEADING EDGE

Planche 46 : **Damage at the level of the leading edge access doors**





Dent and tear on the access door on the outboard side

Fracture of the access door on the inboard side

Planche 47 : **Impacts on the leading edge**

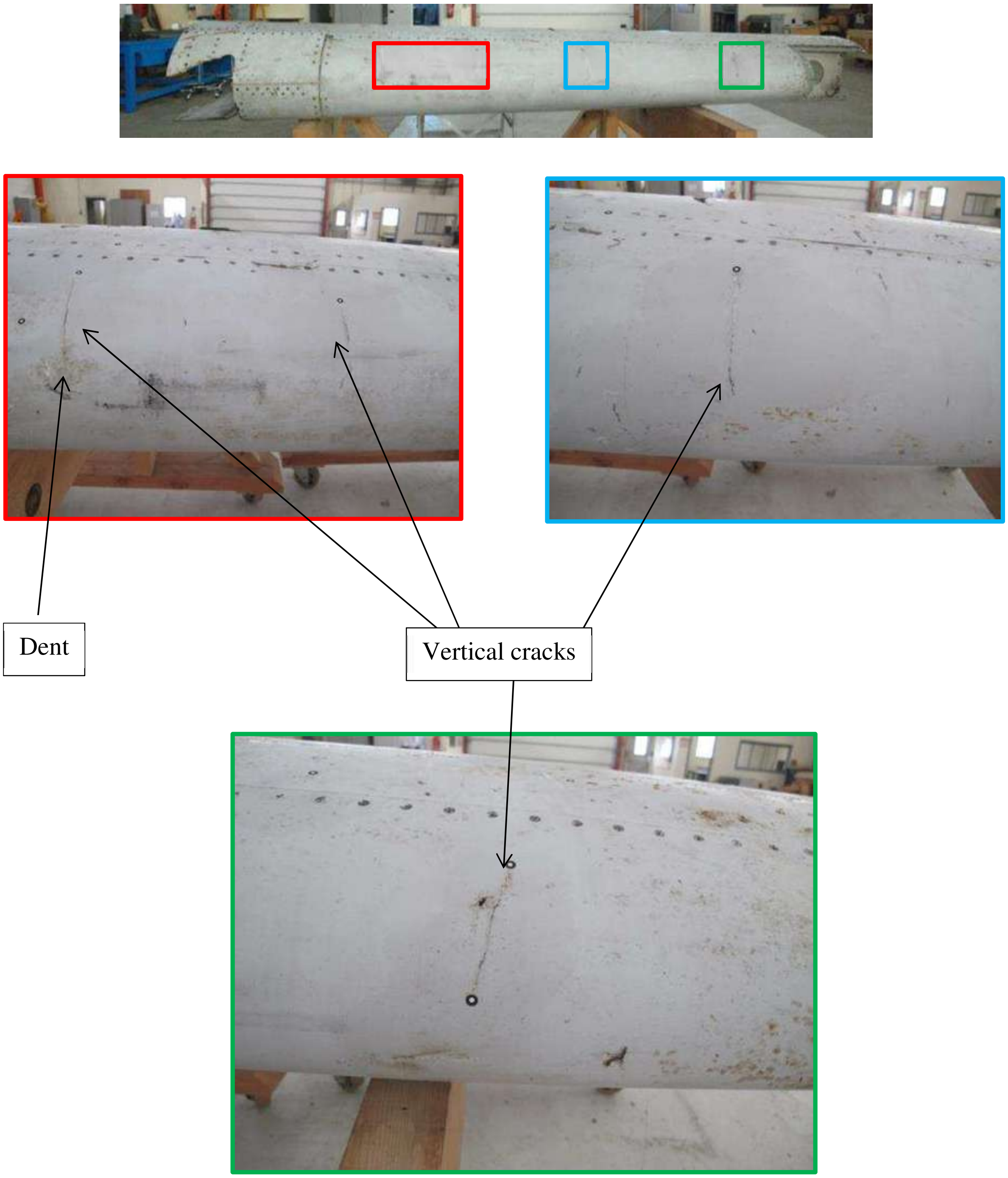
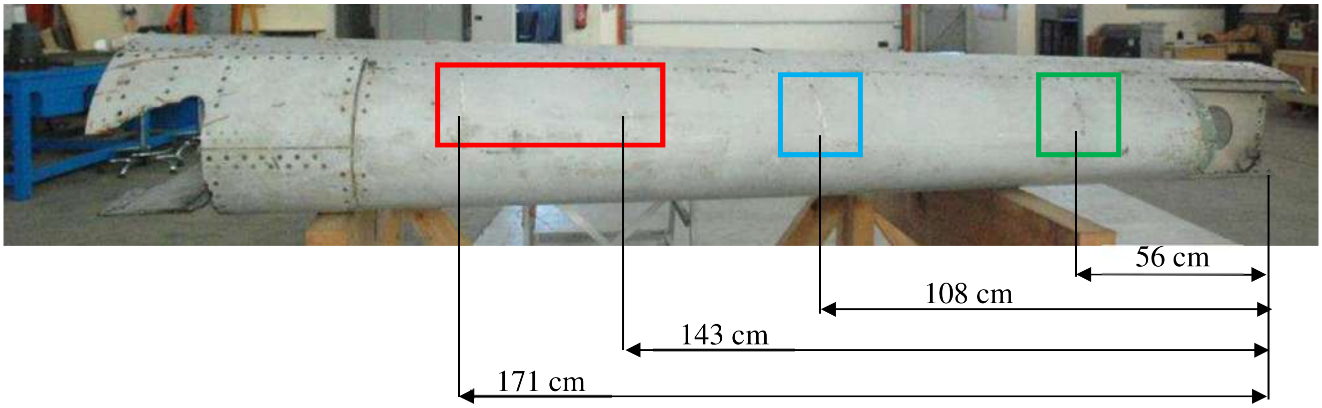
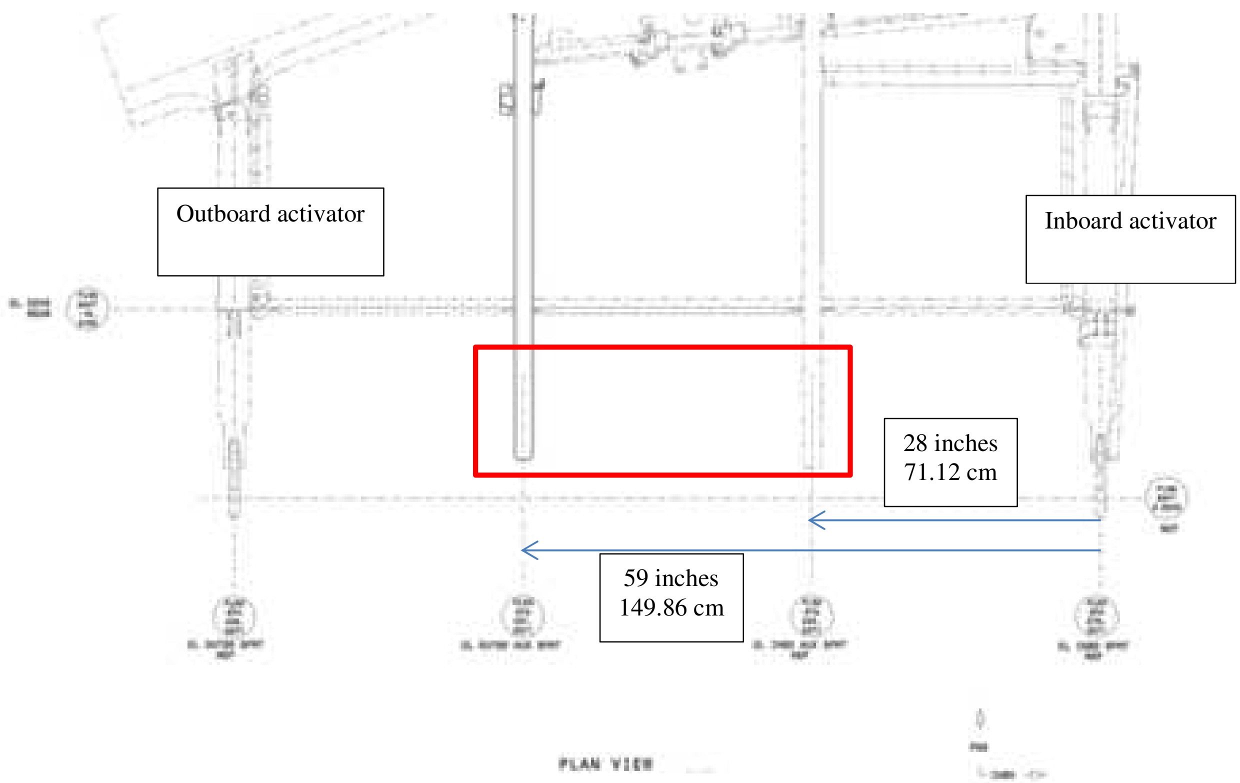


Planche 48 : **Comparison of the impacts with the facing wing panel**

OUTWARDS TOWARDS AEROPLANE





Only two parts facing according to the parts supplied by Boeing

EXAMINATIONS OF LOWER SURFACE

Planche 49 : **Lower surface: dents**

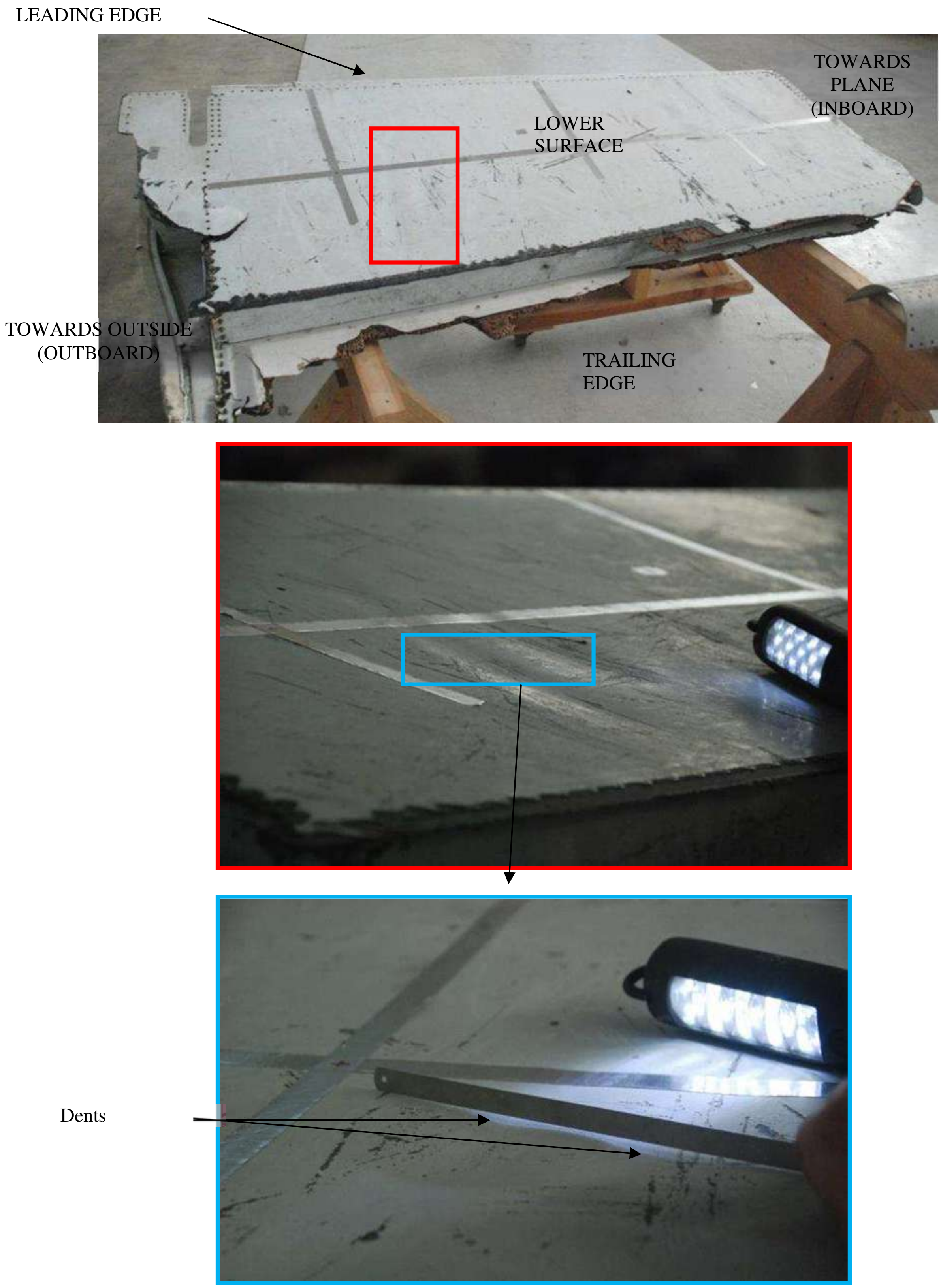


Planche 50 : **Lower surface: irregular fracture on trailing edge**

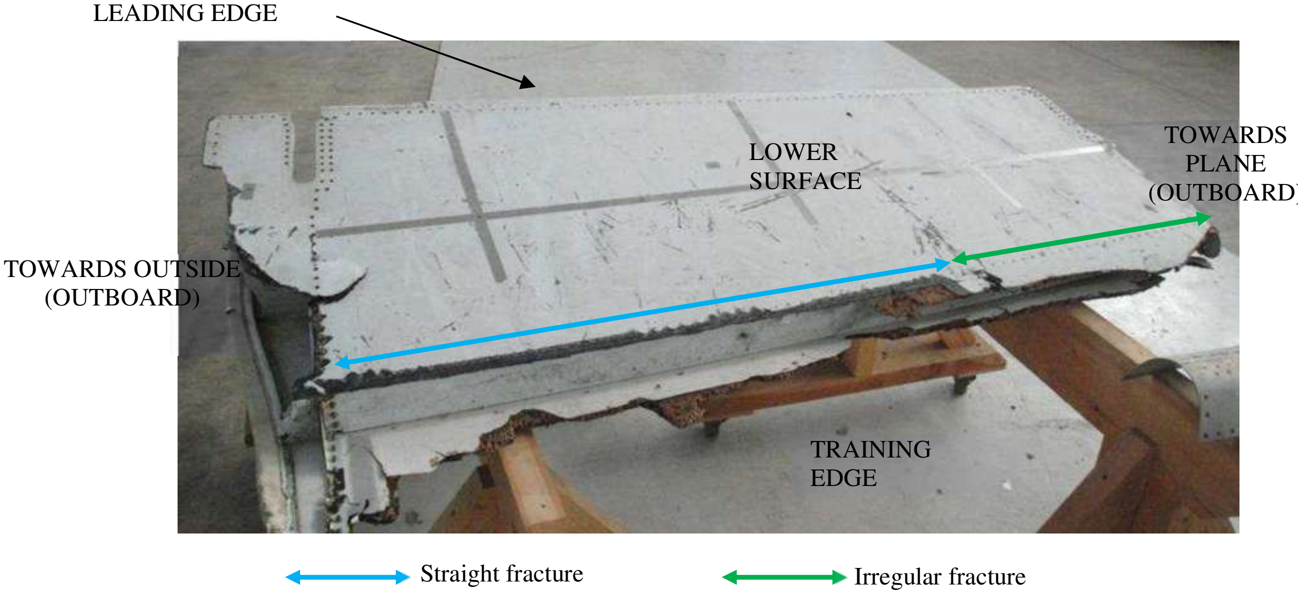
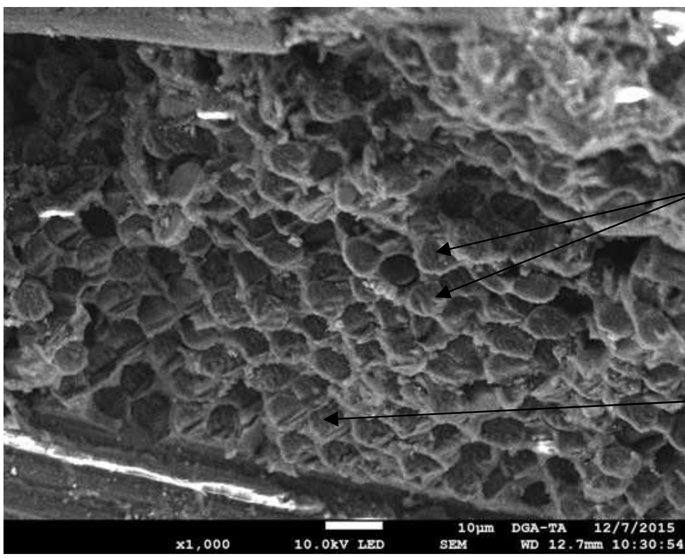


Planche 51 : **Lower surface: irregular fracture on trailing edge – SEM Examination**

Outer skin

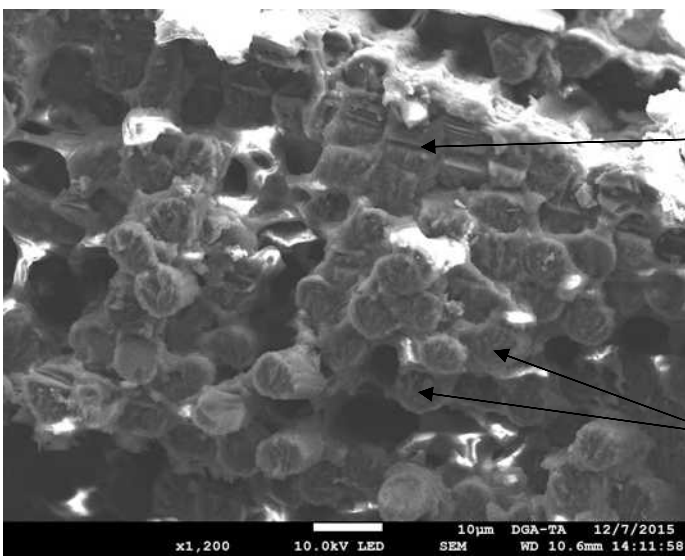
Inner skin



Inner skin : radiating form characteristic of a traction fracture

Inner skin: steps characteristic of a compression fracture

All of the fracture surfaces on the inner skin: majority in compression

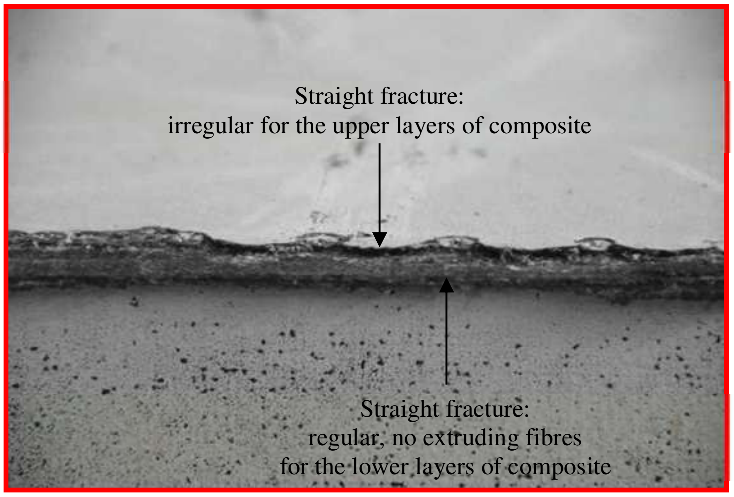


Inner skin: steps characteristic of a compression fracture

All of the fracture surfaces on the outer skin: majority in traction.

Outer skin : Inner skin : radiating form characteristic of a traction fracture

Planche 52 : **Lower surface: straight fracture on trailing edge**



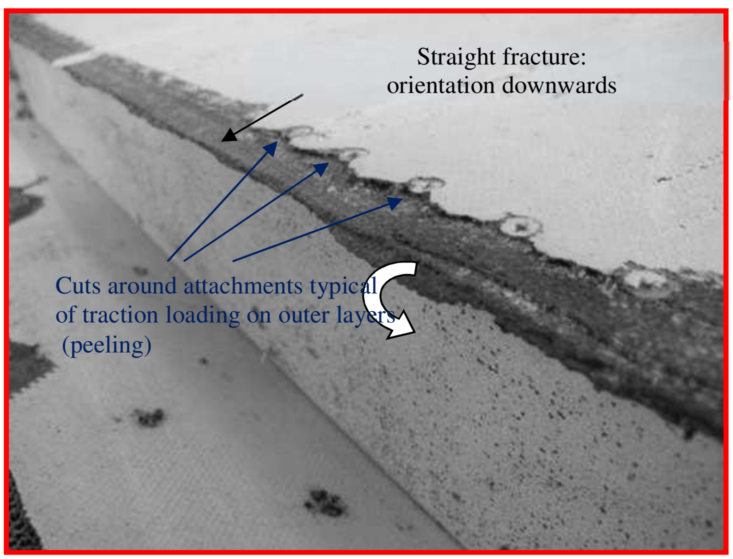
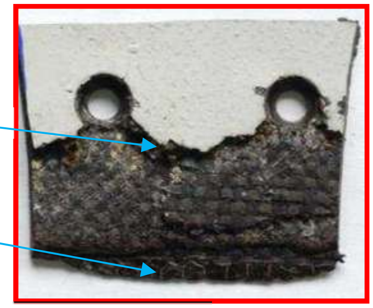


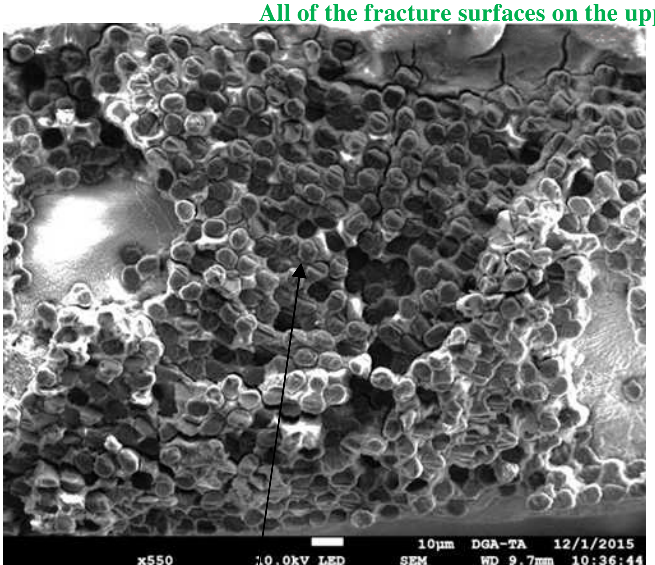
Planche 53 : **Lower surface: straight fracture on trailing edge – SEM Examination**

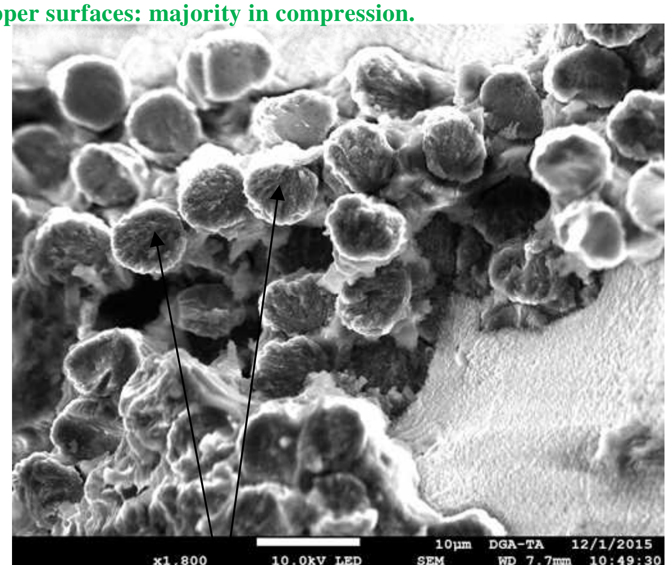
Upper layers

Lower layers



All of the fracture surfaces on the upper surfaces: majority in compression.

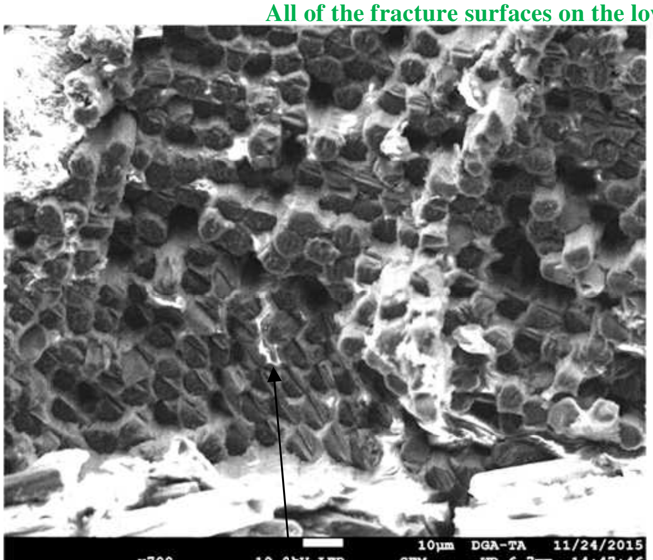


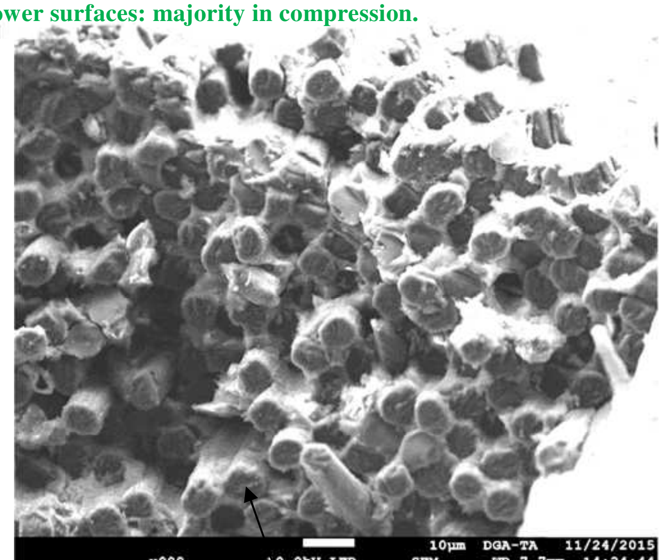


Upper layers : steps characteristic of a compression fracture

Lower layers: radiating form characteristic of a traction fracture

All of the fracture surfaces on the lower surfaces: majority in compression.





Lower layers: steps characteristic of a compression fracture

Upper layers: radiating form characteristic of a traction fracture

EXAMINATIONS OF UPPER SURFACE

Planche 54 : **Upper surface: dents, impacts, crack**

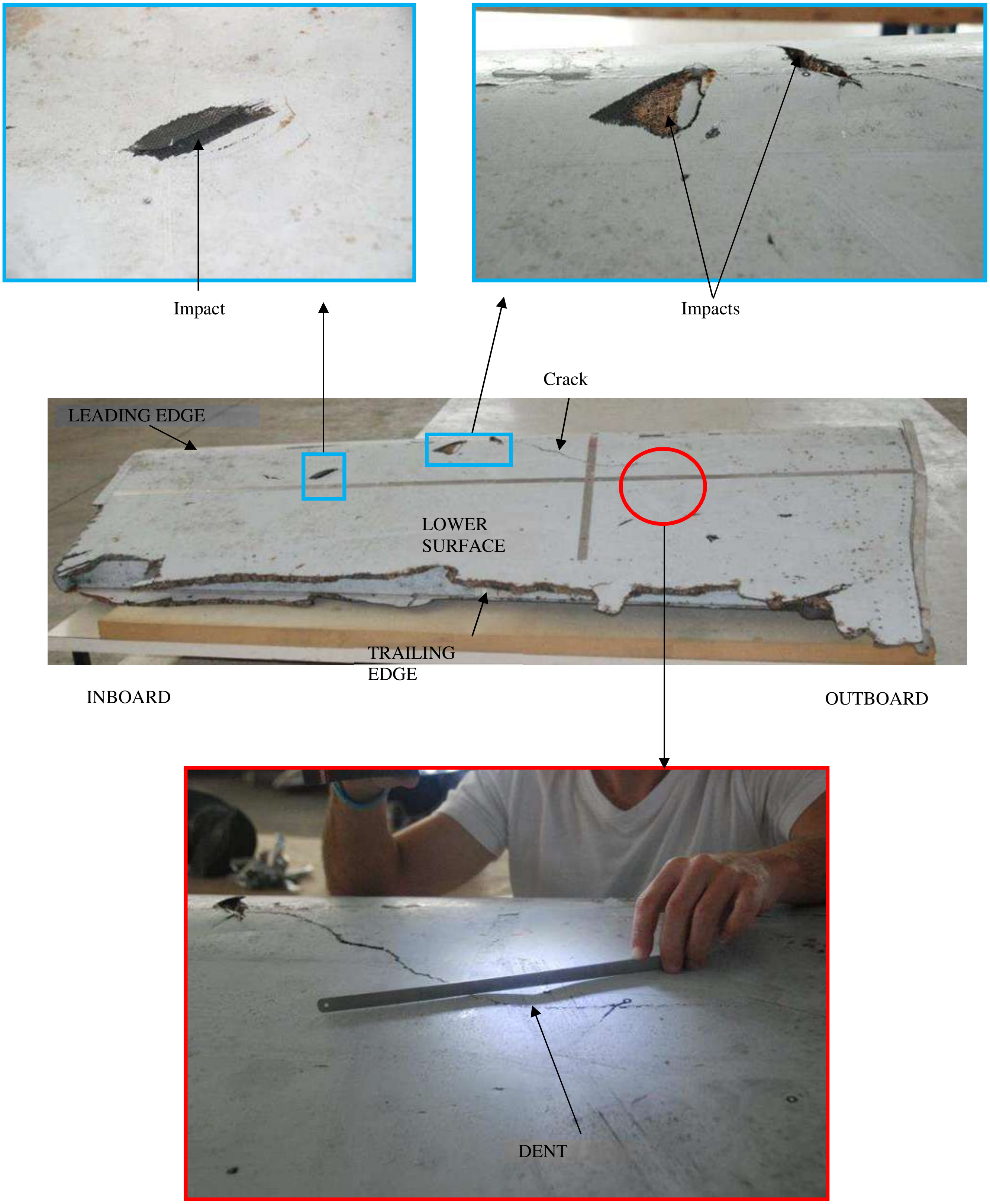
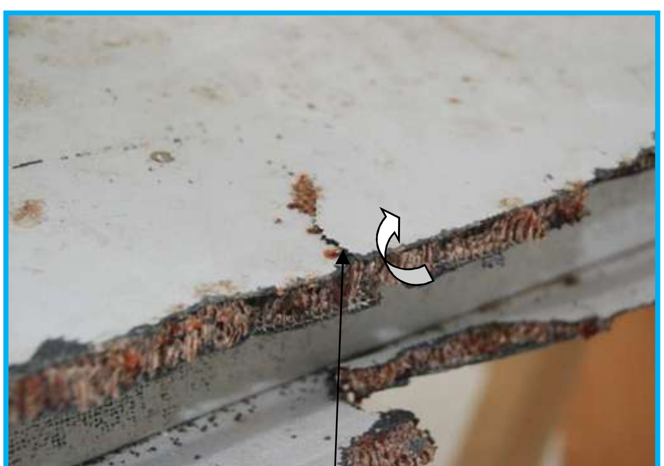


Planche 55 : **Upper surface: fracture on trailing edge**

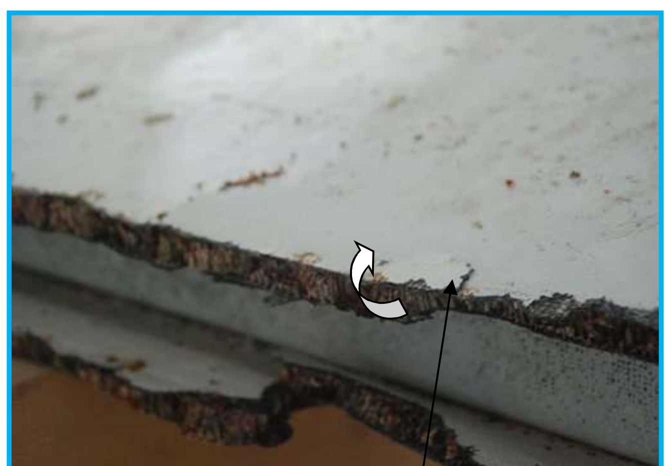
Orientation of material upwards

Orientation of material upwards

Regular fracture, without protruding fibres



Orientation of material upwards



Orientation of material upwards

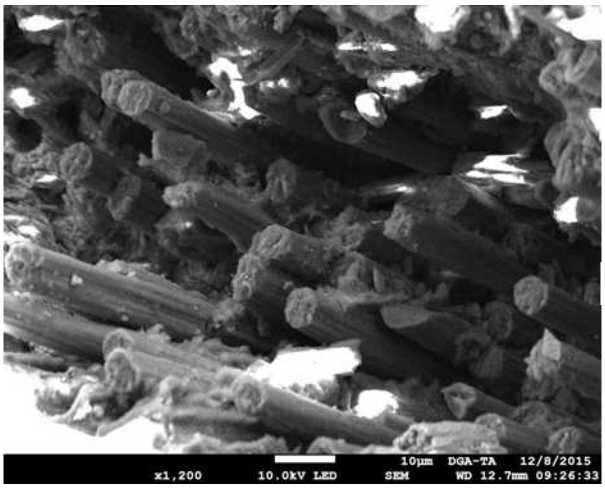
Planche 56 : **Upper surface: fracture on trailing edge – SEM examination**

Outer skin

Inner skin

Inner skin

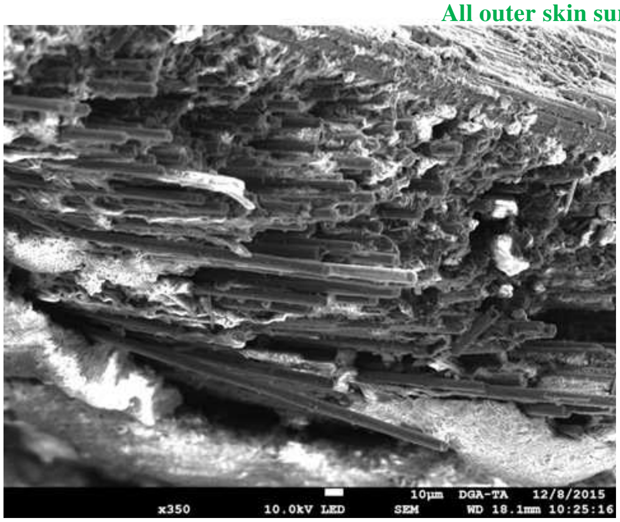
Outer skin



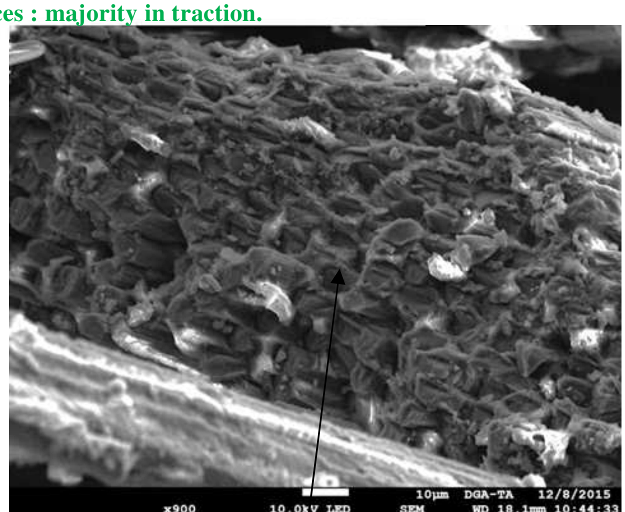
Inner skin : surfaces characteristic of a traction fracture

All inner skin surfaces : majority in traction.

All outer skin surfaces : majority in traction.



Outer skin : surfaces characteristic of a traction fracture



Outer skin: steps characteristic of a compression fracture

Planche 57 : **Upper surface: impact and protruding crack**

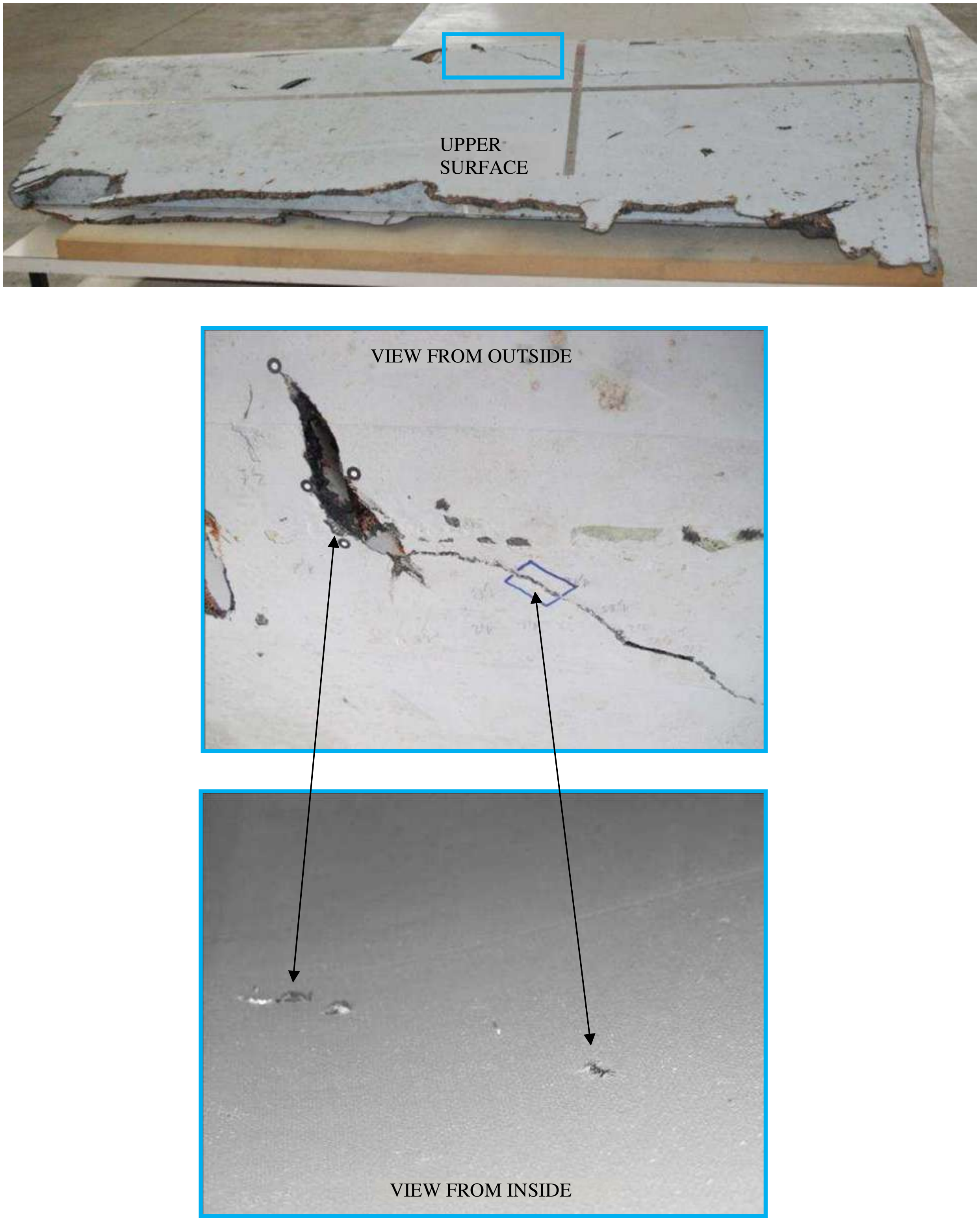
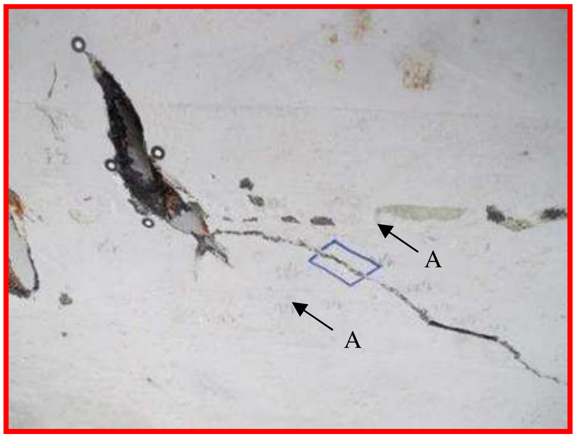


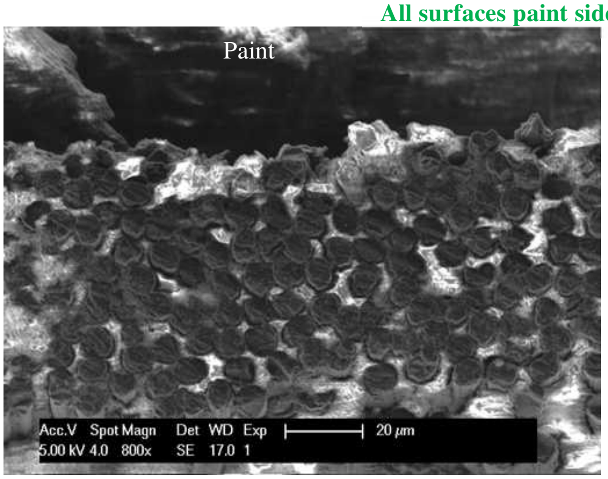
Planche 58 : **Upper surface: observation of the crack in a non-protruding part**



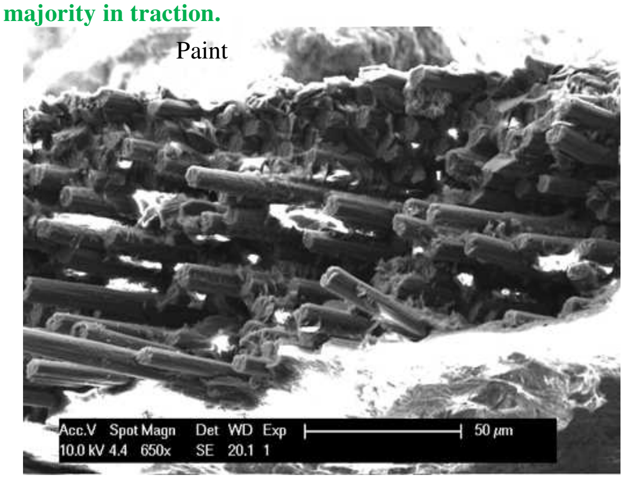
Macroscopically : bending fracture of outer skin

View along A-A

All surfaces paint side : majority in traction.

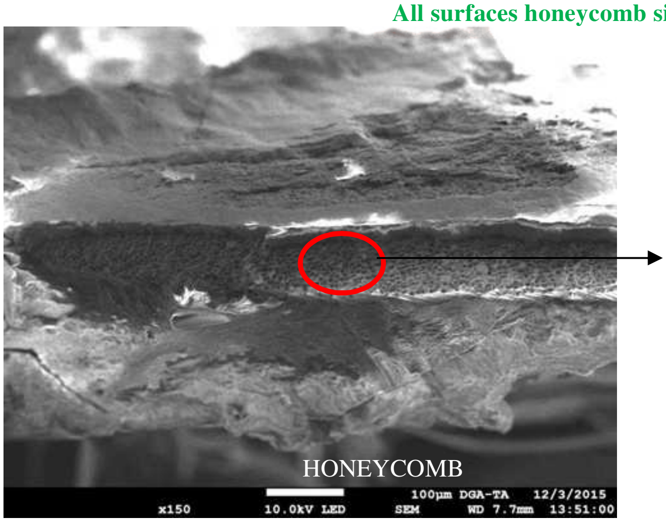


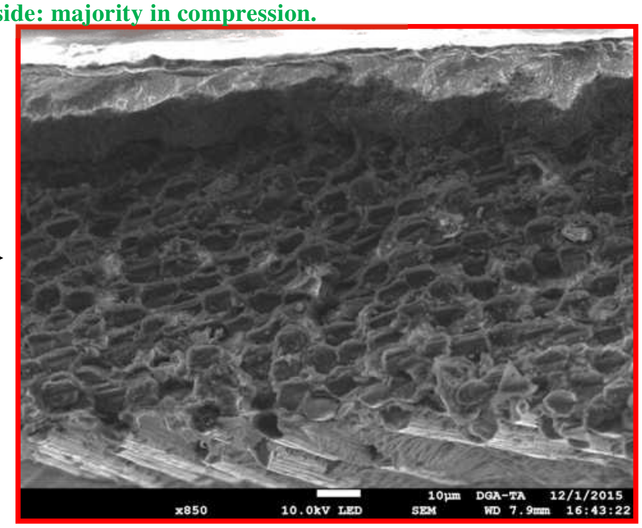
Near paint : steps characteristic of compression fracture



Near paint : surfaces characteristic of traction fracture

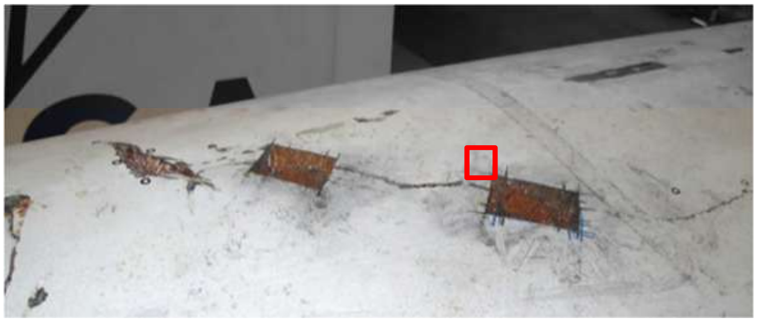
All surfaces honeycomb side: majority in compression.



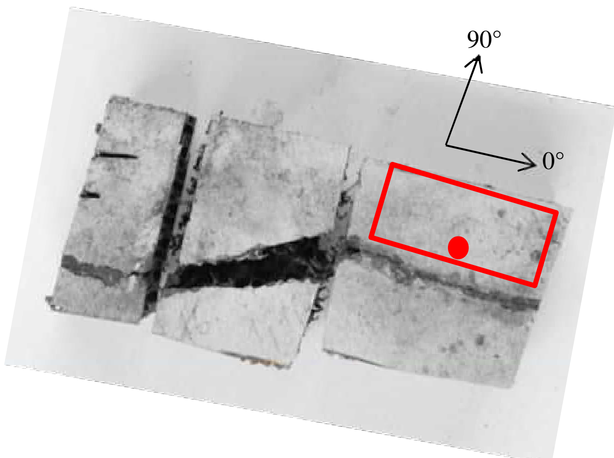


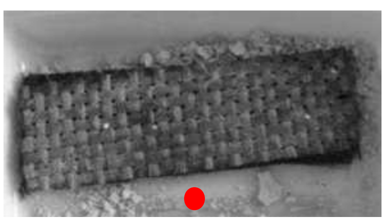
Near honeycomb : steps characteristic of compression fracture

Planche 59 : **Upper surface: orientation of outer skin folds**

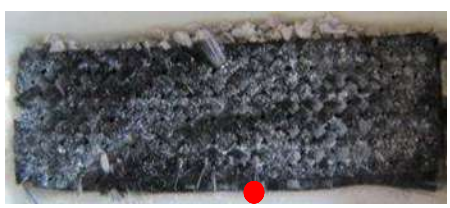


Sample zone





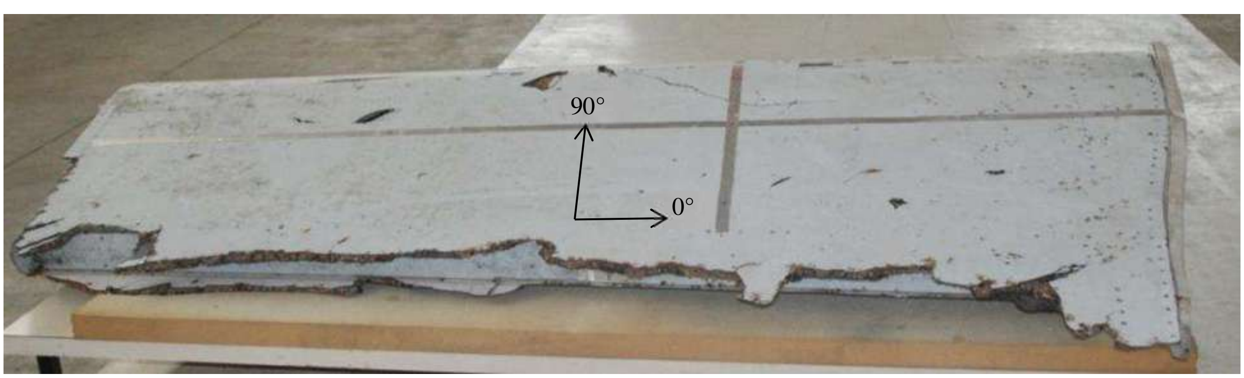
Fold n°1 : Material: 0°/90°



Fold n°2 : Material: 45°/-45°

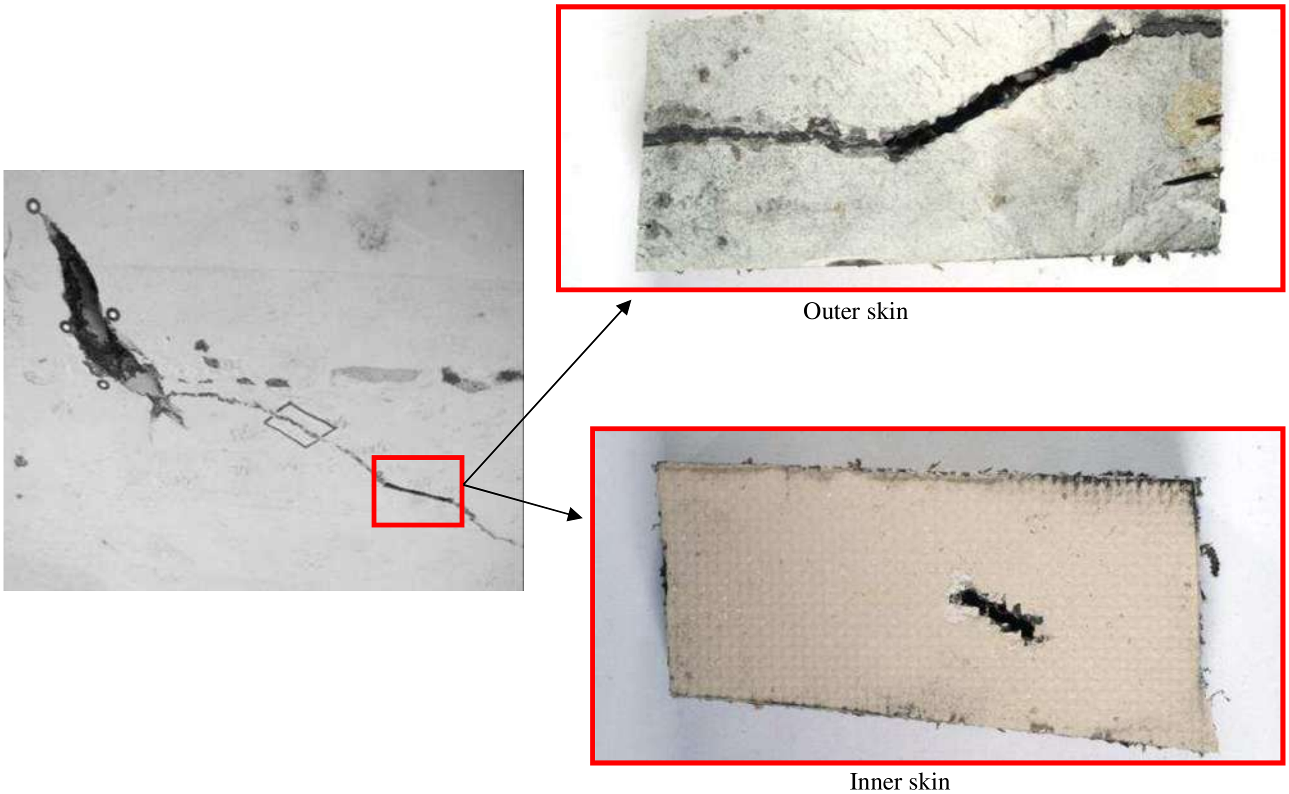
Fold n°3 : Material: 0°/90°

The outer skin consists of three folds, the orientation above is in relation to the crack.



In the flaperon referential, see above, the following draping appears: +/-45°,0/90°,+/-45°.

Planche 60 : **Upper surface: observation of the crack in a protruding part (1/2)**



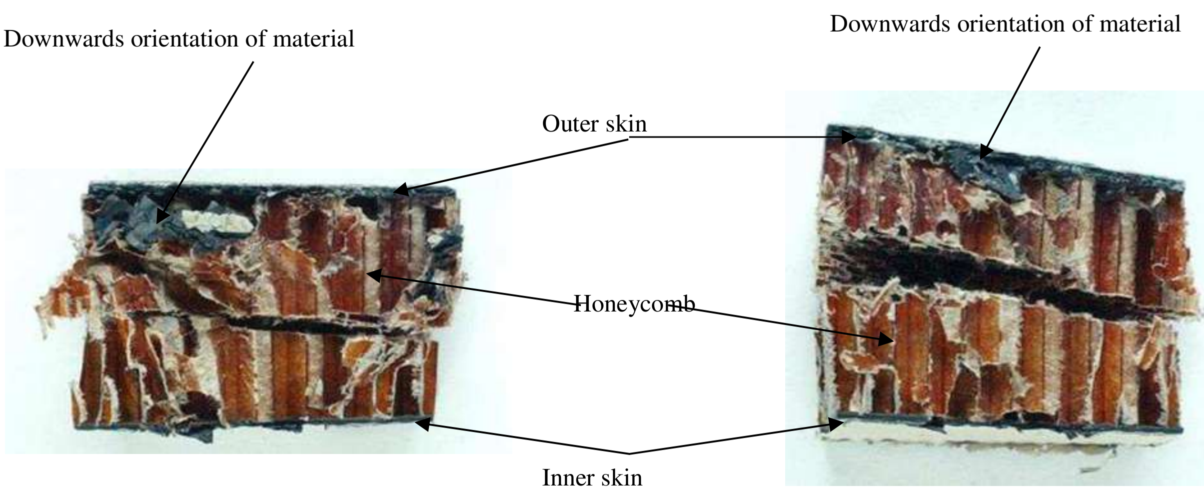
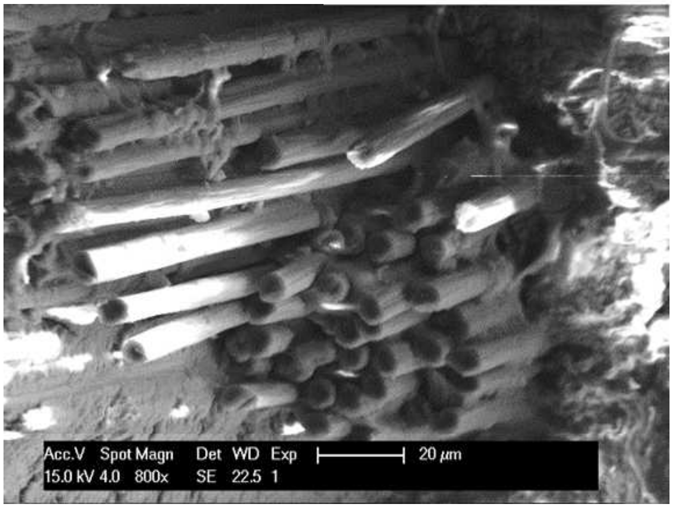
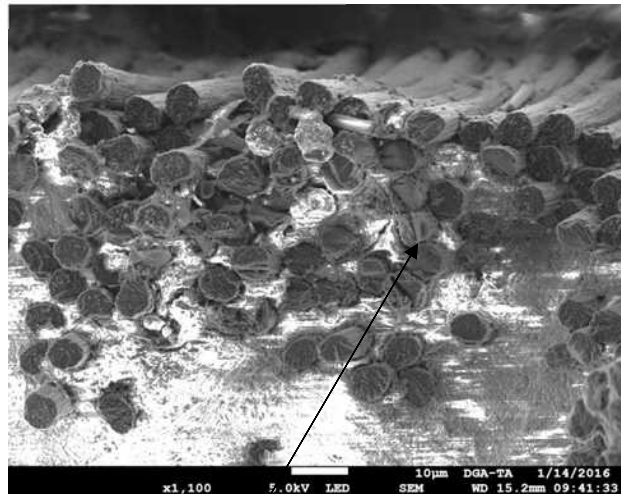


Planche 61 : **Upper surface: observation of the crack in a protruding part (2/2)**

All of inner skin fracture surfaces : majority in traction .



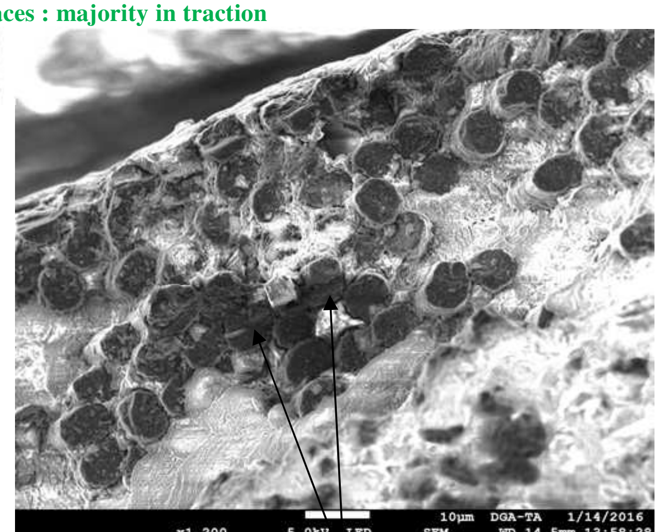
Outer skin: fracture surfaces characteristic of traction fracture



Outer skin: some fibres in compression

All of inner skin fracture surfaces : majority in traction

Peau skin: radiating form : fracture surfaces characteristic of traction:



Inner skin : some fibres in compression

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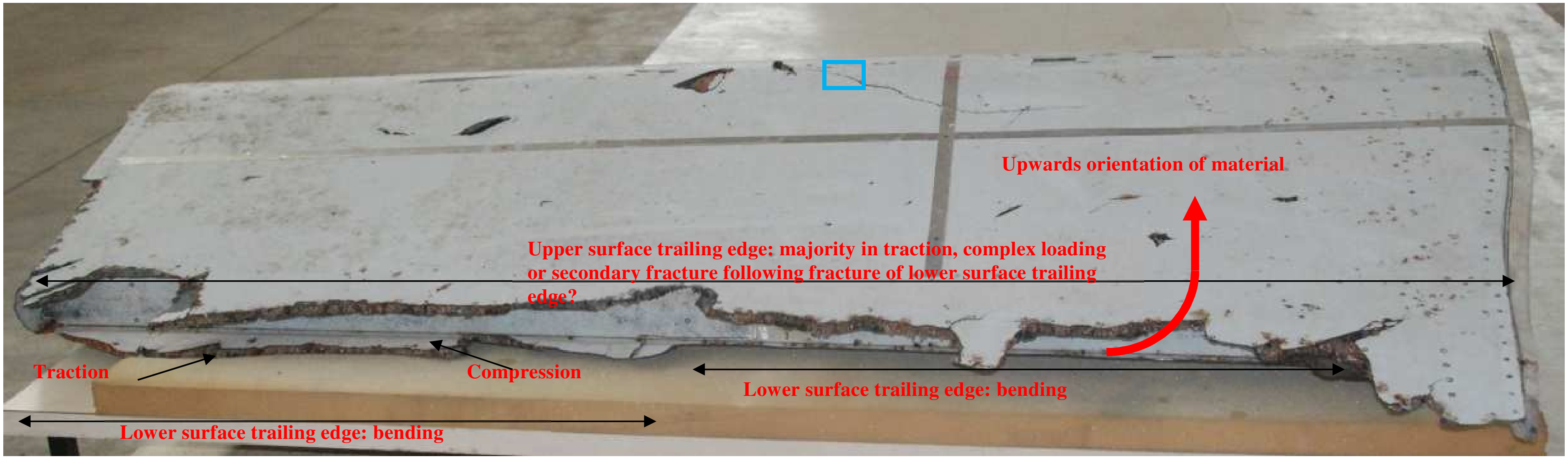
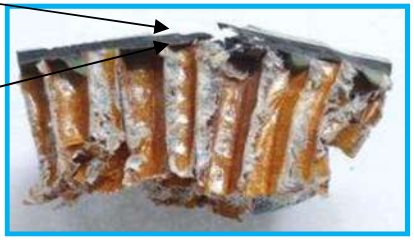
RESTRICTED CIRCULATION

RAPPORT
N° 16-DGATA-MTI-P1501516001002-DR-F-Â

Planche 62 : **Summary of the deductions made based on the observations and examinations on the composite structure of the flaperon**





Non-protruding crack : **bending fracture : skin bowing.**

Australian Government
Australian Transport Safety Bureau

Debris examination – update No. 1

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of two items of debris recovered from beaches in Mozambique

ATSB Technical Examination Report
Aviation
AE-2014-054
Debris examination update 1 – 19 April 2016 (amended 17 August 2017)

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

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Addendum

Page	Change	Date
3, 4, and 5	Corrected the operator's name.	17 August 2017

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of two items of debris recovered in Mozambique

Introduction

On 27 December 2015 and 27 February 2016, two items of debris were independently found, approximately 220km apart, on the Mozambique coast. Both items were delivered to the relevant Civil Aviation Authorities in Mozambique and South Africa in early March 2016. Assistance from the Australian Transport Safety Bureau (ATSB) was requested by the Malaysian Government in the formal identification of the items to determine if they came from the Malaysia Airlines Boeing 777 aircraft, registered 9M-MRO, operating as MH370.

The parts were packaged in Mozambique and South Africa respectively and delivered safe-hand to the ATSB in their original packaging, in the custody of the ICAO Annex 13 Safety Investigation Team members.

The following is a brief summary of the outcomes from the debris examination. This debris examination summary is released with the concurrence of the Malaysian ICAO Annex 13 Safety Investigation Team for MH370.

Quarantine and marine ecology

On arrival into Australia, both parts were quarantined at the Geoscience Australia facility in Canberra. The parts were unwrapped and examined for the presence of marine ecology and remnants of biological material. Visible marine ecology was present on both parts and these items were removed and preserved. The parts were subsequently cleaned and released from quarantine.

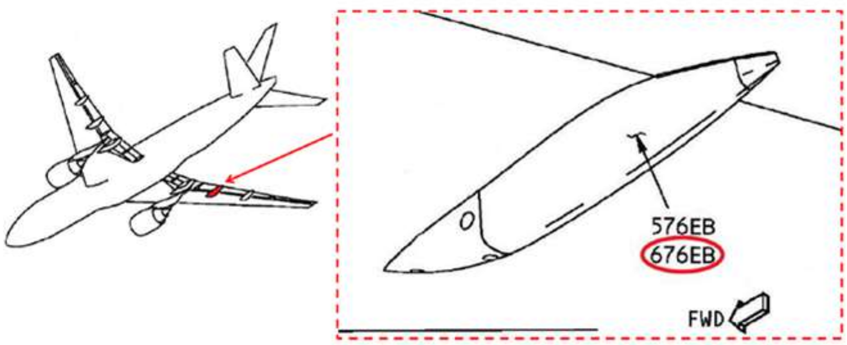
Identification

Part No. 1

The first part was initially identified from a number stencilled on the part (676EB), as a segment from a Boeing 777 flap track fairing (Fairing No. 7) from the right wing (Figure 1). All measurable dimensions, materials, construction and other identifiable features conformed to the applicable Boeing drawings for the identified fairing.

The 676EB stencil font and colour was not original from manufacture, but instead conformed to that developed and used by Malaysia Airlines during painting operations (Figure 2). The part had been repainted, which was consistent with the operator's maintenance records for 9M-MRO.

Figure 1: Location of flap track fairing panel No. 676EB



Source: Boeing 777 aircraft maintenance manual (modified by ATSB)

Figure 2: Flap fairing outer surface showing stencil location and comparison

Source: ATSB

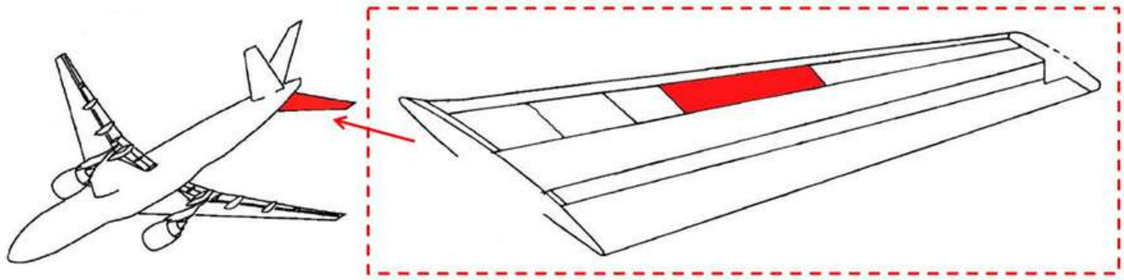
Part No. 2

The second part was primarily identified from images showing the materials, construction and "NO STEP" stencil, as a segment of a Boeing 777 RH horizontal stabilizer panel (Figure 3). All measurable dimensions, materials, construction and other identifiable features conformed to the Boeing drawings for the stabiliser panel.

The part was marked on the upper surface in black paint with "NO STEP". The font and location of the stencil were not original from manufacture, however the stencilling was consistent with that developed and used by Malaysia Airlines (Figure 4).

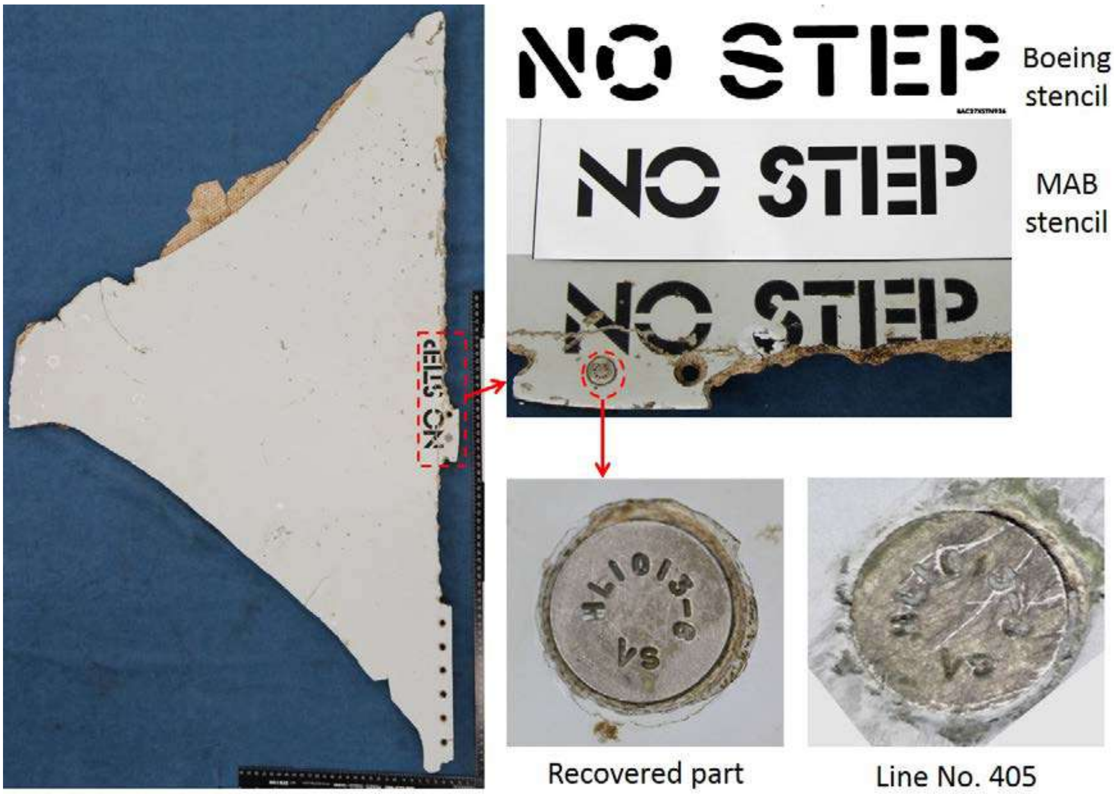
A single fastener was retained in the part. The fastener head markings identified it as being correct for use on the stabiliser panel assembly. The markings also identified the fastener manufacturer. That manufacturer's fasteners were not used in current production, but did match the fasteners used in assembly of the aircraft next in the production line (405) to 9M-MRO (404) (Figure 4).

Figure 3: Location of horizontal stabiliser panel No. 3 upper



Source: Boeing 777 Parts Catalogue (modified by ATSB)

Figure 4: Stabiliser panel "NO STEP" stencil and fastener comparison



Source: ATSB, Boeing

Conclusions

At the time of writing, ongoing work was being conducted with respect to the marine ecology identification as well as testing of material samples. The results from these tests will be provided to the Malaysian investigation team once complete. Nevertheless, from the initial examination it was concluded that:

- Part No. 1 was a flap track fairing segment, almost certainly from the Malaysia Airlines Boeing 777 aircraft, registered 9M-MRO.
- Part No. 2 was a horizontal stabiliser panel segment, almost certainly from the Malaysia Airlines Boeing 777 aircraft, registered 9M-MRO.

Australian Government
Australian Transport Safety Bureau

Debris examination – update No. 2

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of two items of debris recovered from beaches in South Africa and Mauritius

ATSB Technical Examination Report
Aviation
AE-2014-054
Debris examination update 2 – 12 May 2016 (amended 24 May 2016 and 17 August 2017)

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Internet: www.atsb.gov.au

Addendum

Page	Change	Date
3 and 5	Inclusion of text and photograph of Part No. 3 as found on 23 Dec 2015	23 May 2016
3, 4, and 6	Corrected the operator's name and added page numbers.	17 August 2017

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of two items of debris recovered in South Africa and Mauritius

Introduction

On 22 and 30 March 2016, two items of debris were independently found on beaches at Mossel Bay, South Africa and Rodrigues Island in Mauritius. Both items were delivered to the relevant Civil Aviation Authorities in South Africa and Mauritius. Assistance from the Australian Transport Safety Bureau (ATSB) was requested by the Malaysian Government in the formal identification of the items to determine if they came from the Malaysia Airlines Boeing 777 aircraft, registered 9M-MRO, operating as MH370.

The items were packaged in South Africa and Mauritius respectively and delivered safe-hand to the ATSB in their original packaging, in the custody of the ICAO Annex 13 Safety Investigation Team members.

This document (Update 2) is a brief summary of the outcomes from the identification of these items, designated as Part numbers 3 and 4. It follows the identification of Part numbers 1 and 2, the outcomes of which were released by the ATSB in Update 1 on 19 April 2016. This debris identification summary is released with the concurrence of the Malaysian ICAO Annex 13 Safety Investigation Team for MH370.

Quarantine and marine ecology

On arrival into Australia, both parts were quarantined at the Geoscience Australia facility in Canberra. The parts were unwrapped and examined for the presence of marine ecology and remnants of biological material. Visible marine ecology was present on both parts and these items were removed and preserved. The parts were subsequently cleaned and released from quarantine.

Identification

Part No. 3

Part number 3 was initially identified from the partial Rolls-Royce stencil as a segment from an aircraft engine cowling. The panel thickness, materials and construction conformed to the applicable drawings for Boeing 777 engine cowlings.

There were no identifiers on the engine cowling segment that were unique to 9M-MRO, however the Rolls-Royce stencil font and detail did not match the original from manufacture. The stencil was consistent with that developed and used by Malaysia Airlines and closely matched exemplar stencils on other Malaysia Airlines Boeing 777 aircraft (Figure 1).

There were identical inboard and outboard stencils present on the cowlings of each of the engines and the location of the stencils was found to vary between engines. Taking that into consideration, there were no significant differentiators on the cowling segment to assist in determining whether the item of debris was from the left or right side of the aircraft, or the inboard or outboard side the cowling.

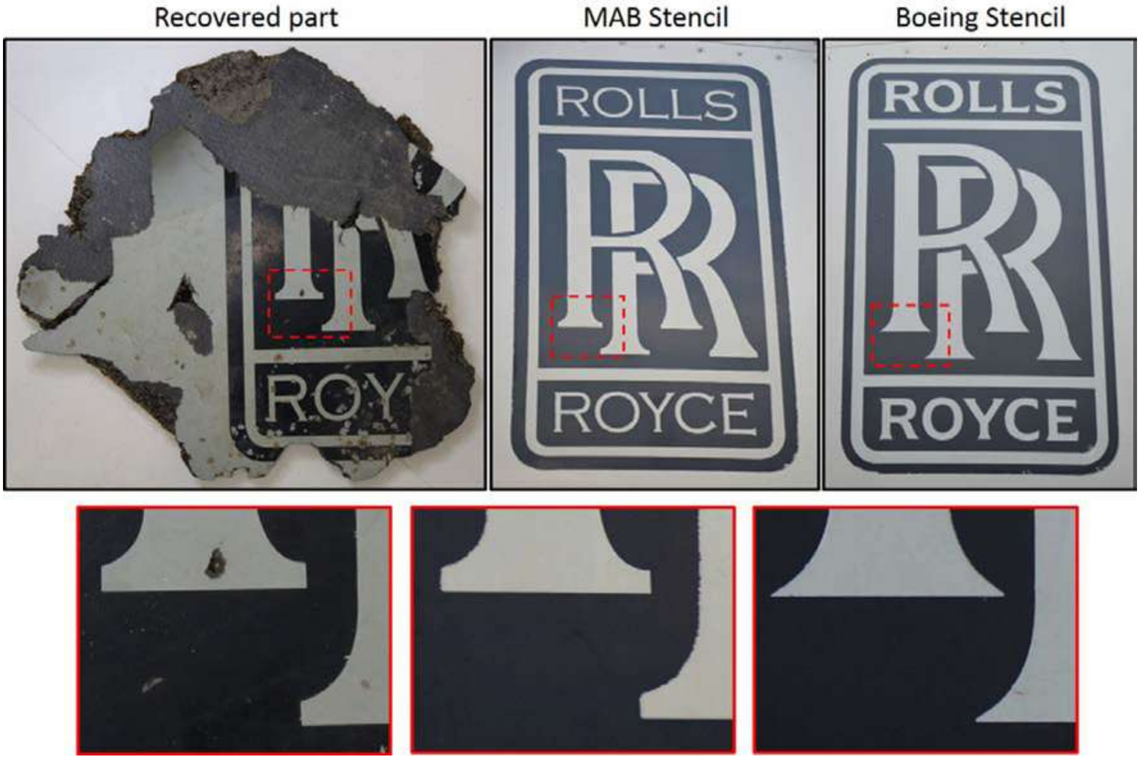
On 17 May 2016, the ATSB was provided with an earlier photograph of the item, taken on 23 December 2015. This photograph showed the part was significantly colonised by barnacles at the time it arrived on the beach (Figure 3).

Part No. 4

Part number 4 was preliminarily identified by the decorative laminate as an interior panel from the main cabin. The location of a piano hinge on the part surface was consistent with a work-table support leg, utilised on the exterior of the Malaysia Airlines Door R1 (forward, right hand) closet panel (Figure 2). The part materials, dimensions, construction and fasteners were all consistent with the drawing for the panel assembly and matched that installed on other Malaysia Airlines Boeing 777 aircraft at the Door R1 location.

There were no identifiers on the panel segment that were unique to 9M-MRO, however the pattern, colour and texture of the laminate was only specified by Malaysia Airlines for use on Boeing 747 and 777 aircraft. There is no record of the laminate being used by any other Boeing 777 customer.

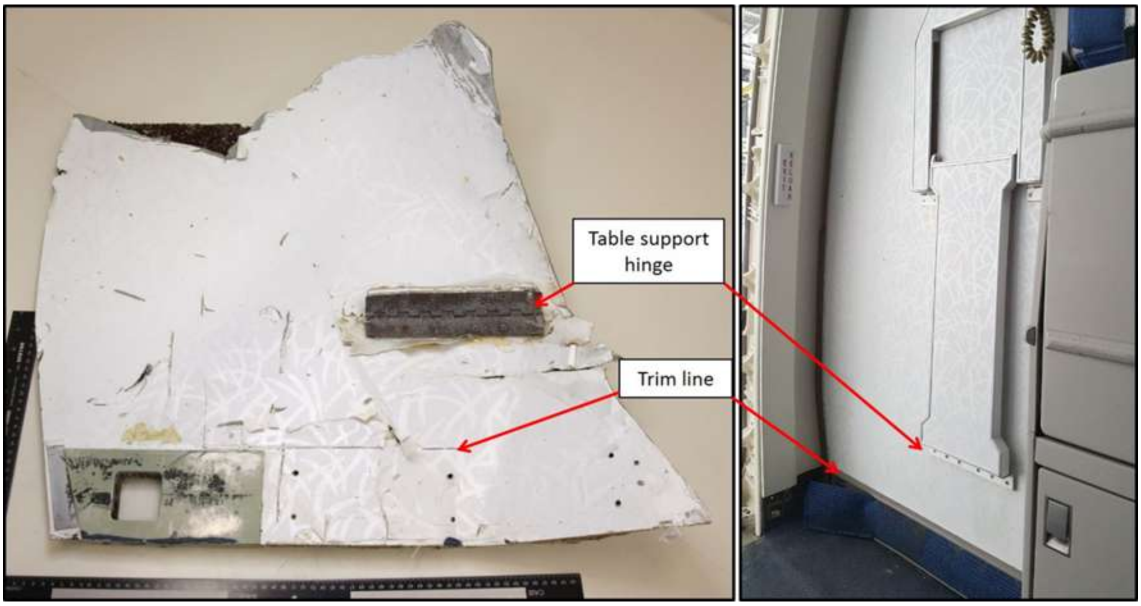
Figure 1: Comparison of Boeing 777 engine cowling stencils



Note the thickness of the "ROYCE" lettering and the serif geometry on the main 'R's (enlarged for ease of comparison).

Source: Malaysian MOT / ATSB

Figure 2: Comparison of recovered item with Malaysia Airlines Boeing 777 Door R1 panel assembly



Source: Malaysian MOT / ATSB

Figure 3: Photograph taken 23 Dec 2015 showing Part No. 3 significantly colonised by barnacles

Source: Schalk Lückhoff

Conclusions

At the time of writing, work was ongoing with respect to the marine ecology samples. The results from these tests will be provided to the Malaysian investigation team once complete. In terms of the identification of the two items of debris, it was concluded that:

- Part No. 3 was a Malaysia Airlines Boeing 777 engine cowling segment, almost certainly from the aircraft registered 9M-MRO.
- Part No. 4 was a Malaysia Airlines Boeing 777 panel segment from the main cabin, associated with the Door R1 closet, almost certainly from the aircraft registered 9M-MRO.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 6 in the "Summary of Possible MH370 Debris Recovered") recovered south of Chidenguele, Mozambique on 24 April 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/01/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370
Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 6 in the "Summary of Possible MH370 Debris Recovered") recovered south of Chidenguele, Mozambique on 24 April 2016

1.0 Introduction

This item was recovered south of Chidenguele in Mozambique on 24 April 2016. It is identified as Item No. 6 from the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered".***

The item was brought back to Malaysia for identification and further examination by the ***"Malaysian ICAO Annex 13 Safety Investigation Team for MH370".***

2.0 Part Characteristics

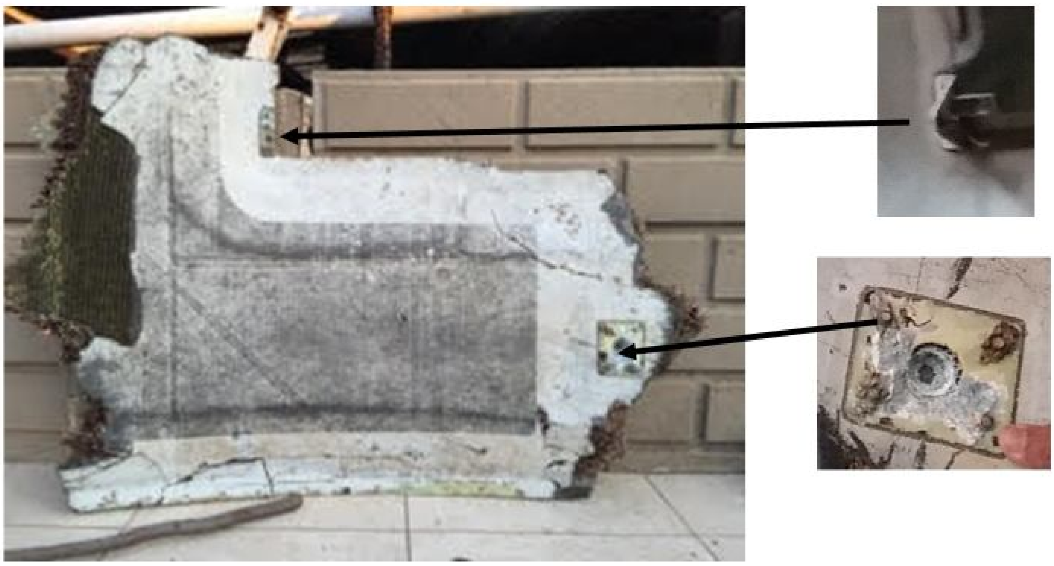
The part was measured to be approximately 54 inches in length and weighed 8.44 Kg.

The structure was of composite honeycomb sandwich with non-metallic core. It had a number of fracture lines and one of the sides which was the 'end of part', was intact. The external skin was dark grey in colour and the inner skin was white.

A part of a metal bracket was still attached on the debris and it was observed that another one had broken off. This was the attachment for the "Hold-Open Stay Rod"

3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. The possible location of the part on the aircraft was determined.



The hinge bracket, number of fasteners and fasteners' pitch on the part were consistent with those on the right engine fan cowl on the aircraft. The mount found on the part was also consistent with the mount of the fan cowl "Hold-Open Stay Rod" in regards to its location, shape and size of the mounting bracket.

The words “HOIST POINT” were still visible and in the correct location. The fonts used for the words on the part matched those on the fan cowl of the aircraft.

The dimension from the forward edge of the part to the start of the core ramp, which was 18 inches, was also consistent with that of the fan cowl on the aircraft, as shown in the above figure.

The part was brought near to the right fan cowl and was found to physically resemble it in terms of shape, size, colour and features.

Based on the above, the part is confirmed to be part of the ***Right Fan Cowl*** of a B777 aircraft.

4.0 Structure Examination

The fracture on the laminate appears to be more likely a tension failure. The honeycomb core was intact and there was no significant crush on the honeycomb core. All the metal parts were detached and the fastener holes for the hinge door brackets were clearly visible. The attachment for the "Hold-Open Stay Rod" was detached and corrosion was visible on the remaining metal part.

5.0 Conclusion

It has been concluded that the debris is part of the ***Right Fan Cowl*** of a B777 aircraft. As the right fan cowls on both the engines are similar, there is no conclusive evidence to determine whether it belongs to the left (No. 1) or right (No. 2) engine. Based on the other features on the recovered part it has also been determined that the part is almost certain from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 7 in the "Summary of Possible MH370 Debris Recovered") recovered at Anvil Bay, Chemucane, Mozambique on 30 April 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/02/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 7 in the "Summary of Possible MH370 Debris Recovered") recovered at Anvil Bay, Chemucane, Mozambique on 30 April 2016

1.0 Introduction

This item was recovered at Anvil Bay, Chemucane, Mozambique on 30 April 2016. It is identified as Item No. 7 of the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered"***.

The item was brought back to Malaysia for identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

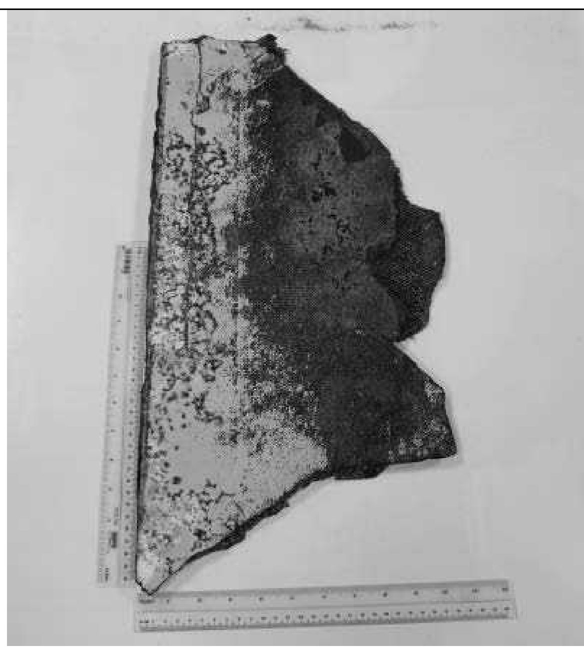
2.0 Part Characteristics

The part was a typical Carbon Fiber Reinforced Plastic (CFRP) with non-metallic honeycomb core. The part was triangular in shape and approximately 22 inches at its longest edge. It weighed 0.31 Kg. The white paint on both sides of the debris had faded. It had an 'end of part' which had a distinctive corner radius but the length of the possible flange could not be determined since it had fractured immediately after the radius. There were no identification numbers on the part. The overall plan form of the part is not flat, it had a curvature.

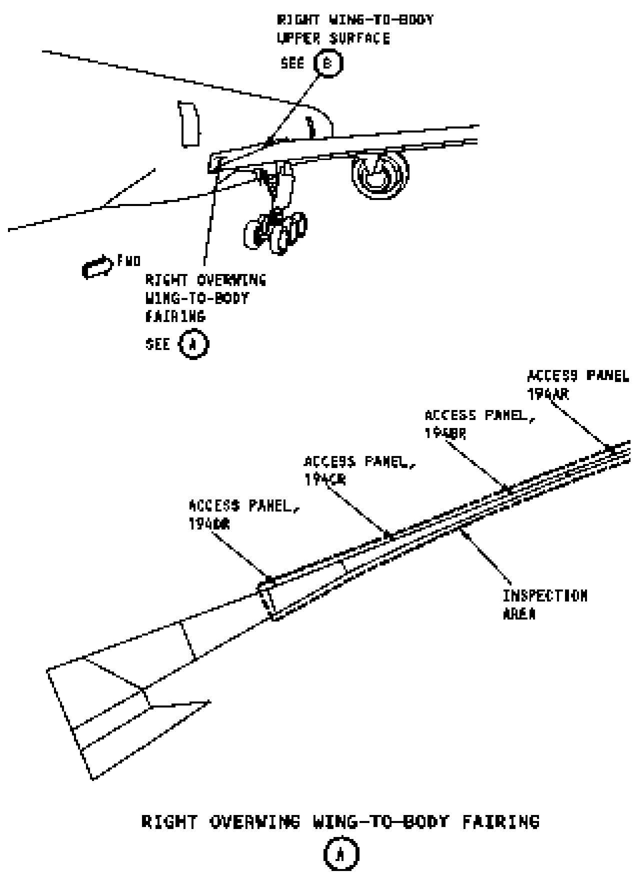
3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes.

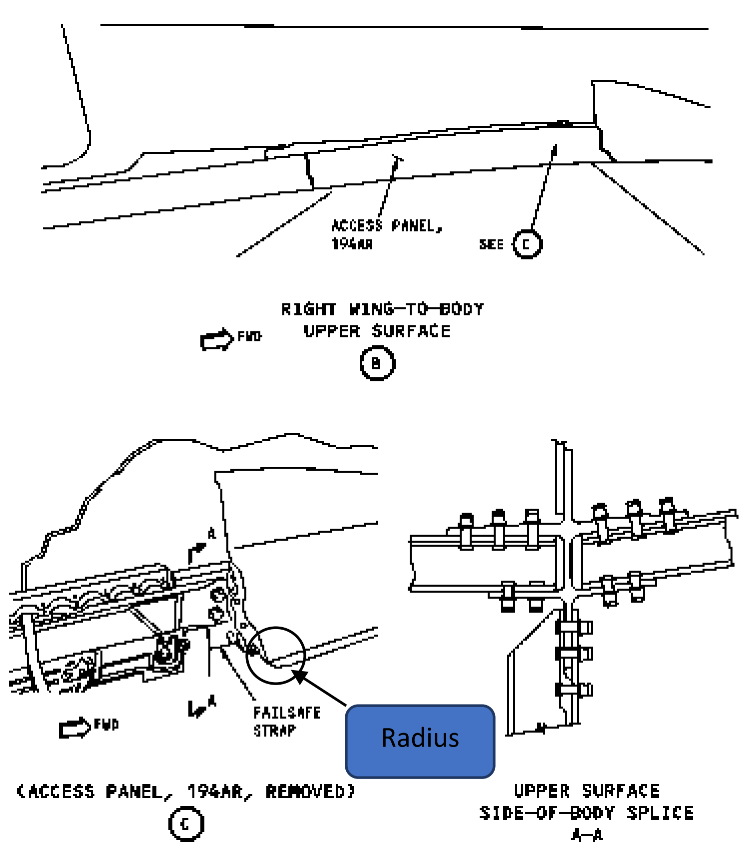
The exact location of the part on the aircraft could not be identified since it did not have any markings or numbers and there were no peculiar features which could match it on the aircraft except for one edge of the part which had a distinct radius, which suggested that the joining part would be at an angle. While the construction was similar to a B777 part, there was no conclusive evidence to determine the origin of this part with respect to the aircraft.



After review of the B777 Illustrated Parts Catalogue (IPC), the most possible location of the part was determined to be the wing to fuselage body fairing. The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is likely from MH370 given that the likelihood of it originating from another source is quite remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.



Upper Surface Side-of-Body Splice (Right Wing) General Visual (Internal)
Figure 241 (Sheet 1 of 2) [illegible]



Upper Surface Side-of-Body Splice (Right Wing) General Visual (Internal)
Figure 241 (Sheet 2 of 2) [illegible]

4.0 Structure Examination

The part had fractured at all sides. One side had fractured immediately after the corner radius. The fibres appeared to have been pulled away and there were no visible kink on the fibres. The core was not crushed; it had fractured along the skin fracture line.

5.0 Conclusion

There is no conclusive evidence to determine the origin of this part with respect to the aircraft however based on its features it is likely to be a part of a panel of the wing to body fairing on a B777 aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is likely that it is from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 8 in the "Summary of Possible MH370 Debris Recovered") recovered at Gris Gris Beach, Mauritius on 24 May 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/03/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 8 in the "Summary of Possible MH370 Debris Recovered") recovered at Gris Gris Beach, Mauritius on 24 May 2016

1.0 Introduction

This item was recovered at Gris Gris Beach, Mauritius on 24 May 2016. It has been identified as Item No. 8 of the items found; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

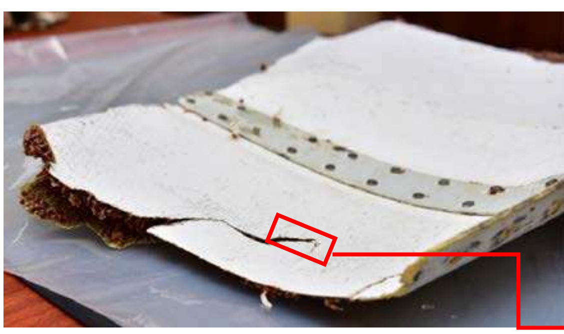
The part was a typical Carbon Fiber Reinforced Plastic (CFRP) with Honeycomb Core. The part weighed 1.21 Kg. A metal strap was still attached on the inner skin, complete with its fasteners.

3.0 Identification

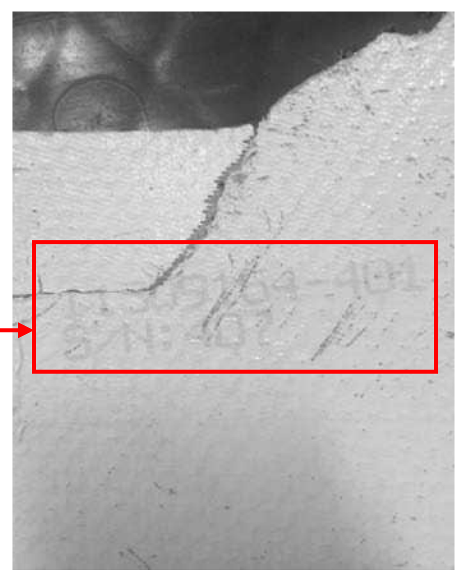
Initial assessment indicated that this could be a flap support fairing tail cone of a B777. The part was identified from the legible numbers that were observed on the inner surface. The following part number 113W9154-401 and serial number 407 were visible on one side. The profile of the part resembled the wing flap support fairing tail cone.

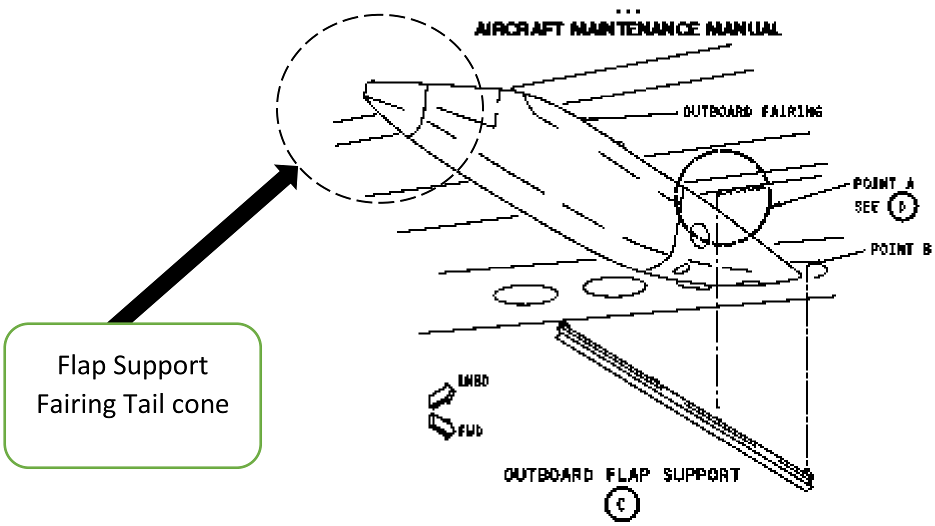
The part number was cross referenced to the Boeing component maintenance manual and drawings. This identified it as a component of the wing flap support fairing assembly and the fit closely matched that of the No. 1 flap support fairing. As the records of where these fairing tail cones are fitted are not normally kept by airlines, the serial number 407 could not be tracked to any particular aircraft.

The Debris – external surface



Inner side of the debris





The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is highly likely from MH370 given that the likelihood of it originating from another source is very remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

The fracture line on the part showed the fibers to be ‘pulled out’ showing tension failure. Most of the core was intact and there was no sign of excessive crush.

5.0 Conclusion

Based on the legible numbers and the fit, it is confirmed that the part is the tail cone of the No. 1 flap support fairing of a B777 aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that it is from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Items 9 and 15 in the "Summary of Possible MH370 Debris Recovered") recovered at Macenta Peninsular, Mozambique on 22 May 2016 and Riake Beach, Nosy Boraha Island, Madagascar on 06 June 2016, respectively

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/04/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

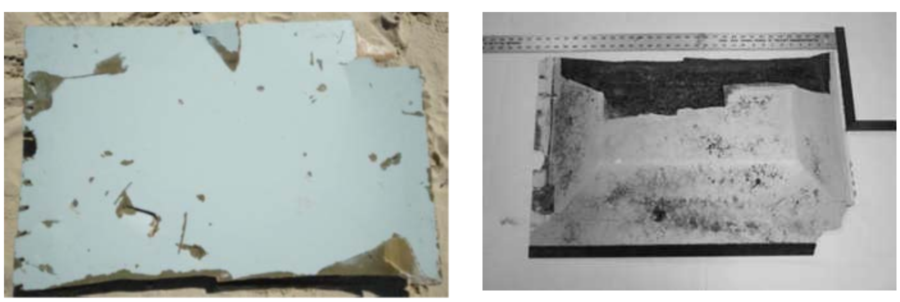
Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Items 9 and 15 in the "Summary of Possible MH370 Debris Recovered") recovered at Macenta Peninsular, Mozambique on 22 May 2016 and Riake Beach, Nosy Boraha Island, Madagascar on 06 June 2016, respectively

1.0 Introduction

Item 9 was recovered at Macenta Peninsular, Mozambique on 22 May 2016 while Item 15 was recovered at Riake beach, Nosy Boraha Island, Madagascar on 06 June 2016. These parts were identified as Item No. 9 and 15 of the items found; refer to the "***Summary of Possible MH370 Debris Recovered "***.

Item 9



Item 15

The items were brought back to Malaysia for identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

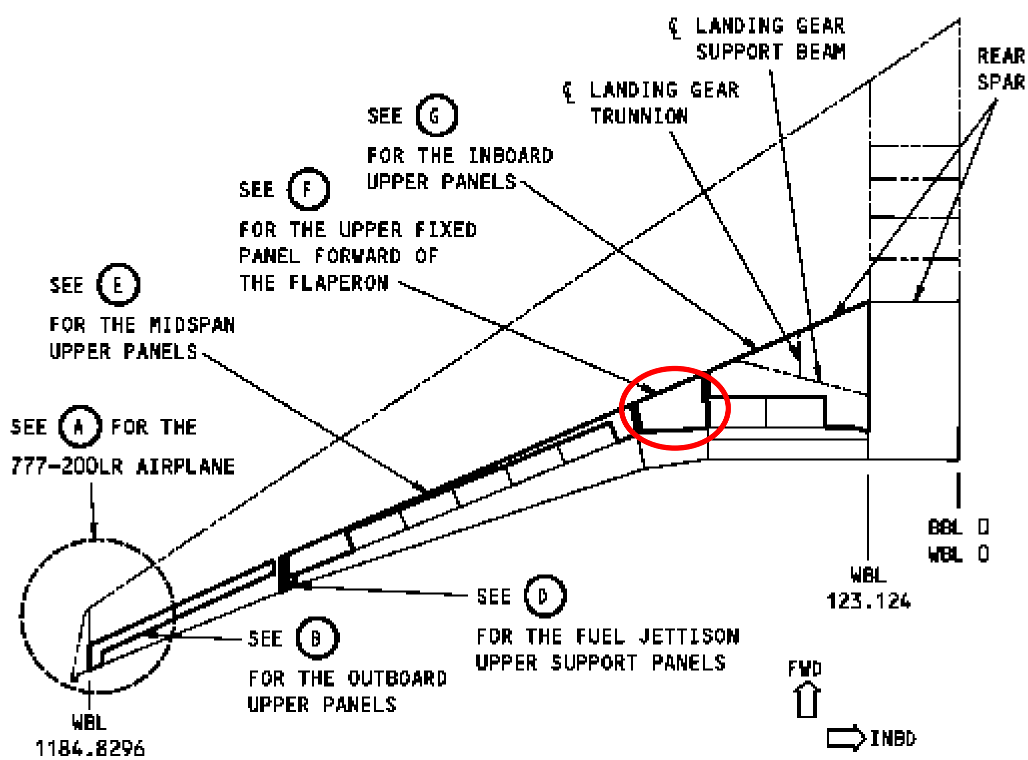
2.0 Parts' Characteristics

Both debris (Items 9 and 15) were of composite structure with non-metallic honeycomb core and of Graphite Fibre Reinforced Plastic (GFRP) construction. The upper surfaces of the parts were painted with grey paint. The core ramps were visible at two places for Item 9 and three places for Item 15. Rub strips were still intact on one edge of the parts. Item 9 was weighed and found to be 2.18 Kg. while Item 15 was 3.34 Kg.

3.0 Identification

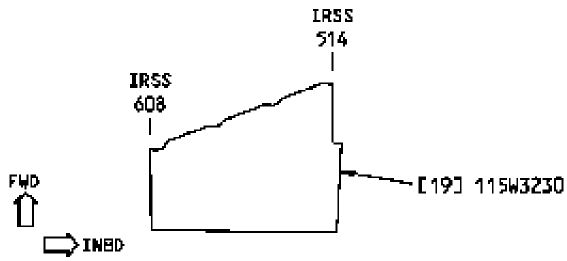
The parts were taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes.

Item 9 matched the left part (outboard section) of the Upper Fixed Panel forward of the flaperon on the **left** wing.



LEFT WING IS SHOWN, RIGHT WING IS OPPOSITE

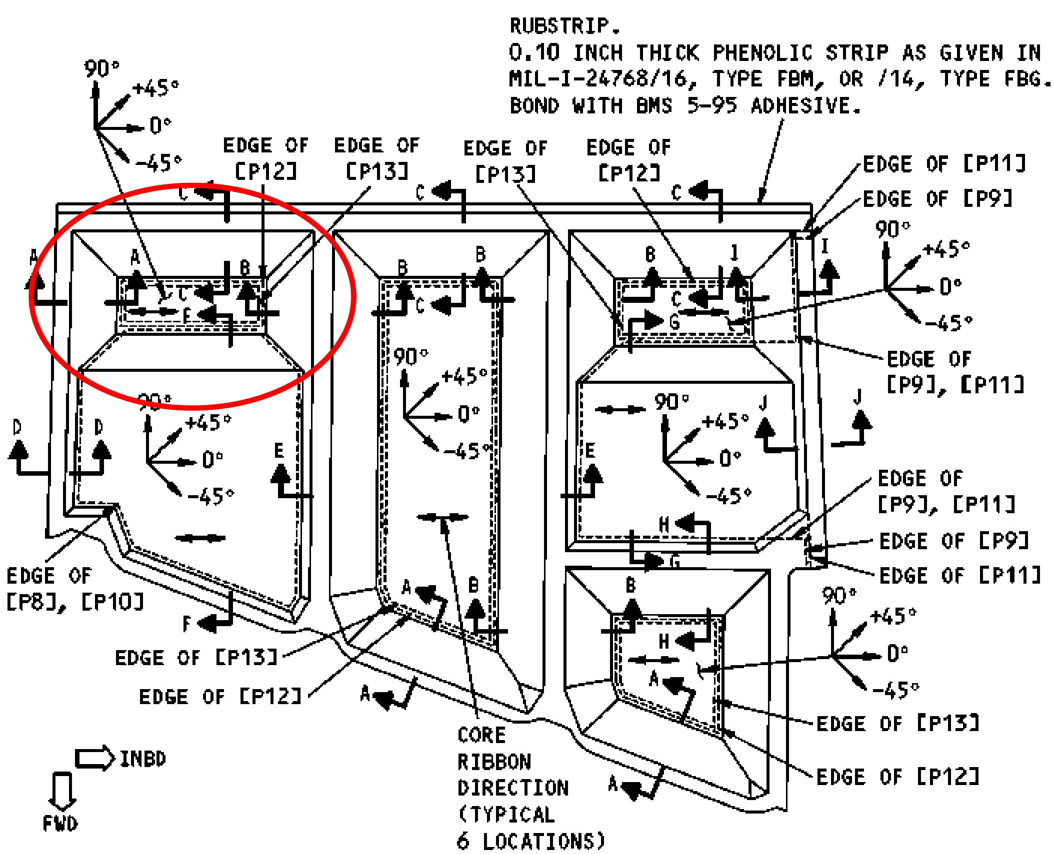
PANEL LOCATIONS - PLAN VIEW



UPPER FIXED PANEL FORWARD OF THE FLAPERON

F

777-200
STRUCTURAL REPAIR MANUAL



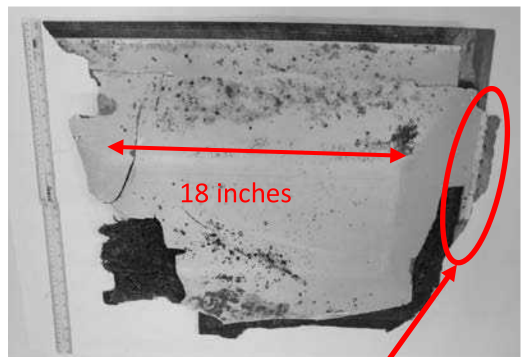
PLY LAYUP AND CORE RIBBON DIRECTION

777-200/200ER AIRPLANES

Further verification was carried out with reference to the B777 Aircraft Structure Repair Manual (SRM) which indicated that the panel was indeed the Upper Fixed Panel forward of the left flaperon.

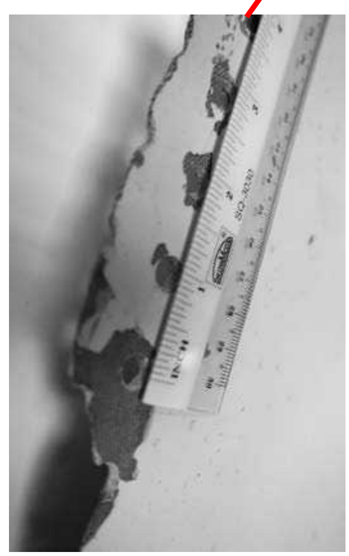
The above figure shows Item 9 as a section of the “Upper Fixed Panel Forward of the Flaperon” on the left wing. It was observed that the outboard side was fractured and on the inboard side the fastener holes were still visible with a pitch of 1 inch. This fastener pitch matched that on the inboard side of the panel of the aircraft. The fasteners’ pitch on the outboard side was 2 inches. The raised portion of the core of the section of the panel (see figure below) of length 18 inches also matched with that on the aircraft panel.

Panel on Aircraft



Debris

Item 9

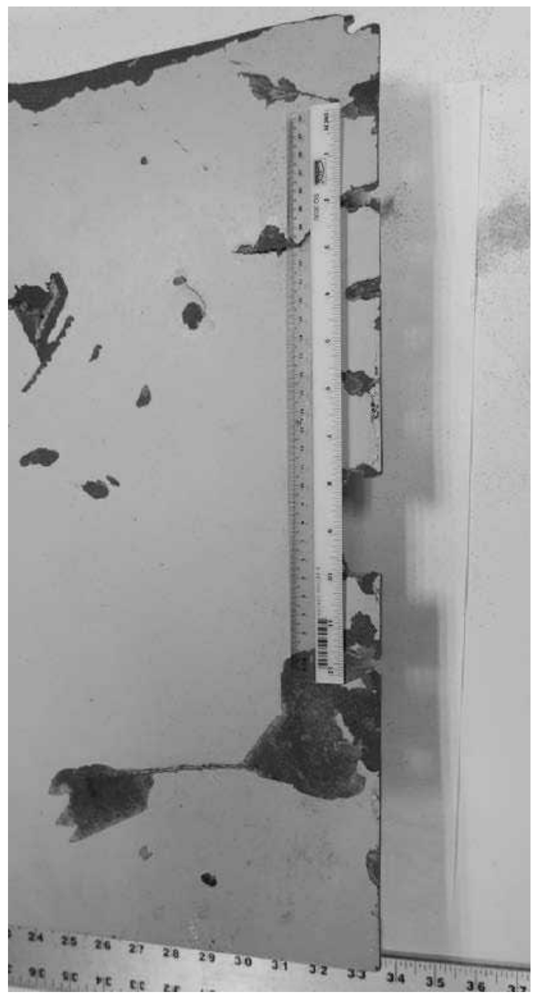


Fastener Pitch – 1 inch

Similar matching process was carried out on Item 15; it was identified to be the outboard section of the “Upper Fixed Panel forward of the flaperon” on the **right** wing (refer to figure below). The pitch of the fasteners’ holes on the right side (outboard) of the panel was measured to be 2 in. and that matched that on the debris.

The Boeing 777 Illustrated Parts Catalog (IPC) indicates that the part numbers of the Upper Fixed Panels forward of the left flaperon to be 115W3210-1 and that forward of the right flaperon to be 115W3210-2, respectively.

Item 15 against Upper Fixed Panel forward of Right Flaperon



Fastener pitch – 2 inches

The locations of where the parts were found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, are consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the parts are highly likely from MH370 given that the likelihood of them originating from another source is quite remote. The reports from the Australian Transport Safety Bureau (ATSB) on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

Item 9 was fractured at three places and one edge was still intact. The intact edge was that with the rub strip and indicated that it was the rear section of the panel. The fracture lines showed that the fibres were pulled but there were no signs they were kinked. The core was intact and had not crushed; it had fractured along the skin.

Item 15 had fractured at two places; the rear section was intact with the rub strip. The outboard section had the fasteners torn out with some of the fastener holes still recognizable. The inboard section was observed to have signs of 'net tension' failure as it had fractured along the fastener holes.

5.0 Conclusion

Item 9 is confirmed to be the outboard section of the "Upper Fixed Panel forward of the flaperon" on the **left** wing whilst item 15 is confirmed to be the outboard section of the "Upper Fixed Panel forward of the flaperon" on the **right** wing. From the locations where they were found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that they are from MH370 (aircraft registered as 9M-MRO).

Australian Government
Australian Transport Safety Bureau

Debris examination – update No. 5

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of wing trailing edge debris recovered from Mauritius

ATSB Technical Examination Report
Aviation
AE-2014-054
Debris examination update 5 – 6 October 2016 (amended 17 August 2017)

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

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Addendum

Page	Change	Date
1	Corrected the operator's name.	17 August 2017

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of wing trailing edge debris recovered from Mauritius

Introduction

An item of composite debris was recovered on the island of Mauritius around 10 May 2016. The item profile was consistent with the trailing edge of an aircraft wing. The item was subsequently collected by a member of the Malayisan investigation team and hand-delivered to the Australian Transport Safety Bureau for identification.

This document is a brief summary of the item identification, designated part number 6. It follows the previous identification and examination reports available on the ATSB website at www.atsb.gov.au/mh370-pages/updates/reports/ . This summary is released with the concurrence of the Malaysian ICAO Annex 13 Safety Investigation Team for MH370.

Identification

Part No. 6

A part number was identified on a section of the debris, identifying it as a trailing edge splice strap, incorporated into the rear spar assembly of a Boeing 777 left outboard flap. This was consistent with the appearance and construction of the debris.

Adjacent to the part number was an “OL” part identifier, similar to those found on the right outboard flap section (Examination update 3). The flap manufacturer supplied records indicating that this identifier was a unique work order number and that the referred part was incorporated into the outboard flap shipset line number 404 which corresponded to the Boeing 777 aircraft line number 404, registered 9M-MRO and operating as MH370.

Figure 1: Left outboard flap trailing edge section showing part identification numbers

Source: ATSB

Conclusion

Part number 6 was a trailing edge section of Boeing 777 left, outboard flap, originating from the Malaysia Airlines aircraft registered 9M-MRO.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 11 in the "Summary of Possible MH370 Debris Recovered") recovered at Riake beach, Nosy Boraha Island, Madagascar On 06 June 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/05/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 11 in the "Summary of Possible MH370 Debris Recovered") recovered at Riake beach, Nosy Boraha Island, Madagascar 0n 06 June 2016

1.0 Introduction

This item was recovered at the Riake beach, Nosy Boraha Island, Madagascar on 06 June 2016. The part is identified as Item No. 11 of the 25 items found; refer to the "***Summary of Possible MH370 Debris Recovered (15 August 2016)***".

The item was brought back to Malaysia for the identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

The part was intact with slight distortion. There was no sign of burnt marks or any other sign that the part had been exposed to fire.

3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes.

The part was identified as the seat back trim panel which encases the In-Flight Entertainment (IFE) monitor, as shown in the photograph below. There was a small fragment of fabric around the coat hanger on the debris, which was greenish in colour. This colour matched the seat fabric used on the Malaysia Airlines (MAS) B777 on the center seats. The location of the coat hanger on the left conforms to the Right Hand, Triple Seat Assembly column in the Economy (EY) class.

The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is highly likely from MH370 given that the likelihood of it originating from another source is very remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

As this was an aircraft interior part no detailed structural examination was conducted.

5.0 Conclusion

The item is confirmed to be part of the seat back trim panel for encasing the IFE monitor. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that it is from MH370 (aircraft registered as 9M-MRO). Features found on the debris also support this likelihood.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 12 in the "Summary of Possible MH370 Debris Recovered") recovered at Riake Beach, Nosy Boraha Island, Madagascar on 06 June 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/06/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

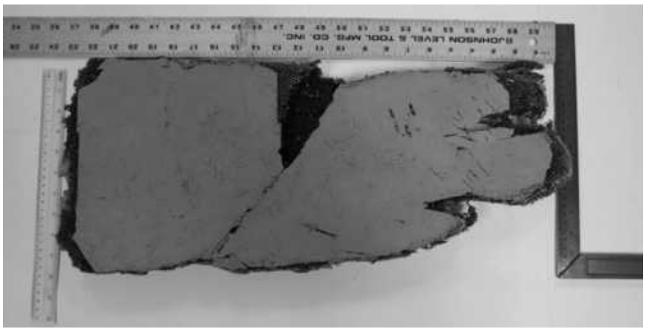
Identification of Debris (Item 12 in the "Summary of Possible MH370 Debris Recovered") recovered at Riake Beach, Nosy Boraha Island, Madagascar on 06 June 2016

1.0 Introduction

This item was recovered at Riake beach, Nosy Boraha Island, Madagascar on 06 June 2016. It is identified as item 12 of the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics



It was made of Carbon Fibre Reinforced Plastic (CFRP) with honeycomb core. The honeycomb core was measured to be more than 1 inch thick. The core taper was observed to be prominent. It was approximately 23 inches by 10 inches in size.

3.0 Identification

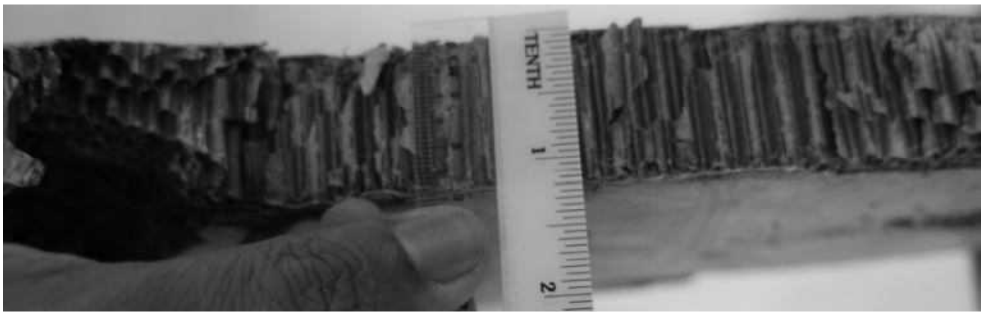
The letters "FB" were clearly visible on the part which indicates that it is a bottom panel on the wing or horizontal stabilizer.

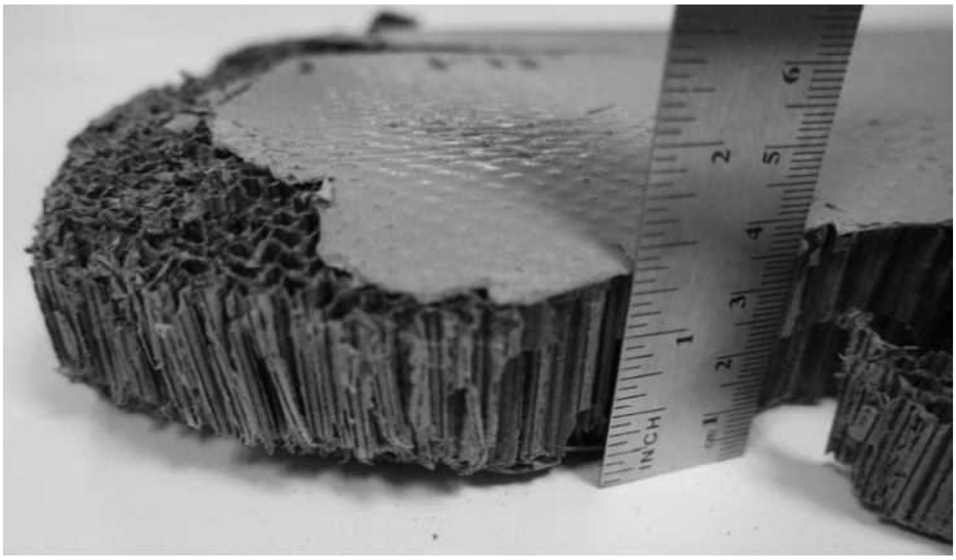
An attempt was made to match the part to all the wing and horizontal stabilizer panels with the identification marks ending with "FB". The thickness and profile of the part did not match any of those panels on the aircraft. However it could be confirmed that it is very likely to be a part from a Boeing aircraft.

The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is likely from MH370 given that the likelihood of it originating from another source is quite remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

The carbon fibre laminate had fractured and appeared to have pulled out but there was no crush on the core.





5.0 Conclusion

Markings on the debris suggest it is very likely from a Boeing aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is likely that it is from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 13 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake Beach, Nosy Boraha Island, Madagascar on 12 June 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/07/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 13 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake Beach, Nosy Boraha Island, Madagascar on 12 June 2016

1.0 Introduction

This item was recovered from Riake Beach, Nosy Boraha Island, Madagascar on 12 June 2016. The part was identified as Item No. 13 of the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for the further examination and identification by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

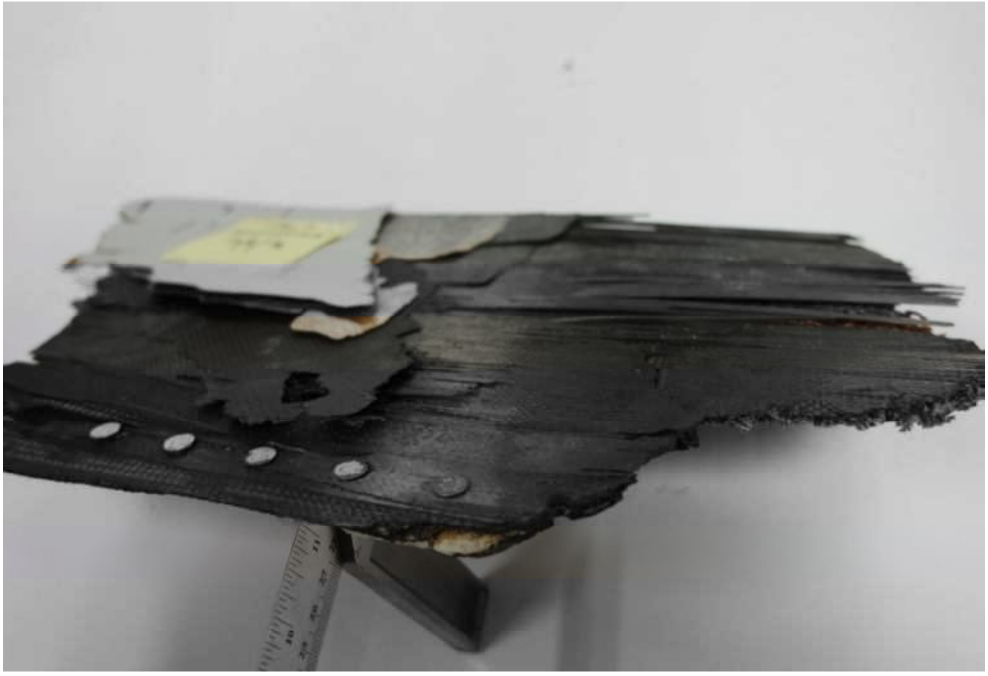
The item was measured to be approximately 19 inches in length and 10 inches in width and weighed 0.375 Kg.

3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. The part could not be matched exactly to any part on the aircraft. There were also no identification numbers on the part.

4.0 Structure Examination

The item was a typical Carbon Fiber Reinforced Plastic (CFRP) construction with honeycomb core. One of the layers in the laminate top surface was clearly visible to be made of Unidirectional Carbon fibers. The fasteners were attached to an angle made of CFRP which was broken at one of the flanges. However, the angle radius was still visible.



5.0 Conclusion

There is insufficient evidence to indicate that it could be from a B777 aircraft or from MH370.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 14 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake Beach, Nosy Boraha Island, Madagascar on 12 June 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/08/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 14 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake Beach, Nosy Boraha Island, Madagascar on 12 June 2016

1.0 Introduction

This item was recovered from Riake Beach, Nosy Boraha Island, Madagascar on 12 June 2016. It was identified as Item No. 14 of the items found; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for the identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

The part was observed to be of non-metallic honeycomb sandwich construction with decorative finish. The part was approximately 20 inches in length and weighed 0.145 Kg.

3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. The part did not have any distinguishing features to match any on the aircraft. The part resembled a cabin interior piece based on the decorative finish. It did not have any identification numbers.

4.0 Structure Examination

The part was fractured on all sides. The fibres appeared to be pulled rather than being compressed.

5.0 Conclusion

There is insufficient evidence to positively identify the part to be from an aircraft.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Items 16 and 17 in the "Summary of Possible MH370 Debris Recovered") recovered from Antsiraka Beach, Madagascar on 12 June 2016

Updated on 30th April 2017

Issued on 4th October 2016

Ref: DB/01/16

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Items 16 and 17 in the "Summary of Possible MH370 Debris Recovered") recovered from Antsiraka Beach, Madagascar on 12 June 2016

Introduction

Items 16 and 17 were found on 12 June 2016 in Antsiraka Beach, Madagascar. These items were taken to Air Accident Investigation Board (AAIB) Malaysia office in Putrajaya, Federal Territory, Malaysia and stored in the quarantine room before they were removed and brought to Science & Technology Research Institute for Defence (STRIDE) for detailed examination.

The MH370 Safety Investigation Team was assisted by the MAB (Malaysia Airlines Berhad) Sdn Bhd, Technical Services Engineer in the part identification process.

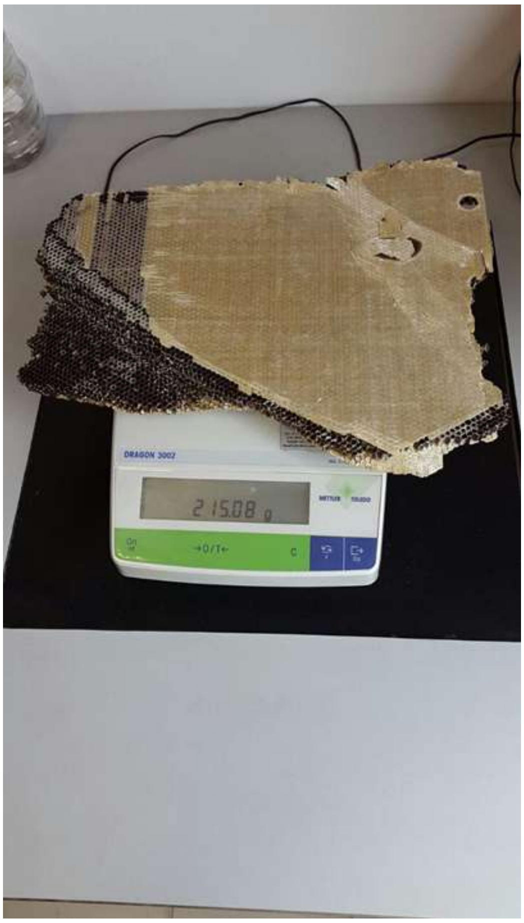
Item No. 16

Item No. 17

Identification

The initial stage was to carry out the identification of the parts, which included a general examination of the items. The size and weight of the items were taken and then they were inspected for any signs of abnormal marks or discoloration which could indicate a specific pattern of failure or destruction.

Item No. 16



Item No. 17

The next phase was to determine the possible clues, which may lead to any evidence of the MH370 end of flight scenario.

The observations and findings on these parts are in the following table.

	Item 16	**Item 17**
Size	Small piece of bigger part	Small piece of bigger part
Weight	235.58 grams	215.08 grams
Color	White with vinyl cover on both sides of the panel, one side just plain white vinyl, the other side with white vinyl with rice plant pattern. This design is unique to Malaysia Airlines B777 and B747 interior as per interior specifications made available by MAB Engineering Technical Services.	Not painted, either has been removed or just bare composite panel
Part Number	Nil	Nil
Serial Number	Nil	Nil
Special features	The honeycomb core was identified as Nomex with a thickness of 1.025 inches. Observed three holes for insert on one side of the panel. White Vinyl with pattern unique to Malaysia Airlines B777 and B747 cabin interior.	There was a hole for pin or fasteners. The size of the hole was 0.514 inches; it appeared to be the hole for a Dzus fastener. However, there was no sign of an insert, which is required for structural panel.
Abnormal marks	Nil	2 localised burn spots. However did not indicate a homogenous fire or heat damage pattern.

Further work

There is no further work required on these two items.

Conclusion

1. Item No. 16 is a cabin interior panel based on the Nomex honeycomb core and panel construction. The vinyl decorative sheet on one side of the panel is the same as the specification used on MAS 777 cabin interior. This item is almost certain from MH 370 (aircraft registered as 9M-MRO).

2. Item No. 17 is not identifiable.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 18 in the "Summary of Possible MH370 Debris Recovered") recovered from Antsiraka beach, Madagascar on 12 June 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/09/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 18 in the "Summary of Possible MH370 Debris Recovered") recovered from Antsiraka beach, Madagascar on 12 June 2016

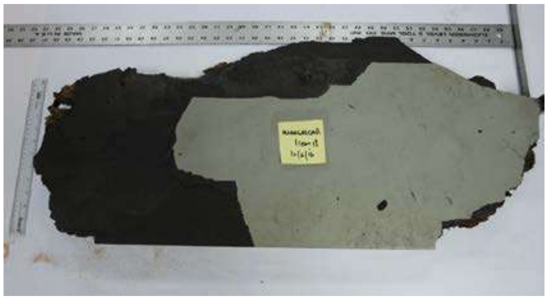
1.0 Introduction

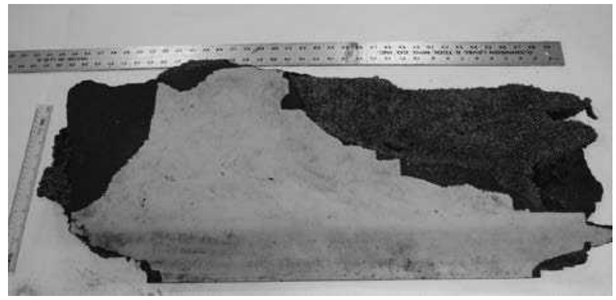
This item was recovered from Antsiraka beach, Madagascar on 12 June 2016. The part is identified as Item No 18 of the items found; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for the identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

The part was observed to be Carbon Fiber Reinforced Plastics (CFRP) honeycomb sandwich. The core was nonmetallic honeycomb. Both the outer and inner skins were made of carbon fibre and were white in colour. The part size was approximately 36 inches by 12 inches in dimension and the weight was 3.34 Kg.

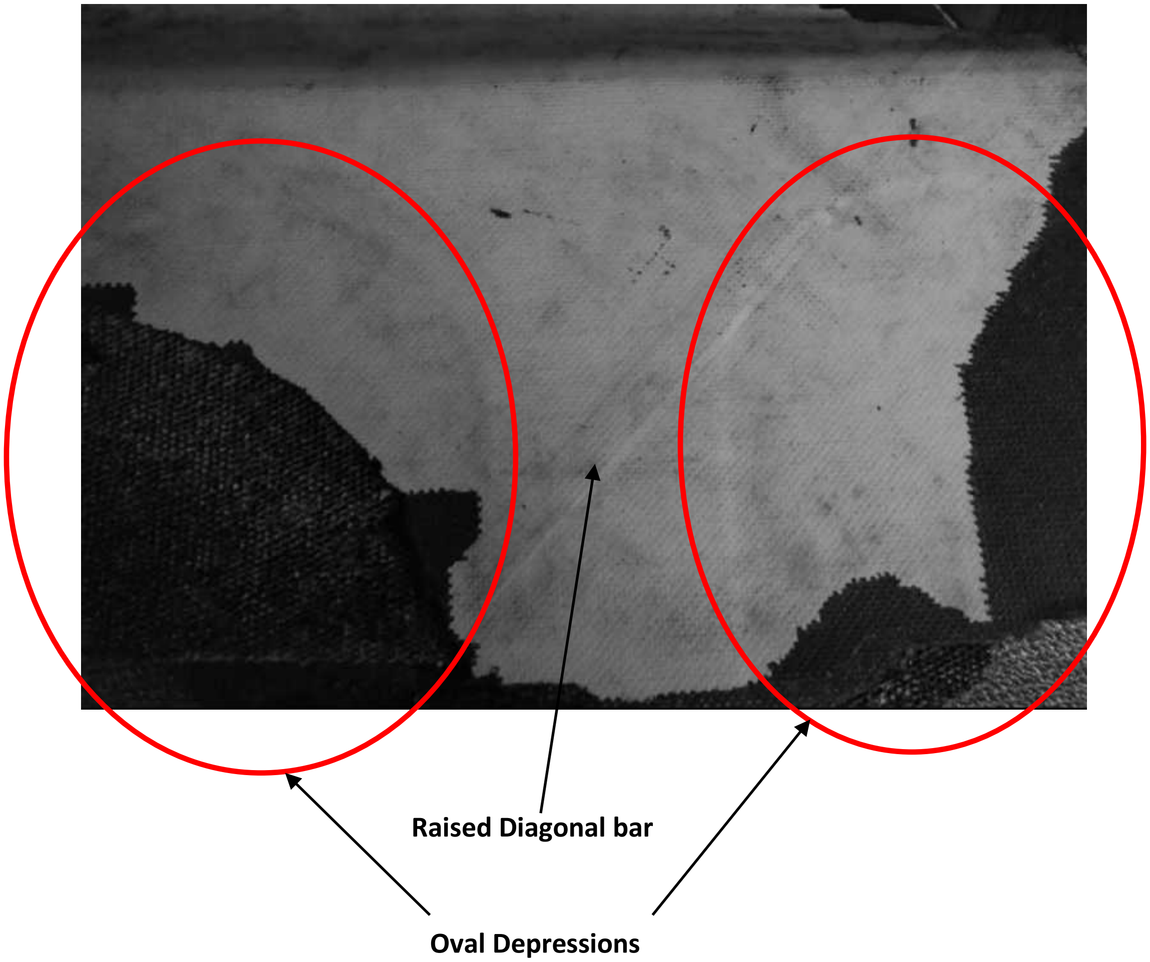




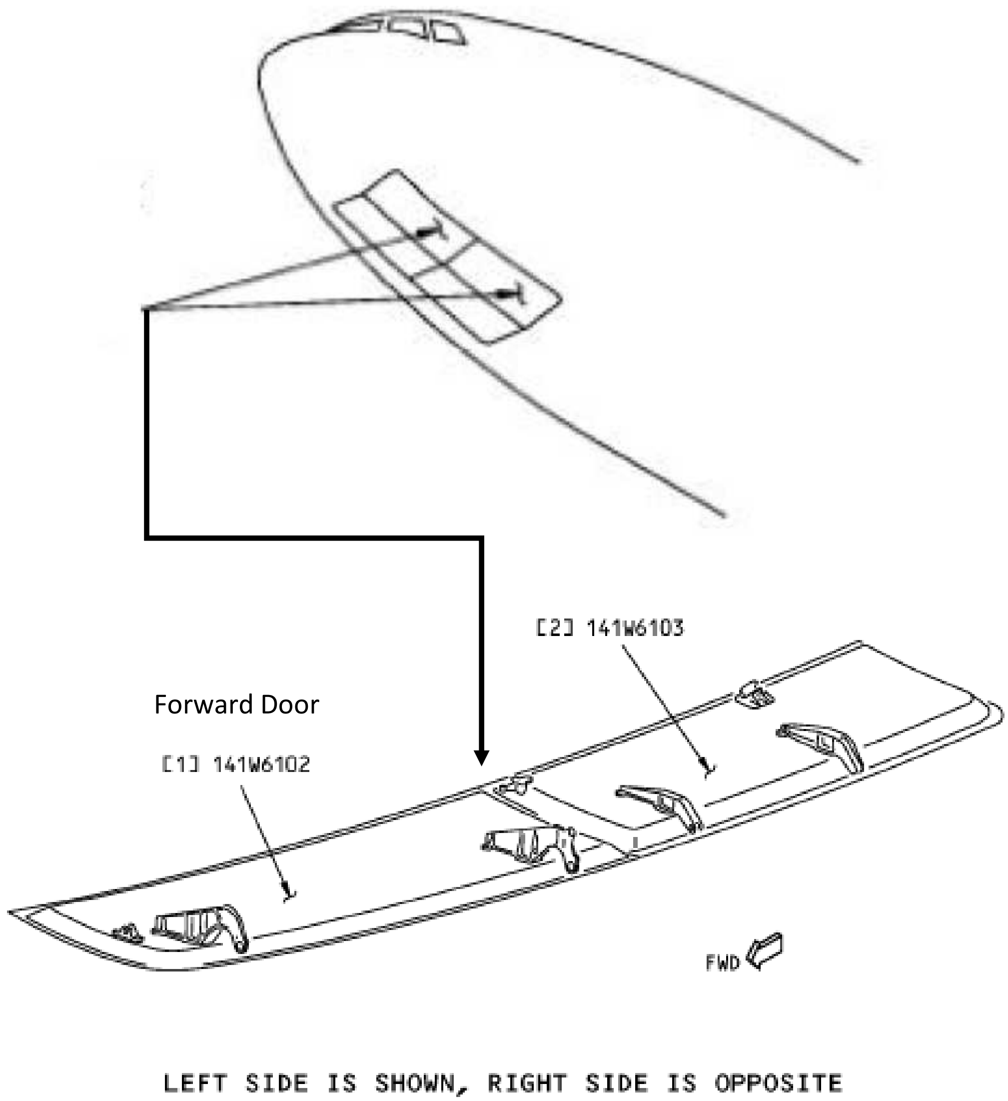
3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. The part did not have any identification numbers on it. However the features on the part resembled the Right Nose Gear Forward Door. The oval depressions on the inner skin and the orientation of a diagonal, raised bar matched that on the Right Nose Gear Forward Door on the aircraft.

The above photo shows the item matched the Right-Hand Nose Gear Forward Door. The photo below shows the oval depressions and the raised diagonal bar.



The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is highly likely from MH370 given that the likelihood of it originating from another source is very remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.



4.0 Structure Examination

The part was fractured on three edges except at one end, the edge where the hinges were installed. Close visual examination of the fracture lines showed the fibers were pulled and there was no sign of kink.

5.0 Conclusion

The part is positively identified as the Right Hand Nose Gear Forward Door of a B777 aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that it is from MH370 (aircraft registered as 9M-MRO).

Australian Government
Australian Transport Safety Bureau

Debris examination – update No. 3

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of large flap section recovered off the Tanzanian coast

ATSB Technical Examination Report
Aviation
AE-2014-054
Debris examination update 3 – 15 September 2016 (amended 17 August 2017)

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

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Addendum

Page	Change	Date
1 and 3	Corrected the operator's name and added page numbers.	17 August 2017

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Identification of large flap section recovered off the Tanzanian coast

Introduction

On 20 June 2016, a large item of debris was found on the island of Pemba, off the coast of Tanzania. Preliminary identification from photographs indicated that the item was likely a section of Boeing 777 outboard flap (Figure 1).

Assistance from the Australian Transport Safety Bureau (ATSB) was requested by the Malaysian Government in the formal identification of the item, to determine if the item came from the Malaysia Airlinesaircraft, registered 9M-MRO and operating as MH370. The Malaysian investigation team secured the item of debris and arranged shipping to the ATSB facilities in Canberra.

This document (Update 3) is a brief summary of the outcomes from the identification of the item, designated as Part number 5. It follows the identification of Part numbers 1 through 4, the outcomes of which were released by the ATSB in Updates 1 and 2, available on the ATSB website at www.atsb.gov.au/mh370-pages/updates/reports/

This debris identification summary is released with the concurrence of the Malaysian ICAO Annex 13 Safety Investigation Team for MH370.

Identification

Part No. 5

Part number 5 was preliminarily identified from photographs as an inboard section of a Boeing 777 outboard flap. On arrival at the ATSB, several part numbers were immediately located on the debris that confirmed the preliminary identification. This was consistent with the physical appearance, dimensions and construction of the part.

A date stamp associated with one of the part numbers indicated manufacture on 23 January 2002 (Figure 2), which was consistent with the 31 May 2002 delivery date for 9M-MRO.

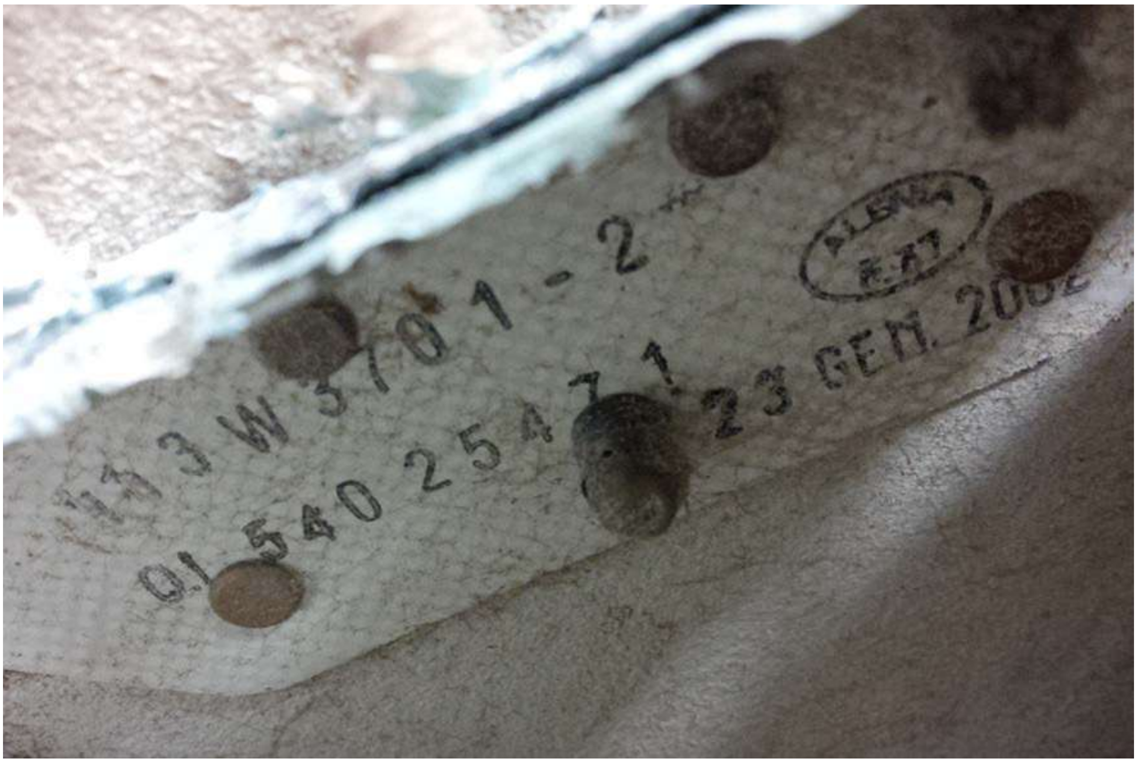
All of the identification stamps had a second “OL” number, in addition to the Boeing part number, that were unique identifiers relating to part construction. The Italian part manufacturer recovered build records for the numbers located on the part and confirmed that all of the numbers related to the same serial number outboard flap that was shipped to Boeing as line number 404. Aircraft line number 404 was delivered to Malaysia Airlines and registered as 9M-MRO.

Based on the above information, the part was confirmed as originating from the aircraft registered 9M-MRO and operating as MH370.

Figure 1: Inboard section of outboard flap (inverted)

Source: ATSB

Figure 2: Exemplar part number and date stamp



Source: ATSB

Further analysis

At the time of writing, the flap section was being examined for any evidence of interaction with mechanisms, supports and surrounding components (such as the flaperon, which abuts the inboard end of the outboard flap) that may indicate the state of flap operation at the time of separation from the wing. This information may contribute to an increased understanding of end of flight scenarios.

Conclusions

It was confirmed that Part No. 5 was the inboard section of a Boeing 777 right, outboard flap, originating from the Malaysia Airlines aircraft registered 9M-MRO.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 20 in the "Summary of Possible MH370 Debris Recovered") recovered from Kosi Bay mouth, Northern Kwa Zulu Natal, South Africa on 21 June 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/10/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 20 in the "Summary of Possible MH370 Debris Recovered") recovered from Kosi Bay mouth, Northern Kwa Zulu Natal, South Africa on 21 June 2016

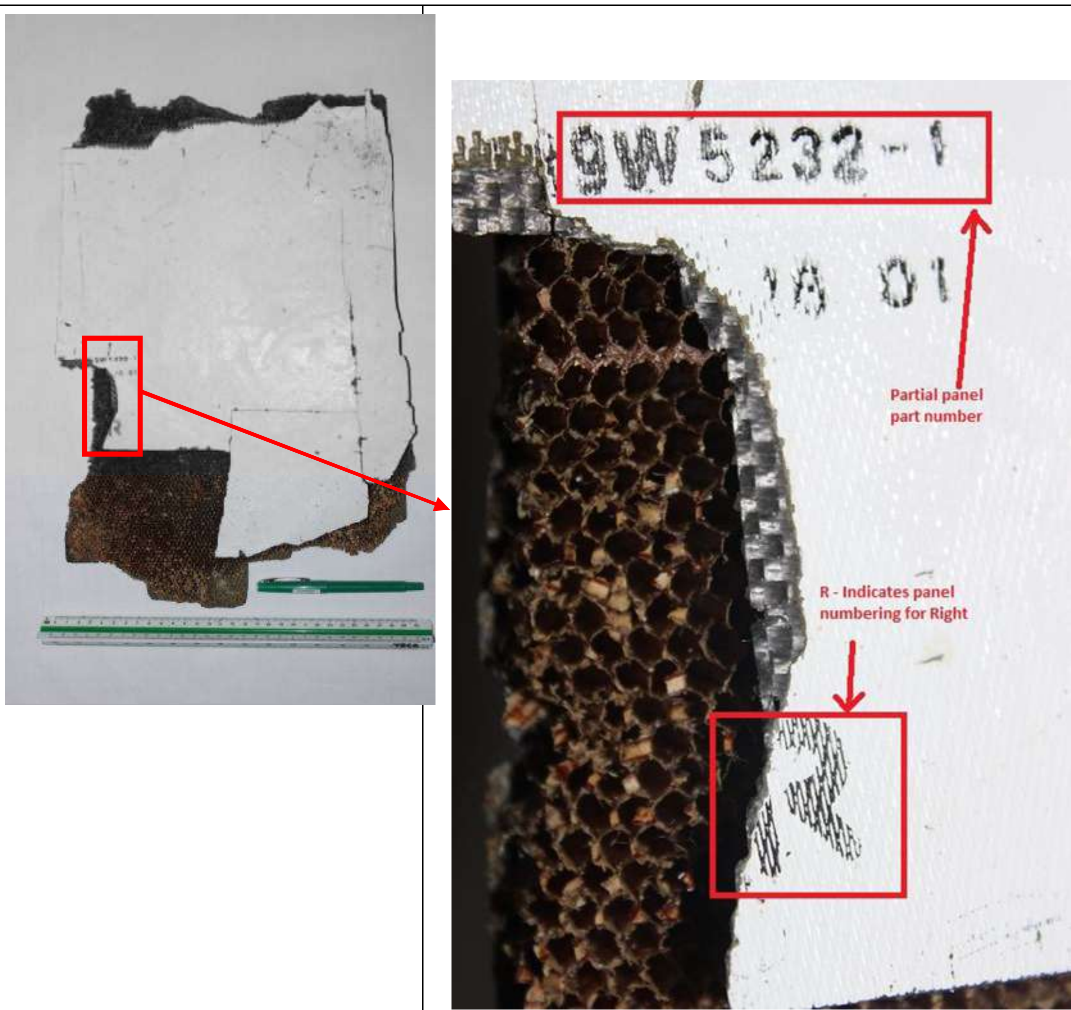
1.0 Introduction

This item was recovered from Kosi Bay mouth, Northern Kwa Zulu Natal, South Africa on 21 June 2016. It was identified as Item No. 20 of the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

The part was Carbon Fibre Reinforced Plastic (CFRP), honeycomb sandwich design. It had non-metallic honeycomb core. The part was measured to be approximately 12 inches by 20 inches in size and weighed 0.315 Kg.



3.0 Identification

Part of the identification number was visible on the debris indicating that it is part of the right aft wing to body fairing panel, 196 MR. Part of the part number, 149W5232-1, was visible with the letter 'R' below it, indicating it is a panel on the right side of the aircraft.

The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is highly likely from MH370 given that the likelihood of it originating from another source is very remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

This part was fractured on all sides. Visual examination of the fracture lines indicated that the fibers appeared to have pulled away with no sign of kink on the fibers.

5.0 Conclusion

This item is confirmed to be part of the right aft wing to body fairing panel from a B777 aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that it is from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 21 in the "Summary of Possible MH370 Debris Recovered") recovered from Northern Kwa Zulu Natal, South Africa on 18 July 2016

Issued on 28th February 2017

Ref: DB/11/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370
Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 21 in the "Summary of Possible MH370 Debris Recovered") recovered from Northern Kwa Zulu Natal, South Africa on 18 July 2016

1.0 Introduction

This item was recovered from Northern Kwa Zulu Natal, South Africa on 18 July 2016. It was identified as No. 21 of the items found; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

The debris was observed to be of Carbon Fiber Reinforced Plastic (CFRP) honeycomb sandwich construction. The honeycomb core was non-metallic. The grey paint top coat was still intact. It was triangular in shape with an approximate length of 21 inches and weighed 0.87 Kg.

3.0 Identification

Based on the structure construction, this part could be a small section of a panel from an aircraft. There were no identification numbers on the part and it could not be positively determined from which aircraft and which section it could have come from.

4.0 Structure Examination

The part was fractured on all sides except on one edge. Some fasteners were still intact in position. The fibers appeared to be pulled and not kinked.

5.0 Conclusion

It could not be positively determined whether the debris could be from a B777 aircraft.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 22 in the "Summary of Possible MH370 Debris Recovered") recovered at Linga Linga beach, Mozambique on 26 August 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/12/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 22 in the "Summary of Possible MH370 Debris Recovered") recovered at Linga Linga beach, Mozambique on 26 August 2016

1.0 Introduction

This debris was recovered at Linga Linga beach, Mozambique on 26 August 2016.The part is identified as Item No 22 of the items found; refer to the "***Summary of Possible MH370 Debris Recovered".***

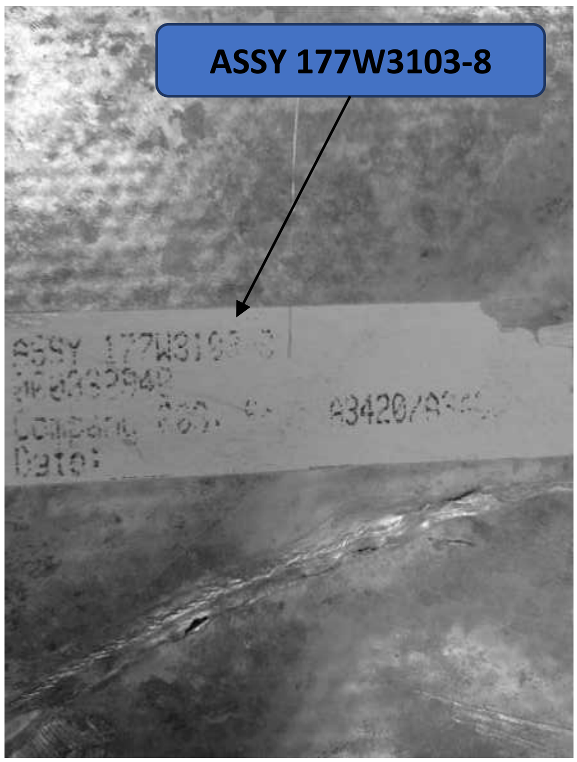
The item was brought back to Malaysia for the identification and further examination by the "Malaysian ICAO Annex 13 Safety Investigation Team for MH370".

2.0 Part Characteristics

It was of Graphite Fibre Reinforced Plastic (GFRP) honeycomb sandwich with Aluminum honeycomb. The part was measured and observed to have an overall dimension of 48 inches in length and weighed 4.77 Kg.

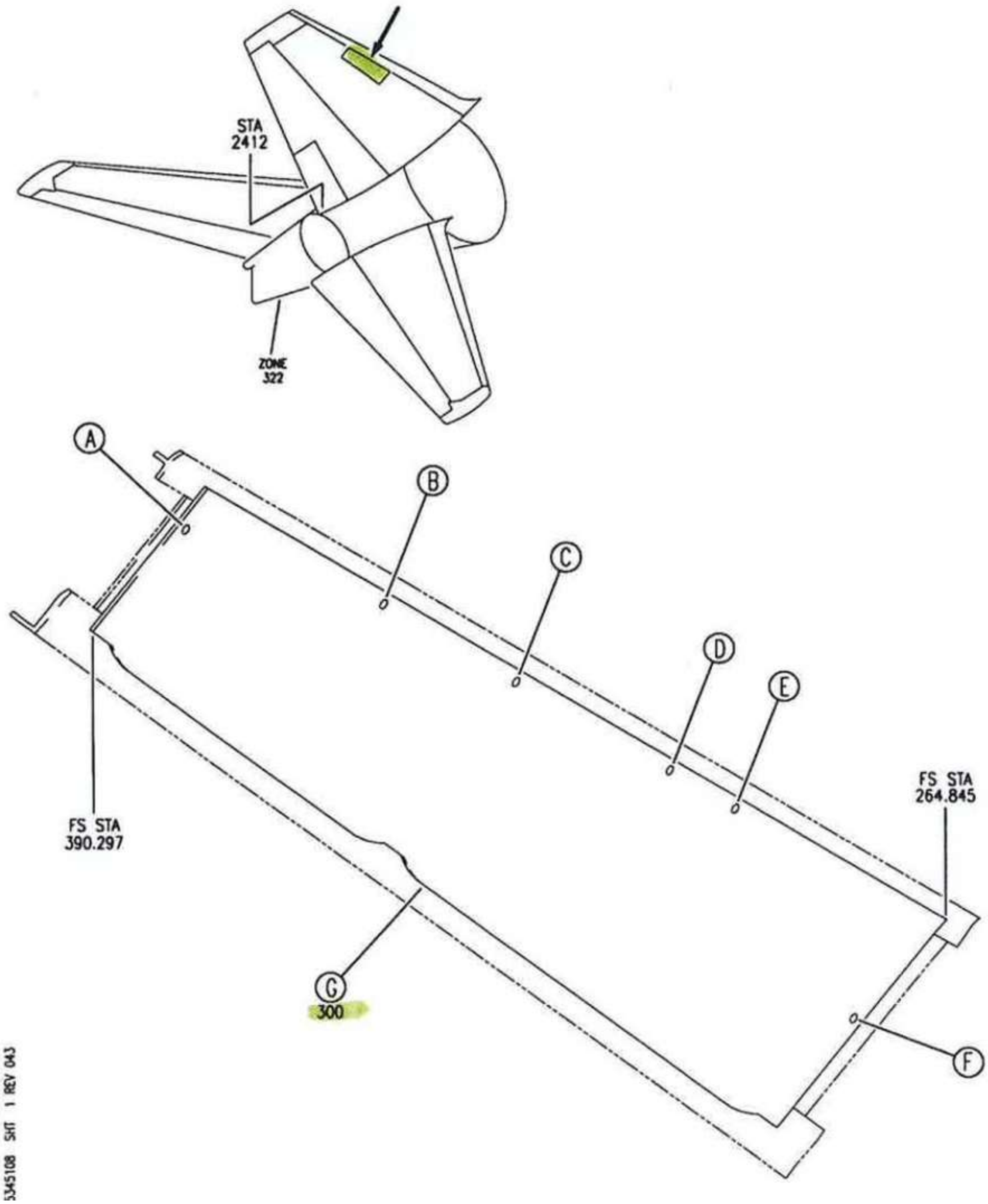
3.0 Identification

On the interior side of the part, there was still a decal with part identification numbers. Refer to the picture below. The Assembly (Assy) Number 177W3103-8 was visible. When referred to the Boeing 777 Illustrated Parts Catalog (IPC) this part was confirmed to be the right vertical stabilizer panel between the auxiliary and front spar. The red/white paint on the panel and the paint configuration appeared to match that of the Malaysia Airlines ‘kite’ logo on the right side of the vertical stabilizer. Refer to the photos below.



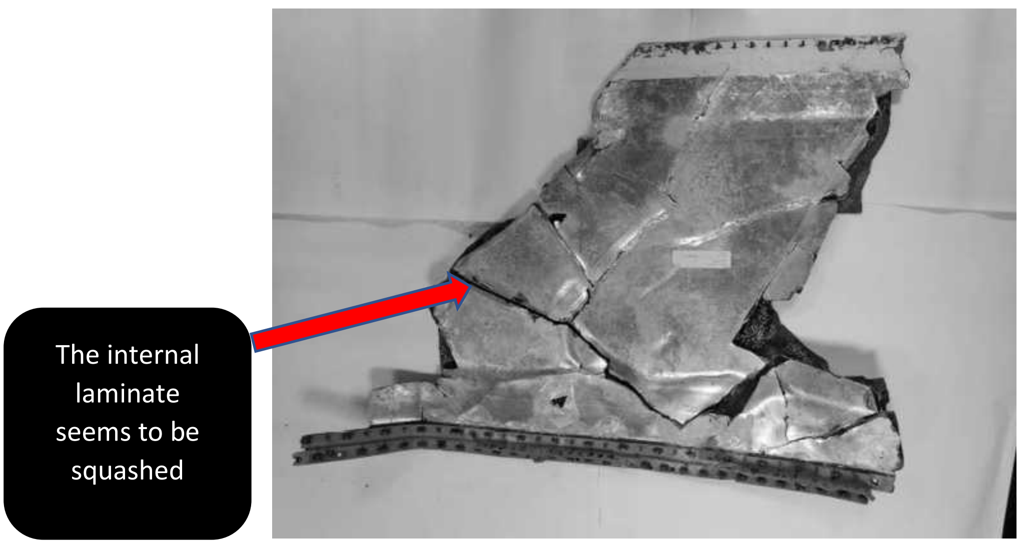

Visit Malaysia Yea
9M-MRO

BOEING
777
PARTS CATALOG (MAINTENANCE)



4.0 Structure Examination

The outer skin had slightly buckled and dented but the inner skin was fractured in several places.



5.0 Conclusion

The debris is confirmed to be part of the right vertical stabilizer panel of a B777. Based on the red/white livery on the panel it is determined to be almost certain from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 23 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake Beach, Nosy Bohara Island, Madagascar in October 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/13/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : *MH370SafetyInvestigation@mot.gov.my*

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 23 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake Beach, Nosy Bohara Island, Madagascar in October 2016

1.0 Introduction

This item was recovered from Riake Beach, Nosy Bohara Island, Madagascar in October 2016. The item is identified as Item No 23 of the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered***".

The item was brought back to Malaysia for the identification and further examination by the "***Malaysian ICAO Annex 13 Safety Investigation Team for MH370***".

2.0 Part Characteristics

It was a basic composite part with non-metallic honeycomb core. The laminate was obviously not made of carbon fiber since it was brown in colour. The part was measured to be approximately 20 inches in length and weighed 0.545 Kg.

3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. The part structure construction characteristics showed that it was not part of the aircraft structure. It appeared more likely to be from the aircraft interior based on the vinyl and edge sealant which was on the part. The vinyl and sealant colour on the part matched that of the parts generally used in aircraft galleys.

4.0 Structure Examination

The fractured fibres on the item indicated the fibres were pulled out which could indicate tension failure on its structure.

5.0 Conclusion

Although it appeared to be part of an aircraft interior there is no conclusive evidence to indicate whether the part could have actually originated from an aircraft.

Australian Government
Australian Transport Safety Bureau

Debris examination – update No. 4

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Preliminary examination of two items of debris recovered near Sainte Luce, Madagascar

ATSB Technical Examination Report
Aviation
AE-2014-054
Debris examination update 4

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Addendum

Page	Change	Date

Missing aircraft, Boeing 777, 9M-MRO, 8 March 2014

Preliminary examination of two items of debris recovered near Sainte Luce , Madagascar

Introduction

Two items of fibreglass-honeycomb composite debris were recovered near Sainte Luce on the south-east coast of Madagascar, having reportedly washed ashore in February 2016. They were hand-delivered to the Australian Transport Safety Bureau on 12 September 2016. The items were initially reported in the media as being burnt.

This document summarises the ATSB's preliminary examination of the items for any evidence of exposure to heat or fire.

Examination

No manufacturing identifiers, such as a part numbers or serial numbers were present on either item, that may have provided direct clues as to their origin. At the time of writing, the items had not been identified and work in this respect is ongoing.

A dark grey colouration was present on a significant proportion of both sides of each item (Figures 1, 2 and 3). Detailed examination of these areas showed that the colour related exclusively to a translucent resin that had been applied to those surfaces (Figure 4).

A cross section through the panel showed a clear delineation between the dark resin and the other surface coatings without any evidence of gradual transition. The lighter grey surface areas resulted from a thinner film of the same resin applied over an off-white background. Figure 5 shows the cross section directly and Figure 6 shows the same section at an oblique angle. This confirmed that the dark colour of the coating was an inherent property of the resin, and not the result of exposure to heat or fire.

Despite no evidence of overall gross heat damage, two small (<10mm) marks on one side of the larger item and one on the reverse side were identified as damage resulting from localised heating (Figures 2 and 3). A burnt odour emanating from the large item was isolated to these discrete areas. The origin and age of these marks was not apparent. However, it was considered that burning odours would generally dissipate after an extended period of environmental exposure, including salt water immersion, as expected for items originating from 9M-MRO.

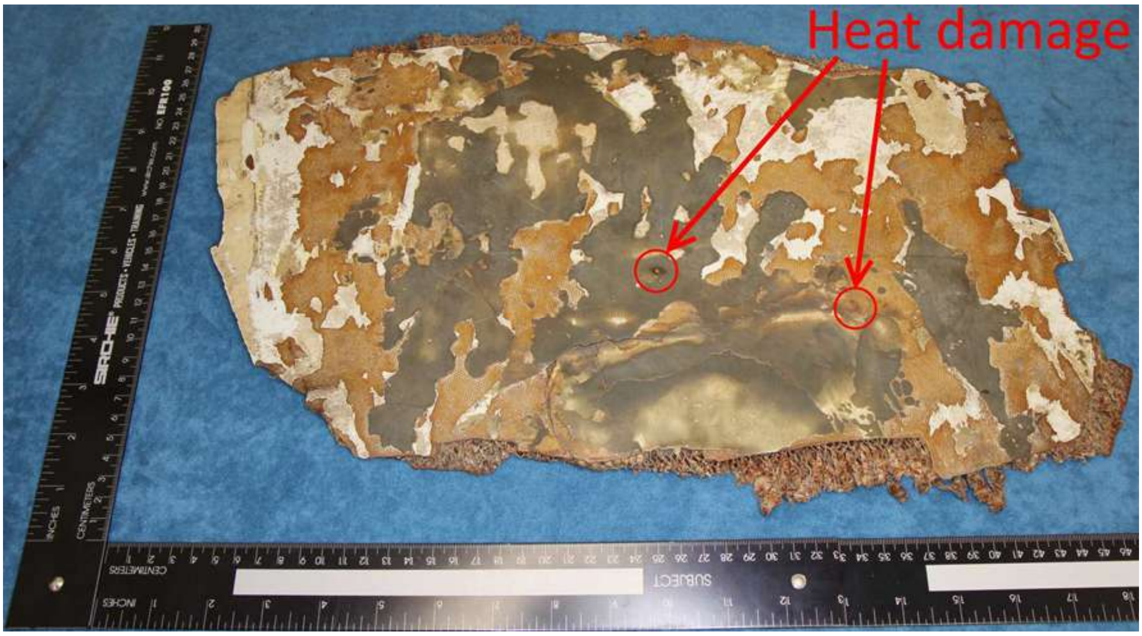
Figure 1: Smaller composite panel

Source: ATSB

Figure 2: Larger composite panel showing discrete area of heat damage

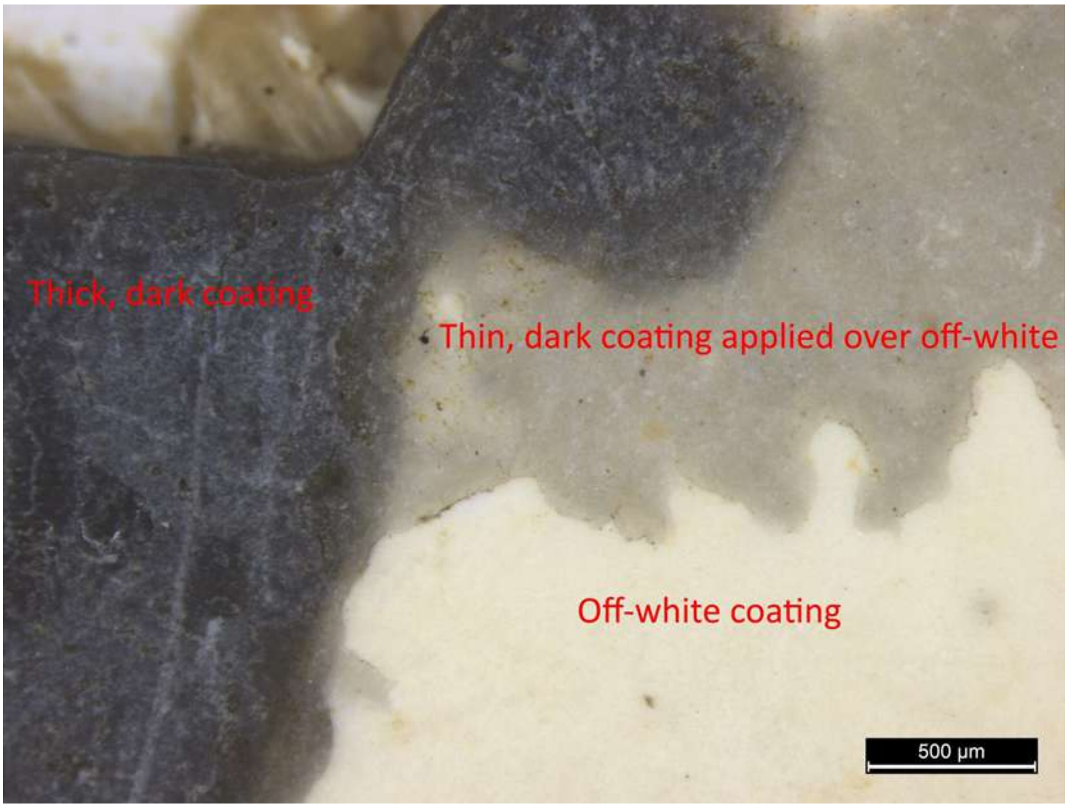
Source: ATSB

Figure 3: Reverse side of larger composite panel showing discrete areas of heat damage



Source: ATSB

Figure 4: Close-up of applied coatings

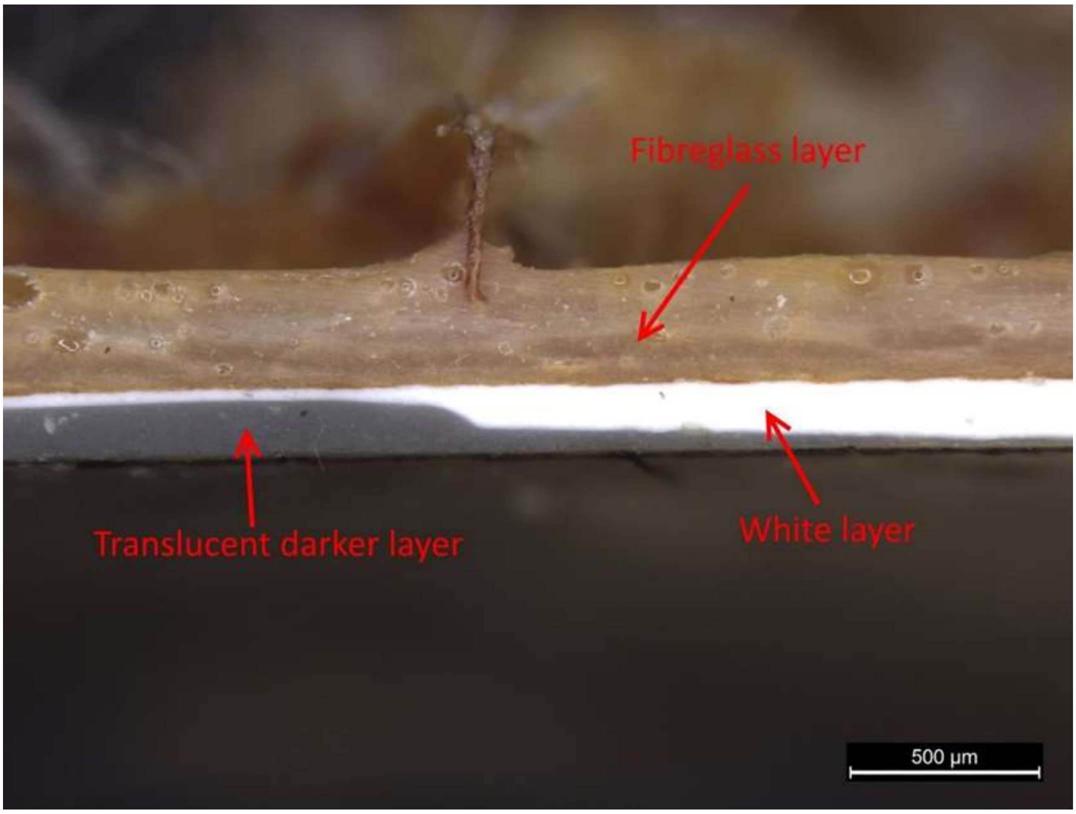


Source: ATSB

Figure 5: Cross-section through composite skin, showing surface colouration through thickness.

Source: ATSB

Figure 6: Higher magnification image of Figure 5, showing clear delineation between layers



Source: ATSB

Summary

The following findings were made during a preliminary examination of two items of composite debris, recovered near Sainte Luce, Madagascar. At the time of writing, work is ongoing to determine the origin of the items, specifically, whether they originated from a Boeing 777 aircraft.

1) The dark grey colouration on the outer surfaces of the items related to an applied resin and was not the result of exposure to heat or fire.
2) Three small marks on the larger item were indicative of localised heating. The age and origin of these marks was not apparent.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 25 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake beach, Nosy Boraha Island, Madagascar in July 2016

Updated on 30th April 2017

Issued on 28th February 2017

Ref: DB/14/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 25 in the "Summary of Possible MH370 Debris Recovered") recovered from Riake beach, Nosy Boraha Island, Madagascar in July 2016

1.0 Introduction

This item was recovered from Riake beach, Nosy Boraha Island, Madagascar in July 2016. It was identified as item 25 of the items recovered; refer to the ***"Summary of Possible MH370 Debris Recovered".***

The item was brought back to Malaysia for examination and identification by the "***Malaysian ICAO Annex 13 Safety Investigation Team for MH370***".

2.0 Part Characteristics

It was of Carbon Fibre Reinforced Plastic (CFRP) honeycomb sandwich construction. The outer and inner skins were carbon fibres and the core was non-metallic. The outer skin was grey in colour.

3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. There were no identification numbers on the part and with the available features it could not be matched to any part on the aircraft.

4.0 Structure Examination

The part was fractured on all sides and some portion of the inner skin had peeled off from the core. Some section of the skin and core were crushed. Visual examination of fibers showed that they were rough and there was no visual evidence of the fibers being kinked.

5.0 Conclusion

The debris was not identifiable to be from a B777 aircraft.

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 26 in the "Summary of Possible MH370 Debris Recovered") recovered from Nautilus Bay, South Africa on 23 December 2016

Issued on 30th April 2017

Ref: DB/15/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 26 in the "Summary of Possible MH370 Debris Recovered") recovered from Nautilus Bay, South Africa on 23 December 2016

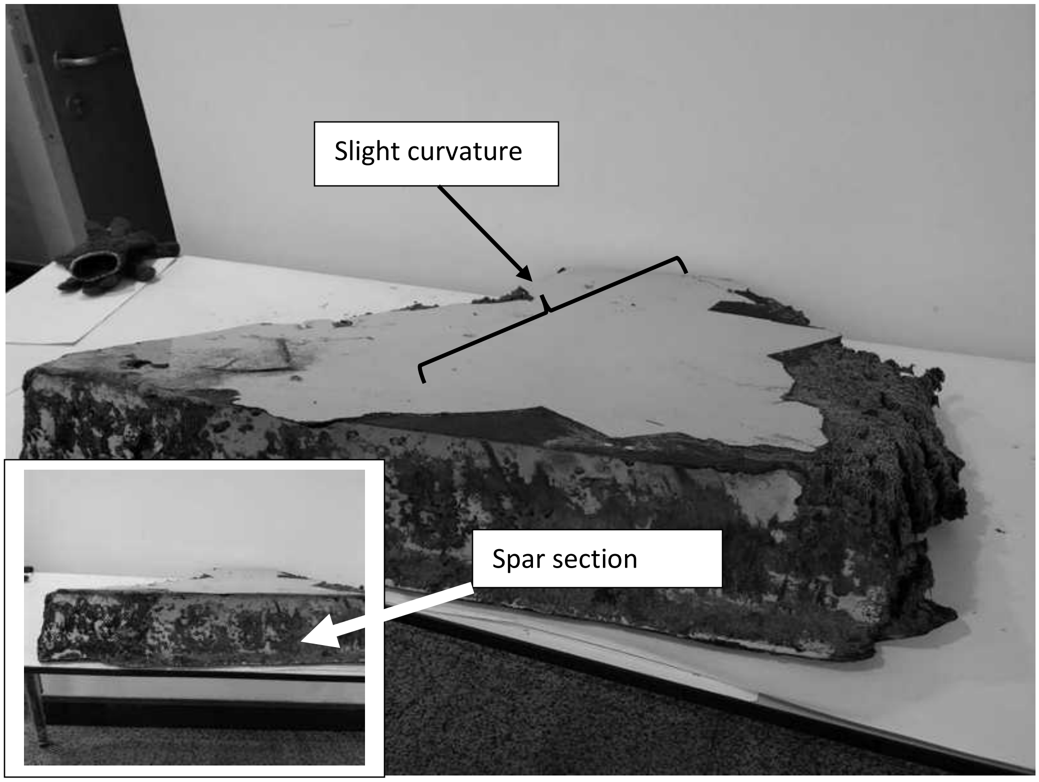
1.0 Introduction

This item was recovered from Nautilus bay, South Africa on 23 December 2016. It is identified as Item No. 26 from the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered".***

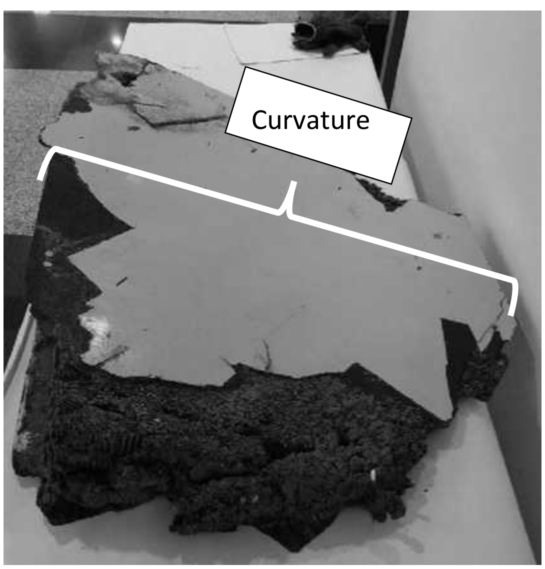
The item was brought back to Malaysia for identification and further examination by the ***"Malaysian ICAO Annex 13 Safety Investigation Team for MH370".***

2.0 Part Characteristics

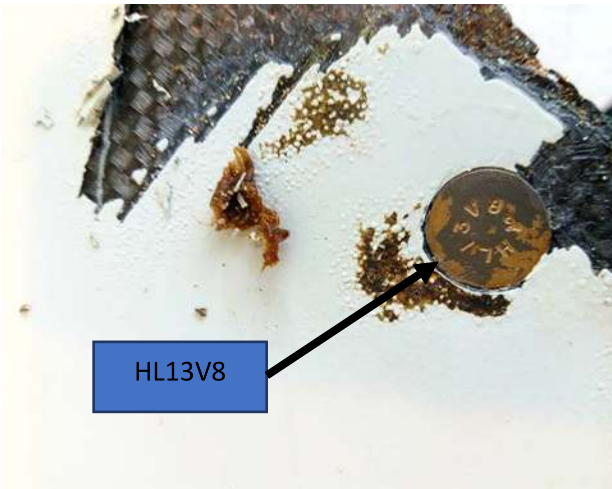
The part was non-metallic honeycomb sandwich made of Carbon Fiber Reinforced Plastic (CFRP). The skin panel was a laminated fibers structure.

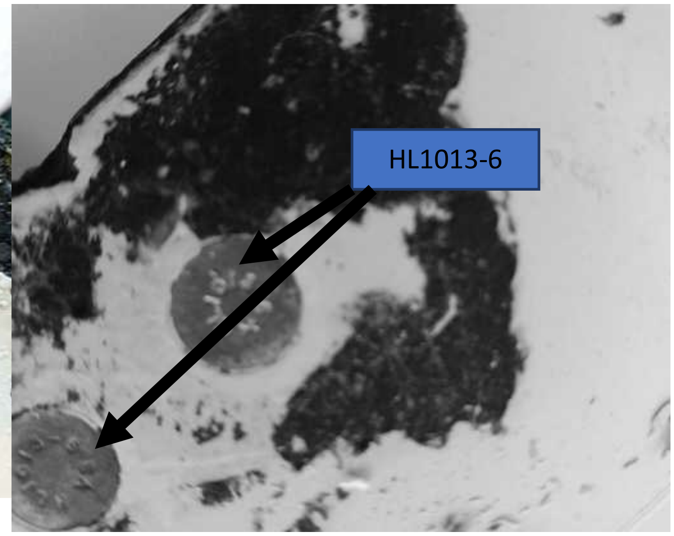


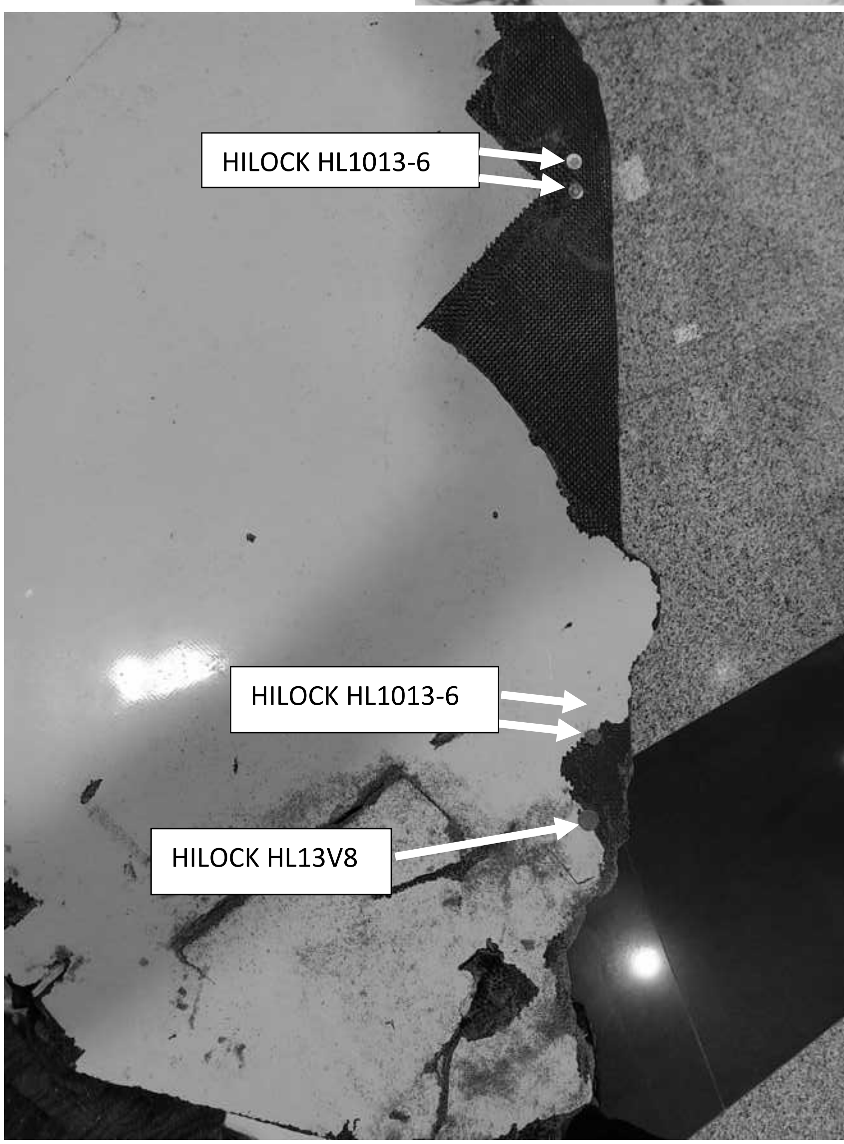
The non-metallic honeycomb was soaked with water resulting in the core material to swell. The following photos show the part's characteristics including the dimension.

 The part showed slight curvature in only one direction; the non-metallic honeycomb core was wet	 The spar like section height was 6.5 inches high

Several Hi-lock fasteners with numbers HL1013-6 and HL13V8 were visible as shown below.

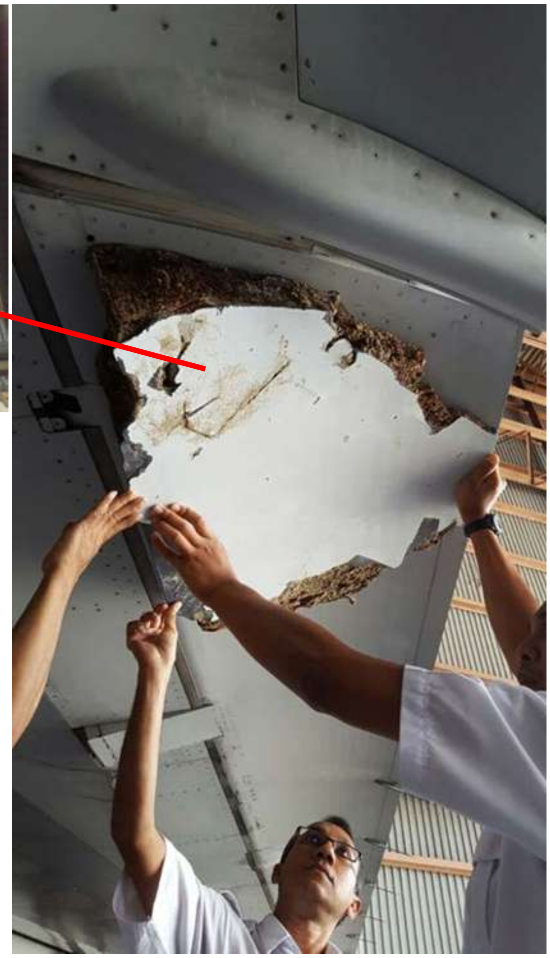






3.0 Identification

The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes.



The debris closely matched the inboard section of the Right Aileron.

 Spacing of fasteners on the aileron on aircraft	 Spacing of fasteners on the debris

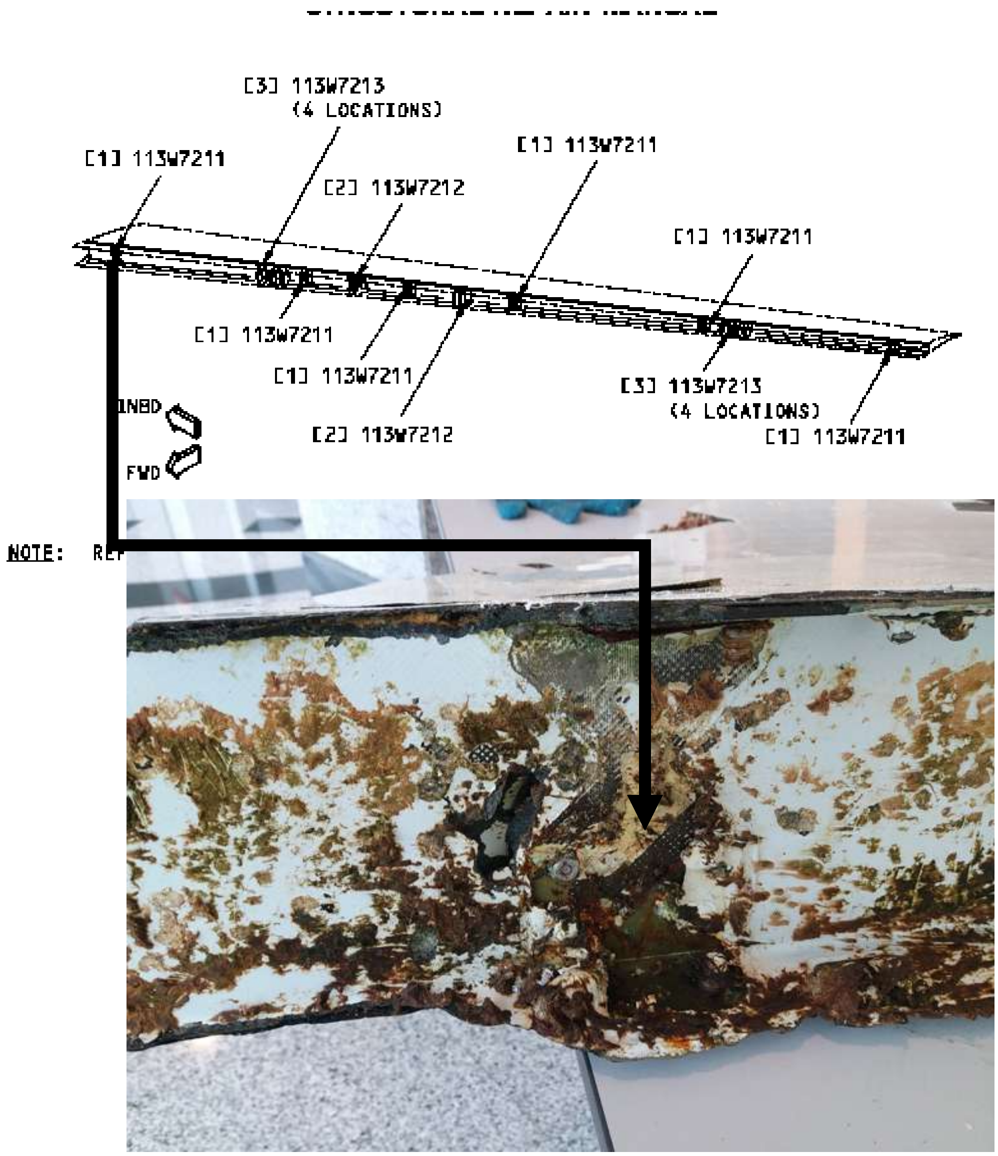
The numbers on the head of the fasteners on the debris were compared with those on the inboard section of the right aileron on the aircraft. These numbers matched. Additionally the spacing of the fasteners on the aileron also matched those on the debris. Refer to the photos above. The core and its dimensions also matched those on the inboard section of the right aileron. These confirmed that the debris is part of the inboard section of the right aileron of a B777 aircraft.

The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is highly likely from MH370 given that the likelihood of it originating from another source is very remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

There were fractures on all sides; however, part of the spar was still intact. Several fasteners were also still intact without failures. Except for the fasteners there were no other identification numbers.

The B777 Structure Repair Manual (SRM) diagram below shows the left aileron (the right is opposite). The hinge fitting area is shown. The fitting on the debris appeared to have suffered a tension overload fracture.



5.0 Conclusion

Based on the dimensions and fit on the aircraft and the visible fasteners it could be confirmed that the debris is part of the inboard section of the right aileron of a B777 aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that it is from MH370 (aircraft registered as 9M-MRO).

DEBRIS EXAMINATION REPORT

SAFETY INVESTIGATION FOR MH370

Malaysia Airlines MH370 Boeing B777-200ER (9M-MRO)
08 March 2014

Identification of Debris (Item 27 in the "Summary of Possible MH370 Debris Recovered") recovered from Mpame Beach, South Africa on 27 January 2017

Issued on 30th April 2017

Ref: DB/16/17

The Malaysian ICAO Annex 13
Safety Investigation Team for MH370

Email : MH370SafetyInvestigation@mot.gov.my

Malaysia Airlines Boeing B777-200ER (9M-MRO), 08 March 2014

Identification of Debris (Item 27 in the "Summary of Possible MH370 Debris Recovered") recovered from Mpame Beach, South Africa on 27 January 2017

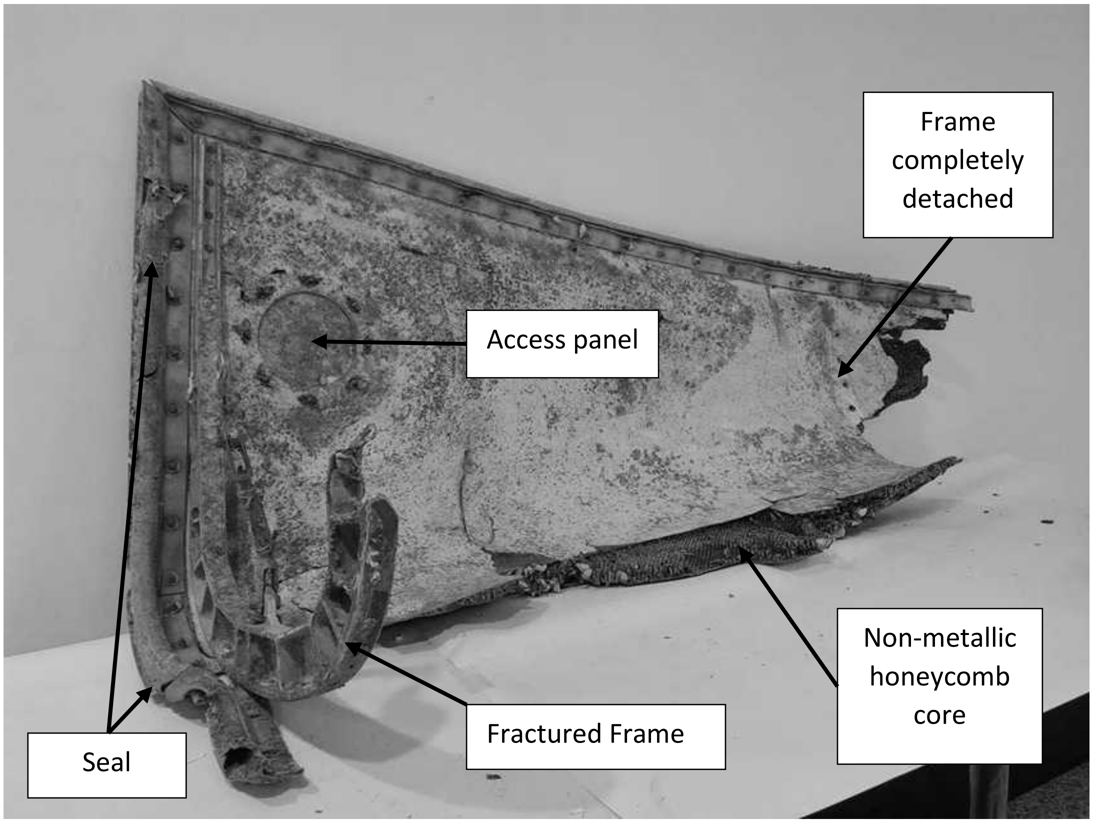
1.0 Introduction

This item was recovered from Mpame beach, South Africa on 27 January 2017. It is identified as Item No. 27 from the items recovered; refer to the "***Summary of Possible MH370 Debris Recovered".***

The item was brought back to Malaysia for identification and further examination by the ***"Malaysian ICAO Annex 13 Safety Investigation Team for MH370".***

2.0 Part Characteristics

This part was made of composite Carbon Fibre Reinforced Plastic (CFRP) with non-metallic honeycomb core. A fractured metallic frame was still attached to the assembly. Seals were still intact around the part. An access panel was also still intact and completely attached in its position. There was evidence of another metallic frame installed on the part shown by its visible fastener holes; however this was completely detached from the part assembly. Refer to the picture below.



3.0 Identification

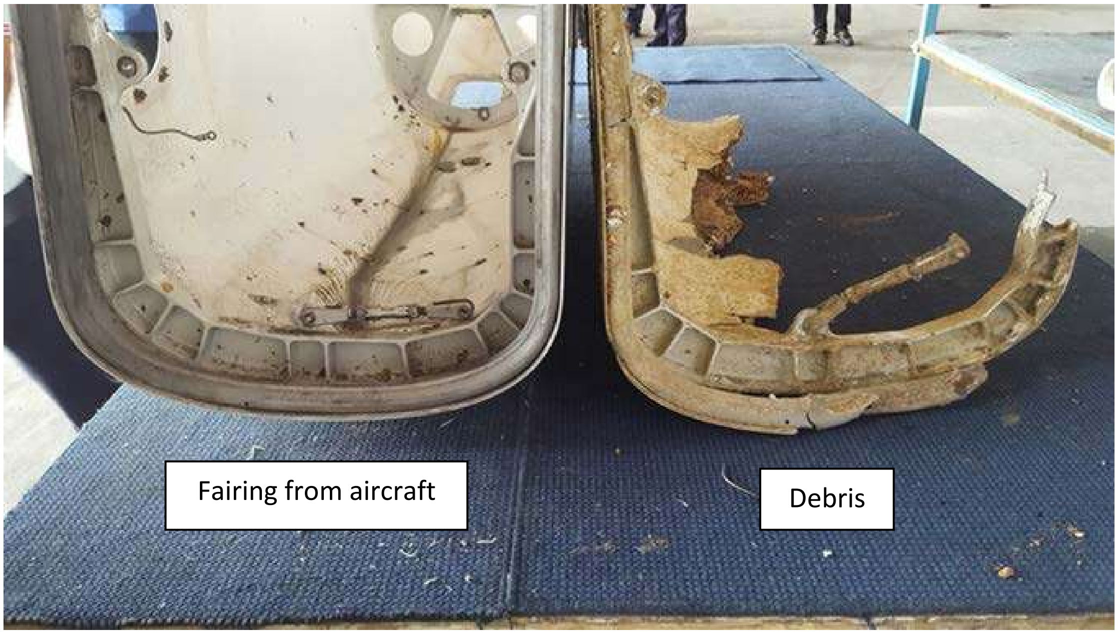
The part was taken to a B777-200ER, formerly operated by Malaysia Airlines (MAS), undergoing a maintenance check at Subang, Malaysia, for identification purposes. The possible location of the part on the aircraft was determined.

It was easily matched to the fixed, forward section of the No. 7 flap support fairing, as shown in the pictures below. Item No. 2, found on 27 December 2015 at Daghatane Beach, Mozambique, is also part of the same fairing; however it is part of the rear, moveable section.

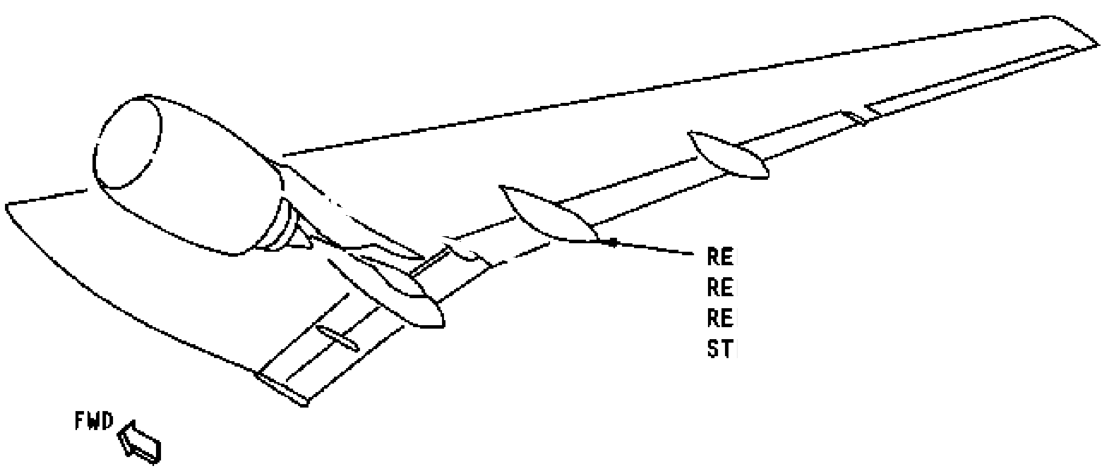

Fixed section of
No. 7 Flap Support Fairing
The part was brought
and matched in situ.


Fixed section of
No. 7 Flap Support Fairing

The fairing from the aircraft was removed and matched side by side with the debris as shown below. The features were found to be identical.

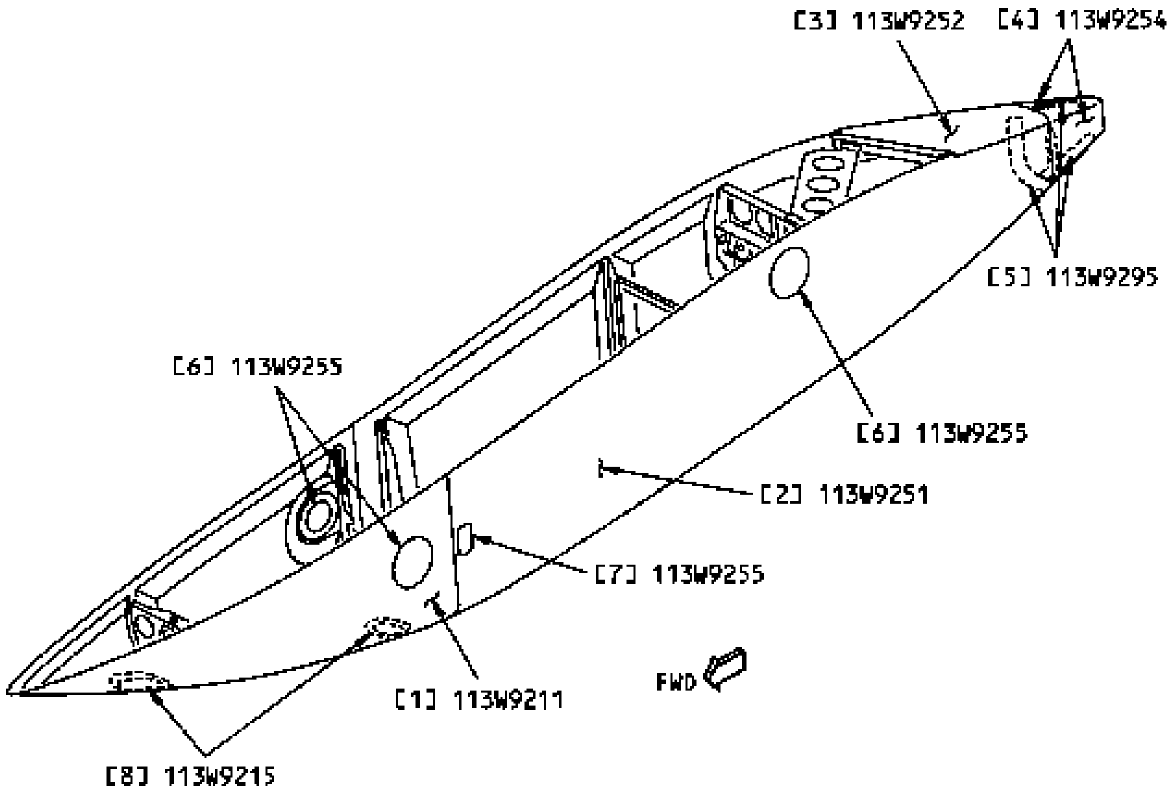


The diagrams below from the B777 Structural Repair Manual (SRM) show the location of the No. 2 flap support fairing and the complete assembly. The No. 7 fairing is in a similar location on the opposite wing.



NUMBER 2 FAIRING IS SHOWN, NUMBER 7 FAIRING IS OPPOSITE

The following diagram shows the complete No. 2 flap fairing, No. 7 is opposite.



NUMBER 2 FAIRING IS SHOWN, NUMBER 7 FAIRING IS OPPOSITE

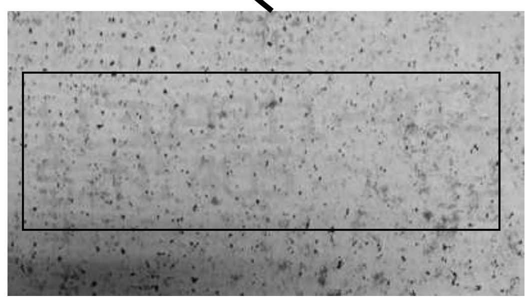
The part and serial numbers were evident on the inner surface of the fairing removed from the aircraft.

The debris was thoroughly cleaned to reveal any identification numbers. After cleaning, the part and serial numbers of the debris were found almost exactly at the same location found on the aircraft part.

The numbers on the debris were 113W9211-402, S/N: 406. The part number was identical to the one found on the fairing removed from the aircraft, which was 113W9211-402 indicating that the debris was indeed a part of the No. 7 flap support fairing of a B777 aircraft. Refer to the pictures below. The serial number could not be used to link it to any particular aircraft as there were no records available to confirm this.

Inside surface of the Debris

This number from the part removed from a B777



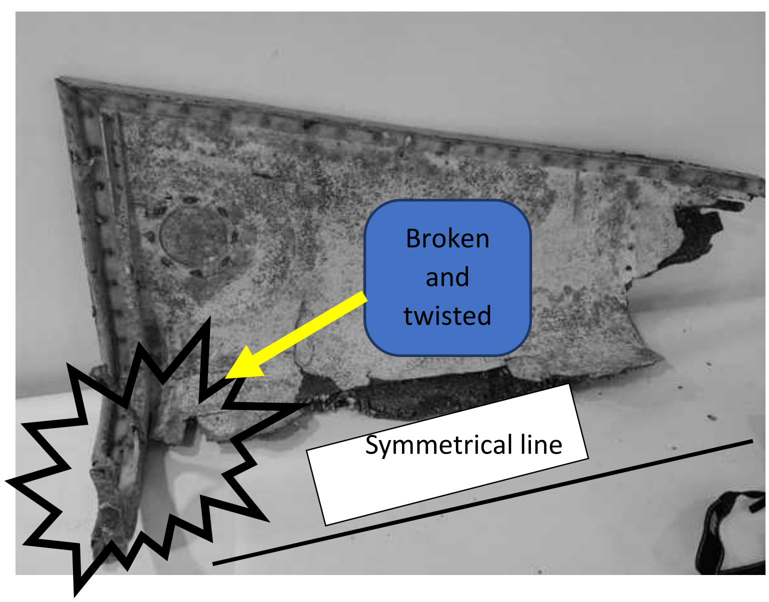
113W9211-402

S/N: 406

The location of where the part was found, considering that MH370 (aircraft registered as 9M-MRO) ended its flight in the South Indian Ocean, is consistent with the drift path modeling produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). This suggests that the part is highly likely from MH370 given that the likelihood of it originating from another source is quite remote. The Australian Transport Safety Bureau (ATSB) reports on the drift modeling can be found at http://www.atsb.gov.au/media/5772107/ae2014054_final-first-principles-report.pdf and http://www.atsb.gov.au/media/5771939/ae-2014-054_mh370-search-and-debris-update_2nov-2016_v2.pdf.

4.0 Structure Examination

The part was fractured almost through its symmetry axis. One of the frames was completely detached from the skin. It may be due to fasteners pull through as the fasteners' holes appeared to be torn off with diameters larger than the fasteners. The bracket had broken off with some sign of twist which is evidently shown by the bent push rod.



5.0 Conclusion

Based on the legible part number and the match of the part on the aircraft it is confirmed that the debris is part of the fixed, forward No. 7 flap support fairing of a B777 aircraft. From the location where it was found, and being consistent with the drift path modeling for debris from an aircraft ending its flight in the South Indian Ocean, it is highly likely that it is from MH370 (aircraft registered as 9M-MRO).

AIR-GROUND COMMUNICATION AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz		AIR-GROUND COMMUNICATION AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
			START AT 1600:00 UTC [0000:00 MYT]
		1603:37 UTC [0003:37 MYT] MAS 16	Lumpur Delivery Malaysian One Six good morning.
		1603:42 UTC [0003:42 MYT] Lumpur Delivery	Malaysian One Six good morning confirm outward one six two seven.
		1603:46 UTC [0003:46 MYT] MAS 16	Affirm sir one six two seven that Malaysian Amsterdam request flight level three zero zero.
		1603:58 UTC [0003:58 MYT] Lumpur Delivery	Malaysian One Six is cleared to Amsterdam via Agosa Alpha Departure six thousand feet squawk two one one three.
		1604:08 UTC [0004:08 MYT] MAS 16	Cleared to Amsterdam Agosa Alpha Departure initially six thousand squawk two one one three, Malaysian One Six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1604:16 UTC [0004:16 MYT] Lumpur Delivery	Malaysian One Six contact Ground.
		1604:17 UTC [0004:17 MYT] MAS 16	Contact Ground Malaysian One Six.
		1625:15 UTC [0025:15 MYT] MAS 6	Lumpur Delivery Malaysian Six salammualaikum.
		1625:20 UTC [0025:20 MYT] Lumpur Delivery	Malaysian Six walaikumsalam confirm outward one six three six.
		1625:26 UTC [0025:26 MYT] MAS 6	Outward one six three niner and da requesting level three two zero to Frankfurt.
		1625:41 UTC [0025:41 MYT] Lumpur Delivery	Whatever la three er two… er zero to err Frankfurt confirm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1625:46 UTC [0025:46 MYT] MAS 6	Affirm level three two zero Malaysian One Malaysian Six.
1625:52 UTC [0025:52 MYT] MAS 370	Delivery Malaysian Three Seven Zero good morning.		
1626:01 UTC [0026:01 MYT] Lumpur Delivery	Malaysian Three Seven Zero standby and……		…..Malaysian Six is cleared to Frankfurt via Agosa Alpha Departure six thousand squawk feet two one zero six.
		1626:10 UTC [0026:10 MYT] MAS 6	Clear to Frankfurt Agosa Alpha Departure six thousand feet squawk two one zero six Malaysian Six.
1626:17 UTC [0026:17 MYT] Lumpur Delivery	Malaysian Six over to Ground good day Malaysian Three Seven Zero request level.		
1626:22 UTC [0026:22 MYT] MAS 370	Malaysian Three Seven Zero we are ready requesting flight level three five zero to Beijing.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1626:41 UTC [0026:41 MYT] Lumpur Delivery	Malaysian Three Zeven Zero is cleared to Beijing via Pibos Alpha Departure six thousand feet squawk two one five seven.		
1626:48 UTC [0026:48 MYT] MAS 370	Beijing Pibos Alpha six thousand squawk two one five seven Malaysian Three Seven Zero thank you.		
1626:54 UTC [0026:54 MYT] Lumpur Delivery	Malaysian Three Seven Zero welcome over to Ground.		
1626:57 UTC [0026:57 MYT] MAS 370	Good day sir.		
1626:59 UTC [0026:59 MYT] Lumpur Delivery	Good day.		
		1637:59 UTC [0037:59 MYT] Unknown	Lumpur Delivery Malaysian ahh….

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1638:10 UTC [0038:10 MYT] Lumpur Delivery	Station calling say again callsign.
		1638:20 UTC [0038:20 MYT] MAS 30	Lumpur Delivery good morning Malaysian er Three Zero.
		1638:25 UTC [0038:25 MYT] Lumpur Delivery	Malaysian Three Zero Delivery good good morning.
		1638:29 UTC [0038:29 MYT] MAS 30	Malaysian Three Zero request three four zero to Istanbul.
		1638:35 UTC [0038:35 MYT] Lumpur Delivery	Three four zero to Istanbul call you back stanby.
		1638:38 UTC [0038:38 MYT] MAS 30	Malaysian Three Zero.
		1640:00 UTC [0040:00 MYT] Lumpur Delivery	Malaysian Three Zero Delivery.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1640:02 UTC [0040:02 MYT] MAS 30	Malaysian Three Zero go ahead.
		1640:03 UTC [0040:03 MYT] Lumpur Delivery	Malaysian Three Zero clear to Istanbul Agosa Apha Departure six thousand feet initially flight level two eight zero higher en-route squawk is two one seven one.
		1640:13 UTC [0040:13 MYT] MAS 30	Clear to Istanbul Agosa Alpha zero six thousand feet initial six thousand feet and er initial altitude two eight zero higer level en-route squawk two one seven one Malaysian Three Zero.
		1640:24 UTC [0040:24 MYT] Lumpur Delivery	Malaysian Three Zero contact Ground good morning.
		1642:08 UTC [0042:08 MYT] MAS 6075	Lumpur Delivery Malaysian Six Zero Seven Five good morning.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1642:13 UTC [0042:13 MYT] Lumpur Delivery	Malaysian Six Zero Seven Five good morning.
		1642:17 UTC [0042:17 MYT] MAS 6075	Six Zero Seven Five request clearance flight level four one zero to Jakarta received Juliet.
		1642:24 UTC [0042:24 MYT] Lumpur Delivery	Flight level four one zero to Jakarta standby.
		1642:48 UTC [0042:48 MYT] Lumpur Delivery	Malaysian Six Zero Seven Five will you accept flight level three eight zero.
		1642:51 UTC [0042:51 MYT] MAS 6075	Affirm Malaysian Six Zero Seven Five.
		1642:54 UTC [0042:54 MYT] Lumpur Delivery	Standby.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1643:08 UTC [0043:08 MYT] Lumpur Delivery	Malaysian Six Zero Seven Five clear to Jakarta Mitos Alpha Departure six thousand feet squawk is two one six two.
		1643:15 UTC [0043:15 MYT] MAS 6075	Jakarta Mitos Alpha six thousand squawk two one six two Malaysian Six Zero Seven Five good day.
		1643:22 UTC [0043:22 MYT] Lumpur Delivery	Good day.
		1646:55 UTC [0046:55 MYT] XAX 506	Lumpur Delivery Xanadu Five Zero Six good morning.
		1647:00 UTC [0047:00 MYT] Lumpur Delivery	Xanadu Five Zero Six good morning Delivery.
		1647:03 UTC [0047:03 MYT] XAX 506	Xanadu Five Zero Six er request clearance to Incheon flight level three niner zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

AIRWAYS CLEARANCE DELIVERY - FREQUENCY 126.0 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1647:11 UTC [0047:11 MYT] Lumpur Delivery	Three Niner Zero copied standby.
		1647:23 UTC [0047:23 MYT] Lumpur Delivery	Xanadu Five Zero Six clear to Incheon Kimat Alpha Departure six thousand feet squawk is two one two five.
		1647:30 UTC [0047:30 MYT] XAX 506	Cleared to Incheon Kimat Alpha Departure six thousand feet squawk two one two five Xanadu Five Zero Six and over to Ground good day.
		1647:39 UTC [0047:39 MYT] Lumpur Delivery	Good day

END OF AIRWAYS CLEARANCE DELIVERY TRANSCRIPT

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
			START TIME 1600:00 UTC [0000:00 MYT]
		1600:00 UTC [0000:00 MYT] Lumpur Ground	Bravo Bravo One Three hold short of Bravo initially.
		1600:06 UTC [0000:06 MYT] AXM 941	Holding Point Alfa One One via Kilo Bravo Bravo One Three hold short of Bravo initially sir Nine Four One.
		1600:17 UTC [0000:17 MYT] XAX 236	Lumpur Ground good morning Xanadu Two Three Six.
		1600:21 UTC [0000:21 MYT] Lumpur Ground	Xenadu Two Three Six Lumpur Ground morning standby for… Xenadu Two Three Six after clear of towing aircraft Runway Kilo push back and start Runway Three Two Right on to Kilo face east.
		1600:32 UTC [0000:32 MYT] XAX 236	After towed aircraft push back Three Two Right Kilo face east Xenadu Two Three Six POB two eight five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR GROUND FREQUENCY 122.27 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1600:43 UTC [0000:43 MYT] Lumpur Ground	Two eight five copied.
		1600:44 UTC [0000:44 MYT] AXM 1258	Lumpur Ground Asian Express One Two Five Eight good morning.
		1600:49 UTC [0000:49 MYT] Lumpur Ground	Express One Two Five Lumpur Ground morning continue via Hotel Three Kilo for Foxtrot Six Two.
		1601:00 UTC [0001:00 MYT] Lumpur Ground	Copied.
		1601:07 UTC [0001:07 MYT] Lumpur Ground	…Press Nine Four One after Kilo Alfa ah…Airbus Three Twenty crossing on Bravo left to right continue via Bravo Bravo One Three.
		1601:15 UTC [0001:15 MYT] AXM 941	After the Airbus crossing from left to right continue Kilo Bravo Bravo One Three Press Nine Four One.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - OTHER FLIGHTS
		1601:58 UTC [0001:58 MYT] Unknown	xxxxx [illegible] Bravo xxxxx [illegible] decimal eight.
		1602:04 UTC [0002:04 MYT] Unknown	Ah… you are cutting out say again.
		1602:07 UTC [0002:07 MYT] Lumpur Ground	Nine Four One contact Tower one one eight decimal eight.
		1602:10 UTC [0002:10 MYT] AXM 941	One one eight decimal eight Nine Four One selamat malam.
		1602:14 UTC [0002:14 MYT] Lumpur Ground	Malam.
		1602:15 UTC [0002:15 MYT] MAS 2 Super	Lumpur Ground Malaysian Two Super good morning.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
	AIR-GROUND COMMUNICATION **LUMPUR GROUND FREQUENCY 122.27 MHz**		**AIR-GROUND COMMUNICATION** **LUMPUR GROUND FREQUENCY 122.27 MHz**
		1602:18 UTC [0002:18 MYT] Lumpur Ground	Good morning Malaysian Two Super Lumpur Ground… CharlieThree Seven push back and start approved Runway Three Two Right until Hotel.
		1602:28 UTC [0002:28 MYT] MAS 2 Super	Start approved clear to right until Hotel Malaysian Two.
		1602:33 UTC [0003:33 MYT] FFC	Lumpur Ground please advise Foxtrot Foxtrot Charlie.
		1602:37 UTC [0002:37 MYT] Lumpur Ground	Foxtrot Foxtrot Charlie continue to via Delta to hanger.
		1602:44 UTC [0002:44 MYT] FFC	To delta to hanger Foxtrot Foxtrot Charlie.
		1602:47 UTC 0002:47 MYT Lumpur Ground	Malaysian Five Two hold short of Bravo Tower one one eight decimal eight.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR GROUND FREQUENCY 122.27 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1602:51 UTC 0002:51 MYT MAS 52	Hold short of Bravo Tower one one eight decimal eight Malaysian Five Two good night.
		1602:54 UTC [0002:54 MYT] Lumpur ground	Good night.
		1603:18 UTC [0003:18 MYT] MAS 2	Malaysian Two we are Niner Mike Mike November Echo POB of four four eight.
		1603:25 UTC [0003:25 MYT] Lumpur ground	Copied (xxxxx) [illegible] (xxxx) [illegible]
		1605:30 UTC [0005:30 MYT] XAX 236	Xenadu Two Three Six request taxi.
		1605:32 UTC [0005:32 MYT] Lumpur Ground	Xenadu Two Three Six taxi Holding Point Three Two Right via Kilo Bravo Bravo One Three.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - OTHER FLIGHTS
		1605:38 UTC [0005:38 MYT] XAX 236	Holding Point Three Two Right via Kilo Bravo Bravo One Three Xenadu Two Three Six.
		1607:27 UTC [0007:27 MYT] MAS 2 Super	Malaysian Two Super request taxi clearance.
		1607:31 UTC [0007:31 MYT] Lumpur Ground	Two Super taxi holding point Alfa One One Tree Two Right via standard route.
		1607:37 UTC [0007:37 MYT] MAS 2 Super	Alfa One One Three Two Right via standard route Malaysian Two.
		1608:00 UTC [0008:00 MYT] XAX 236	Xenadu Two Three Six proceed via One One (xxxx) [illegible]
		1608:03 UTC [0008:03 MYT] Lumpur Ground	Tower one one eight decimal eight.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR GROUND FREQUENCY 122.27 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1608:06 UTC [0008:06 MYT] XAX 236	Tower one one eight decimal eight Xenadu Two Three Six
		1608:09 UTC [0008:09 MYT] Lumpur Ground	Malaysian Two Super hold short of Bravo Tower one one eight decimal eight.
		1608:13 UTC [0008:13 MYT] MAS 2 Super	Hold short of Bravo one one eight decimal eight good night.
		1608:16 UTC [0008:16 MYT] Lumpur Ground	Good night.
		1616:31 UTC [0016:31 MYT] 5649	Lumpur Ground is Five Six Four Niner good evening Niner Mike Alfa Quebec Victor.
		1616:37 UTC [0016:37 MYT] Lumpur Ground	Four Niner Victor (xxxx) [facing] Kilo Bravo November Victor Foxtrot o one hundred.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1616:47 UTC [0016:47 MYT] 5619	Clear Bravo November to Foxtrot One Zero Zero Five Six One Niner.
		1617:01 UTC [0017:01 MYT] unknown source	Lumpur Ground ah…Towing complete Alfa Foxtrot Charlie good day sir.
		1617:06 UTC [0017:06 MYT] unknown source	Good day.
		1618:50 UTC [0018:50 MYT] AXM 1824	Lumpur Ground Express One Eight Two Four good evening.
		1618:54 UTC [0018:54 MYT] Lumpur Ground	Good evening Express One Eight Two Four Lumpur Ground continue via Kilo Bravo and November One Foxtrot Eight Kilo.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR GROUND FREQUENCY 122.27 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1619:04 UTC [0019:04 MYT] AXM 1824	Ah… continue Kilo Bravo November One for Foxtrot Eight Kilo Express One Eight Two Four.
		1619:13 UTC [0019:13 MYT] Lumpur Ground	One eight two four aircraft give.
		1619:16 UTC [0019:16 MYT] unknown	In Alfa Quebec track Charlie sir.
		1626:27 UTC [0026:27 MYT] MAS 6	Lumpur Ground Malaysian Six salamualaikum stand Charlie Two Two request push back and start.
		1626:34 UTC [0026:34 MYT] Lumpur Ground	Lumpur Ground push back (xxx) (xxx) [illegible] Sierra Two.
		1626:44 UTC [0026:44 MYT] MAS 6	Ah Reading you intermitent and er…. confirm push back exit Sierra Two and we got POB of two niner six Mike Romeo Hotel Malaysian Six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1627:01 UTC [0027:01 MYT] Lumpur Ground	(xxxx) [illegible] six er… affirm push er… and exit via Sierra Two.
		1627:08 UTC [0027:08 MYT] MAS 6	Roger push back and start approved exit Sierra Two Malaysian Six.
		1627:13 UTC [0027:13 MYT] Lumpur Ground	Ah Malaysian Six reclear er… exit via Sierra Three.
		1627:16 UTC [0027:16 MYT] MAS 6	Roger roger reclear Sierra Three Malaysian knot Six.
1627:26 UTC [0027:26 MYT] MAS 370	Ah.. Ground Malaysian Three Seven Zero good morning Charlie One requesting push and start.		
1627:32 UTC [0027:32 MYT] Lumpur Ground	(xxx) [illegible] Lumpur Ground morning push back and start approved Runway Three Two Right exit via Sierra Four.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - OTHER FLIGHTS
1627:39 UTC [0027:39 MYT] MAS 370	Push back and start approved Three Two Right exit Sierra Four POB two three niner Mike Romeo Oscar.		
1627:46 UTC [0027:46 MYT] Lumpur Ground	Copied.		
		1631:23 UTC [0031:23 MYT] MAS 6	Malaysian Six request taxi.
		1631:27 UTC [0031:27 MYT] Lumpur Ground	Taxi Standard Route hold short of Bravo.
		1631:32 UTC [0031:32 MYT] MAS 6	Three Two Right Standard Route hold short of Bravo Malaysia Six.
1632:13 UTC [0032:13 MYT] MAS 370	Malaysian Three Seven Zero request taxi.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - OTHER FLIGHTS
1632:17 UTC [0032:17 MYT] Lumpur Ground	(xxxxxxx) [illegible] Right Standard Route hold short of Bravo.		
1632:25 UTC [0032:25 MYT] MAS 370	Ah Ground Malaysian Three Seven Zero you are unreable say again.		
1632:30 UTC [0032:30 MYT] Lumpur Ground	Malaysian Three Seven Zero taxi to holding point Alfa One One Runway Three Two Right via Standard Route hold short of Bravo.		
1632:37 UTC [0032:37 MYT] MAS 370	Alfa one one Standard Standard Route hold short of Bravo Malaysian Three Seven Zero.		
		1632:43 UTC [0032:43 MYT] AXM 6121	Tower Asian Express Six One Two One Niner Mike Afla Hotel Zulu.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1632:49 UTC [0032:49 MYT] Lumpur Ground	Six One Two One Lumpur Ground continue via Kilo Bravo November to Foxtrot bay (xxxx) [illegible]
		1632:58 UTC [0032:58 MYT] AXM 6121	Bravo November Two for fox thirty Asian Express Six One Two One.
		1633:05 UTC [0033:05 MYT] Lumpur Ground	tration.
		1633:07 UTC [0033:07 MYT] AXM 6121	Niner Mike Alfa Hotel Zulu.
		1633:47 UTC [0033:47 MYT] Lumpur Ground	Malaysian Six contact Tower one one eight decimal eight good night.
		1633:50 UTC [0033:50 MYT] MAS 6	Tower one one eight decimal eight salamualaikum.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1633:53 UTC [0033:53 MYT] Lumpur Ground	(xxxx) [illegible] salam (xxxx) [illegible]
1636:19 UTC [0036:19 MYT] Lumpur Ground	(xxx) [illegible] Three Seven Zero Tower (xxx) (xxx) [illegible]		
1636:25 UTC [0036:25 MYT] MAS 370	One one eight eight Malaysian Three Seven Zero thank you.		
		1637:44 UTC [0037:44 MYT] UAE 343	Ground good morning Emirates Three Four Three.
		1637:50 UTC [0037:50 MYT] Lumpur Ground	Emirates Three Four Three Lumpur Ground morning.
		1637:56 UTC [0037:56 MYT] UAE 343	Emirates Three Four Three we are in Charlie Twenty Seven and daa… estimated (xxx) [illegible] departure is seventeen ten er… do you know which runway we can expect for departure Three Two Left or Right.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR GROUND FREQUENCY 122.27 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1638:16 UTC [0038:16 MYT] Lumpur Ground	Seventeen ten er… still for Three Two Right departure.
		1638:21 UTC [0038:21 MYT] UAE 343	Thank you and (xxx) [illigible] Three Four Three expect Three Two Right for departure.
		1641:55 UTC [0041:55 MYT] AXM 1655	Lumpur Ground good morning Asian Express One Six Five Five Niner Mike Alfa Quebec Uniform on Kilo.
		1642:02 UTC [0042:02 MYT] Lumpur Ground	(xxxx)[illegible] Lumpur Ground continue Kilo Foxtrot.
		1642:09 UTC [0042:09 MYT] AXM 1655	Continue Kilo Foxtrot Five Five Six Asian Express One Six Five Five.
		1643:08 UTC [0043:08 MYT] UAE 343	Confirm calling Emirates Three Four Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - OTHER FLIGHTS
		1643:12 UTC [0043:12 MYT] Source unknowr	Negative.
		1643:30 5UTC [0043:30 MYT] MAS 6075	Lumpur Ground Malaysian Six Zero Seven Five good morning.
		1643:35 UTC [0043:35 MYT] Lumpur Ground	(xxxxx) [illegible]
		1643:39 UTC [0043:39 MYT] MAS 6075	Aah… I say again Malaysian Six Zero Seven Five good morning Foxtrot Six request push back and start.
		1643:49 UTC [0043:49 MYT] Lumpur Ground	(xxxx) [illegible] Lumpur Ground Foxtrot Six push back and start approve Rnway Three Two Right on to Kilo face east.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1643:57 UTC [0043:57 MYT] MAS 6075	Roger clear for push back on to Kilo face east Malaysian Six Zero Seven Five POB two Mike Uniform Bravo.
		1644:05 UTC [0044:05 MYT] Lumpur Ground	Copied.
		1645:14 UTC [0045:14 MYT] Lumpur Ground	(xxxx) [illegible] Five after push to pull forward keep clear of the aah… Stand Foxtrot Seven.
		1645:22 UTC [0045:22 MYT] MAS 6075	Keep clear of Stand Foxtrot Seven Malaysian Six Zero Seven Five.
		1648:04 UTC [0048:04 MYT] GSB 305	Lumpur Ground Gading Sari Three Zero Five good morning.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

LUMPUR GROUND FREQUENCY 122.27 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1648:08 UTC [0048:08 MYT] Lumpur Ground	Garing Sari Three Zero Five continue… Kilo Foxtrot Seven Nine.
		1648:13 UTC [0048:13 MYT] GSB 305	Continue Kilo Foxtrot Seven Nine Niner Mike Golf Sierra Bravo two POB.
		1648:19 UTC [0048:19 MYT] Lumpur Ground	Copied.
		1648:23 UTC [0048:23 MYT] MAS 6075	Ground Malaysian Six Zero Seven Five request taxi.
		1648:26 UTC [0048:26 MYT] Lumpur Ground	Malaysian Six Zero Seven Five taxi Holding Point Alfa One One Three Two Right take Kilo Bravo Bravo One Three.
		1648:33 UTC [0048:33 MYT] MAS 6075	Taxi Kilo Bravo Bravo One Three holding point Alfa One One Malaysian Six Zero Seven Five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz CONTENT - OTHER FLIGHTS
		1650:57 UTC [0050:57 MYT] XAX 506	Lumpur Ground Xanadu Five Zero Six morning.
		1651:01 UTC [0051:01 MYT] Lumpur Ground	Morning Xanadu Five Zero Six Lumpur Ground push back and start approved Runway Three Two Right on to Hotel Three.
		1651:07 UTC [0051:07 MYT] XAX 506	Push back approved for Runway Three Two Right to Hotel Three and… we have three five five POB Niner Mike X-ray X-ray Papa Xanadu Five Zero Six.
		1651:18 UTC [0051:18 MYT] Lumpur Ground	Five Zero Six copied.
		1651:46 UTC [0051:46 MYT] Lumpur Ground	(xxxx) [illigible] Six Zero Seven Five Tower one one eight decimal eight good night.

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1651:52 UTC [0051:52 MYT] MAS 6075	One one eight eight Malaysian Six Zero Seven Five Good night.
		1652:32 UTC [0052:32 MYT] MAS 30	Lumpur Ground good evening good morning Malaysian Three Zero.
		1652:38 UTC 0052:38 MYT Lumpur Ground	Morning Malaysian Three Zero Lumpur Ground Foxtrot ah… correction Charlie Two Four push back start up approved Runway Three Two Right exit via Sierra Two.
		1652:49 UTC [0052:49 MYT] MAS 30	Roger clear for push back and start push back Three Two Right exit Sierra Two we have POB two seven one Mike Romeo Mike.
		1652:58 UTC [0052:58 MYT] Lumpur Ground	Copied.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1653:21 UTC [0053:21 MYT] AXM 1949	(xxxx) [illegible] Express One Niner Four Niner good evening.
		1653:33 UTC [0053:33 MYT] Lumpur Ground	Express One Niner Four Niner Lumpur Ground.
		1653:37 UTC [0053:37 MYT] Lumpur Ground	Te Super One Niner Four Niner continue Kilo Foxtrot Six Five.
		1653:42 UTC [0053:42 MYT] AXM 1949	Continue Kilo Foxtrot Six Five Asian Express One Niner Four Niner registration Niner Mike Alfa Quebec Alfa.
		1653:50 UTC [0053:50 MYT] Lumpur Ground	Copied
		1656:15 UTC [0056:15 MYT] XAX 506	Ground ne… Xanadu Five Zero Six ready for taxi.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1656:21 UTC [0056:21 MYT] Lumpur Ground	Xanadu Five Zero Six taxi Holding Point Three Two Right Kilo Bravo Bravo One Three.
		1656:27 UTC [0056:27 MYT] XAX 506	Taxi holding point Three Two Right via Kilo Bravo Bravo One Three Xanadu Five Zero Six.
		1656:35 UTC [0056:35 MYT] MAS 30	Lumpur Ground Malaysian Three Zero request taxi.
		1656:39 UTC [0056:39 MYT] Lumpur Ground	Malaysian Three Zero taxi holding point eer… Alfa One OneThree Two Rght via Sierra Two Bravo One One Alfa.
		1656:46 UTC [0056:46 MYT] MAS 30	Taxi holding point Alfa One OneThree Two right via Sierra Two Bravo One One Alfa Malaysian Three Zero.
		1657:33 UTC [0057:33 MYT] Lumpur Ground	Three Zero contact Tower one one eight decimal eight.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz		AIR-GROUND COMMUNICATION LUMPUR GROUND FREQUENCY 122.27 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1657:37 UTC [0057:37 MYT] MAS 30	One one eight decimal eight Malaysian Three Zero good night.
		1657:41 UTC [0057:4 MYT] Lumpur Ground	Xanadu Five Zero Six Tower one one eight.
		1657:46 UTC [0057:46 MYT] XAX 506	Tower one one eight eight Xanadu Five Zero Six good day.

END OF LUMPUR GROUND RADIOTELEPHONY TRANSCRIPT

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
			START TIME 1610:00 UTC [0010:00 MYT]
		1610:14 UTC [0010:14 MYT] Lumpur Tower	Malaysian Two Zero are you ready.
		1610:15 UTC [0010:15 MYT] MAS 20	Affirm Malaysian Two Zero.
		1610:17 UTC [0010:17 MYT] Lumpur Tower	Malaysian Two Zero line up Three Two Right via Alfa One Zero.
		1610:21 UTC [0010:21 MYT] MAS 20	Line up Three Two Right Alfa One Zero Malaysian Two Zero.
		1610:24 UTC [0010:24 MYT] Lumpur Tower	Malaysian Two Super hold short Bravo.
		1610:28 UTC [0010:28 MYT] MAS 2 Super	Hold short Bravo Malaysian Two Super.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz		AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1611:45 UTC [0011:45 MYT] Lumpur Tower	Malaysian Two Zero…Runway Three Two Right clear for take-off.
		1611:49 UTC [0011:49 MYT] MAS 20	Clear for take-off Runway Three Two Right Malaysian Two Zero good night sir.
		1611:52 UTC [0011:52 MYT] Lumpur Tower	Good night.
		1612:15 UTC [0012:15 MYT] MAS 2	Malaysian Two can we move forward to Alfa Ten.
		1612:18 UTC [0012:18 MYT] Lumpur Tower	Affirm continue taxi Alfa Ten.
		1612:20 UTC [0012:20 MYT] MAS 2	Roger continue taxi Alfa One Zero Malaysia Two.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1612:29 UTC [0012:29 MYT] Lumpur Tower	Xenadu Three Two Six correction Korean Air Six Seven Two line up Three Two Right Alfa One Zero.
		1612:33 UTC [0012:33 MYT] KAL 672	Lining up Three Two Right Alfa One Zero Korean Air Six Seven Two.
		1614:33 UTC [0014:33 MYT] Lumpur Tower	Korean Air Six Seven Two... Runway Three Two Right clear for take-off.
		1614:38 UTC [0014:38 MYT] KAL 672	Clear for take, clear for take-off Three Two Right Korean Air Six Seven Two.
		1614:43 UTC [0014:43 MYT] KAL 672	Confirm one two one one two five after departure.
		1614:45 UTC [0014:45 MYT] Lumpur Tower	Affirm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1614:47 UTC [0014:47 MYT] KAL 672	Clear for take-off Three Two Right Korean Air Six Seven Two.
		1614:51 UTC [0014:51 MYT] Lumpur Tower	(xxxx) [illegible] Two Three Six line up Three Two One One.
		1614:53 UTC [0014:53 MYT] XAX 236	Line up Three Two One One Xanadu Two Three Six.
		1615:54 UTC [0015:54 MYT] KAL 672	We change to departure clearance Six Seven Two.
		1615:57 UTC [0015:57 MYT] Lumpur Tower	Korean Air Six Seven Two good day.
		1616:01 UTC [0016:01 MYT] Lumpur Tower	Xenadu Two Three Six is right clear for take-off.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1616:04 UTC [0016:04 MYT] XAX 236	Runway Three Two Rght clear for take-off Xenadu Two Three Six.
		1616:30 UTC [0016:30 MYT] Lumpur Tower	Malaysian Two Super after departing traffic line up Alfa One (xxx) [illegible] Zero.
		1616:34 UTC [0016:34 MYT] MAS 2	After departing traffic line up Alfa One Zero (xxx) [illegible] Malaysian Two.
		1617:01 UTC [0017:01 MYT] MAS 16	Lumpur Tower Malaysian One Six good morning
		1617:04 UTC [0017:04 MYT] Lumpur Tower	One Six good morning … Alfa One Zero Three Two Right.
		1617:07 UTC [0017:07 MYT] MAS 16	Holding point Alfa One Zero Runway Three Two Right Malaysian One Six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1617:48 UTC [0017:48 MYT] Lumpur Tower	Malaysian Two Two Super Runway Three Two Right clear for take-off good night.
		1617:51 UTC [0017:51 MYT] MAS 2 Super	Clear for take-off Malaysian Two Super good night.
		1620:53 UTC [0020:53 MYT] MAS 16	Malaysian One Six request ah holding point Alfa One One.
		1620:56 UTC [0020:56 MYT] Lumpur Tower	Approved route via Alfa One One now.
		1620:59 UTC [0020:59 MYT] MAS 16	Thank you sir Alfa One One Malaysia One Six.
		1622:32 UTC [0022:32 MYT] Lumpur Tower	One Six eer… line up Runway ThreeTwo Right via Alfa One One.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1622:36 UTC [0022:36 MYT] MAS 16	Line up Runway Three Two Right via Alfa One One Malaysian One Six.
		1622:43 UTC [0022:43 MYT] Lumpur Tower	Malaysian One Six you have another five minute to go eer… correction line up (xxxx) [illegible] One One.
		1622:50 UTC [0022:50 MYT] MAS 16	Aah…copy sir line up via Alfa One One Malaysian One Six.
		1624:43 UTC [0024:43 MYT] Lumpur Tower	Malaysian One Six Three Two Right clear for take-off good night.
		1624:47 UTC [0024:47 MYT] MAS 16	Three Two Right clear for take-off Malaysian One Six good night.
		1633:58 UTC [0033:58 MYT] MAS 6	Lumpur Tower Malaysian Six selamalaikum.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1634:04 UTC [0034:04 MYT] Lumpur Tower	Malaysian Six walaikumsalam Lumpur Tower taxi Alfa One Zero Three Two Right.
		1634:07 UTC [0034:07 MYT] MAS 6	Alfa One Zero Three Two Right Malaysian Six.
		1634:54 UTC [0034:54 MYT] Lumpur Tower	(xxxx) [illegible] Six line up Three Two Alfa One Zero.
		1635:01 UTC [0035:01 MYT] MAS 6	Line up Three Two Alfa One Zero Malaysian Six.
1636:30 UTC [0036:30 MYT] MAS 370	Tower Malaysian Three Seven Zero morning.		
1636:34 UTC [0036:34 MYT] Lumpur Tower	Three Seven Zero good morning Lumpur Tower holding point for Alfa One Zero Three Two Right.		
1636:37 UTC [0036:37 MYT] MAS 370	Alfa One Zero Malaysian Three Seven Zero.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1636:39 UTC [0036:39 MYT] Lumpur Tower	Malaysian Six line up Three Two Right Alfa One Zero.
		1636:43 UTC [0036:43 MYT] MAS 6	Line up Three Two Right Alfa One Zero Malaysian Six.
		1638:04 UTC [0038:04 MYT] MAS 6	Malaysian Six we are ready.
		1638:06 UTC [0038:06 MYT] Lumpur Tower	Malaysian Six clear for take-off.
		1638:08 UTC [0038:08 MYT] MAS 6	Clear for take-off Malaysian Six.
1638:43 UTC [0038:43 MYT] Lumpur Tower	Three Seven Zero line up Three Two Right Alfa One Zero.		
1638:45 UTC [0038:45 MYT] MAS 370	Line up Three Two Right Alfa One Zero Malaysian Three Three Seven Zero.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
1640:37 UTC [0040:37 MYT] Lumpur Tower	Three Seven Zero Three Two Right clear for take-off good night.		
1640:40 UTC [0040:40 MYT] MAS 370	Three Two Right clear for take-off Malaysian Three Seven Zero thank you bye.		
		1651:56 UTC [0051:56 MYT] MAS 6075	Lumpur Tower Malaysian Six Zero Seven Five good morning we are ready.
		1652:03 UTC [0052:03 MYT] Lumpur Tower	Good morning Malaysian Six Zero Seven Five Lumpur Tower taxi holding point Alfa One One Three Two Right.
		1652:08 UTC [0052:08 MYT] MAS 6075	Holding point Alfa One One Malaysian Six Zero Seven Five.
		1652:18 UTC [0052:18 MYT] Lumpur Tower	Zero Seven Five aah… Line up Three Two Right via One One.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1652:24 UTC [0052:24 MYT] MAS 6075	Clear line up Three Two Right via Alfa One One Malaysian Six Zero Seven Five.
		1654:04 UTC [0054:04 MYT] Lumpur Tower	Six Zero Seven Five free track clear for take-off.
		1654:08 UTC [0054:08 MYT] MAS 6075	Free track clear for take-off Malaysian Six Zero Seven Five good night.
		1657:39 UTC [0057:39 MYT] Unknown	Load cargo.
		1657:41 UTC [0057:41 MYT] MAS 30	Lumpur Tower good morning Malaysian Three Zero.
		1657:42 UTC [0057:42 MYT] Lumpur Tower	Three Zero good morning Lumpur Tower Holding Point Alfa One Zero Three Two Right.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1657:46 UTC [0057:46 MYT] MAS 30	Holding Point Alfa One Zero Three Two Right Malaysian Three Zero.
		1658:28 UTC [0058:28 MYT] XAX 506	Lumpur Ground …eh ai ai Lumpur Tower Xenadu Five Zero Six approaching Bravo good morning.
		1658:37 UTC [0058:37 MYT] Lumpur Tower	Eer… Five Zero Six Lumpur Ground Holding Point Alfa One Zero Three Two Right.
		1658:39 UTC [0058:39 MYT] XAX 506	Holding point Alfa One Zero Three Two Right Xenadu Five Zero Six.
		1659:22 UTC [0059:22 MYT] MAS 30	Malaysian Three Zero we're ready.
		1659:26 UTC [0059:26 MYT] Lumpur Tower	Three Zero line up Alfa One Zero Three Two Right.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1659:28 UTC [0059:28 MYT] MAS 30	Line up Alfa One Zero Three Two Right Malaysian Three Zero.
		1659:54 UTC [0059:54 MYT] Lumpur Tower	Malaysian Three Zero Three Two Right clear for take-off night.
		1700:00 UTC [0100:00 MYT] MAS 30	Clear for take-off Three Two Right Malaysian Three Zero.
		1700:50 UTC [0100:50 MYT] Lumpur Tower	Xenadu Five Zero Six Runway Three… correction line up Runway Three Two Right via Alfa One One.
		1700:55 UTC [0100:55 MYT] XAX 506	Line up Runway Three Two Right via Alfa One One Xenadu Five Zero Six.
		1702:23 UTC [0102:23 MYT] Lumpur Tower	Xenadu Five Zero Six Three Two Right clear for take-off good night.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - MAS 370	SOURCE	AIR-GROUND COMMUNICATION LUMPUR TOWER FREQUENCY 118.8 MHz CONTENT - OTHER FLIGHTS
		1702:28 UTC [0102:28 MYT] XAX 506	Runway Three Two Right clear for take-off Xenadu Five Zero Six good night sir thank you.

END OF LUMPUR TOWER RADIO TELEPHONY TRANSCRIPT

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

	AIR-GROUND COMMUNICATION **APPROACH RADAR - FREQUENCY 121.25 MHz**		**AIR-GROUND COMMUNICATION** **APPROACH RADAR - FREQUENCY 121.25 MHz**
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
			START TIME1631:00 UTC [0031:00 MYT]
		1631:45 UTC [0031:45 MYT] GSB 305	Lumpur Radar Gading Sari Three Zero Five morning descend to flight level one five zero squawking two zero six zero direct to Nipah.
		1631:53 UTC [0031:53 MYT] Lumpur Radar	Gading Sari Three Zero Five good morning cancel STAR direct to Gosmo maintain high speed descend seven thousand feet one zero one two.
		1632:03 UTC [0032:03 MYT] GSB 305	Direct to Gosmo descend seven thousand (xxxx) [illegible] high speed Gading Sari Three Zero Five
		1632:11 UTC [0032:11 MYT] Lumpur Radar	Asian Express One Six Five Five descend four thousand five hundred feet.
		1632:15 UTC [0032:15 MYT] AXM 1655	Descend four thousand five hundred feet Six Five Five.

AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz		AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1632:21 UTC [0032:21 MYT] AXM 1949	Lumpur Radar Asian Express One Niner Four Niner maintaining flight level one niner zero.
		1632:25 UTC [0032:25 MYT] Lumpur Radar	Express One Niner Four Niner descend one one thousand one zero one two
		1632:30 UTC [0032:30 MYT] AXM 1949	Descend one one thousand feet one zero one two Asian Express One Niner Four Niner.
		1632:34 UTC [0032:34 MYT] Lumpur Radar	Gading Sari Three Zero Five high speed below ten thousand as well.
		1632:39 UTC [0032:39 MYT] GSB 305	High pun below ten Gading Three Zero Five.
		1632:59 UTC [0032:59 MYT] MAS 433	Lumpur Radar Malaysian Four Three Three good evening flight level two two two for level one five zero direct lima.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz		AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1633:04 UTC [0033:04 MYT] Lumpur Radar	Malaysian Four Three Three good evening descend seven thousand feet one zero one two descend speed two niner zero knots for space.
		1633:13 UTC [0033:13 MYT] MAS 433	(xxxx)[illegible] speed of two niner zero knots seven thousand feet one zero one two Malaysian Four Three Three.
		1633:23 UTC [0033:23 MYT] Lumpur Radar	And Malaysian Four Three Three cancel STAR track direct to Gosmo.
		1633:26 UTC [0033:26 MYT] MAS 433	Cancel STAR direct to Gosmo Malaysian Four Three Three confirm high speed below ten as well.
		1633:32 UTC [0033:32 MYT] Lumpur Radar	Malaysian Four Three Three affirmitive until further advice.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
APPROACH RADAR - FREQUENCY 121.25 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1633:35 UTC [0033:35 MYT] MAS 433	Malaysian Four Three Three.
		1633:37 UTC [0033:37 MYT] Lumpur Radar	Malaysian One Six contact Lumpur Radar one three two decimal eight selamat jalan.
		1633:43 UTC [0033:43 MYT] MAS 16	Lumpur Radar one three two eight Malaysian One Six (xxxx) [illegible] Two Six
		1633:47 UTC [0033:47 MYT] Lumpur Radar	Asian Express One Six Five Five descend three thousand feet clear for ILS Approach Runway Three Two Left.
		1633:54 UTC [0033:54 MYT] Lumpur Radar	We are clear three thousand (xxxx) [illegible] approach Runway Three Two Left Express One Six Five Five.
		1635:47 UTC [0033:47 MYT] Lumpur Radar	Garing Sari Three Zero Five descend four thousand five hundred feet.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
APPROACH RADAR - FREQUENCY 121.25 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1635:50 UTC [0035:50 MYT] GSB 305	Descend four thousand five hundred Gading Sari Three Zero Five.
		1635:55 UTC [0035:55 MYT] Lumpur Radar	Malaysian Four Three Three descend five thousand five hundred feet.
		1635:58 UTC [0035:58 MYT] MAS 433	Five thousand five hundred Malaysian Four Three Three.
		1636:01 UTC [0036:01 MYT] Lumpur Radar	Asian Express One Nine Four Nine descend seven thousand feet.
		1636:04 UTC [0036:04 MYT] AXM 1949	Descend seven thousand Asian Express one nine four nine.
		1636:07 UTC [0036:07 MYT] Lumpur Radar	Asian Express One Six Five Five establish Localizer Tower one one eight five good night.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
APPROACH RADAR - FREQUENCY 121.25 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1636:12 UTC [0036:12 MYT] AXM 1655	One one eight five Six Five bye.
		1637:56 UTC [0037:56 MYT] Lumpur Radar	Gading Sari Three Zero Five descend three thousand feet clear for ILS Approach Runway Three Two Left.
		1638:02 UTC [0038:02 MYT] GSB 305	Clear three thoudand feet clear for ILS Approach Three Two Left Gading Sari Three Zero Five.
		1638:08 UTC [0038:08 MYT] Lumpur Radar	Malaysian Four Three Three descend four thousand five hundred.
		1638:11 UTC [0038:11 MYT] MAS 433	Four thousand five hundred Malaysian Four Three Three.
		1638:21 UTC [0038:21 MYT] Lumpur Radar	Asian Express One Niner Four Niner cancel STAR fly heading one five five expect radar vector for ten you have four four track miles.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
APPROACH RADAR - FREQUENCY 121.25 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1638:31 UTC [0038:31 MYT] AXM 1949	Copy four four track miles fly heading one five five Asian Express One Niner Four Niner can expect radar vector.
		1638:38 UTC [0038:38 MYT] Lumpur Radar	Affirm heading one five five sir.
		1638:40 UTC [0038:40 MYT] AXM 1949	Copy one five five heading Express One Niner Four Niner.
		1638:45 UTC [0038:45 MYT] Lumpur Radar	Malaysian Four Three Three you can resume normal speed.
		1638:49 UTC [0038:49 MYT] MAS 433	Normal speed Malaysian Four Three Three.
		1638:58 UTC [0038:58 MYT] Lumpur Radar	Gading Sari Three Zero Five resume normal speed.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz		AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1639:01 UTC [0039:01 MYT] GSB 305	Resume normal speed Garing Sari Three Zero Five.
		1639:04 UTC [0039:04 MYT] unknown	Jason.
		1639:12 UTC [0039:12 MYT] Lumpur Radar	Asian Express One Nine Four Nine maintain seven thousand feet standby lower.
		1639:16 UTC [0039:16 MYT] AXM 1949	Maintain seven thousand feet Asian Express One Niner Four Niner.
		1639:37 UTC [0039:37 MYT] MAS 6	Lumpur Malaysian Six salammualaikum selamat pagi passing one thousand for six thousand Agosa Alpha Departure.
		1639:44 UTC [0039:44 MYT] Lumpur Radar	Malaysian Six waalaikumsalam identified climb flight level one eight zero cancel S I D direct to Sukat.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz		AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1639:51 UTC [0039:51 MYT] MAS 6	Climb level one eight zero cancel S I D direct Sukat Malaysian Six.
		1640:30 UTC [0040:30 MYT] Lumpur Radar	Malaysian Four Three Three descend three thousand feet clear for ILS Approach Runway Three Two Left.
		1640:35 UTC [0040:35 MYT] MAS 433	Three thousand clear ILS Three Two Left Malaysian Four Three Three will call you establish.
		1641:05 UTC [0041:05 MYT] Lumpur Radar	Garing Sari Three Zero Five establish Localizer contact Tower one one eight five good night.
		1641:11 UTC [0041:11 MYT] GSB 305	Tower one one eight five selamat malam sir Gading Sari Three Zero Five.
		1641:15 UTC [0041:15 MYT] Lumpur Radar	Selamat malam.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz CONTENT - OTHER FLIGHTS
		1641:21 UTC [0041:21 MYT] Lumpur Radar	Asian Express One Nine Four Niner further right heading one six zero and descend three thousand five hundred.
		1641:28 UTC [0041:28 MYT] AXM 1949	Further right heading one six zero and descend three thousand five hundred feet Asian Express One Nine Four Niner.
1642:50 UTC [0042:50 MYT] MAS 370	Departure Malaysian aaa… Three Seven Zero.		
1642:53 UTC [0042:53 MYT] Lumpur Radar	Malaysian Three Seven Zero selamat pagi identified climb flight level one eight zero cancel S I D turn right direct to IGARI.		
1643:01 UTC [0043:01 MYT] MAS 370	Okay… level one eight zero direct IGARI Malaysian One… aaa Three Seven Zero.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz		AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1643:18 UTC [0043:18 MYT] Lumpur Radar	Malaysian Four Three Three established Localizer contact tower one one eight decimal five good day.
		1643:24 UTC [0043:24 MYT] MAS 433	One one eight five Malaysia Four Three Three good night.
		1644:09 UTC [0044:09 MYT] Lumpur Radar	Asian Express One Nine Four Nine maintain three thousand five hundred feet standby lower.
		1644:13 UTC [0044:13 MYT] AXM 1949	Say again three thousand five hundred feet standby for lower Asian Express One Niner Four Niner.
		1645:10 UTC [0045:10 MYT] Lumpur Radar	Asian Express One Nine Four Niner descend two thousand five hundred feet base turn in three miles.

AIR-GROUND COMMUNICATION
APPROACH RADAR - FREQUENCY 121.25 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1645:15 UTC [0045:15 MYT] AXM 1949	Copy descend two thousand five hundred base turn in three miles Asian Express One Niner Four Niner.
		1645:20 UTC [0045:20 MYT] Lumpur Radar	Malaysian Six contact Lumpur Radar one three two decimal eight selamat jalan.
		1645:26 UTC [0045:26 MYT] MAS 6	Lumpur one three two eight salamualaikum Malaysian Six.
		1645:30 UTC [0045:30 MYT] Lumpur Radar	Waalaikumsalam.
		1645:44 UTC [0045:44 MYT] Lumpur Radar	Asian Express One Nine Four Niner turn right heading two two five for base.

AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz		AIR-GROUND COMMUNICATION APPROACH RADAR - FREQUENCY 121.25 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1645:48 UTC [0045:48 MYT] AXM 1949	Turn right heading two two five for base Asian Express One Niner Four Niner.
		1646:03 UTC [0046:03 MYT] AXM 1367	Lumpur Express One Three Six Seven selamat pagi cending one three zero passing one nine zero.
		1646:08 UTC [0046:08 MYT] Lumpur Radar	Asian Express One Three Six Seven selamat pagi high speed direct Gosmo descend seven thousand feet one zero one two.
		1646:15 UTC [0046:15 MYT] AXM 1367	High speed drect Gosmo seven thousand one zero one three seven three six seven.
1646:39 UTC [0046:39 MYT] Lumpur Radar	Malaysian Three Seven Zero contact Lumpur Radar one three two six good night.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

APPROACH RADAR - FREQUENCY 121.25 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1646:42 UTC [0046:42 MYT] MAS 370	Night one three two six Malaysian err… Three Seven Zero.		
		1646:47 UTC [0046:47 MYT] Lumpur Radar	Express One Nine Four Nine turn right heading two niner zero clear for ILS Approach Runway Three Two Left.
		1646:52 UTC [0046:52 MYT] AXM 1949	Right heading two niner zero clear for ILS Approach for Runway Three Two Left.

END OF LUMPUR APPROACH RADAR TRANSCRIPT

AIR-GROUND COMMUNICATION
LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
			START TIME 1630:20 UTC [0030:20 MYT]
		1630:29 UTC [0030:29 MYT] Lumpur Radar	Singapore Nine Five Two ah climb flight level three two zero.
		1630:34 UTC [0030:34 MYT] Lumpur Radar	Singapore Three Five Two climb flight level three two zero.
		1630:37 UTC [0030:37 MYT] SIA 352	Climb level three two zero Singapore Three Five Two
		1630:40 UTC [0030:40 MYT] Lumpur Radar	Zest Nine Four One contact Singapore one two three decimal seven.
		1630:45 UTC [0030:45 MYT] Thai 41	One two three decimal seven Thai Air Four One selamat malam.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1630:52 UTC [0030:52 MYT] MAS 433	Malaysian Four Three Three maintaining flight level two six zero.
		1630:55 UTC [0030:55 MYT] Lumpur Radar	Malaysian Four Three Three.
		1631:09 UTC [0031:09 MYT] Lumpur Radar	Korean Air Six Seven ah… Two climb flight level ah… two niner zero expedite reaching.
		1631:15 UTC [0031:15 MYT] KAL 672	Two nine zero Korean Air Six Seven Two.
		1631:25 UTC [0031:25 MYT] Lumpur Radar	Malaysian Four Three Three descend flight level one five zero.
		1631:28 UTC [0031:28 MYT] MAS 433	Level one five zero Malaysia Four Three Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	**AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370**	**TIME & SOURCE**	**AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS**
		1631:30 UTC [0031:30 MYT] Lumpur Radar	Gading Sari Three Zero Five contact Lumpur Radar one two one two five.
		1631:34 UTC [0031:34 MYT] GSB 305	One two one two five Gading Sari Three Zero Five selamat malam sir.
		1631:38 UTC [0031:38 MYT] Lumpur Radar	Selamat malam.
		1631:47 UTC [0031:47 MYT] Lumpur Radar	Korean Air Six Seven Two expedite passing level two seven zero.
		1631:51 UTC [0031:51 MYT] KAL 672	Through two seven zero now Korean Air Six Seven Two thank you.
		1632:48 UTC [0032:48 MYT] Lumpur Radar	Malaysian Four Three Three contact radar one two one two five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1632:51 UTC [0032:51 MYT] MAS 433	One two one two five Malaysian Four Three Three good night.
			DIRECT LINE COMMUNICATION BETWEEN LUMPUR RADAR AND SINGAPORE
		1633:37 UTC [0033:37 MYT] Singapore	Singapore.
		1633:38 UTC [0033:38 MYT] Sec 3 Radar Line	Singapore Three Two Four stop climb level two six zero.
		1633:41 UTC [0033:41 MYT] Singapore	Singapore Three Two Four stop climb fliight level two six zero copied.
			END OF DIRECT LINE COMMUNICATION
		1633:46 UTC [0033:46 MYT] KAL 672	Six Seven Two er vacating two seven zero ah… request three six zero the final.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1633:51 UTC [0033:51 MYT] Lumpur Radar	Korean Six Seven Two I say again climb level two niner zero expect passing two seven zero.
		1633:58 UTC [0033:58 MYT] KAL 672	Affirmative we are through two seven zero climbing two niner zero Korean Air Six Seven Two request three six zero the final.
		1634:03 UTC [0034:03 MYT] Lumpur Radar	Copied standby.
		1634:06 UTC [0034:06 MYT] SIA 324	Selamat malam Singapore Three Two Four climbing level two six zero.
		1634:11 UTC [0034:11 MYT] Lumpur Radar	Singapore Three Two Four confirm squawk.
		1634:14 UTC [0034:14 MYT] SIA 324	Squawking two two two seven Singapore Three Two Four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1634:18 UTC [0034:18 MYT] Lumpur Radar	Singapore Three Two Four identified maintain level two six zero.
		1634:22 UTC [0034:22 MYT] SIA 324	Roger maintain level two six zero Singapore Three Two Four.
		1635:23 UTC [0035:23 MYT] SIA 352	Singapore Three Five Two maintaining level three two zero.
		1635:26 UTC [0035:26 MYT] Lumpur Radar	Singapore Three Five Two.
		1635:29 UTC [0035:29 MYT] Lumpur Radar	Singapore Three Five Two climb flight level two eight zero.
		1635:32 UTC [0035:32 MYT] SIA 324	Climb flight level two eight zero Singapore Two Four.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1636:51 UTC [0036:51 MYT] Lumpur Radar	Korean Air Six Seven Two contact Singapore one two three decimal seven.
		1636:55 UTC [0036:55 MYT] KAL 672	Twenty three seven Korean Air Six Seven Two good day sir.
		1636:58 UTC [0036:58 MYT] Lumpur Radar	Yap.
		1637:07 UTC [0037:07 MYT] Lumpur Radar	Singapore Three Two Four climb flight level three zero zero
		1637:11 UTC [0037:11 MYT] SIA 324	Ahh… confirm SingaporeThree Two Four.
		1637:14 UTC [0037:14 MYT] Lumpur Radar	Singapore Three Two Four climb level three zero zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1637:18 UTC [0037:18 MYT] SIA 324	Climb flight level three zero zero Singapore Three Two Four.
		1639:04 UTC [0039:04 MYT] SIA 324	Singapore Three Two Four request climb flight level three two zero.
		1639:08 UTC [0039:08 MYT] Lumpur Radar	Singapore Three Two Four final three zero zero.
		1639:12 UTC [0039:12 MYT] SIA 324	Final level three zero zero Singapore Three Two Four.
		1645:19 UTC [0045:19 MYT] Lumpur Radar	Malaysian Five Two contact Ho Chi Minh one two zero decimal niner.
		1645:24 UTC [0045:24 MYT] MAS 52	Ho Chi Minh one two zero decimal niner Malaysian Five Two good night.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1645:51 UTC [0045:51 MYT] TSE 738	Lumpur Control Transmile Seven Three Eight good evening flight level three four zero approaching Victor Papa Kilo two zero four zero.
		1646:01 UTC [0046:01 MYT] Lumpur Radar	Transmile Seven Three Eight radar identified Nipah correction clear to Subang Caledonian One Arrival Runway One Five Pibos Transition level three four zero.
		1646:09 UTC [0046:09 MYT] TSE 738	Clear to Subang Caledonian ah… One Arrival ah Runway One Five Subang and naa… Pibos Transition maintain flight level three four zeroTransmile Seven Three Eight.
		1646:23 UTC [0046:23 MYT] Lumpur Radar	Transmile Seven Three Eight pilot discretion direct to Pibos now.
		1646:27 UTC [0046:27 MYT] TSE 738	Transmile Seven Three Eight tracking direct Pibos now.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1646:55 UTC [0046:55 MYT] MAS 370	Lumpur Control Malaysian aa Three Seven Zero.		
1646:58 UTC [0046:58 MYT] Lumpur Radar	Malaysian Three Seven Zero Lumpur Radar good morning climb flight level two five zero.		
1647:03 UTC [0047:03 MYT] MAS 370	Level two five zero Malaysian aaThree Seven Zero.		
		1648:34 UTC [0048:34 MYT] Lumpur Radar	Singapore Three Five Two contact Bangkok one two three decimal niner five.
		1648:38 UTC [0048:38 MYT] SIA 352	One two three niner five Singapore Three Five Two good day.
		1648:41 UTC [0048:41 MYT] Lumpur Radar	Good day sir.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
1650:08 UTC [0050:08 MYT] Lumpur Radar	Malaysian Three Seven Zero climb flight level three five zero.		
1650:11 UTC [0050:11 MYT] MAS 370	Flight level three five zero Malaysian aa Three Seven Zero.		
		1651:13 UTC [0051:13 MYT] TSE 378	TransmileThree Seven Eight (xxxxxx) illegible.
		1651:17 UTC [0051:17 MYT] Lumpur Radar	Transmile Three Seven Eight descend flight level one niner zero.
		1651:20 UTC [0051:20 MYT] TSE 378	Descend level one niner zero Transmile Seven Three Eight.
		1652:49 UTC [0052:49 MYT] TSE 738	Transmile Seven Three Eight (xxxx) illegible direct Victor Bravo Alfa.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1652:53 UTC [0052:53 MYT] Lumpur Radar	Transmile Seven Three Eight track direct Victor Bravo Alfa approved.
		1652:57 UTC [0052:57 MYT] TSE 738	Direct Victor Bravo Alfa approved thank you (xxxx) [illegible]
		1653:11 UTC [0053:11 MYT] CPA 791	Lumpur good evening Cathay Seven Nine One flight level three nine zero squawking five three five one.
		1653:19 UTC [0053:19 MYT unknown	four seven.
		1653:22 UTC [0053:22 MYT] AXM 1017	Express One Zero One Seven good morning level three five zero squawking five one seven six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1653:29 UTC [0053:29 MYT] Lumpur Radar	Asian Express One Zero One Six Lumpur Radar identified maintain level three five zero and track direct for Nipah Nipah Three Arrival Runway Three Two Right.
		1653:40 UTC [0053:40 MYT] AXM 1017	To Nipah for Three Two Right Express One Zero One Seven identified.
		1653:49 UTC [0053:49 MYT] CPA 791	Lumpur good morning Cathay Seven Nine One flight level three nine zero squawk five three five four.
		1653:54 UTC [0053:54 MYT] Lumpur Radar	Cathay Seven Nine One Lumpur Radar identified Nipah Three Alpha Arrival Runway Three Two Right Pibos Alpha Transition level three nine zero standby for direct track.
		1654:05 UTC [0054:05 MYT] CPA 791	(xxxxx) (xxxxx) [illegible] out of three nine zero (xxxxx) (xxxxx) [illegible] south arrival three two right Pibos Transition Cathay Seven Nine One.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1654:35 UTC [0054:35 MYT] Lumpur Radar	Singapore Three Two Four contact Bangkok one two three decimal nine five.
		1654:39 UTC [0054:39 MYT] SIA 324	One two three niner five Singapore Three Two Four good day.
		1654:43 UTC [0054:43 MYT] Lumpur Radar	Good day.
		1654:58 UTC [0054:58 MYT] Lumpur Radar	Thai Peace Nine Two One contact Singapore one two three decimal seven.
		1655:03 UTC [0055:03 MYT] BBC 921	Contact Singapore two three seven Niner Two One.
		1655:13 UTC [0055:13 MYT] Lumpur Radar	Transmile Seven Three Eight descend to flight level one five zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1655:17 UTC [0055:17 MYT] TSE 738	(xxx) (xxx) [illegible] one five zero Transmile Seven Three Eight.
		1656:23 UTC [0056:23 MYT] CPA 791	Cathay Seven Nine One request descend.
		1656:26 UTC [0056:26 MYT] Lumpur Radar	Cathay Seven Nine One descend flight level three zero zero.
		1656:30 UTC [0056:30 MYT] CPA 791	Descend flight level three zero zero Cathay Seven Nine One.
		1656:42 UTC [0056:42 MYT] AXM 1017	Asian Express One Zero One Seven request descend.
		1656:45 UTC [0056:45 MYT] Lumpur Radar	Express One Zero One Seven descend flight level one nine zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1656:49 UTC [0056:49 MYT] AXM 1017	Flight level one nine zero Asian Express One Zero One Seven.
		1657:45 UTC [0057:45 MYT] Lumpur Radar	Cathay Seven Nine One naa… direct to Nipah and reduce speed two eight zero.
		1657:52 UTC [0057:52 MYT] CPA 792	Nipah reduce speed two eight zero Cathay Seven Nine One..
		1657:56 UTC [0057:56 MYT] Lumpur Radar	Express One Zero One Seven maintain high speed descend level one five zero.
		1658:01 UTC [0058:01 MYT] AXM 1017	High speed to one five zero Express One Zero One Seven.
		1658:04 UTC [0058:04 MYT] Lumpur Radar	Transmile Seven Three Eight contact radar one two one two five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1658:07 UTC [0058:07 MYT] TSE 738	One two one two fiveTransmile Seven Three Eight.
		1659:40 UTC [0059:40 MYT] Lumpur Radar	Cathay Seven Nine One descend flight level two eight zero.
		1659:44 UTC [0059:44 MYT] CPA 791	Descend flight level two eight zero Cathay Seven Nine One.
		1701:09 UTC [0101:09 MYT] Lumpur Radar	Cathay Seven Nine One descend flight level two four zero.
		1701:12 UTC [0101:12 MYT] CPA 791	Descend flight level two four zero Cathay Seven Nine One.
1701:17 UTC [0101:17 MYT] MAS 370	Malaysian aa Three Seven Zero maintaining level three five zero.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
1701:21 UTC [0101:21 MYT] Lumpur Radar	Malaysian Three Seven Zero.		
		1701:36 UTC [0101:36 MYT] Lumpur Radar	Cathay Seven Nine One descend flight level one niner zero.
		1701:40 UTC [0101:40 MYT] CPA 791	Descend flight level one niner zero Cathay Seven Niner One.
		1702:38 UTC [0102:38 MYT] Lumpur Radar	Asian Express One Zero One Seven direct to ANSOK maintain high speed.
		1702:44 UTC [0102:44 MYT] AXM 1014	Maintain high speed and aah …… say again that point.
		1702:48 UTC [0102:48 MYT] Lumpur Radar	One zero one seven direct to ANSOK.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1702:51 UTC [0102:51 MYT] AXM 1017	To ANSOK high speed Express One Zero One Seven.
		1702:55 UTC [0102:55 MYT] Lumpur Radar	Cathay Seven Nine One Runway Three Two Right sir and daa… maintain level one nine zero.
		1703:01 UTC [0103:01 MYT] CPA 791	Cathay Seven Nine One say again.
		1703:03 UTC [0103:03 MYT] Lumpur Radar	Cathay Seven Nine One Runway Three Two Right in used.
		1703:06 UTC [0103:06 MYT] CPA 791	Copy Runway Three Two Right maintain flight level one nine zero Cathay Seven Nine One.
		1703:20 UTC [0103:20 MYT] AXM 7092	Lumpur Control Asia Seven Zero Nine Two good morning flight level three five zero squawk three one four seven.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1703:33 UTC [0103:33 MYT] Lumpur Radar	Asian Express One Zero Eight Niner Radar say again your squawk.
		1703:38 UTC [0103:38 MYT] AXM 1089	Squawk three one four seven.
		1703:41 UTC [0103:41 MYT] Lumpur Radar	Express One Zero Eight Niner identified direct to Nipah Nipah Three Alfa Arrival Runway Three Two Right level three five zero.
		1703:49 UTC [0103:49 MYT] AXM 1089	Track direct Nipah clear ahh Lumpur Nipah Three Alfa Three Two Right Pibos Alfa Transition and track Nipah confirm.
		1703:58 UTC [0103:58 MYT] Lumpur Radar	Affirm aah direct to Nipah.
		1704:00 UTC [0104:00 MYT] AXM 1089	Nipah Express One Zero Eight Niner.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1704:04 UTC [0104:04 MYT] Lumpur Radar	Cathay seven nine one descend level one seven zero.
		1704:08 UTC [0104:08 MYT] CPA 791	Descend one seven zero Cathay Seven Nine One.
		1704:11 UTC [0104:11 MYT] Lumpur Radar	Express One Zero One Seven nahhh… Descend one one thousand QNH is one zero one two contact Radar one two one two five.
		1704:23 UTC [0104:23 MYT] Lumpur Radar	Express One Zero One Seven descend one one thousand on QNH one zero one two contact Radar one two one two five.
		1704:35 UTC [0104:35 MYT] Lumpur Radar	Express One Zero One Seven Lumpur.
		1704:56 UTC [0104:56 MYT] Lumpur Radar	Express One Zero One Seven Lumpur.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1705:12 UTC [0105:12 MYT] Lumpur Radar	Cathay Seven Nine One descend level one five zero.
		1705:15 UTC [0105:15 MYT] CPA 791	Descend flight level one five zero Cathay Seven Niner One.
		1705:25 UTC [0105:25 MYT] AXM 1089	Express One Zero Eight Niner request descend.
		1705:29 UTC [0105:29 MYT] Lumpur Radar	Express One Zero Eight Niner descend flight level two five zero.
		1705:34 UTC [0105:34 MYT] AXM 1089	Descend to flight level two five zero Express One Zero Eight Niner.
		1705:39 UTC [0105:39 MYT] Lumpur Radar	Asian Express One Zero One Seven Lumpur Radar how do you read.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1705:44 UTC [0105:44 MYT] AXM 1017	Lumpur Express One Zero One Seven how do you read.
		1705:50 UTC [0105:50 MYT] AXM 1017	Lumpur Lumpur Express One Zero One Seven.
		1705:53 UTC [0105:53 MYT] Lumpur Radar	Express One Zero One Seven descend one one thousand.
		1705:57 UTC [0105:57 MYT] AXM 1017	Descend to one one thousand Express (xxxx) (xxxx) [illegible]
		1706:03 UTC [0106:03 MYT] Lumpur Radar	Express One Zero One Seven QNH one zero one two contact Radar one two one two five.
		1706:08 UTC [0106:08 MYT] AXM 1017	One two one two five Control One Seven good day sir.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1706:36 UTC [0106:36 MYT] Lumpur Radar	Cathay Seven Niner One cantact Radar one two one two five.
		1706:39 UTC [0106:39 MYT] CPA 792	One two one two five Cathay Seven Nine One good night.
1707:56 UTC [0107:56 MYT] MAS 370	Ehhh… Seven Three Seven Zero maintaining level three five zero.		
1708:02 UTC [0108:02 MYT]	Malaysian Three Seven Zero.		
		1710:54 UTC [0110:54 MYT] XAX 506	Lumpur Xanadu Five Zero Six passing ten thousand seven hundred feet for flight level one eight zero good morning.
		1711:05 UTC [0111:05 MYT] Lumpur Radar	Xanadu Five Zero Six straight climb flight level two zero zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION

LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1711:10 UTC [0111:10 MYT] XAX 506	Climb flight level two zero zero and request direct aah… Victor Papa Golf if possible Xanadu Five Zero Six.
		1711:16 UTC [0111:16 MYT] Lumpur Radar	Xanadu Five Zero Six route via Kimat and Approach will advice you for direct track.
		1711:22 UTC [0111:22 MYT] XAX 506	Roger Kimat Xanadu Five Zero Six.
		1712:51 UTC [0112:51 MYT] Lumpur Radar	Asian Express One Zero Eight Niner descend flight level one five zero.
		1712:56 UTC [0112:56 MYT] AXM 1089	Flight level one five zero Express One Zero Eight niner.
		1712:59 UTC [0112:59 MYT] Lumpur Radar	Xanadu Five Zero Six climb flight level two niner zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
		1713:02 UTC [0113:02 MYT] XAX 506	Climb flight level two niner zero Xanadu Five Zero Six.
		1715:00 UTC [0115:00 MYT] Lumpur Radar	Xanadu Five Zero Six direct Papa Kilo.
		1715:03 UTC [0115:03 MYT] XAX 506	Direct Papa Kilo Xanadu Five Zero Six thank you.
		1715:25 UTC [0115:25 MYT] Lumpur Radar	Asian Express One Zero Eight Niner contact Radar one two one two five.
		1715:30 UTC [0115:30 MYT] AXM 1089	One two one two five (xxx) [illegible] One Zero Eight Nine good bye.
		1715:33 UTC [0115:33 MYT] Lumpur Radar	night.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz CONTENT - OTHER FLIGHTS
1719:26 UTC [0119:26 MYT] Lumpur Radar	Malaysian Three Seven Zero contact Ho Chi Minh one two zero decimal niner good night.		
1719:30 UTC [0119:30 MYT] MAS 370	Good night Malaysian Three Seven Zero.		
		1723:43 UTC [0123:43 MYT] XAX 506	Xanadu Five Zero Six approaching Papa Kilo.
		1723:48 UTC [0123:48 MYT] Lumpur Radar	Xanadu Five Zero Six contact Singapore one two three decimal seven.
		1723:52 UTC [0123:52 MYT] XAX 506	Contact Singapore one two three decimal seven Xanadu Five Zero Six good night.
		1726:17 UTC [0126:17 MYT] CES 5093	Err… Lumpur Control err… China Air Five Zero Niner Three flight level three seven zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz		AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1726:26 UTC [0126:26 MYT] Lumpur Radar	China Air Five Zero Nine Three Lumpur Radar identified maintain level three seven zero.
		1726:33 UTC [0126:33 MYT] CES 5093	(xxxx) (xxxx) [illegible] Zero Nine Three.
		1729:10 UTC [0129:10 MYT] GBG 76	Lumpur good evening Global Jet Seven Six flight level four one zero.
		1729:34 UTC [0129:34 MYT] GBG 76	Lumpur Global Jet Seven Six flight level four one zero.
		1729:41 UTC [0129:41 MYT] Lumpur Radar	Roger Seven Six Lumpurr control maintain flight level four one zero standby by for arrival.
		1729:49 UTC [0129:49 MYT] GBG 76	Maintain four one zero Global Jet Seven Six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator tor Malaysia Airlines: MAS

AIR-GROUND COMMUNICATION
LUMPUR RADAR - FREQUENCY 132.6 MHz

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1731:57 UTC [0131:57 MYT] Lumpur Radar	Global Jet Seven Six clear to Subang Caledonean One Arrival Runway One Five Pibos transition level four one zero.
		1732:06 UTC [0132:06 MYT] GBG 76	Clear to Subang Caledonean One Arrival Runway One Five emm…daa… request descend.
		1732:13 UTC [0132:13 MYT] Lumpur Radar	Global Jet Seven Six descend to flight level one niner zero.
		1732:17 UTC [0132:17 MYT] GBG 76	Descend to flight level one niner zero Global Jet Seven Six.

END OF SECTOR 3 + 5 RADAR TRANSCRIPT

TIME & SOURCE	LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
			START TIME 1730:00 UTC [0130 MYT]
		1731:57 UTC [0131:57 MYT] Lumpur Radar	Global Jet Seven Six clear to Subang Caledonean One Arrival Runway One Five Pibos Transition level four one zero.
		1732:06 UTC [0132:06 MYT] GBG 76	Clear to Subang Caledonean One Arrival Runway One Five emm…daa… request descend.
		1732:13 UTC [0132:13 MYT] Lumpur Radar	Global Jet Seven Six descend to flight level one niner zero.
		1732:17 UTC [0132:17 MYT] GBG 76	Descend to flight level one niner zero Global Jet Seven Six.
			Direct Line Telephone Conversation Between KL ACC and Bangkok ACC
		1739:16 UTC [0139:16 MYT] KL ACC	Lumpur.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1739:17 UTC [0139:17 MYT] Bangkok ACC	Estimate Kota Bharu on Silk Air Nine Three Seven.
		1739:23 UTC [0139:23 MYT] KL ACC	Silk Air Nine Three Seven go ahead.
		1739:25 UTC [0139:25 MYT] Bangkok ACC	Kota Bharu one nine zero six one nine zero six flight level three nine zero squawk one five one three.
		1739:36 UTC [0139:36 MYT] KL ACC	Okay Silk Air Nine Three Seven Victor Kilo Bravo one niner zero six level three nine zero squawk one niner one three.
		1739:44 UTC [0139:44 MYT] Bangkok ACC	One five one three affirm.

End of Direct Line Telephone Conversation Between KL ACC and Bangkok ACC

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1740:11 UTC [0140:11 MYT] GBG 76	(xxxx) [illegible] Global Jet Seven Six request further descend.
		1740:16 UTC [0140:16 MYT] Lumpur Radar	Global Jet Seven Six descend flight level aa… one five zero contact Lumpur Radar one two one two five.
		1740:23 UTC [0140:23 MYT] GBG 76	One five zero over one two five Global Jet Seven Six.
1741:23 UTC 0141:23 MYT] Lumpur Radar	Malaysian Three Seven Zero Lumpur Radar how do you read, do you read.		
		1742:08 UTC [0142:08 MYT] CES 539	Lumpur Control good morning China Eastern Five Three Niner maintaining level three six zero squawk five one one one.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1742:20 UTC [0142:20 MYT] Lumpur Radar	China Eastern Five Three Nine Lumpur Radar identified maintain level three six zero Nipah Three Alfa Arrival Runway Three Two Left Pibos Tran correction Nipah Three Alpha Arrival Runway Three Two Right Pibos Apha Transition.
		1742:35 UTC [0142:35 MYT] CES 539	Nipah Three Alpha Pibos Transition Runway Three Two Right China Southern Five Three Niner.
		1746:21 UTC [0146:21 MYT] CEB 501	Lumpur Radar good morning Cebu Five Zero One.
		1746:28 UTC [0146:28 MYT] Lumpur Radar	Cebu Five Zero One Radar good morning squawk ident and report level.
		1746:38 UTC [0146:38 MYT] CEB 501	And daa… Lumpur Radar Cebu Five Zero One request descend.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1746:44 UTC [0146:44 MYT] Lumpur Radar	Cebu Five Zero One identified descend level one nine zero Nipah Three Alpha Arrival RunwayThree Two Right Eastan Alpha Transition.
		1746:55 UTC [0146:55 MYT] CEB 501	Descend level one niner zero and daa… Nipah Three Alpha Arrival Runway Three Two Right Cebu Five Zero One.
		1747:08 UTC [0147:08 MYT] CES 539	Lumpur Control China Eastern Five Three Niner request descend.
		1747:15 UTC [0147:15 MYT] Lumpur Radar	China Eastern Five Three Niner descend flight level one niner.
		1747:19 UTC [0147:19 MYT] CES 539	Descend flight level one niner zero China Eastern Five Three Niner.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1748:09 UTC [0148:09 MYT] Lumpur Radar	Five zero one direct to Nipah.
		1748:13 UTC [0148:13 MYT] 5551	Say again where to Cebu Five Zero One you are coming in garble sir.
		1748:17 UTC [0148:17 MYT] Lumpur Radar	Five Zero One track direct Nipah.
		1748:21 UTC [0148:21 MYT] CEB 501	Direct but Cebu Five Zero One.
			Direct Line Telephone Coversation Between KL ACC and HCM ACC
		1749:54 UTC [0149:54 MYT] KL ACC	Ho Chi Minh Lumpur.
		1749:56 UTC [0149:56 MYT] HCM ACC	I transfer IGARI for Malaysian Six One Six Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1750:01 UTC [0150:01 MYT] Lumpur Radar	Malaysian eeer… Six One Six Three go ahead.
		1750:07 UTC [0150:07 MYT] HCM ACC	IGARI one eight three five flight level request three six zero squawk six three four five.
		1750:15 UTC [0150:15 MYT] KL ACC	Malaysian Six One Six Three IGARI one eight three five flight level three six zero is approved squawk six three four five.
		1750:23 UTC [0150:23 MYT] HCM ACC	Okay transfer three six zero for Malaysian Six One Six Three.
1750:27 UTC [0150:27 MYT] KL ACC	Affirm…. and confirm still negative contact with Malaysian Three Seven Zero.		
1750:32 UTC [0150:32 MYT] HCM ACC	Affirm negative contact.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1750:34 UTC [0150:34 MYT] KL ACC	Err… okay thank you advise me…		
1750:38 UTC [0150:38 MYT] HCM ACC	Okay.		
	End Of Direct Line Coversation Between KL ACC and HCM ACC		
		1751:06 UTC [0151:06 MYT] Lumpur Radar	China Eastern Five Three Niner direct to Nipah and descend level one niner zero.
		1751:13 UTC [0151:13 MYT] CES 539	Direct to Nipah and descend to level one niner zero China Eastern Five Three Niner.
		1751:19 UTC [0151:19 MYT] Lumpur Radar	China Eastern Five Zero Niner Three contact Singapore one two three decimal seven.
		1751:26 UTC [0151:26 MYT] CES 5093	One two three decimal seven err… good night China Eastern Five Zero Nine Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1751:36 UTC [0151:36 MYT] Lumpur Radar	Cebu Five Zero One descend flight level one five zero.
		1751:40 UTC [0151:40 MYT] CEB 5093	Descend flight level one five zero Cebu Five Zero One.
		1752:46 UTC [0152:46 MYT] Lumpur Radar	Cebu Five Zero One speed three zero zero or greater.
		1752:51 UTC [0152:51 MYT] CEB 501	Three zero zero or greater Cebu Five Zero One.
		1753:04 UTC [0153:04 MYT] Lumpur Radar	Cebu Five Cebu Five Zero One contact Lumpur Radar one two one two five.
		1753:10 UTC [0153:10 MYT] SIA 501	One two one two five good day.

AIR-GROUND COMMUNICATION

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1754:40 UTC [0154:40 MYT] Lumpur Radar	China Eastern Five Three Niner contact Lumpur Radar one two one two five.
		1754:45 UTC [0154:45 MYT] CES 539	One two one two five China Eastern Five Three Nine good day.
		1801:46 UTC [0201:46 MYT] MAS 386	Lumpur Control Malaysian Three Eight Six passing one flight level one two four for flight level one eight zero.
		1801:56 UTC [0201:56 MYT] Lumpur Radar	Three Eight Six Lumpur radar …Good morning climb flight level two one zero.
		1802:01 UTC [0202:01 MYT] MAS 386	Level two one zero Malaysian Three Eight Six.
		1803:04 UTC [0203:04 MYT] Lumpur Radar	Malaysian Three Eight Six climb initially flight level three three zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1803:09 UTC 0203:09 MYT [MAS 386]	Level three six zero initially Malaysian Three Eight Six.
		1803:13 UTC [0203:13 MYT] Lumpur Radar	Malaysian Three Eight Six initially flight level three three zero.
		1803:16 UTC [0203:16 MYT] MAS 386	Initially flight level three three zero Malaysian Three Eight Six.

TELEPHONE CONVERSATION

1803:34 UTC [0203:34] MYT KL ACC	Ah okay okay okay carry on I tell Singa Ho Chi Minh la we told the airline to contact.		
1803:38 UTC [0203:38 MYT]	*Direct line telephone ringing tone.*		
1803:41 UTC [0203:41 MYT] KL ACC	Good night.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1803:48 UTC [0203:48 MYT] KL ACC	Helo.		
1803:49 UTC [0203:49 MYT] KL ACC	Ho Chi Minh.		
1803:50 UTC [0203:50 MYT] HCM ACC	Yes sir.		
1803:51 UTC [0203:51 MYT] KL ACC	Any news for Malaysian Three Seven Zero.		
1803:54 UTC [0203:54 MYT] HCM ACC	Negative sir until now they probably out of radar.		
1803:57 UTC [0203:57 MYT] KL ACC	Okay.		
1803:58 UTC [0203:58 MYT] HCM ACC	We have no information about Malaysian Three Seven Zero right now.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1804:02 UTC [0204:02 MYT] KL ACC	Okay Malaysian.		
1804:03 UTC [0204:03 MYT] HCM ACC	No radar target yeah.		
1804:05 UTC [0204:05 MYT] KL ACC	No radar target confirm.		
1804:07 UTC [0204:07 MYT] HCM ACC	Standby.		
1804:08 UTC [0204:08 MYT] KL ACC	You don't have radar contact.		
1804:12 UTC [0204:12 MYT] HCM ACC	Go ahead sir.		
1804:13 UTC [[0204:13 MYT] KL ACC	No confirm you don't have any radar contact.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1804:17 UTC [0204:17 MYT] HCM ACC	Yeah no radar contact no ADSB contact no communication.		
		1804:23 UTC [0204:23 MYT] THA 483	Lumpur Control Thai Four Eight Three good evening.
	DIRECT LINE TELEPHONE CONVERSATION INTERRUPTED BY AIRCRAFT CALLING		
1804:25 UTC [0204:25 MYT] KL ACC	Eer… Standby please.		
		THA 483	Squawking six one one four.
		1804:30 UTC [0204:30 MYT] Lumpur Radar	Thai Four Eight Three Lumpur Radar identified maintain level three seven zero.
		1804:33 UTC [0204:33 MYT] THA 483	Maintain level three seven zero Thai Four Eight Three.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
	CONTINUE DIRECT LINE CONVERSATION WITH HO CHI MINH		
1804:36 UTC [0204:36 MYT] KL ACC	Okay Ho Chi Minh.		
1804:38 UTC [0204:38 MYT] HCM ACC	Yes sir.		
1804:39 UTC [0204:39 MYT] KL ACC	Okay reference to the… company Malaysian Airlines the aircraft is still flying is over somewhere over Cambodia.		
1804:50 UTC [0204:50 MYT] HCM ACC	Somewhere over Cambodia.		
1804:51 UTC [0204:51 MYT] KL ACC	Affirm.		
1804:52 UTC [0204:52 MYT] HCM ACC	That's mean not enter our FIR.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1804:58 UTC [0204:58 MYT] KL ACC	Okay I am not very sure about that but daa… this is what the airlines represent MAS said that the aircraft …		
1805:05 UTC [0205:05 MYT] HCM ACC	Okay okay let me check with Cambodia.		
1805:08 UTC [0205:08 MYT] KL ACC	Yeap please check with Cambodia please.		
1805:09 UTC [0205:09 MYT] HCM ACC	Yeah.		
1805:10 UTC [0205:10 MYT] KL ACC	Okay and call me back.		
	End of Direct Line Telephone Conversation Between KL ACC and HCM ACC		
		1809:35 UTC [0209:35 MYT] TGW 2657	Lumpur Control GoCat Two Six Five Seven good morning we are flight level three five zero squawking four seven zero four over Victor KIlo Bravo.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1809:46 UTC [0209:46] MYT Lumpur Radar	GoCat Two Six Five Seven Lumpur Radar identified maintain flight level four three seven correction three five zero.
		1809:53 UTC [0209:53 MYT] TGW 2657	Maintain GoCat Two Six Five Seven.
		1815:27 UTC [0215:27 MYT] CCA 405	Lumpur Control ah good morning China Four Zero Four maintain level two eight zero.
		1815:34 UTC [0215:34 MYT] Lumpur Radar	Air China Four Zero Four Lumpur Radar confirm squawk.
		1815:38 UTC [0215:38 MYT] CCA 405	Squawk two two one seven.
		1815:41 UTC [0215:41 MYT] Lumpur Radar	Air China Four Zero Four identified climb level three four zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1815:46 UTC [0215:46 MYT] CCA 405	Climb to three our zero Air China Four Zero Four.
		1816:05 UTC [0216:05 MYT]	*Sound of telephone ringing.*
		1816:13 UTC [0216:13 MYT] Source unknown	Helo.
		1816:17 UTC [0216:17 MYT] Source unknown	Helo.
		1816:21 UTC [0216:21 MYT]	Telephone line cut-off tone TOO TOO TOO TOO.
		1816:30 UTC [0216:30 MYT]	*End of Telephone line cut-off tone.*
		1816:36 UTC [0216:36 MYT] THA 465	Lumpur Control Thai Four Six Five good morning maintaining flight level three seen zero.
		1816:46 UTC [0216:46 MYT] Lumpur Radar	Thai Four Six Five Lumpur squawk ident.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1816:49 UTC [0216:49 MYT] THA 465	Squawk six one one six idening Thai Four Six Five.
		1817:01 UTC [0217:01 MYT] Lumpur Radar	Four Six Five identified mainain level daa…three seven zero.
		1817:06 UTC [0217:06 MYT] THA 465	Maintain flight level three seven zero Thai Four Six Five.
		1817:10 UTC [0217:10 MYT] Lumpur Radar	Malaysian Three Eight Six climb initially level three four zero.
		1817:19 UTC [0217:19 MYT] Lumpur Radar	Malaysian Three Eight Six climb initially level three four zero.
		1817:22 UTC [0217:22 MYT] MAS 386	To three four zero Malaysian Three Eight Six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1820:24 UTC [0220:24 MYT] MAS 386	Three Eight Six maintaining flight level three four zero request higher.
		1820:32 UTC [0220:32 MYT] Lumpur Radar	Three Eight Six standby.
			Direct Line Telephone Conversation Between KL ACC and Bangkok ACC
		1821:50 UTC [0221:50 MYT] KL ACC	Yeah Bangkok.
		1821:51 UTC [0221:51 MYT] Bangkok ACC	Helo three estimates Kota Bharu.
		1821:53 UTC [0221:53 MYT] Source unknown	Songkran around.
		1822:02 UTC [0222:02 MYT] KL ACC	Okay Bangkok go ahead.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1822:04 UTC [0222:04 MYT] Bangkok ACC	First one Zero One Cargo Five Three Zero.
		1822:08 UTC [0222:08 MYT] KL ACC	Go ahead.
		1822:10 UTC [0222:10 MYT] Bangkok ACC	Kota Bharu one nine one five flight level three five zero squawk six one one seven.
		1822:18 UTC [0222:18 MYT] KL ACC	Next.
		1822:19 UTC [0222:19 MYT] Bangkok ACC	Silk Air Five Zero Nine.
		1822:22 UTC [0222:22 MYT] KL ACC	Go ahead.
		1822:24 UTC [0222:24 MYT] Bangkok ACC	Kota Bharu one nine four two flight level three five zero squawk seven four zero two.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1822:31 UTC [0222:31 MYT] KL ACC	Next.
		1822:31 UTC [0222:31 MYT] Bangkok ACC	Last one Singapore Four Four Seven.
		1822:35 UTC [0222:35 MYT] KL ACC	Go ahead.
		1822:37 UTC [0222:37 MYT] Bangkok ACC	Two zero one three flight level three nine zero squawk four seven five one.
		1822:43 UTC [0222:43 MYT] KL ACC	Okay I read back er... (xxx) [illegible] Cargo Five Three Zero Kota Bharu one nine one five flight level three five zero squawk six one one seven, Silk Air Five Two Niner Kota Bharu one nine four two flight level three five zero squawk seven four zero two and last one Singapore Four Four Seven IGARI two zero one six one three flight level three niner zero squawk four seven five one confirm.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1823:04 UTC [0223:04 MYT] Bangkok ACC	Yes the second one is Silk Air Five Zero Niner.
		1823:07 UTC [0223:07 MYT] KL ACC	Five Silk Air Five Zero Niner copied.
		1823:09 UTC [0223:09 MYT] Bangkok ACC	Affirm thank you.
			End of Direct Line Telephone Conversation Between KL ACC and Bangkok ACC
		1823:16 UTC [0223:16 MYT] Lumpur Radar	Malaysian Three Five Zero climb level three five zero.
		1823:20 UTC [0223:20 MYT] Lumpur Radar	Malaysian Three Eight Six climb level three five zero.
		1823:22 UTC [0223:22 MYT] MAS 386	Three five zero Malaysian Three Eight Six.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1823:26 UTC [0223:26 MYT] Lumpur Radar	Malaysian Three Eight Six expect igher later by… Ho Chi Minh.
		1823:29 UTC [0223:29 MYT] MAS 386	Malaysian Three Eight Six.
		1827:06 UTC [0227:06 MYT] Lumpur Radar	Thai Four Eight Three contact Singapore one two three decimal seven.
		1827:09 UTC [0227:09 MYT] THA 483	Singapore one two three decimal seven Thai Four Eight Three.
		1830:40 UTC [0230:40 MYT] Lumpur Radar	Thai Four Six Five contact Singapore one two three decimal seven.
		1830:45 UTC [0230:45 MYT] THA 465	One two three decimal seven Thai Four Six Five.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1832:23 UTC [0232:23 MYT] MAS 6163	Lumpur Six One SixThree morning.
		1832:32 UTC [0232:32 MYT] MAS 6163	Lumpur Malaysian Six One Six Three.
		1832:42 UTC [0232:42 MYT] MAS 6163	Lumpur Malaysian Six One Six Three one three four two five.
		1832:46 UTC [0232:46 MYT] Lumpur Radar	Malaysian Six One Six Three Lumpur Radar firm squawk and level.
		1832:51 UTC [0232:51 MYT] MAS 6163	Level three six zero squawking six three four five Malaysian Six One Six Three.
		1832:57 UTC [0232:57 MYT] Lumpur Radar	Malaysian Six One Six Three identified maintain level three six zero.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1833:00 UTC [0233:00 MYT] MAS 6163	Roger Malaysian Six One Six Three.
		1833:18 UTC [0233:18 MYT] Lumpur Radar	Malaysian Three Eight Six contact Ho Chi Minh one two zero decimal niner.
		1833:22 UTC [0233:22 MYT] MAS 386	One two zero decimal nine Malaysian Three Eight Six.
		1833:26 UTC [0233:26 MYT] Lumpur Radar	GoCat Two Six Five Seven contact Singapore one two three decimal seven.
		1833:31 UTC [0233:31 MYT] TGW 2657	One two three decimal seven GoCat Two Six Five Seven.
1833:50 UTC [0233:50 MYT]	**LUMPUR RADAR DAILING TELEPHONE LINE**		
1833:53 UTC [0233:53 MYT]	Telephone ringing tone.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1833:59 UTC [0233:59 MYT] MAS Operations	Helo.		
1834:00 UTC 0234:00 MYT KL ACC	Okay aah… helo good good mor morning.		
1834:02 UTC [0234:02 MYT] MAS Operations	Yeah yeah.		
1834:03 UTC [0234:03 MYT] KL ACC	Calling from Subang Centre lah.		
1834:06 UTC [0234:06 MYT] MAS Operations	err… ya.		
1834:07 UTC [0234:07 MYT] KL ACC	This is MAS Operations is it.		
1834:09 UTC [0234:09 MYT] MAS Operations	Ya ya		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1834:10 UTC [0234:10 MYT] KL ACC	Okay err…. regarding your Malaysian Three Seven Zero.		
1834:13 UTC [0234:13 MYT] MAS Operations	Herha.		
1834:14 UTC [0234:14 MYT] KL ACC	Ho Chi Minh said still negative contact.		
1834:17 UTC [0234:17 MYT] MAS Operations	Haa.		
1834:17 UTC [0234:17 MYT] KL ACC	And the no radar target at all.		
1834:20 UTC [0234:20 MYT] MAS Operations	Okay.		
1834:21 UTC [0234:21 MYT] KL ACC	But earlier we checked with MAS I think your side somebody said that the aircraft still flying and you already send signal to the aircraft.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1834:29 UTC [0234:29 MYT] MAS Operations	Ya.		
1834:30 UTC [0234:30 MYT] KL ACC	Okay and daa… what is daa… I mean did they reply to you or not.		
1834:34 UTC [0234:34 MYT] MAS Operations	No no no they never reply.		
1834:36 UTC [0234:36 MYT] KL ACC	Malaysian Three Seven Zero.		
1834:37 UTC [0234:37 MYT] MAS Operations	Hmm ya.		
1834:38 UTC [0234:38 MYT] KL ACC	But daa…how do you know that they ooo…ya…		
1834:41 UTC [0234:41 MYT] MAS Operations	Because of the…. message went through successfully.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1834:44 UTC [0234:44 MYT] KL ACC	Successfully went through.		
1834:45 UTC [0234:45 MYT] MAS Operations	Aaa…		
1834:46 UTC [0234:46 MYT] KL ACC	Okay amm…. can you I mean is there (xxx) [illegble] any possible for the aircraft to answer you.		
1834:53 UTC [0234:53 MYT] MAS Operations	Eer…		
1834:54 UTC [0234:54 MYT] KL ACC	Anyway aircraft can answer you.		
1834:58 UTC [0234:58 MYT] MAS Operations	Do know daa…. You have to try the SATCOM la sir.		
1835:02 UTC [0235:02 MYT] KL ACC	hmm hamm.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1835:02 UTC [0235:02 MYT] MAS Operations	Will try the SATCOM and see.		
1835:03 UTC [0235:03 MYT] KL ACC	Okay.		
1835:05 UTC [0235:05 MYT] KL ACC	Hah hah see whether they can I am sure whether the position or whether they contact with anyone and the estimate for landing or anything.		
1835:13 UTC [0235:13 MYT] MAS Operations	Okay.		
1835:14 UTC [0235:14 MYT] KL ACC	Okay and daa okay daa because da Ho Chi Minh still worry because they have eercompletely no contact at all either radio or radar.		
1835:26 UTC [0235:26 MYT] MAS Operations	Okay.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1835:27 UTC [0235:27 MYT] KL ACC	Okay so.		
1835:29 UTC [0235:29 MYT] MAS Operations	Can fax them the…because is still down loading the….. aircraft movement.		
1835:35 UTC [0235:35 MYT] KL ACC	Ah huh.		
1835:36 UTC [0235:36 MYT] MAS Operations	Aircraft still sending the … movement message.		
1835:38 UTC [0235:38 MYT] KL ACC	Okay.		
1835:39 UTC [0235:39 MYT] MAS Operations	Positioning message.		
1835:40 UTC [0235:40 MYT] KL ACC	Positioning message okay okay aah….		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1835:43 UTC [0235:43 MYT] MAS Operations	Roughly aaa… somewhere Vietnam.		
1835:46 UTC [0235:46 MYT] KL ACC	Okay can you tell what is the last position aircraft passed now.		
1835:52 UTC [0235:52 MYT] MAS Operations	Is the last position was eer…Lat Long fourteen fourteen point nine zero zero zero zero.		
1836:06 UTC [0236:06 MYT] KL ACC	Eer… say again please.		
1836:07 UTC [0236:07 MYT] MAS Operations	Eer… Latitude is fourteen point nine eer….		
1836:11 UTC [0236:11 MYT] KL ACC	eeh eeh		
1836:12 UTC [0236:12 MYT] MAS Operations	Zero zero zero zero.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1836:15 UTC [0236:15 MYT] KL ACC	Four, four time zero.		
1836:16 UTC [0236:16 MYT] MAS Operations	Yeah.		
1836:18 UTC [0236:18 MYT] KL ACC	Okay.		
1836:19 UTC [0236:19 MYT] MAS Operations	Longtitude is one zero niner.		
1836:22 UTC [0236:22 MYT] KL ACC	One zero nine.		
1836:24 UTC [0236:24 MYT] MAS Operations	One five five zero zero.		
1836:25 UTC [0236:25 MYT] KL ACC	One five zero zero at what time please.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1836:28 UTC [0236:28 MYT] MAS Operations	At one eight three three five six.		
1836:30 UTC [0236:30 MYT] KL ACC	One eight three three huh.		
1836:32 UTC [0236:32 MYT] MAS Operations	Auh.		
1836:32 UTC [0236:32 MYT] KL ACC	Okay this is the position aircraft passed by one eight three three uh.		
1836:36 UTC [0236:36 MYT] MAS Operations	Huh		
1836:37 UTC [0236:37 MYT] KL ACC	Okay aah… this one let them call okay and daaadvise okay you try to raise the aircraft and then like aah… I mean to reply you whether they are eer… contact any of the ATC unit along unit or not.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1836:55 UTC [0236:55 MYT] MAS Operations	Alright.		
1836:56 UTC [0236:56 MYT] KL ACC	Okay please thank you.		
1837:00 UTC [0237:00 MYT]	Tone of telephone cut off too too too.		
	End of Direct Line Conversation Between KL ACC and MAS Operations Centre		
1837:15 UTC [0237:15 MYT]	Direct line ringing tone.		
1837:21 UTC 0237:21 MYT] KL ACC	They will try ***[back ground conversation]***		
1837:24 UTC [0237:24 MYT] KL ACC	Aircraft still flying it seem [back ground conversation]		
1837:25 UTC [0237:25 MYT]	**Telephone ringing at this time.**		

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1837:34 UTC [0237:34 MYT] HCM ACC	Yes.		
1837:35 UTC [0237:35 MYT] KL ACC	Okay Ho Chi Minh.		
1837:36 UTC [0237:36 MYT] HCM ACC	Sir.		
1837:37 UTC [0237:37 MYT] KL ACC	The… Malaysian Three Seven Zero.		
1837:40 UTC [0237:40 MYT] HCM ACC	Yes.		
1837:41 UTC [0237:41 MY] KL ACC	Okay aircraft is eer… still flying and then keep on sending position report to the company.		
1837:49 UTC [0237:49 MYT] HCM ACC	Yeah.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1837:49 UTC [0237:49 MYT] KL ACC	Okay.		
1837:50 UTC [0237:50 MYT] HCM ACC	The aircraft is landing at (xxxx) [illegible]		
1837:52 UTC [0237:52 MYT] KL ACC	Say again.		
1837:53 UTC [0237:53 MYT] HCM ACC	Say again say again for Malaysian Three Seven Zero.		
1837:56 UTC [0237:56 MYT] KL ACC	Affirm Malaysian Three Seven Zero still flying aircraft keep sending position report to the airline okay to the company okay it last at time one eight three three at time one eight three three aircraft passed position one eer… one four nine zero zero zero zero.		
1838:18 UTC [0238:18 MYT] HCM ACC	Yes.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1838:19 UTC [0238:19 MYT] KL ACC	And the… one zero nine east one five zero zero.		
1838:25 UTC [0238:25 MYT] HCM ACC	Five zero zero.		
1838:26 UTC [0238:26 MYT] KL ACC	Yeah affirm.		
1838:27 UTC [0238:27 MYT] HCM ACC	Say again the first one, one four nine.		
1838:29 UTC [0238:29 MYT] KL ACC	One four nine zero zero zero zero.		
1838:31 UTC [0238:31 MYT] HCM ACC	Yes and one zero nine east and one five zero zero at time one eight three three.		
1838:36 UTC [0238:36 MYT] KL ACC	Affirm.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1838:38 UTC [0238:38 MYT] HCM ACC	Alright okay thank you information we check position.		
1838:40 UTC [0238:40 MYT] KL ACC	Okay right thank you.		
	Direct Line Telephone Conversation Between KL ACC and HCM ACC		
		1840:30 UTC [0240:30 MYT] MAS 6163	Malaysian Six One Six Three request descend.
		1840:36 UTC [0240:36 MYT] Lumpur Radar	Malaysian Six One Six Three descend flight level three five zero.
		1840:40 UTC [0240:40 MYT] MAS 6163	When ready descend now to flight level three five zero Malaysian Six One Six Three.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1843:01 UTC [0243:01 MYT] MAS 6163	Malaysian naa Six One Six Three leaving three six zero for flight level three five zero.
		1843:09 UTC [0243:09 MYT] Lumpur Radar	Malaysian Six One Six Three.
		1844:19 UTC [0244:19 MYT] Lumpur Radar	Malaysian Six One Six Three descend to flight level one six zero.
		1844:25 UTC [0244:25 MYT] MAS 6163	K Continue descend now to flight level one six zero Malaysian Six One Six Three.
		1844:30 UTC [0244:30 MYT] OCA 404	Air Asian Four Zero Four contact Bangkok one two three decimal niner five.
		1844:34 UTC [0244:34 MYT] OCA 404	One two three nine five Four Zero Four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1849:17 UTC [0249:17 MYT] GIA 894	Singapore good morning Indonesia Eight Niner Four flight level three six zero.
		1849:28 UTC [0249:28 MYT] Lumpur Radar	Station calling say again.
		1849:30 UTC [0249:30 MYT] GIA 894	Indonesia Eight Niner Four eer… Flight level three six zero.
		1849:36 UTC [0249:36 MYT] Lumpur Radar	Indonesia Eight Niner Four position please.
		1849:39 UTC [0249:39 MYT] GIA 894	We are just approaching DOGOG sir Indonesia Eight Niner Four squawk seven one one four.
		1849:49 UTC [0249:49 MYT] Lumpur Radar	Indonesia Eight Niner Four say again your squawk number.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1849:53 UTC [0249:53 MYT] GIA 894	Squawk seven one one four Indonesia Eight Niner Four.
		1849:57 UTC [0249:57 MYT] Lumpur Radar	Roger Indonesia Eight Niner Four wrong frequency sir and this is Kuala Lumpur.
		1850:04 UTC [0250:04 MYT] GIA 894	Okay Indonesia Eight Niner Four thank you.
		1852:46 UTC [0252:46 MYT] MAS 6163	Approaching flight level one six zero.
		1852:49 UTC [0252:49 MYT] Lumpur Radar	Malaysian Six One Six Three contact Butterworth one two five decimal eight.
		1852:53 UTC [0252:53 MYT] MAS 6163	Five eight Malaysian Six One Six Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1853:48 UTC [0253:48 MYT] MAS 386	Malayisan Three Seven Zero this is Malaysian Three Eight Six.		
1854:02 UTC [0254:02 MYT] MAS 386	Malayisan Three Seven Zero this is Malaysian Three Eight Six.		
1854:14 UTC [0254:14 MYT] Lumpur Radar	Malaysian Three Eight Six eer… this is Lumpur Radar confirm you are trying to call Malaysian Three Seven Zero.		
1854:21 UTC [0254:21 MYT] MAS 386	That is affirm sir eer because Ho Chi Minh asked us to contact them they have lost contact eer… with them.		
1854:28 UTC [0254:28 MYT] Lumpur Radar	Yeah okay affirm already transfer to Ho Chi Minh and Ho Chi Minh negative contact with the aircraft eer please try to raise the aircraft on maybe on emergency frequency.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1854:39 UTC [0254:39 MYT] MAS 386	Roger we try one two one five eer… now we try on one two three four five, thank you.		
1854:52 UTC [0254:52 MYT] Lumpur Radar	Malaysian Three Eight Six Lumpur.		
		1904:24 UTC [0304:24 MYT] SLK 937	Lumpur Control very good morning Silk Air Nine Three Seven flight level three nine zero approaching Victor Kilo Bravo squawk one five one three.
		1904:38 UTC [0304:38 MYT] Lumpur Radar	Silk Air Niner Three Seven Lumpur Radar identified maintain level three nine zero.
		1904:44 UTC [0304:44 MYT] SLK 937	Silk air Nine Three Seven roger.
		1909:36 UTC [0309:36 MYT] CEB 502	Lumpur Radar good morning Cebu Five Zero Two squawk two one four three climbing level one eight zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1909:45 UTC [0309:45 MYT] Lumpur Radar	Cebu Five Zero Two good morning climb level two niner zero direct Victor Papa Kilo.
		1909:53 UTC [0309:53 MYT] CEB 502	Climb level two niner zero and daa…say again the direct waypoint sir.
		1909:59 UTC [0309:59 MYT] Lumpur Radar	Cebu Five Zero Two direct Victor Papa Kilo.
		1910:02 UTC [0310:02 MYT] CEB 502	Track direct Victor Papa Kilo aah Five Zero Two.
		1912:40 UTC [0312:40 MYT] GEC 530	Lumpur eer good evening German Cargo Five Three Zero flight level three five zero.
		1912:56 UTC [0312:56 MYT] GEC 530	Lumpur good evening German Cargo Five Three Zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1913:04 UTC [0313:04 MYT] Lumpur Radar	Station calling standby.
		1913:16 UTC [0313:16 MYT] Lumpur Radar	German Cargo Five Zero Two confirm squawk and level.
		1913:20 UTC [0313:20 MYT] GEC 530	Squawking six one one seven and level, level at three five zero approaching ah ah Victor Kilo Barvo German Cargo Five Three Zero.
		1913:28 UTC [0313:28 MYT] Lumpur Radar	German Cargo Three Five Zero identified maintain level three five zero.
		[1913:32 UTC] [0313:32 MYT] GEC 530	Maintain level three five zero German Cargo Three Five Zero.
		1917:33 UTC [0317:33 MYT] CES 540	Lumpur Radar good morning China Eastern Five Four Zero climb level one eight zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1917:51 UTC 0317:51 MYT CES 540	Lumpur Radar morning China Eastern Five Four Zero.
		1918:00 UTC [0318:00 MYT] CES 540	Lumpur Approach Five Four Zero.
		1918:07 UTC [0318:07 MYT] Lumpur Radar	(xxxx) [illegible] Five four Zero stanby.
		1918:09 UTC [0318:09 MYT] Source unknown	(xxxx) [illegible]
		1918:13 UTC [0318:13 MYT] Lumpur Radar	(xxxx) [illegible] Five Four Zero eer climb to two five zero.
		1918:18 UTC [0318:18 MYT] CES 540	Confirm level two five zero China Air Five Four Zero.
		1918:22 UTC [0318:22 MYT] Lumpur Radar	Affirm direct Victor Papa Kilo.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1918:25 UTC [0318:25 MYT] CES 540	Two five zero thank you.
		1920:06 UTC [0320:06 MYT] Lumpur Radar	China Eastern Five Four Zero climb flight level two niner zero.
		1920:10 UTC [0320:10 MYT] CES 540	Level two niner zero China Five Four Zero.
		1920:13 UTC [0320:13 MYT] Lumpur Radar	Cebu Five Zero Three contact Singpore one two three decimal seven.
		1920:18 UTC [0320:18 MYT] CEB 503	One two three decimal seven good day.
		1922:17 UTC [0322:17 MYT] CES 540	Lumpur Radar China Eastern Five Four Zero.
		1922:20 UTC [0322:20 MYT] Lumpur Radar	China Eastern Five Four Zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1922:23 UTC [0322:23 MYT] CES 540	China Eastern request direct to Victor Papa Kilo.
		1922:28 UTC [0322:28 MYT] Lumpur Radar	China Eastern Five Four Zero direct Victor Papa Kilo approved.
		1922:32 UTC [0322:32 MYT] Lumpur Radar	Approved China Eastern Five Four Zero.
		1930:55 UTC [0330:55 MYT] Lumpur Radar	China Eastern Five Four Zero contact Singapore one two three decimal seven.
		1931:00 UTC [0331:00 MYT] CES 540	Comfirm (xxxx) [illegible] China Five Four Zero.
		1931:03 UTC [0331:03 MYT] Lumpur Radar	China Eastern Five Four Zero affirm one two three seven good day.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1931:06 UTC [0331:06 MYT] CES 540	One two three seven China Eastern Five Four Zero.
		1932:40 UTC [0332:40 MYT] Lumpur Radar	Silk Air Nine Three Seven contact Singapore one two three decimal seven.
		1932:50 UTC [0332:50 MYT] Lumpur Radar	Silk Air Nine Three Seven contact Singapore one two three seven.
		1932:54 UTC [0332:54 MYT] SLK 937	Three seven Silk Air Nine Three Seven bye bye.
		1932:56 UTC [0332:56 MYT] Lumpur Radar	Bye bye.
		1933:52 UTC [0333:52 MYT] AXA 377	Lumpur Control good morning Xanadu Three Seven Seven flight level three six zero squawk two six three six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1933:59 UTC [0333:59 MYT] Lumpur Radar	Xanadu Three Seven Seven identified direct Nipah for Nipah Three Alpha Arrival Three Two Right and naa… for Istan Transition level three six zero.
		1934:12 UTC [0334:12 MYT] AXA 377	Clear to Lumpur aah for Istan Transition Nipah Three Two Right and aah maintain flight level three six zero, request descend.
		1934:20 UTC [0334:20 MYT] Lumpur Radar	Xanadu Three Seven Seven aah Traffic crossing on your eer on your right standby,
		1934:25 UTC [0334:25 MYT] AXA 377	Roger copied,
		1936:24 UTC [0336:24 MYT] GEC 530	German Cargo Five Three Zero request desend,
		1936:30 UTC [0336:30 MYT] Lumpur Radar	German Cargo Five Three Zero standby,

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
			Lumpur Sector 3+5 calling Singapore on Direct Line
		1936:40 UTC [0336:40 MYT] Singapore ACC	Lumpur Singapore.
		1936:41 UTC [0336:41 MYT] KL ACC	Aah German Cargo Five Three Zero can desend now.
		1936:44 UTC [0336:44 MYT] Singapore ACC	Can naa descend to flight level two niner zero.
		1936:46 UTC [0336:46 MYT] KL ACC	Two nine zero thank you.
			END OF DIRECT LINE COMMUNICATION
		1936:50 UTC [0336:50 MYT] Lumpur Radar	Cargo Five Three Zero descend to flight level two niner zero.
		1936:55 UTC [0336:55 MYT] GEC 530	Descend to flight level two nine zero German Cargo Five Three Zero.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1936:59 UTC [0336:59 MYT] Lumpur Radar	Affirm.
		1937:32 UTC [0337:32 MYT] Lumpur Radar	Xanadu Three Seven Seven desend to flight level one niner zero.
		1937:37 UTC [0337:37 MYT] AXA 377	Flight level one niner zero Xanadu Three Seven Seven.
		1938:03 UTC [0338:03 MYT] Lumpur Radar	German Cargo Five Three Zero contact Singapore now one two three seven.
		1938:08 UTC [0338:08 MYT] GEC 530	Three seven German Cargo Five Three Zero good night.
		1938:12 UTC [0338:12 MYT] Lumpur Radar	Good night.
		1942:13 UTC [0342:13 MYT] Lumpur Radar	Three Seven Seven descend to flight level one five zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1942:16 UTC [0342:16 MYT] AXA 377	Confirm desend to flight level one five zero for Xanadu Three Seven Seven.
		1942:20 UTC [0342:20 MYT] Lumpur Radar	Xanadu Three Seven Seven affirm descend one five zero.
		1942:24 UTC [0342:24 MYT] AXA 377	Roger descend to flight level one five zero Xanadu Three Seven Seven.
		1942:50 UTC [0342:50 MYT] SLK 509	Lumpur Control Silk Air Five Zero Niner good morning.
		1942:54 UTC [0342:54 MYT] Lumpur Radar	Silk Air Five Zero Nine morning confirm squawk.
		1942:58 UTC [0342:58 MYT] SLK 509	Squawk seven four zero two flight level three nine zero Victor Kilo Bravo.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1943:04 UTC [0343:04 MYT] Lumpur Radar	Five Zero Nine identified maintain three nine zero.
		1943:07 UTC [0343:07 MYT] SLK 509	Flight level three nine zero Silk Air Five Zero Nine.
		1945:18 UTC [0345:18 MYT] AXA 377	Xanadu Three Seven Seven request lower.
		1945:24 UTC [0345:24 MYT] Lumpur Radar	Xanadu Three Seven Seven contact Approach one two one two five.
		1945:28 UTC [0345:28 MYT] AXA 377	One two one two five Xanadu Three Seven Seven.
		1945:52 UTC [0345:52 MYT] TAX 5094	Good morning Jonathan Five Zero Nine Four passing flight level two six seven for flight level two eight zero squawk two two one zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		1946:06 UTC [0346:06 MYT] Lumpur Radar	Five Zero Nine Four Five Zero Nine climb to flight level three four zero.
		1946:14 UTC [0346:14 MYT] TAX 5094	Climb to flight level three four zero Jonathan Five Zero Nine Four.
	Radar direct line ringing Background talking by Sector 3+5 Radar Controller		
1948:46 UTC [0348:46 MYT] KL ACC	One seven one seven (bukan aku punya) [National Language]		
1948:52 UTC [0348:52 MYT] HCM ACC	Kuala Lumpur Ho Chi Minh.		
1948:53 UTC [0348:53 MYT] KL ACC	Ho Chi Minh regarding the Malaysian Three Seven Zero earlier any any any news from the aircraft.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1949:02 UTC [0349:02 MYT] HCM ACC	Until now nothing.		
1949:04 UTC [0349:04 MYT] KL ACC	Nothing aa so far because aircaft suppose to pass IGARI at time two two IGARI two two so far you negative contact at all with the aircraft.		
1949:15 UTC [0349:15 MYT] HCM ACC	Standby.		
1949:16 UTC [0349:16 MYT] KL ACC	You check with adjacent FIR.		
1949:20 UTC [0349:20 MYT] HCM ACC	Sorry.		
1949:21 UTC [0349:21 MYT] KL ACC	Aah…. Halo.		
1949:22 UTC [0349:22 MYT] HCM ACC	Yeah.		

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1949:23 UTC [0349:23 MYT] KL ACC	Yeah regarding the Malaysian Three Seven Zero earlier.		
1949:26 UTC [0349:26 MYT] HCM ACC	Yeah.		
1949:27 UTC [0349:27 MYT] KL ACC	Yeah is there any news (dia punya dia punya) [National Language] aircraft.		
1949:32 UTC [0349:32 MYT] HCM ACC	Sorry news.		
1949:33 UTC [0349:33 MYT] KL ACC	News you have anything about the aircraft.		
1949:34 UTC [0349:34 MYT] HCM ACC	Yeah we don't have any information until now.		
1949:37 UTC [0349:37 MYT] KL ACC	Ya informtion that aircraft supposed to pass IGARI time two two aah.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1949:42 UTC [0349:42 MYT] HCM ACC	Sorry.		
1949:43 UTC [0349:43 MYT] KL ACC	Suppose to pass IGARI one seven two two estimate IGARI one seven two two earlier.		
1949:49 UTC [0349:49 MYT] HCM ACC	Yeah.		
1949:50 UTC [0349:50 MYT] KL ACC	Can you check with the adjacent FIR is the aircraft is going to Beijing.		
1949:55 UTC [0349:55 MYT] HCM ACC	Ah… ah...Oh yes I, I after position naa… we have no information and no contact the aircraft at position naaa… IGARI and then about few minutes later the aircraft disappear our radar.		
1950:08 UTC [0350:08 MYT] KL ACC	There there there is the aircraft whether whether contact with you aa… I mean aaa.		

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1950:16 UTC [0350:16 MYT] HCM ACC	We just see him on the radar screen one time and after a few minutes later disappear.		
1950:21 UTC [0350:21 MYT] KL ACC	After ah… after ah a few minutes later disappear.		
1950:26 UTC [0350:26 MYT] HCM ACC	Yeah.		
1950:27 UTC [0350:27 MYT] KL ACC	Okay then so far you have no news about the aircraft.		
1950:31 UTC [0350:31 MYT] HCM ACC	Yeah until now we ask many aircraft company or the aircraft on frequency but no response no one ah… know about Malaysian Three Seven Zero until now.		
1950:42 UTC [0350:42 MYT] KL ACC	No one know okay actually by the routing aa after IGARI how is tracking to which FIR which FIR he will be going.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1950:51 UTC [0350:51 MYT] HCM ACC	Yeah Sanya.		
1950:53 UTC [0350:53 MYT] KL ACC	Ah… aah…		
1950:54 UTC [0350:54 MYT] HCM ACC	Yeah, Chinese Sanya Chinese.		
1950:56 UTC [0350:56 MYT] KL ACC	Sanya Chinese can you check with them whether they are is there,		
1950:59 UTC [0350:59 MYT] HCM ACC	I asked already, I already untill now no response from him.		
1951:02 UTC [0351:02 MYT] KL ACC	Okay no response okay in that case if anything you got any news on this thing because operations is asking if you got any news you give me or you just inform Lumpur.		

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1951:12 UTC [035112 MYT] HCM ACC	Yeah sure.		
1951:13 UTC [0351:13 MYT] KL ACC	And so so so the the the you have taken immediate action about the aircraft, you taken any action about the aircraft,		
1951:22 UTC [035122 MYT] HCM ACC	Taking,		
1951:23 UTC [0351:23 MYT] KL ACC	Action action what what action are you taking with regarding the aircraft,,		
1951:27 UTC [035127 MYT] HCM ACC	Aah… currently we are try to coordination with Sanya about the information because the time transfer, flight level,		
1951:36 UTC [0351:36 MYT] KL ACC	Aaah …		

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1951:37 UTC [0351:37 MYT] HCM ACC	And we have information to the Sunny nothing.		
1951:41 UTC [0351:41 MYT] KL ACC	Okay okay if there is anything you advise Lumpur please aah…		
1951:44 UTC [0351:44 MYT] HCM ACC	Yeah.		
1951:45 UTC [0351:45 MYT] KL ACC	Okay okay we will keep in touch thank you.		
	End Of Direct Line Telephone Conversation Between KL ACC (Sector 3+5) with HCM ACC		
	Direct Line Telephone Conversation Between KL ACC (Sector 3+5) And MAS Operations		
1956:13 UTC [0356:13 MYT] KL ACC	Dailing Direct Telephone Line.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1956:19 UTC [0356:19 MYT] KL ACC	(Satu dua Enam Empat) [National Language]		
1956:22 UTC [0356:22 MYT]	Direct Telephone ringing		
1956:27 UTC [0356:27 MYT] MAS Operations	Hello selamat pagi[National Language]		
1956:29 UTC [0356:29 MYT] KL ACC	Pagi [National Language] Operation Centre here.		
1956:31 UTC [0356:31 MYT] MAS Operations	Centre yeah Centre.		
1956:32 UTC [0356:32 MYT] KL ACC	Is there anything on any news on Mal Malaysian Three Seven Zero.		
1956:35 UTC [0356:35 MYT] MAS Operations	Not yet laa sir.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1956:36 UTC [0356:36 MYT] KL ACC	Not yet.		
1956:37 UTC [0356:37 MYT] MAS Operations	Aah… takdak lagi [National Language]		
1956:38 UTC [0356:38 MYT] KL ACC	Masa I check with Ho Chi Minh we we can check with Ho Chi Minh laa.. Ho Chi Minh kata takdak dia pun tak contact tapi at one time dia kata nampak blip tau. [National Language]		
1956:45 UTC [0356:45 MYT] MAS Operations	Nampak bling. [National Language]		
1956:46 UTC [0356:46 MYT] KL ACC	Aah… dia nampak blip aaa... IGARI side la kan. [National Language]		
1956:50 UTC [0356:50 MYT] MAS Operations	IGARI side lah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1956:51 UTC [0356:51 MYT] KL ACC	Aah dia kata last last itu nampak blip tetapi [National Language]		
1956:53 UTC [0356:53 MYT] MAS Operations	Pukul berapa itu. [National Language]		
1956:55 UTC [0356:55 MYT] KL ACC	Aaa…eeh…estimate IGARI tadi lebih kurang pukul pukul satu dua puluh lima laa lebih kurang tu lah. [National Language]		
1957:01 UTC [0357:01 MYT] MAS Operations	Okay.		
1956:02 UTC [0356:02 MYT] KL ACC	Eh lepas tu dia kata nampak blip lepas tu takdak. [National Language]		
1957:06 UTC [0357:06 MYT] MAS Operations	Dalam monitor dia orang masih ada lagi tak. [National Language]		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1956:08 UTC [0356:08 MYT] KL ACC	Takdak tadak dia nampak sekejap dalam monitor dia orang cakap nampak sekejap macam tu lah lebih pada tu takdak contact, no contact. [National Language]		
1957:16 UTC [0357:16 MYT] MAS Operations	Alamak. [National Language]		
1957:16 UTC [0357:16 MYT] KL ACC	Aah... itulah so saya suruh dia check dia check adjacent FIR aah so far takdak lagi no news dia kata. [National Language]		
1957:24 UTC [0357:24 MYT] MAS Operations	No news so kita orang pun try juga [National Language] I… aircraft.		
1957:28 UTC [0357:28 MYT] KL ACC	Aah.		
1957:28 UTC [0357:28 MYT] MAS Operations	Belum ada response lagi. [National Language]		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1957:30 UTC [0357:30 MYT] KL ACC	Okaylah anything you you just inform us lah aah.		
1957:32 UTC [0357:32 MYT] MAS Operations	Aah okay okay.		
1957:33 UTC [0357:33 MYT] KL ACC	Kita dapat apa apa we inform you lah. [National Language]		
1957:35 UTC [0357:35 MYT] MAS Operations	Okay okay.		
1957:36 UTC [0357:36 MYT] KL ACC	Eer okay okay right.		
1957:37 UTC [0357:37 MYT] MAS Operations	Siapa cakap ni [National Language]		
1957:37 UTC [0357:37 MYT] KL ACC	Aaa... saya xxxxx sini [National Language]		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
1957:39 UTC [0357:39 MYT] MAS Operations	Okay okay.		
1957:39 UTC [0357:39 MYT] KL ACC	Okay right.		
	End of Direct Line Telephone Conversation Between KL ACC and MAS Operations Centre		
		2003:11 UTC [0403:11 MYT] Lumpur Radar	Silk Air Five Zero Niner contact Singapore one two three decimal seven.
		2003:17 UTC [0403:17 MYT] SLK 509	You are coming in broken can you say again Silk Air Five Zero Nine.
		2003:20 UTC [0403:20 MYT] Lumpur Radar	Singapore one two three decimal seven.
		2003:23 UTC [0403:23 MYT] SLK 509	One two three decimal seven good day Silk Air Five Zero Nine.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2005:19 UTC [0405:19 MYT] Lumpur Radar	Silk Air Five Zero Nine contact Singapore one two three seven good day.
		2005:26 UTC [0405:26 MYT] Jonathan 5094	Confirm Jonathan Five Zero Nine Four.
		2005:30 UTC [0405:30 MYT] Lumpur Radar	Silk Air, Silk Air Five Zero Niner Singapore one two three seven.
		2006:46 UTC [0406:46 MYT] SIA 67	Lumpur Control Singapore Six Seven good morning passing Victor Kilo Bravo zero niner flight level three seven zero squawk one two one four.
		2006:56 UTC [0406:56 MYT] Lumpur Radar	Singapore Six Seven Lumpur Radar can confirm squawk one two one four.
		2007:01 UTC [0407:01 MYT] SIA 67	Affirm Singapore Six Seven.

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2007:04 UTC [0407:04 MYT] Lumpur Radar	Singapore Six Seven identified.
		2007:07 UTC [0407:07 MYT] SIA 67	Singapore Six Seven.
		2009:22 UTC [0409:22 MYT] KAL 385	Lumpur Radar Korea Air Three Eight Five good morning maintain level three five zero.
		2009:31 UTC [0409:31 MYT] Lumpur Radar	Korean Air Three Eight Five identified direct to Nipah for Nipah Three Alpha Arrival Runway Three Two Right, descend when ready to flight level one five zero.
		2009:45 UTC [0409:45 MYT] KAL 385	Korean Air Three Eight Five confirm direct Nipah, Nipah Three Alpha and when ready one five zero, Three Two Right confirm.
		2009:55 UTC [0409:55 MYT] Lumpur Radar	Korean Air Three Eight Five that is affirm.

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2009:57 UTC [0409:57 MYT] KAL 385	Thank you.
		2011:20 UTC [0411:20 MYT] KAL 385	Lumpur Radar Korean Air Three Eight five leaving three five zero for one five zero.
		2011:25 UTC [0411:25 MYT] Lumpur Radar	Roger Three Eight Five.
		2012:15 UTC [0412:15 MYT] TAX 5094	Jonathan Five Zero Nine Four maintain flight level three four zero, approaching Victor Kilo Bravo.
		2012:30 UTC [0412:30 MYT] TAX 5094	Jonathan Five Zero Nine Four Victor Kilo Bravo.
		2012:37 UTC [0412:37 MYT] Lumpur Radar	Five Zero Nine Four call Bangkok one two three niner five.
		2012:42 UTC [0412:42 MYT] TAX 5094	One two three niner five Jonathan Five Zero Nine Four.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2015:17 UTC [0415:17 MYT] SIA 447	Lumpur Control selamat pagi Singapore Four Four Seven flight level three nine zero squawk four seven five one estimate Victor Kilo Bravo one six.
		2015:30 UTC [0415:30 MYT] Lumpur Radar	Singapore Four Four Seven identified maintain flight level three nine zero.
		2015:33 UTC [0415:33 MYT] SIA 447	Flight level three nine zero Singapore Four Four Seven.
		2015:40 UTC [0415:40 MYT] Lumpur Radar	Korean Air Three Eight Five contact Approach one two one two five.
		2015:45 UTC [0415:45 MYT] KAL 385	One two one two five Korean Air Three Eight Five good day.

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2015:48 UTC [0415:48 MYT] Lumpur Radar	Good day.
			Noise caused by static from 2016:22 until 2020:48
		2020:40 UTC [0420:40 MYT] Lumpur Radar	Singapore Six Seven Lumpur Control radio check how do you read.
		2023:42 UTC [0423:42 MYT] MAS 381	Lumpur Control Malaysian naa...Three Eight One aah good morning flight level three five zero squawk three one two seven.
		2023:51 UTC [0423:51 MYT] Lumpur Radar	Good morning Three Eight One direct to Pibos for Nipah Three Alpha Arrival Pibos Transition Three Two Left descend level one five zero.
		2023:58 UTC [0423:58 MYT] MAS 381	Direct Pibos eer... Nipah Three Alpha Arrival Three Two Right confirm and ready desend to flight level one five zero.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2024:08 UTC [0424:08 MYT] Lumpur Radar	Affirm Runway Three Two Right.
		2024:10 UTC [0424:10 MYT] MAS 381	Runway Three Two Right Malaysian Three Eight One.
	Direct Line Telephone Conversation Between KL ACC and HCM ACC		
2025:22 UTC [0425:22 MYT] KL ACC	Lumpur.		
2025:23 UTC [0425:23 MYT] HCM ACC	Yeah this is Tango Alfa Supervisor in Ho Chi MInh let me talk to your supervisor please.		
2025:28 UTC [0425:28 MYT] KL ACC	, Okay anything anything.		
2025:31 UTC [0425:31 MYT] HCM ACC	I want to talk about Malaysian Three Seven Zero you have any information from company Malaysian Airlines.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2025:37 UTC [0425:37 MYT] KL ACC	Negative, negative they are still checking also that's why I am also checking with you.		
2025:43 UTC [0425:43 MYT] HCM ACC	Negative infromation about our Malaysian Three Seven Zero from Malaysian Airlines.		
2025:48 UTC [0425:48 MYT] KL ACC	Affirm negative, negative information from the Operation negative negative information.		
2025:54 UTC [0425:54 MYT] HCM ACC	Ah okay I want to confirm the last position we have aa… contact with the aircraft.		
2026:01 UTC [0426:01 MYT] KL ACC	The last position we contact the last position we contact that was about IGARI.		
			Lumpur controller communicating with aircraft
		2026:04 UTC [0426:04 MYT] MAS 381	(xxx) [illegible] direct NIPAH (xxx) [illegible] one five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2026:06 UTC [0426:06 MYT] HCM ACC	IGARI.		
		2026:09 UTC [0426:09 MYT] Lumpur Radar	Roger Three Eight One track direct to Nipah.
2026:10 UTC [0426:10 MYT] HCM ACC	Helo.		
2026:11 UTC [0426:11 MYT] KL ACC	Helo yeah.		
		2026:12 UTC [0426:12 MYT] Lumpur Radar	Malysian Three Eight One.
2026:13 UTC [0426:13 MYT] HCM ACC	The the the Malaysian Three Seven Zero aah still in contact with you at IGARI.		

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2026:19 UTC [0426:19 MYT] KL ACC	Aah... Time ah... Still flying aah fly over over airspace … hold on aah hold on aah I still still aah the log book aah negative contact aah emm IGARI one seven two two aaa Ho Chi Minh has lost radar contact to aah one eight one zero hold on aah hold on the last the last position contact was aircraft was flying. *[Note: controller is reading the log book]* Aah I am not sure what what the last the last contact what was the time but the aircraft was I mean estimate IGARI estimate IGARI one seven two two if is there a possibility the aircraft calling you.		
2027:07 UTC [0427:07 MYT] HCM ACC	Neg negative negative.		
2027:17 UTC [0427:10 MYT] KL ACC	So what aah... you you observe on radar you observe on radar, what time was it last observed on radar.		
2027:17 UTC [0427:17 MYT] HCM ACC	Aah... After IGARI aah... The position BITOD at BITOD after disappear.		
2027:25 UTC [0427:25 MYT] KL ACC	Ooh … you you you for how how long you you		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2027:27 UTC [0427:27 MYT] MAS 381	Three Eight One leaving for one five confirm.
2027:29 UTC [0427:29 MYT] KL ACC	Hold hold on aah…		
		2027:31 UTC [0427:31 MYT] Lumpur Radar	Three Eight One roger.
2027:32 UTC [0427:32 MYT] KL ACC	So you observe aah at position BITOD, so for how long you observe the aircraft at what level.		
2027:42 UTC [0427:42 MYT] HCM ACC	Standby.		
2027:42 UTC [0427:42 MYT] KL ACC	You have any idea on it.		
2027:50 UTC [0427:50 MYT] HCM ACC	Helo.		

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2027:50 UTC [0427:50 MYT] KL ACC	Yes.		
2027:52 UTC [0427:52 MYT] HCM ACC	Aah... You said you asked about the flight level		
2027:55 UTC [0427:55 MYT] KL ACC	Ah yes, when you you observe on the radar what what level of the aircraft.		
2028:00 UTC [0428:00 MYT] HCM ACC	Three Five Zero.		
2028:01 UTC [0428:01 MYT] KL ACC	Three five zero so after that once you observe the thing and then no contact at all after that.		
2028:08 UTC [0428:08 MYT] HCM ACC	Yeah, no at IGARI we don't have the contact I just seen on the radar three five zero.		

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2028:14 UTC [0428:14 MYT] KL ACC	Ooh Three five zero.		
2028:15 UTC [0428:15 MYT] HCM ACC	And after BITOD so we… disappear the aircraft.		
2028:19 UTC [0428:19 MYT] KL ACC	The aircraft disappear from the screen so you you you try to contact through relay by another aircraft.		
2028:26 UTC [0428:26 MYT] HCM ACC	Yeah…. yeah sure all frequencies we have and and all aircraft but no reponse.		
2028:31 UTC [0428:31 MYT] KL ACC	No response even on emergency frequency no response also.		
2028:34 UTC [0428:34 MYT] HCM ACC	Yea that's all.		

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2028:36 UTC [0428:36 MYT] KL ACC	Yeah because Lumpur have no response so no contact even operation MAS operation aah... has no contact.		
2028:42 UTC [0428:42 MYT] HCM ACC	Yeah until now.		
2028:44 UTC [0428:44 MYT] KL ACC	Until now yes until now so.		
2028:46 UTC [0428:46 MYT] HCM ACC	Operation from Malaysia Malaysian Airlines.		
2028:48 UTC [0428:48 MYT] KL ACC	Yes operation from Malaysian Airlines there is no contact with the aircraft so they try they try anything I call you and so if you have anything also you inform me okay.		
2028:58 UTC [0428:58 MYT] HCM ACC	Yea…that is right.		

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2029:00 UTC [0429:00 MYT] KL ACC	Okay okay take immediate action take action then okay thank you.		
	End of Direct Line Telephone Conversation Between KL ACC and HCM ACC		
		2030:40 UTC [0430:40 MYT] SIA 67	Singapore Six Seven request descend.
		2030:44 UTC [0430:44 MYT] Lumpur Radar	Aah… Singapore Six Seven contact now one two three decimal seven.
		2030:48 UTC [0430:48 MYT] SIA 67	Confirm is one two three decimal seven.
		2030:52 UTC [0430:52 MYT] Lumpur Radar	That is affirm one two three decimal seven.
		2030:55 UTC [0430:55 MYT] SIA 67	Jumpa lagi Singapore Six Seven.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2030:57 UTC [0430:57 MYT] Lumpur Radar	See you.
		2035:12 UTC [0435:12 MYT] MAS 386	Malaysian Three Eight One approaching one five zero.
		2035:17 UTC [0435:17 MYT] Lumpur Radar	Three Eight One contact Approach on one two one decimal two five.
		2035:20 UTC [0435:20 MYT] MAS 386	One two one two five Malaysian aaa... Three Eight Six good morning.
		2035:24 UTC [0435:24 MYT] Lumpur Radar	Morning.
		2035:28 UTC [0435:28 MYT] AXM 1019	Lumpur Control good evening Express One Zero One Niner eer... Descend to flight level three six zero squawk three one three zero.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2035:37 UTC [0435:37 MYT] Lumpur Radar	One Zero One Nine Control idenitfied track direct to Pibos for Nipah Three Alpha Arrival Pibos Alpha Transition Runway Three Two Right descend to flight level one five zero.
		2035:48 UTC [0435:48 MYT] AXM 1019	Aaa when ready descend to flight level one five zero Pibos aa... Runway Three Two Right for Nipah Three Alpha Arrival, Express One Zero One Niner when available request track direct Pibos.
		2036:00 UTC [0436:00 MYT] Lumpur Radar	Roger will advise.
		2036:23 UTC [0436:23 MYT] Lumpur Radar	Singapore Four Four Seven contact Singapore now one two three decimal seven.
		2036:28 UTC [0436:28 MYT] SIA 447	Three seven Singapore Four Four Seven selamat pagi.

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2036:32 UTC [0436:32 MYT] Lumpur Radar	Pagi.
		2039:45 UTC [0439:45 MYT] GSB 304	Lumpur Radar good morning Gading Three Zero Four on the climb to level one eight zero passing one one seven squawking two one three five direct Victor Papa Kilo.
		2039:54 UTC [0439:54 MYT] Lumpur Radar	Morning Gading Three Zero Four direct Victor Papa Kilo climb two niner zero.
		2040:00 UTC [0440:00 MYT] GSB 304	Direct Victor Papa Kilo climb two niner zero Gading Three Zero Four.
		2041:22 UTC [0441:22 MYT] AXM 1019	Aah Express One Zero One Niner standing by direct Nipah.

Malaysia Time [MYT] - UTC + 8 hours
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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2041:29 UTC [0441:29 MYT] Lumpur Radar	Zero One Niner track direct to Pibos initially, I got traffic tracking direct to Victor Papa Kilo advise when clear.
		2041:37 UTC [0441:37 MYT] AXM 1019	Roger standing by.
		2042:09 UTC [0442:09 MYT] Lumpur Radar	One Zero One Nine fly heading two four zero initially.
		2042:14 UTC [0442:14 MYT] AXM 1019	Heading two four zero Express One Zero One Nine.
		2046:13 UTC [0446:13 MYT] Lumpur Radar	One Zero One Nine track direct to Nipah.
		2046:16 UTC [0446:16 MYT] AXM 1019	Track direct Nipah One Zero One Nine.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2049:28 UTC [0449:28 MYT] Lumpur Radar	Express One Zero One Nine contact Approach one two one two five.
		2049:32 UTC [0449:32 MYT] AXM 1019	One two one two five good day Express One Zero One Nine.
		2049:35 UTC [0449:35 MYT] Lumpur Radar	Day.
		2054:37 UTC [0454:37 MYT] GSB 304	Gading Three Zero Four request climb to flight level three three zero.
		2054:43 UTC [0454:43 MYT] Lumpur Radar	Three Zero Four contact Singapore now on one two three decimal seven.
		2054:47 UTC [0454:47 MYT] GSB 304	Singapore one two three decimal seven Gading Sari Three Zero Four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2054:50 UTC [0454:50 MYT] Lumpur Radar	Good day.
		2104:32 UTC [0504:32 MYT] GSB 306	Lumpur Control selamat pagi Gading Sari Three Zero Six passing one zero thousand.
		2104:37 UTC [0504:37 MYT] Lumpur Radar	Morning Gading Sari Three Zero Six climb level two seven zero direct Victor Papa Kilo.
		2104:41 UTC [0504:41 MYT] GSB 306	Seven zero direct Papa Kilo Gading Sari Three Zero Six terima kasih.
		2105:27 UTC [0505:27 MYT] Lumpur Radar	Gading Three Zero Six climb flight level two niner zero.
		2105:32 UTC [0505:32 MYT] GSB 306	Continue climb two nine zero Gading Sari Three Zero Six.

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2108:19 UTC [0508:19 MYT] SIA 345	Lumpur Singapore Three Four Five ah selamat pagi maintaining flight level three niner zero.
		2108:26 UTC [0508:26 MYT] Lumpur Radar	Singapore Three Four Five maintain flight level three niner zero.
		2108:29 UTC [0508:29 MYT] THAI 462	Thai Four Six Two flight level three eight zero.
		2108:36 UTC [0508:36 MYT] Lumpur Radar	Thai Four Six Two flight level three eight zero report TIDAR.
		2108:39 UTC [0508:39 MYT] THAI 462	Maintain three eight zero report TIDAR Thai Four Six Two.
		2113:36 UTC [0513:36 MYT] Lumpur Radar	The Thai Four Six Two contact Bangkok now one two three niner five.

TIME & SOURCE	**AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370**	**TIME & SOURCE**	**AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS**
		2113:43 UTC [0513:43 MYT] THAI 462	Bangkok one two three nine five good day Thai Four Six Two.
		2113:47 UTC [0513:47 MYT] Lumpur Radar	Good day.
		2113:51 UTC [0513:51 MYT] Lumpur Radar	Gading Sari Three Zero Five contact Singapore now one two three decimal seven.
		2113:56 UTC [0513:56 MYT] GSB 305	Singapore one two three seven (xxxx) [illegible] sir.
		2113:58 UTC [0513:58 MYT] Lumpur Radar	Aah.
	Direct Line Telephone Conversation Between KL ACC and HCM ACC		
2118:32 UTC [0518:32 MYT] KL ACC	Lumpur.		

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ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2118:34 UTC [0518:34 MYT] HCM ACC	Yeah, Lumpur any news information for Malaysian Three Seven Zero from Malaysian Airlines.		
2118:40 UTC [0518:40 MYT] KL ACC	No nothing nothing no news no news.		
2118:42 UTC [0518:42 MYT] HCM ACC	Aah nothing right.		
2118:44 UTC [0518:44 MYT] KL ACC	So how about your side is there any news from Hong Kong or Beijing any news.		
2118:48 UTC [0518:48 MYT] HCM ACC	I am waiting for them but aaa No reply right now.		
2118:52 UTC [0518:52 MYT] KL ACC	No reply naa…		
2118:53 UTC [0518:53 MYT] HCM ACC	Yeah no reply yeah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2118:54 UTC [0518:54 MYT] KL ACC	I see I see so…		
2118:55 UTC [0518:55 MYT] HCM ACC	I am waiting for them and waiting for you too.		
2118:57 UTC [0518:57 MYT] KL ACC	No I am waiting from your side also aa ah.		
2118:59 UTC [0518:59 MYT] HCM ACC	Ah ha yeah.		
2119:00 UTC [0519:00 MYT] KL ACC	Okay who ever got the news all this thing please be informed aah.		
2119:03 UTC [0519:03 MYT] HCM ACC	Yeah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	**AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370**	**TIME & SOURCE**	**AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS**
2119:04 UTC [0519:04 MYT] KL ACC	Okay okay sorry okay right.		
	End of Direct Line Telephone Conversation Between KL ACC and HCM ACC		
	RINGING AT 2120:08 UTC [0520:08 MYT] ANSWERED BY MAS OPS: 2120:16 UTC [0521:16 MYT]		
	Direct Line Telephone Conversation Between KL ACC and MAS Operation		
2120:16 UTC [0520:16 MYT] MAS Operations	Morning.		
2120:17 UTC [0520:17 MYT] KL ACC	Morning Mas ops aaa centre here any news on Eight Seven Zero.		
2120:20 UTC [0520:20 MYT] MAS Operations	Negative sir … still … we are …haa.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2120:23 UTC [0520:23 MYT] KL ACC	I see.		
2120:23 UTC [0520:23 MYT] MAS Operations	This is aaa… actually I don't know how to explain but we are under aa… mode very stressful mode down here.		
2120:35 UTC [0520:35 MYT] KL ACC	Yeah yeah yeah laa because even Ho Chi Minh.		
2120:38 UTC [0520:38 MYT] MAS Operations	Okay boss.		
2120:39 UTC [0520:39 MYT] KL ACC	Aah.		
2120:39 UTC [0520:39 MYT] MAS Operations	Just hang on my xxxx *[name redacted]* want to talk to you.		
2120:42 UTC [0520:42 MYT] KL ACC	Okay okay.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2120:44 UTC [0520:44 MYT] MAS Operations	Good morning xxx xxx *[name redacted]* here who's on the line please.		
2120:46 UTC [0520:46 MYT] KL ACC	Good morning I am xxxx *[name redacted]* here from Air Traffic Control Centre.		
2120:47 UTC [0520:47 MYT] MAS Operations	xxxx *[name redacted]* is aah xxxx *[name redacted]* on duty aa takda.		
2120:51 UTC [0520:51 MYT] KL ACC	Yeah.		
2120:52 UTC [0520:52 MYT] MAS Operations	xxxx xxxx *[name redacted]*		
2120:54 UTC [0520:54 MYT] KL ACC	xxxxx *[name redacted]* takda hari ini.		
2120:55 UTC [0520:55 MYT] MAS Operations	Takda aaa I SMS him I think he's still sleeping anyway.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2120:57 UTC [0520:57 MYT] KL ACC	haa.		
2120:58 UTC [0520:58 MYT] MAS Operations	aem... Can you please tell me.		
2121:01 UTC [0521:01 MYT] KL ACC	Aaa…		
2121:02 UTC [0521:02 MYT] MAS Operations	The aaa... (coughing) is the aircraft aaah… had a positive aaah… reply to handover to Ho Chi Minh.		
2121:12 UTC [0521:12 MYT] KL ACC	Aah… I see because I… I … took over roughly three three something I, I am not sure about it I can't say I….I can't I, I don't want to commit lah.		
2121:22 UTC [0521:22 MYT] MAS Operations	Okay.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2121:22 UTC [0521:22 MYT] KL ACC	aah.		
2121:23 UTC [0521:23 MYT] MAS Operations	fine, fair enough.		
2121:23 UTC [0521:23 MYT] KL ACC	ah but.		
2121:24 UTC [0521:24 MYT] MAS Operations	can you find out		
2121:25 UTC [0521:25 MYT] KL ACC	ah		
2121:25 UTC [0521:25 MYT] MAS Operations	with the previous controller		
2121:26 UTC [0521:26 MYT] KL ACC	ah		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2121:26 UTC [0521:26 MYT] MAS Operations	or your system record,		
2121:28 UTC [0521:28 MYT] KL ACC	aah ha		
2121:29 UTC [0521:29 MYT] MAS Operation	I suggest aaa… whatever we have here.		
2121:32 UTC [0521:32 MYT] KL ACC	hm.		
2121:33 UTC [0521:33 MYT] MAS Operations	Suggest that the aircraft had never leave Lumpur airspace, okay.		
2121:41 UTC [0521:41 MYT] KL ACC	Had never leave Lumpur airspce.		
2121:42 UTC [0521:42 MYT] MAS Operations	Yea he have not left Lumpur airspace because he has failed to call Ho Chi Minh.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2121:48 UTC [0521:48 MYT] KL ACC	Aah,		
2121:49 UTC [0521:49 MYT] MAS Operations	That's what that's what Ho Chi Minh said lah,		
2121:51 UTC [0521:51 MYT] KL ACC	hm hm hm,		
2121:51 UTC [0521:51 MYT] MAS Operations	Is it confirm or not you don't know lah,		
2121:53 UTC [0521:53 MYT] KL ACC	No I don't know but I, I check I check with Ho Chi Minh.		
2121:57 UTC [0521:57 MYT] MAS Operations	aaa.		
2121:58 UTC [0521:58 MYT] KL ACC	Aah I check with Ho Chi Minh he said he he observed on radar.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2122:04 UTC [0522:04 MYT] MAS Operations	aah…		
2122:05 UTC [0522:05 MYT] KL ACC	Somewhere BITOD the aaa… IGARI, BITOD, BITOD side that's mean under under Ho Chi minh airspace.		
2122:10 UTC [0522:10 MYT] MAS Operations	They observed it on radar until BITOD.		
2122:13 UTC [0522:13 MYT] KL ACC	Aaa… somewhere BITOD they said few seconds only there just a blip there then I, I asked him what level was the aircraft.		
2122:19 UTC [0522:19 MYT] MAS Operations	Aaa,		
2122:20 UTC [0522:20 MYT] KL ACC	Then he said level three five zero that that mean true lah, based on aaa because aircraft was flying on three five zero.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2122:26 UTC [0522:26 MYT] MAS Operations	Okay.		
2122:27 UTC [0522:27 MYT] KL ACC	Aah.		
2122:27 UTC [0522:27 MYT] MAS Operations	All the FIR further down the line,		
2122:29 UTC [0522:29 MYT] KL ACC	Aah		
2122:30 UTC [0522:30 MYT] MAS Operations	Has aah fail to pick up aaa… pick it up on radar and communication.		
2122:36 UTC [0522:36 MYT] KL ACC	Ehem.		
2122:37 UTC [0522:37 MYT] MAS Operations	So one when was the last communication Ho Chi Minh.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2122:42 UTC [0522:42 MYT] KL ACC	Ya leh last communicatin I also I can't say because based on radar now… nowaday kan…nowaday last communication whenever you talk with the aircraft we didn't we didn't put in the time the timing normally no timing no timing we ar ar ar no.		
2122:58 UTC [0522:58 MYT] MAS Operations	I suggest		
2122:59 UTC [0522:59 MYT] KL ACC	Aah		
2122:59 UTC [0522:59 MYT] MAS Operations	I suggest,		
2123:01 UTC [0523:01 MYT] KL ACC	Yes yes.		
2123:02 UTC [0523:02 MYT] MAS Operations	You get,		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2123:02 UTC [0523:02 MYT] KL ACC	I, I.		
2123:03 UTC [0523:03 MYT] MAS Operations	Try to trace back the record.		
2123:04 UTC [0523:04 MYT] KL ACC	Aaa I see, I see yeah.		
2123:05 UTC [0523:05 MYT] MAS Operations	Voice record.		
2123:06 UTC [0523:06 MYT] KL ACC	Aah.		
2123:06 UTC [0523:06 MYT] MAS Operations	Aaa what time was that positive hand over.		
2123:09 UTC [0523:09 MYT] KL ACC	Ya.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2123:10 UTC [0523:10 MYT] MAS Operations	To Ho Chi Minh because we need to know where is the aircraft you know.		
2123:13 UTC [0523:13 MYT] KL ACC	Okay okay okay I got it.		
2123:14 UTC [0523:14 MYT] MAS Operations	This this I appreciate you tell me that that the radar blip at BITOD.		
2123:18 UTC [0523:18 MYT] KL ACC	Aaaa… never mind laa I wake up my supervisor and ask him to check again to go to the room and check what what the last contact all this thing lah.		
2123:27 UTC [0523:27 MYT] MAS Operations	Yes.		
2123:27 UTC [0523:27 MYT] KL ACC	I will ask them to check la.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2123:29 UTC [0523:29 MYT] MAS Operations	Okay.		
2123:29 UTC [0523:29 MYT] KL ACC	Okay okay who is on the line?		
2123:30 UTC [0523:30 MYT] MAS Operations	Eer xxx *[name redacted]* here I'll give you my mobile number		
2123:33 UTC [0523:33 MYT] KL ACC	Aah.. hold on hold on		
2123:34 UTC [0523:34 MYT] MAS Operations	Zero one two.		
2123:34 UTC [0523:34 MYT] KL ACC	Hold on hold on yeah aaa eee hmm…. aaa…xxxxx xxxx *[name redacted]* aaa okay zero one two.		
2123:46 UTC [0523:46 MYT] MAS Operations	xxx xxx xxx *[number redacted]*		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2123:47 UTC [0523:47 MYT] KL ACC	xxx xxx xxxx *[number redacted]*		
2123:48 UTC [0523:48 MYT] MAS Operations	xxx xxx xxx xxxx *[number redacted]*		
2123:50 UTC [0523:50 MYT] KL ACC	xxx xxx xxx xxxx *[number redacted]* aah		
2123:53 UTC [0523:53 MYT] MAS Operations	Okay xxxxx *[name redacted]* how do I get you?		
2123:54 UTC [0524:54 MYT] KL ACC	Aah.. okay you keep give my centre centre number.		
2123:57 UTC [0523:57 MYT] MAS Operations	Okay what is the number please.		
2123:59 UTC [0523:59 MYT] KL ACC	Aah…hold on naa		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2124:14 UTC [0524:14 MYT] Source unknown	"Eeh eeh up up" "via Papa Kilo" *(background voice)*		
2124:18 UTC [0524:18 MYT] KL ACC	xxxxxxxx okay xxxx xxxx xxxx *[number redacted]*		
2124:24 UTC [0524:24 MYT] MAS Operations	ahm		
2124:25 UTC [0524:25 MYT] KL ACC	xxx xxx aah xxx xxx *[number redacted]*		
2124:29 UTC [0524:29 MYT] MAS Operations	Sorry xxx xxx xxx *[number redacted]*		
2124:30 UTC [0524:30 MYT] KL ACC	xxx xxx xxx xxx xxx *[number redacted]* hold on hold on.		
		2124:33 UTC [0524:33 MYT] JSA 20	Lumpur good morning Jet Airways Two Zero flight level three seven zero squawk zero five one five

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2124:38 UTC [0524:38 MYT] KL ACC	Hold on aah *Controller answering aircraft's transmission*		
		2124:39 UTC [0524:39 MYT] Lumpur Radar	Jets Airway Two Zero Control morninng identified maintain level three seven zero.
		2124:43 UTC [0524:43 MYT] JSA 20	Maintain three seven zero Jets Airway Two Zero.
2124:49 UTC [0524:49 MYT] KL ACC	Aaa halo		
2124:50 UTC [0524:50 MYT] MAS Operations	Ya		
2124:51 UTC [0524:51 MYT] KL ACC	Halo xxx xxx xxx xxxx *[number redacted]*		
2124:53 UTC [0524:53 MYT] MAS Operations	xxx xxx xxx xxx *[number redacted]*		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2124:54 UTC [0524:54 MYT] KL ACC	xxx xxx xxx xxx *[number redacted]*		
2124:55 UTC [0524:55 MYT] MAS Operations	xxx xxx xxx xxx *[number redacted]* aah		
2124:56 UTC [0524:56 MYT] KL ACC	hm hm		
2124:58 UTC [0524:58 MYT] MAS Operations	Okay thank you.		
2124:59 UTC [0524:59 MYT] KL ACC	Okay right.		
	End of Direct Line Telephone Conversation Between KL ACC and MAS Operations Centre		
		2132:03 UTC [0532:03 MYT] SIA 345	Lumpur SingporeThree Four Five request descend.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2132:07 UTC [0532:07 MYT] Lumpur Radar	Singapore Three Four Five contact Singpore one two three decimal seven.
		2132:11 UTC [0532:11 MYT] SIA 345	One two three seven good day.
		2132:53 UTC [0532:53 MYT] SIA 517	Eer Lumpur Control good morning Singapore Five One seven flight level three niner zero.
		2133:00 UTC [0533:00 MYT] Lumpur Radar	Morning Singapore Five One Seven Control identfied maintain level three nine zero.
		2133:04 UTC [0533:04 MYT] SIA 517	Three nine zero Singapore Five one Seven.
	Direct Line Telephone Conversation Between KL ACC and HCM ACC		
2141:20 UTC [0541:20 MYT] KL ACC	Lumpur		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2141:21 UTC [0541:21 MYT] HCM ACC	Ho Chi Minh ACC aah any information about Malaysian Three Seven Zero from the company.		
2141:27 UTC [0541:27 MYT] KL ACC	Negative company is checking with me also and negative no no information about it no information about it so we are checking we are playing back back the tape we are we want to track back where the aircraft when was the last contact all this thing we too we play we play the tape and if there is informatin we inform you.		
2141:49 UTC [0541:49 MYT] HCM ACC	Roger.		
2141:50 UTC [0541:50 MYT] KL ACC	Okay okay then if there any from your side or from the Beiing side all this thing you inform Lumpur please.		
2141:56 UTC [0541:56 MYT] HCM ACC	Okay any information will advise you.		

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2141:59 UTC [0541:59 MYT] KL ACC	Yap, okay okay.		
	End of Direct Line Telephone Conversation Between KL ACC and HCM ACC		
		2147:38 UTC [0547:38 MYT] JSA 20	(xxxx) (xxxx) [illegible] Jets Airway Two Zero.
		2147:48 UTC [0547:48 MYT] JSA 20	Lumpur Jets Airway Two Zero.
		2147:51 UTC [0547:51 MYT] Lumpur Radar	Jets Airway Two Zero contact Singapore one two three seven for descend.
		2147:55 UTC [0547:55 MYT] JSA 20	Singapore one two three seven good day.
		2151:25 UTC [0551:25 MYT] Lumpur Radar	Singapore Five One Seven naa change squawk zero four two six and contact Singapore now one two three decimal seven.

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2151:33 UTC [0551:33 MYT] SIA 517	Squawk on zero four two six and one two three seven Singapore Five One Seven good day.
		2151:40 UTC [0551:40 MYT] Lumpur Radar	One Seven good day.
		2152:16 UTC [0552:16 MYT] Thai Piece 920	Lumpur Control Thai Peace Niner Two Zero good morning maintain three eight zero approaching Victor Papa Kilo squawk two three four two.
		2152:27 UTC [0552:27 MYT] Lumpur Radar	(xxx) (xxx) (xxx) (xxx) [illegible] Nine Two Zero control maintain three eight zero.
		2152:32 UTC [0552:32 MYT] Thai Piece 920	Maintain three eight zero Thai Peace Nine Two Zero.
		2152:36 UTC [0552:36 MYT] Lumpur Radar	Thai Peace Nine Two Zero.

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TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2153:13 UTC [0553:13 MYT] AXM 1012	Lumpur Radar Express One Zero One Two good morning climbing level one eight zero direct IGARI.
		2153:21 UTC [0553:21 MYT] Lumpur Radar	Good morning aa Express One Zero One Two Control identified climb to flight level three five zero.
		2153:26 UTC [0553:26 MYT] AXM 1012	Three five zero Asian Express One Zero One Two.
		2153:34 UTC [0553:34 MYT] AXM 1012	Asian Express One Zero One Two request direct to BITOD.
		2153:37 UTC [0553:37 MYT] Lumpur Radar	One Zero One Two track IGARI initially.
		2153:40 UTC [0553:40 MYT] AXM 1012	Asian One Zero One Seven.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
			Direct Line Telephone Conversation Between KL ACC and Singapore ACC
		2207:54 UTC [0607:54 MYT] KL ACC	Lumpur.
		2207:55 UTC [0607:55 MYT] Singapore ACC	Eer Lumpur two estimates first Malaysian Two Five Four Seven.
		2207:59 UTC [0607:59 MYT] KL ACC	Hold on hold on hold on please eer... Malaysian Two Five Four Seven go ahead.
		2208:06 UTC [0608:06 MYT] Singapore ACC	Affirm PADLI two three zero four flight level three four zero squawk two zero six three and next Malaysian Three Six One.
		2208:14 UTC [0608:14 MYT] KL ACC	Eer… (xxx) (xxx) (xxx) [illegible] Malaysian.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2208:17 UTC [0608:17 MYT] Singapore ACC	Three Six One.
		2208:18 UTC [0608:18 MYT] KL ACC	Three Six One go.
		2208:20 UTC [0608:20 MYT] Singapore ACC	TAKSU two three two seven flight level four zero zero squawk zero zero one three.
		2208:25 UTC [0608:25 MYT] KL ACC	Zero zero one three four hundred two three six seven Three Six One and…Malaysian Two Five Four Seven PADLI two zero two three zero four and two zero six three.
		2208:38UTC [0608:38 MYT] Singapore ACC	Affirm Siera Bravo.
		2208:39 UTC [0608:39 MYT] KL ACC	Okay (xxx) (xxx) [illegible] thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2209:42 UTC [0609:42 MYT] XAX 523	Kuala Lumpur Control selamat pagi Xanadu Five two Three three four niner descending three four zero transponder three six five one.
		2209:52 UTC [0609:52 MYT] Lumpur Radar	Xanadu Five Two Three Lumpur Control good morning identified Lumpur for NIPAH Three Alpha Arrival Eastan Runway Three Two Left and descend to flight level aaah one niner zero.
		2210:03 UTC [0610:03 MYT] XAX 523	NIPAH Three Alpha Arrival Eastan Transition and … Runway Three Two Left confirm you said flight level one nine zero sir, Xanadu Five Two Three.
		2210:12 UTC [0610:12 MYT] Lumpur Radar	Five Two Three affirm descend level one niner zero direct to NIPAH.
		2210:16 UTC [0610:16 MYT] XAX 523	Roger descend flight level one niner zero direct NIPAH Xanadu Five Two Three,

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2210:33 UTC [0610:33 MYT] XAX 523	Xanadu Five Two Three request high speed and aah below ten.
		2210:40 UTC [0610:40 MYT] Lumpur Radar	Five Two Three to be advised by Approach.
		2210:43 UTC [0610:43 MYT] XAX 523	Thank you Five Two Three.
		2212:41 UTC [0612:41 MYT] AXM 1034	Lumpur Radar Asian Express One Zero Three Four selamat pagi climbing flight level one eight zero passing eight thousand eight hundred.
		2212:49 UTC [0612:49 MYT] Lumpur Radar	(xxx) (xxx) [illegible] Lumpur Control good morning climb flight level two nine zero.
		2212:53 UTC [0612:53 MYT] AXM 1034	Flight level two nine zero Asian Express One Zero Three Four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2212:56 UTC [0612:56 MYT] Lumpur Radar	Zero Four and level requesting.
		2212:59 UTC [0612:59 MYT] AXM 1034	Requesting flight level Three Five Zero final Asian Express One zero Three Four.
		2213:03 UTC [0613:03 MYT] Lumpur Radar	Thanks.
			Direct Line Telephone Conversation Between KL ACC and HCM ACC
		2213:36 UTC [0613:36 MYT] HCM ACC	Helo.
		2213:37 UTC [0613:37 MYT] KL ACC	Ho Chi Minh estimate on Asian Express One Zero Three Four
			Conversation interrupted by aircraft radio transmission
		2213:41 UTC [0613:41 MYT] HCM ACC	Standby, One Zero Three Four go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
		2213:50 UTC [0613:50 MYT] KL ACC	Express One Zero Three Four estimate IGARI two two five……eight flight level three five zero squawk two one two one.
		2214:03 UTC [0614:03 MYT] HCM ACC	Asian Express One Zero Three Four IGARI aa two two five eight level three five zero approved squawk two one two one.
		2214:11 UTC [0614:11 MYT] KL ACC	Affirm and tranfer level three five zero.
2214:13 UTC [0614:13 MYT] KL ACC	and anyway your aah SAR you activated your SAR room.		
2214:18 UTC [0614:18 MYT] HCM ACC	Yes standby.		
2214:26 UTC [0614:26 MYT] HCM ACC	Yap.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2214:27 UTC [0614:27 MYT] KL ACC	Halo your you’re your SAR room is act… active now.		
2214:31 UTC [0614:31 MYT] HCM ACC	Aah … for Malaysian Three Seven Zero.		
2214:33 UTC [0614:33 MYT] KL ACC	Affirm affirm Malaysian Three Seven Zero is it activate your your SAR your SAR search and rescue is it activated uuh.		
2214:41 UTC [0614:41 MYT] HCM ACC	Estimated.		
2214:42 UTC [0614:42 MYT] KL ACC	Negative is it aah… you aah… you activated your SAR room or not you open up your your..		
2214:49 UTC [0614:49 MYT] HCM ACC	I am not understand you say confirm you have any information about it.		

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2214:52 UTC [0614:52 MYT] KL ACC	Neg… negative negative we don't have any information so at the moment we activate we activate our SAR Room now.		
2215:00 UTC [0615:00 MYT] HCM ACC	SAR SAR Room.		
2215:01 UTC [0615:01 MYT] KL ACC	SAR Search and Rescue, Search and Rescue.		
2215:05 UTC [0615:05 MYT] HCM ACC	Ah yes you know on search and rescue		
2215:07 UTC [0615:07 MYT] KL ACC	Aaah..		
2215:08 UTC [0615:08 MYT] HCM ACC	Yeah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - MAS 370	TIME & SOURCE	AIR-GROUND COMMUNICATION LUMPUR RADAR - FREQUENCY 132.6 MHz AND RADAR DIRECT LINE COMMUNICATION CONTENT - OTHER FLIGHTS
2215:09 UTC [0615:09 MYT] KL ACC	Na… naa… your your search and rescue is activate now you activated your search and rescue.		
2215:12 UTC [0615:12 MYT] HCM ACC	Ya that's right, that's right.		
2215:13 UTC [0615:13 MYT] KL ACC	I see okay okay right okay.		
	End of Direct Line Telephone Conversation Between KL ACC and HCM ACC		
	END AT 2218:00 UTC [0618:00MYT]		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
			START TIME 1620:00 UTC [0020:00 MYT]
		1620:20 UTC [0020:20 MYT] KL ACC	Lumpur Sector aah Five.
		1620:23 UTC [0020:23 MYT] Bangkok ACC	Thai Peace Nine Two One revise level three five zero.
		1620:28 UTC [0020:28 MYT] KL ACC	Thai Peace Nine Two One revise flight level three five zero confirm.
		1620:33 UTC [0020:33 MYT] Bangkok ACC	Affirm.
		1620:33 UTC [0020:33 MYT] KL ACC	Three five zero copied.
		1620:38 UTC [0020:38 MYT] KL ACC	Call you back for higher.
		1620:40 UTC [0020:40 MYT] KL ACC	Call you back for higher.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1620:42 UTC [0020:42 MYT] KL ACC	Call you back for higher Background "helo"
		1620:47 UTC [0020:47 MYT] KL ACC	*Background conversation "Mai saya buat jar ha"*
		1620:48 UTC [0020:48 MYT] KL ACC	*Background conversation " Huh huh buat lah tadi itu Bangkok bukan Singapore"*
		1620:55 UTC [0020:55 MYT] KL ACC	Helo Singapore.
		1621:05 UTC [0021:05 MYT] KL ACC	Singapore.
		1621:08 UTC [0021:08 MYT] Singapore ACC	Singapore.
		1621:08 UTC [0021:08 MYT] KL ACC	Singapore I get one estimate and one revision.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1621:11 UTC [0021:11 MYT] Singapore ACC	Go ahead revision.
		1621:12 UTC [0021:12 MYT] KL ACC	Eer okay Beach Air Nine Two One revise now Victor Papa Kilo one six five three and requesting flight level three five zero.
		1621:19 UTC [0021:19 MYT] Singapore ACC	One six five three .
		1621:21 UTC [0021:21 MYT] KL ACC	Affirm.
		1621:22 UTC [0021:22 MYT] Singapore ACC	Standby.
		1621:30 UTC [0021:30 MYT] Singapore ACC	Ah confirm transfer only three three zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1621:32 UTC [0021:32 MYT] KL ACC	Transfer only three three zero eh.
		1621:34 UTC [0021:34 MYT] Singapore ACC	Affirm.
		1621:35 UTC [0021:35 MYT] KL ACC	Okay copied and eer estimate for you Korean Air Six Seven Two.
		1621:39 UTC [0021:39 MYT] Singapore ACC	Korean Six Seven Two go ahead.
		1621:42 UTC [0021:42 MYT] KL ACC	Victor Papa Kilo one six three five requesting flight level three six zero squawk two one four one.
		1621:48 UTC [0021:48 MYT] Singapore ACC	Korean Six Seven Two Victor Papa Kilo one six three five request flight level three six zero squawk two one four one.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1621:56 UTC [0021:56 MYT] KL ACC	Affirm.
		1621:56 UTC [0021:56 MYT] Singapore ACC	Climb to flight level two nine zero.
		1621:58 UTC [0021:58 MYT] KL ACC	Two nine zero copied thank you mdm.
		1622:02 UTC [0022:02 MYT] Singapore ACC	Thank you.
		1622:07 UTC [0022:07 MYT] KL ACC	Okay reference to Thai Peace Nine Two One.
		1622:11 UTC [0022:11 MYT] Bangkok ACC	Go head.
		1622:12 UTC [0022:12 MYT] KL ACC	Okay only flight level three three zero from Singapore due traffic.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1622:16 UTC [0022:16 MYT] Bangkok ACC	Okay.
		1622:16 UTC [0022:16 MYT] KL ACC	And I got estimate helo.
		1622:21 UTC [0022:21 MYT] KL ACC	*Backgound talking* Yang nak kena ni.
		1622:25 UTC [0022:25 MYT] KL ACC	*Backgound talking* Eer tau kena tak suruh pergi Jakarta.
		1622:28 UTC [0022:28 MYT] KL ACC	Helo.
		1622:28 UTC [0022:28 MYT] Bangkok ACC	Go ahead.
		1622:29 UTC [0022:29 MYT] KL ACC	Okay one estimate and… Singapore Three Two Four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1622:34 UTC [0022:34 MYT] Bangkok ACC	Go ahead.
		1622:35 UTC [0022:35 MYT] KL ACC	Singapore Three Two Four Kota Bahru one seven one four request flight level three two zero squawk two two two seven.
		1622:42 UTC [0022:42 MYT] Bangkok ACC	Approve three zero zero.
		1622:44 UTC [0022:44 MYT] KL ACC	Three zero zero only mdm confirm three two zero not approve okay how about Singapore Three Five Two is it three two zero approve.
		1622:50 UTC [0022:50 MYT] Bangkok ACC	Expect three four zero.
		1622:51 UTC [0022:51 MYT] KL ACC	Expect three four zero climb three two zero confirm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1622:53 UTC [0022:53 MYT] Bangkok ACC	Affirm.
		1622:54 UTC [0022:54 MYT] KL ACC	Okay copied.
		1622:57 UTC [0022:57 MYT] KL ACC	Singapore Lumpur.
		1622:59 UTC [0022:59 MYT] Singapore ACC	Lumpur reference to Korean Six Seven Two.
		1623:01 UTC [0023:01 MYT] KL ACC	Go ahead.
		1623:02 UTC [0023:02 MYT] Singapore ACC	Reclear flight level two seven zero.
		1623:05 UTC [0023:05 MYT] KL ACC	Two seven zero copied mdm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1623:06 UTC [0023:06 MYT] Singapore ACC	Affirm subject to Singapore departure Singapore Three Two Four.
		1623:10 UTC [0023:10 MYT] KL ACC	Singapore Three Two Four copied.
		1623:13 UTC [0023:13 MYT] Singapore ACC	And got one estimate Global Jet Seven Six.
		1623:15 UTC [0023:15 MYT] KL ACC	Okay Singapore Three Five Two still with you.
		1623:18 UTC [0023:18 MYT] Singapore ACC	Singapore Three Five Two standby.
		1623:21 UTC [0023:21 MYT] Singapore ACC	***Background conversation*** Singapore Three Five Two still with you.
		1623:24 UTC [0023:24 MYT] Singapore ACC	Ah affirm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1623:24 UTC [0023:24 MYT] KL ACC	Okay you may climb to flight level three zero zero now and Singapore Three Two Four step climb flight level two eight zero.
		1623:30 UTC [0023:30 MYT] Singapore ACC	Three zero zero feet.
		1623:32 UTC [0023:32 MYT] KL ACC	Okay.
		1623:33 UTC [0023:33 MYT] Singapore ACC	Standby haa.
		1623:33 UTC [0023:33 MYT] KL ACC	Okay.
		1623:35 UTC [0023:35 MYT] Singapore ACC	***Background conversation*** Ah Singapore Three Five Two still with you then naa Singapore Three Two Four two eighty.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1623:40 UTC [0023:40 MYT] Singapore ACC	Ah I got estimate Global Jet Seven Six.
		1623:42 UTC [0023:42 MYT] KL ACC	Global Jet Seven Six Global Jet Seven Six eer okay go ahead.
		1623:47 UTC [0023:47 MYT] Singapore ACC	Victor Papa Kilo one seven three five request flight level four one zero squawk two zero four three.
		1623:52 UTC [0023:52 MYT] KL ACC	Two zero four three flight level four one zero approved and Victor Papa Kilo one seven three five confirm.
		1624:00 UTC [0024:00 MYT] Singapore ACC	Thank you.
		1624:00 UTC [0024:00 MYT] KL ACC	Welcome.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1626:30 UTC [0026:30 MYT] KL ACC	Helo Sector Three yes go ahead.
		1626:33 UTC [0026:33 MYT] Singapore ACC	Dess Niner Four One can you put over to me and I will climb subject to Singapore Three Five Two.
	A		
		1626:40 UTC [0026:40 MYT] KL ACC	Dess Niner Four One okay put over say again level.
		1626:46 UTC [0026:46 MYT] Singapore ACC	Eer Dess Niner Four One you can climb to flight level two nine zero and put over to me now.
		1626:50 UTC [0026:50 MYT] KL ACC	Put over to you now Dess Niner Four One eer subject to.
		1626:55 UTC [0026:55 MYT] Singapore ACC	Aah… no no I will I mean I will climb Singpore Three Five Two SUBJECT TO Dess Niner Four One.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1626:59 UTC [0026:59 MYT] KL ACC	Okay copied thank you.
		1627:01 UTC [0027:01 MYT] Singapore ACC	Thank you.
		1627:19 UTC [0027:19 MYT] Singapore ACC	Singapore.
		1627:19 UTC [0027:19 MYT] KL ACC	Okay reference to…Zest Air and Singapore Three Five Two Singapore Three Five Two you stop climb two two eight zero and transfer to us because we gay ada trafficlah Yea two eight zero.
		1627:28 UTC [0027:28 MYT] Singapore ACC	Transfer only two eight zero.
		1627:29 UTC [0027:29 MYT] KL ACC	Ya.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1627:30 UTC [0027:30 MYT] Singapore ACC	For Singapore Three Five Two.
		1627:31 UTC [0027:31 MYT] KL ACC	Three Five Two affirm.
		1627:33 UTC [0027:33 MYT] Singapore ACC	And one revision.
		1627:34 UTC [0027:34 MYT] KL ACC	Go ahead.
		1627:35 UTC [0027:35 MYT] Singapore ACC	Cebu Five Zero One.
		1627:36 UTC [0027:36 MYT] KL ACC	Say again callsign.
		1627:37 UTC [0027:37 MYT] Singapore ACC	Cebu Five Zero One.

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER
		1627:37 UTC [0027:37 MYT] KL ACC	Go ahead.
		1627:40 UTC [0027:40 MYT] Singapore ACC	Revise PADLI one seven five niner.
		1627:42 UTC [0027:42 MYT] KL ACC	One seven five niner okay copied.
		1627:46 UTC [0027:46 MYT] Singapore ACC	Thank you.
		1630:30 UTC [0030:30 MYT] KL ACC	Lumpur Sector Three.
		1630:31 UTC [0030:31 MYT] Singapore ACC	Lumpur reference to Korean Air Six Seven Two.
		1630:34 UTC [0030:34 MYT] KL ACC	Okay Korean Air Six Seven Two go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1630:37 UTC [0030:37 MYT] Singapore ACC	Reclear to flight level two niner zero no closing speed with Zest Niner Four One.
		1630:41 UTC [0030:41 MYT] KL ACC	Okay ah two niner zero okay ah no closing aa speed with Zest Niner Four One copied thank you.
		1630:50 UTC [0030:50 MYT] Singapore ACC	Thank you.
		1632:03 UTC [0032:03 MYT] KL ACC	Singapore.
		1632:04 UTC [0032:04 MYT] Singapore ACC	Lumpur Korean Air Six Seven Two you want to put over to me and I will sort with Singapore Three Two Five correction Singapore Three Two Four.
		1632:10 UTC [0032:10 MYT] KL ACC	Three Two Four eer… standby. Transfer to Lumpur ***(background voice [male])*** Ah… Singapore ah yes transfer to Lumpur.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1632:21 UTC [0032:21 MYT] Singapore ACC	Copied.
		1632:22 UTC [0032:22 MYT] KL ACC	Thank you.
1643:30 UTC [0043:30 MYT] HCM ACC	Helo.		
1643:31 UTC [0043:31 MYT] KL ACC	Kay Ho Chi Minh ah estimate Malaysian Three Seven Zero.		
1643:36 UTC [0043:36 MYT] HCM ACC	Go ahead.		
1643:37 UTC [0043:37 MYT] KL ACC	Okay estimate IGARI one seven two two request flight level three five zero and squawk two one five seven.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1643:46 UTC [0043:46 MYT] HCM ACC	Two one five seven three five zero is approved one seven two two.		
1643:50 UTC [0043:50 MYT] KL ACC	Okay copied thank you..		
		1702:14 UTC [0102:14 MYT] KL ACC	Lumpur Sector Three.
		1702:17 UTC [0102:17 MYT] Singapore ACC	Lumpur revision Cebu Five Zero One.
		1702:19 UTC [0102:19 MYT] KL ACC	Cebu Five Zero One go.
		1702:22 UTC [0102:22 MYT] Singapore ACC	Revise PADLI one seven five two.
		1702:24 UTC [0102:24 MYT] KL ACC	One seven five two copied thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1702:28 UTC [0102:28 MYT] Singapore ACC	Thank you.
		1705:16 UTC [0105:16 MYT] Singapore ACC	Singapore.
		1705:16 UTC [0105:16 MYT] KL ACC	Singapore one estimate.
		1705:18 UTC [0105:18 MYT] Singapore ACC	Go ahead.
		1705:19 UTC [0105:19 MYT] KL ACC	Xanadu Five Zero Six.
		1705:21 UTC [0105:21 MYT] Singapore ACC	Xanadu Five Zero Six go ahead.
		1705:23 UTC [0105:23 MYT] KL ACC	Victor Papa Kilo one seven two four request flight level three niner zero and squawk two one two five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1705:34 UTC [0105:34 MYT] Singapore ACC	Xanadu Five Zero Six Victor Papa Kilo one seven two four flight request flight level three niner zero squawk two one two five climb to flight level two niner zero.
		1705:43 UTC [0105:43 MYT] KL ACC	Two niner zero copied.
		1705:45 UTC [0105:45 MYT] Singapore ACC	Affirm.
		1705:46 UTC [0105:46 MYT] KL ACC	Thank you.
		1708:40 UTC [0108:40 MYT] KL ACC	Lumpur Sector Five.
		1708:42 UTC [0108:42 MYT] Bangkok ACC	Transfer Victor Kilo Bravo Thai Four Eight Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1708:46 UTC [0108:46 MYT] KL ACC	Okay aah say again callsign mdm.
		1708:48 UTC [0108:48 MYT] Bangkok ACC	Thai Four Eight Three.
		1708:51 UTC [0108:51 MYT] KL ACC	Thai Four Eight Three Victor Kilo Bravo go ahead mdm.
		1708:55 UTC [0108:55 MYT] Bangkok ACC	One eight zero five flight level three seven zero six one one four.
		1709:02 UTC [0109:02 MYT] KL ACC	Thai Four Eight Three Victor Kilo Bravo one eight zero five flight level three seven zero squawk six one one four.
		1709:10 UTC [0109:10 MYT] Bangkok ACC	Affirm next.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1709:11 UTC [0109:11 MYT] KL ACC	Go ahead mdm.
		1709:13 UTC [0109:13 MYT] Bangkok ACC	Go Cat Two Six Five Seven.
		1709:17 UTC [0109:17 MYT] KL ACC	***Background voice*** Two Six Five Seven.
		1709:20 UTC [0109:20 MYT] KL ACC	Two Six Five Seven go ahead mdm.
		1709:23 UTC [0109:23 MYT] Bangkok ACC	One eight one two flight level three three zero transponder four seven zero four.
		1709:31 UTC [0109:31 MYT] KL ACC	Okay Go Cat Two Six Five Seven Victor Kilo Bravo one eight one two flight level three three zero squawk four seven zero four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1709:40 UTC [0109:40 MYT] Bangkok ACC	Affirm.
		1709:42 UTC [0109:42 MYT] KL ACC	Thank you.
		1711:24 UTC [0111:24 MYT] Lumpur Sector 1	Sector One.
		1711:25 UTC [0111:25 MYT] Lumpur Sec 3+5	Yes Sector One busy.
		1711:26 UTC [0111:26 MYT] Lumpur Sector 1	Busy.
		1715:04 UTC [0115:04 MYT] Singapore ACC	Singapore.
		1715:06 UTC [0115:06 MYT] KL ACC	Singpore two estimates.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1715:08 UTC [0115:08 MYT] Singapore ACC	Go ahead.
		1715:09 UTC [0115:09 MYT] KL ACC	The first one Thai Four Eight Three.
		1715:13 UTC [0115:13 MYT] Singapore ACC	Thai Four Eight Three go ahead.
		1715:14 UTC [0115:14 MYT] KL ACC	Victor Papa Kilo one eight two seven flight level three seven zero and squawk six one one four.
		1715:23 UTC [0115:23 MYT] Singapore ACC	Thai Four Eight Three Victor Papa Kilo one eight two seven flight level three seven zero squawk six one one four next.
		1715:29 UTC [0115:29 MYT] KL ACC	Ah yes squawk six one one four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION — **KL ACC SECTOR 3+5 PLANNER**

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1715:33 UTC [0115:33 MYT] Singapore ACC	Squawk six one one four copied.
		1715:35 UTC [0115:35 MYT] KL ACC	Next is Go Cat Two Six Five Seven.
		1715:40 UTC [0115:40 MYT] Singapore ACC	Go Cat Two Six Five Seven go ahead.
		1715:41 UTC [0115:41 MYT] KL ACC	Victor Papa Kilo one eight three five flight level three three zero squawk four seven zero four.
		1715:49 UTC [0115:49 MYT] Singapore ACC	Go Cat Two Six Five Seven Victor Papa Kilo one eight three zero squawk four seven zero four.
		1715:56 UTC [0115:56 MYT] KL ACC	Yes read back correct.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1715:58 UTC [0115:58 MYT] Singapore ACC	Thank you.
		1715:58 UTC [0115:58 MYT] KL ACC	Thank you.
		1721:44 UTC [0121:44 MYT] KL ACC	Sector Five.
		1721:46 UTC [0121:46 MYT] Bangkok ACC	Transfer TIDAR Thai Four Six Five.
		1721:50 UTC [0121:50 MYT] KL ACC	Thai Four Six Five TIDAR.
		1721:55 UTC [0121:55 MYT] Bangkok ACC	Affirm.
		1721:57 UTC [0121:57 MYT] KL ACC	Okay go ahead mdm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1721:58 UTC [0121:58 MYT] Bangkok ACC	One eight one seven flight level three seven zero transponder six one one five.
		1722:06 UTC [0122:06 MYT] KL ACC	Okay aah… Thai Four Six Five TIDAR one eight one seven flight level three seven zerosquawk six one one five.
		1722:14 UTC [0122:14 MYT] Bangkok ACC	Affirm.
		1722:14 UTC [0122:14 MYT] KL ACC	Call you back for level mdm [male voice] Ya ah I call you back for…… level [female voice]
		1722:20 UTC [0122:20 MYT] KL ACC	*Background voice* Panggil
		1722:50 UTC [0122:50 MYT] KL ACC	Singapore.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1722:52 UTC [0122:52 MYT] KL ACC	Okay ah Singapore.
		1722:53 UTC [0122:53 MYT] Singapore ACC	Yes go ahead.
		1722:54 UTC [0122:54 MYT] KL ACC	Okay ah… Thai ah okay estimate Thai Four Six Five.
		1723:00 UTC [0123:00 MYT] Singapore ACC	Thai Four Six Five go ahead.
		1723:02 UTC [0123:02 MYT] KL ACC	TIDAR one eight one seven request flight level three seven zero squawk six one one five.
		1723:09 UTC [0123:09 MYT] Singapore ACC	Six one one five Thai Four Six Five TIDAR one eight one seven flight level three seven zero is approved and squawk six one one five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		1723:17 UTC [0123:17 MYT] KL ACC	Okay copied thank you.
		1723:19 UTC [0123:19 MYT] KL ACC	You.
		1723:30 UTC [0123:30 MYT] Bangkok ACC	(xxx) (xxx) (xxx) [illegible] [words spoken in Thai]
		1723:31 UTC [0123:31 MYT] KL ACC	Sector Five okay aah… Bangkok reference to Thai Four Six Five flight level three seven zero is approved.
		1723:40 UTC [0123:40 MYT] Bangkok ACC	Thai Four Six Five transfer to you three seven zero and…Go Cat Two Six Five Seven request flight level three five zero.
		1723:47 UTC [0123:47 MYT] KL ACC	Two Six Five Seven aah… say again.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1723:50 UTC [0123:50 MYT] Bangkok ACC	Request three five zero.
		1723:51 UTC [0123:51 MYT] KL ACC	Request three five zero.
		1723:53 UTC [0123:53 MYT] Bangkok ACC	Affirm.
		1723:54 UTC [0123:54 MYT] KL ACC	Okay standby I call you back.
		1723:56 UTC [0123:56 MYT] Bangkok ACC	Call back okay.
		1723:59 UTC [0123:59 MYT] KL ACC	Aaah…… dia tak (words spoken in National Language) [Malay Language]

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1724:12 UTC [0124:12 MYT] KL ACC	Dia tak bagi tahu lagi dia approve tak (words spoken in National Language) [Malay Language]
		1724:14 UTC [0124:14 MYT] Bangkok ACC	Yes.
		1724:15 UTC [0124:15 MYT] KL ACC	Okay Go Cat Two Six Five Seven flight level three five zero is approved.
		1724:20 UTC [0124:20 MYT] Bangkok ACC	Revised transfer three five zero thank you.
		1724:22 UTC [0124:22 MYT] KL ACC	Thank you.
		1724:33 UTC [0124:33 MYT] Singapore ACC	Singapore.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1724:34 UTC [0124:34 MYT] KL ACC	Singapore aah… level change.
		1724:38 UTC [0124:38 MYT] Singapore ACC	Yes mdm go.
		1724:39 UTC [0124:39 MYT] KL ACC	Okay aah… for Go Cat Two Six Five Seven flight level.
		1724:44 UTC [0124:44 MYT] Singapore ACC	Go ahead.
		1724:45 UTC [0124:45 MYT] KL ACC	Three five zero flight level three five zero.
		1724:49 UTC [0124:49 MYT] Singapore ACC	Three five zero for Go Cat Two Six Give Seven copied mdm thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1739:03 UTC [0139:03 MYT] KL ACC	Lumpur		
1739:06 UTC [0139:06 MYT] HCM ACC	Any information on Malaysian Three Seven Zero sir.		
1739:08 UTC [0139:08 MYT] KL ACC	Malaysian Three Seven Zero already transfer to you right		
1739:12 UTC [0139:12 MYT] HCM ACC	Yeah yeah I know at time two zero but we have no just about in contact after… BITOD we have na… radar lost with him the other one here to track identified on my radar.		
1739:24 UTC [0139:24 MYT] KL ACC	Okay at what point.		
1739:25 UTC [0139:25 MYT] HCM ACC	And no contact right now.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1739:26 UTC [0139:26 MYT] KL ACC	At what point.		
1739:27 UTC [0139:27 MYT] HCM ACC	Yea.		
1739:28 UTC [0139:28 MYT] KL ACC	At what point.		
1739:29 UTC [0139:29 MYT] HCM ACC	Yea.		
1739:30 UTC [0139:30 MYT] KL ACC	At what point you lost cotact.		
1739:33 UTC [0139:33 MYT] HCM ACC	BITODS.		
1739:34 UTC [0139:34 MYT] KL ACC	BITODS hah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1739:35 UTC [0139:35 MYT] HCM ACC	Yea.		
1739:36 UTC [0139:36 MYT] KL ACC	BITODS okay ………call you back.		
		1740:26 UTC [0140:26 MYT] Unknown	Go ahead.
		1740:26 UTC [0140:26 MYT] Unknown	You call earlier.
		1740:29 UTC [0140:29 MYT] Unknown	No.
		1740:29 UTC [0140:29 MYT] Unknown	Okay copied.
1741:10 UTC [0141:10 MYT] HCM ACC	Yap.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1741:11 UTC [0141:11 MYT] KL ACC	Hello Ho Chi Minh.		
1741:12 UTC [0141:12 MYT] HCM ACC	Yes sir.		
1741:13 UTC [0141:13 MYT] KL ACC	Okay Malaysian Three Seven Zero never call us after IGARI.		
1741:17 UTC [0141:17 MYT] HCM ACC	Eer sorry.		
1741:18 UTC [0141:18 MYT] KL ACC	Never call us after IGARI.		
1741:21 UTC [0141:21 MYT] HCM ACC	Never call you.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1741:22 UTC [0141:22 MYT] KL ACC	Yea yea after IGARI we transferred to you and aircraft never call me back.		
1741:26 UTC [0141:26 MYT] HCM ACC	Yea we have radar contact but not verbal contact until BITOD we are no ADSB identity and no radar contact.		
1741:35 UTC [0141:35 MYT] KL ACC	Eh Okay copied that.		
1741:37 UTC [0141:37 MYT] HCM ACC	Yea.		
1746:47 UTC [0146:47 MYT] KL ACC	Go ahead Lumpur.		
1746:49 UTC [0146:49 MYT] HCM ACC	Yes do you have any information from Malaysian Three Seven Zero currently.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1746:54 UTC [0146:54 MYT] KL ACC	Negative sir what information do you want.		
1746:57 UTC [0146:57 MYT] HCM ACC	Yes we just told you before la we have radar contact over IGARI not verbal contact and after BITOD we have no radar ident also ADS-B identity .		
1747:08 UTC [0147:08 MYT] KL ACC	And how about earlie.r		
1747:09 UTC [0147:09 MYT] HCM ACC	And we call him many times until naa more than 20 minutes.		
1747:14 UTC [0147:14 MYT] KL ACC	Yea how about earlier after IGARI did he call you or not.		
1747:17 UTC [0147:17 MYT] HCM ACC	Negative sir just verbal just radar contact only.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1747:22 UTC [0147:22 MYT] KL ACC	No contact since IGARI confirm.		
1747:25 UTC [0147:25 MYT] HCM ACC	Affirm.		
1747:26 UTC [0147:26 MYT] KL ACC	Okay I will try aah…… give a call and then eer… after your helo.		
1757:49 UTC [0157:49 MYT] KL ACC	Yea Ho Chi Minh.		
1757:51 UTC [0157:51 MYT] HCM ACC	Yes sir we officially no contact from Malaysian Three Seven Zero until now and we tried on many frequencies and all the airraft calling no response from Malaysian Three Seven Zero.		
1758:06 UTC [0158:06 MYT] KL ACC	Okay.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1758:06 UTC [0158:06 MYT] HCM ACC	Could you check back for your side.		
1758:08 UTC [0158:08 MYT] KL ACC	Okay we will do that and the first at IGARI did you ever in contact with the aircraft or not first place.		
1758:17 UTC [0158:17 MYT] HCM ACC	Negative sir we have radar contact only not verbal contact.		
1758:21 UTC [0158:21 MYT] KL ACC	But no when aircraft passed IGARI did the aircraft call you.		
1758:26 UTC [0158:26 MYT] HCM ACC	Negative sir.		
1758:27 UTC [0158:27 MYT] KL ACC	Negative why you didn't tell me first within five minutes you should be called me.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1758:31 UTC [0158:31 MYT] HCM ACC	After BITOD seven minute we have no radar contact then ask you.		
1758:37 UTC [0158:37 MYT] KL ACC	Okay okay we will try to call the company.		
1758:40 UTC [0158:40 MYT] HCM ACC	Yea.		
		1759:27 UTC [0159:27 MYT] KL ACC	Go ahead Singapore.
		1759:28 UTC [0159:28 MYT] Singapore ACC	Lumpur one transfer one estimate transfer Singapore departure Air China Four Zero Four.
		1759:33 UTC [0159:33 MYT] KL ACC	Air China Four Zero Four go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1759:36 UTC [0159:36 MYT] Singapore ACC	Estimating Victor Papa Kilo one eight one niner request flight level three four zero squawk two two one seven.
		1759:42 UTC [0159:42 MYT] KL ACC	Two two one seven climb initially flight level two eight zero.
		1759:46 UTC [0159:46 MYT] Singapore ACC	Two eight zero for Air China Four Zero Four next Xanadu Three Seven Seven.
		1759:51 UTC [0159:51 MYT] KL ACC	Xanadu Three Seven Seven go ahead.
		1759:53 UTC [0159:53 MYT] Singapore ACC	PADLI one niner four zero flight level four zero zero squawk two six three six.
		1759:57 UTC [0159:57 MYT] KL ACC	Two six three six flight level four zero zero, PADLI one niner four zero copied thank you mdm,

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1800:02 UTC [0200:02 MYT] Singapore ACC	Thank you.
		1800:17 UTC [0200:17 MYT] HCM ACC	Lumpur Ho Chi Minh.
		1800:18 UTC [0200:18 MYT] KL ACC	Okay estimate for you Malaysian Three Eight Six.
		1800:21 UTC [0200:21 MYT] HCM ACC	Three Eight Six yes.
		1800:22 UTC [0200:22 MYT] KL ACC	Okay IGARI one eight three six flight level three seven zero squawk two one three one.
		1800:28 UTC [0200:28 MYT] HCM ACC	Helo standby one eight three six flight aah...squawk two one three one say again the flight level.
		1800:34 UTC [0200:34 MYT] KL ACC	Three seven zero sir.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1800:36 UTC [0200:36 MYT] HCM ACC	Three seven zero okay copied.
1807:47 UTC [0207:47 MYT] KL ACC	Yea Ho Chi Minh.		
1807:48 UTC [0207:48 MYT] HCM ACC	Yeap just confirm that aircraft in Phnom Penh FIR.		
1807:52 UTC [0207:52 MYT] KL ACC	Say again.		
1807:54 UTC [0207:54 MYT] HCM ACC	The Malaysian Three Seven Zero sorry.		
1807:56 UTC [0207:56 MYT] KL ACC	Okay yeah go ahead.		
1807:59 UTC [0207:59 MYT] HCM ACC	Aah…confirm that the aircraft enter Phnom Penh FIR.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1808:04 UTC [0208:04 MYT] KL ACC	Okay from the… MAS operator the airlines from the airlines itself he said the aircraft is still flying and now is over Cambodia airspace.		
1808:14 UTC [0208:14 MYT] HCM ACC	Oh… really we call you we don't have any information before and we ask Phnom Penh Phnom Penh don't know any information Malaysian Three Seven Zero.		
1808:22 UTC [0208:22 MYT] KL ACC	Oh…he also didn't no no contact with the aircraft right.		
1808:25 UTC [0208:25 MYT] HCM ACC	Yeah.		
1808:26 UTC [0208:26 MYT] KL ACC	Okay okay I will check with my Supervisor again.		
1808:28 UTC [0208:28 MYT] HCM ACC	Thank you.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1809:26 UTC [0209:26 MYT] KL ACC	Macam macam (xxx) [illegible] (words spoken in National Language) [Malay Language]
		1809:26 UTC [0209:26 MYT] Bangkok ACC	Yes.
		1809:27 UTC [0209:27 MYT] KL ACC	Okay estimate for you Air China Four Zero Four.
		1809:30 UTC [0209:30 MYT] Bangkok ACC	Four Zero Four yes.
		1809:32 UTC [0209:32 MYT] KL ACC	Victor Kilo Bravo one eight four two flight level three four zero squawk two two one seven.
		1809:39 UTC [0209:39 MYT] Bangkok ACC	One eight four two three four zero two two one seven.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1809:43 UTC [0209:43 MYT] KL ACC	Affirm.
		1809:44 UTC [0209:44 MYT] Bangkok ACC	Thank you.
		1809:44 UTC [0209:44 MYT] KL ACC	Welcome.
		1809:57 UTC [0209:57 MYT] BUTTERWORTH	Go ahead sir.
		1809:58 UTC [0209:58 MYT] KL ACC	Estimate Malaysian Six One Six Three.
		1810:00 UTC [0210:00 MYT] BUTTERWORTH	Standby.
		1810:02 UTC [0210:02 MYT] BUTTERWORTH	Six One Six Three go.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1810:04 UTC [0210:04 MYT] KL ACC	Okay estimate Victor Papa Golf one niner one four flight level three six zero squawk six three four five.
		1810:11 UTC [0210:11 MYT] BUTTERWORTH	Six three four five thank you.
		1810:13 UTC [0210:13 MYT] KL ACC	Welcome.
		1812:01 UTC [0212:01 MYT] HCM ACC	Yeah Lumpur Ho Chi Minh.
		1812:02 UTC [0212:02 MYT] KL ACC	Okay reference to Malaysian Three Eight Six.
		1812:05 UTC [0212:05 MYT] HCM ACC	Yes.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1812:07 UTC [0212:07 MYT] KL ACC	Okay due traffic transfer to you flight level three five zero higher from Ho Chi Minh.
		1812:11 UTC [0212:11 MYT] HCM ACC	Three five zero.
		1812:12 UTC [0212:12 MYT] KL ACC	Higher from you.
		1812:13 UTC [0212:13 MYT] HCM ACC	Okay.
		1812:14 UTC [0212:14 MYT] KL ACC	Okay.
		1812:15 UTC [0212:15 MYT] HCM ACC	Okay.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1812:15 UTC [0212:15 MYT] KL ACC	And then naa Malaysian Seven Five Zero still aah… Three Seven Zero still no information from us la.		
1812:22 UTC [0212:22 MYT] HCM ACC	Ah No information.		
1812:23 UTC [0212:23 MYT] KL ACC	Yea.		
1812:26 UTC [0212:26 MYT] HCM ACC	Okay.		
		1818:07 UTC [0218:07 MYT] Singapore ACC	Singapore.
		1818:08 UTC [0218:08 MYT] KL ACC	Okay reveision Thai Four Six Five.
		1818:11 UTC [0218:11 MYT] Singapore ACC	Thai Four Six Five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1818:13 UTC [0218:13 MYT] KL ACC	Okay squawk Six One One Six.
		1818:16 UTC [0218:16 MYT] Singapore ACC	Copied.
		1818:18 UTC [0218:18 MYT] KL ACC	Right.
1818:50 UTC [0218:50 MYT] HCM ACC	Helo.		
1818:51 UTC [0218:51 MYT] KL ACC	Ho Chi Minh.		
1818:53 UTC [0218:53 MYT] HCM ACC	Liau.		
1818:53 UTC [0218:53 MYT] KL ACC	Okay the reference to Malaysian Three Seven Zero confirm you received the flight plan.		

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1819:02 UTC [0219:02 MYT] HCM ACC	Affirm.		
1819:03 UTC [0219:03 MYT] KL ACC	Okay aah… the flight plan suppose to be over Ho Chi Minh or over Cambodia.		
1819:10 UTC [0219:10 MYT] HCM ACC	Originally over Ho Chi Minh.		
1819:12 UTC [0219:12 MYT] KL ACC	Okay and then aircraft didn't enter Ho Chi Minh confirm.		
1819:18 UTC [0219:18 MYT] HCM ACC	Aaah… According to the reord the aircraft passing that position IGARI disappear radar symbol.		
1819:26 UTC [0219:26 MYT] KL ACC	Harhar.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1819:26 UTC [0219:26 MYT] HCM ACC	Naaa…five minutes … later.		
1819:30 UTC [0219:30 MYT] KL ACC	Hmm hmm.		
1819:31 UTC [0219:31 MYT] HCM ACC	Is gone and we try with many capacity to call him		
1819:36 UTC [0219:36 MYT] KL ACC	No aft after IGARI confirm after IGARI you have lost radar contact after IGARI.		
1819:44 UTC [0219:44 MYT] HCM ACC	After position BITOD.		
1819:46 UTC [0219:46 MYT] KL ACC	BITOD aircraft aaah… lost radar contact.		
1819:50 UTC [0219:50 MYT] HCM ACC	Aaah… disappeared.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1819:53 UTC [0219:53 MYT] KL ACC	Disappeared okay.		
1819:56 UTC [0219:56 MYT] KL ACC	Okay eer…		
1819:56 UTC [0219:56 MYT] HCM ACC	Yeah.		
1819:57 UTC [0219:57 MYT] KL ACC	And then…… the aircraft daa…still until now you don't have any radar contact.		
1820:02 UTC [0220:02 MYT] HCM ACC	Not at all.		
1820:04 UTC [0220:04 MYT] KL ACC	Not at all okay what about Ho Chi Minh aah… aah Cambodia.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	**DIRECT LINE COORDINATION COMMUNICATION** **KL ACC SECTOR 3+5 PLANNER** **CONTENT - MAS 370**	**TIME & SOURCE**	**DIRECT LINE COORDINATION COMMUNICATION** **KL ACC SECTOR 3+5 PLANNER** **CONTENT - OTHER FLIGHTS**
1820:09 UTC [0220:09 MYT] HCM ACC	They said they have no information.		
1820:15 UTC [0220:15 MYT] KL ACC	No information so you are takng radio failure action.		
1820:19 UTC [0220:19 MYT] HCM ACC	Pardon.		
1820:20 UTC [0220:20 MYT] KL ACC	You are taking necessary action for the aircraft.		
1820:24 UTC [0220:24 MYT] HCM ACC	Position operation.		
1820:26 UTC [0220:26 MYT] KL ACC	Those radio failure action and naa that action.		
1820:36 UTC [0220:36 MYT] HCM ACC	What do you mean by that.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1820:38 UTC [0220:38 MYT] KL ACC	No confirm that you are in contact with Malaysian Three Seven Zero now.		
1820:43 UTC [0220:43 MYT] HCM ACC	Just one time.		
1820:45 UTC [0220:45 MYT] KL ACC	Once only.		
1820:46 UTC [0220:46 MYT] HCM ACC	Once but aah… by radar symbol.		
1820:51 UTC [0220:51 MYT] KL ACC	I am asking radio contact.		
1820:55 UTC [0220:55 MYT] HCM ACC	No voice.		
1820:56 UTC [0220:56 MYT] KL ACC	No voice communi communication.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1820:58 UTC [0220:58 MYT] HCM ACC	Yeah.		
1820:59 UTC [0220:59 MYT] KL ACC	Okay and daa… so you're your advice me when you receive aah any information about this aricraft.		
1821:09 UTC [0221:09 MYT] HCM ACC	So far…is coming up three zero minutes and naa I afraid that something wrong with him but I don't know what.		
1821:21 UTC [0221:21 MYT] KL ACC	Hmm okay according to the.		
1821:23 UTC [0221:23 MYT] HCM ACC	Actually actually should be appear by radar.		
1821:27 UTC [0221:27 MYT] KL ACC	Hmm…		

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1821:28 UTC [0221:28 MYT] HCM ACC	But then naa…Ho Chi Minh naa eight zero miles from Tan Tansonnhat but is something wrong nothing.		
1821:36 UTC [0221:36 MYT] KL ACC	Nothing yet.		
1821:37 UTC [0221:37 MYT] HCM ACC	Just radar…just aa… flight plan track you know what.		
1821:41 UTC [0221:41 MYT] KL ACC	Just flight plan track only.		
1821:43 UTC [0221:43 MYT] HCM ACC	Ah ha.		
1821:44 UTC [0221:44 MYT] KL ACC	You confirm just flight plan track only.		
1821:47 UTC [0221:47 MYT] HCM ACC	Just flight plan track only.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1821:51 UTC [0221:51 MYT] KL ACC	Okay naa thank you advise me if you have any information.		
1821:56 UTC [0221:56 MYT] HCM ACC	So so so you get the just daa you contact with the his company and na I think there's some like ah the internal call.		
1822:09 UTC [0222:09 MYT] KL ACC	Aah no I already inform the company.		
1822:13 UTC [0222:13 MYT] HCM ACC	Eer… ha.		
1822:14 UTC [0222:14 MYT] KL ACC	Okay so the company already.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1822:15 UTC [0222:15 MYT] HCM ACC	What did they say.		
1822:17 UTC [0222:17 MYT] KL ACC	Nah I am not sure but the company already sent signal to the aircraft to contact relevant ATC unit.		
1822:24 UTC [0222:24 MYT] HCM ACC	Yea but aa…I would like to know after IGARI have you received any signal or any voice contact or something like aah radar symbol.		
1822:38 UTC [0222:38 MYT] KL ACC	Negative.		
1822:39 UTC [0222:39 MYT] HCM ACC	Before you transfer to me.		
1822:40 UTC [0222:40 MYT] KL ACC	Yea after after I transfer and then naa… we aa…I mean no other information after IGARI.		

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1822:49 UTC [0222:49 MYT] HCM ACC	But before IGARI before in your airspace what aa… was it work.		
1822:55 UTC [0222:55 MYT] KL ACC	It is working until IGARI.		
1822:58 UTC [0222:58 MYT] HCM ACC	Working normally.		
1823:00 UTC [0223:00 MYT] KL ACC	Affirm affirm working normal until IGARI.		
1823:03 UTC [0223:03 MYT] HCM ACC	Yea … okay okay thank you.		
1823:05 UTC [0223:05 MYT] KL ACC	Thank you.		
		1823:55 UTC [0223:55 MYT] KL ACC	Lumpur.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1823:56 UTC [0223:56 MYT] Bangkok ACC	Ah Lumpur revision for Silk Air Five Zero Nine.
		1824:00 UTC [0224:00 MYT] KL ACC	Silk Air Five Zero Niner go ahead.
		1824:03 UTC [0224:03 MYT] Bangkok ACC	Flight level three niner zero.
		1824:05 UTC [0224:05 MYT] KL ACC	Three niner zero copied.
		1830:37 UTC [0230:37 MYT] Singapore ACC	Singapore.
		1830:38 UTC [0230:38 MYT] KL ACC	Two estimate for you number one Silk Air Nine Three Seven.
		1830:42 UTC [0230:42 MYT] Singapore ACC	Silk Air Nine Three Seven go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1830:44 UTC [0230:44 MYT] KL ACC	Victor Papa Kilo one niner two niner flight level three niner zero squawk five one five one three.
		1830:50 UTC [0230:50 MYT] Singapore ACC	Silk Air Niner Three Seven Victor Papa Kilo one niner two niner flight level three niner zero squawk one five one three.
		1830:56 UTC [0230:56 MYT] KL ACC	Affirm next German Cargo Five Three Zero.
		1831:00 UTC [0231:00 MYT] Singapore ACC	German Cargo Five Three Zero go ahead.
		1831:02 UTC [0231:02 MYT] KL ACC	Victor Papa Kilo one niner three six flight level three five zero squawk six one one seven.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1831:08 UTC [0231:08 MYT] Singapore ACC	German Cargo Five Three Zero Victor Papa Kilo one niner three six flight level three five zero squawk six one one seven.
		1831:14 UTC [0231:14 MYT] KL ACC	Readback correct thank you.
		1831:15 UTC [0231:15 MYT] Singapore ACC	Thank you.
1834:56 UTC [0234:56 MYT] KL ACC	Lumpur.		
1834:59 UTC [0234:59 MYT] KL ACC	Lumpur.		
1835:01 UTC [0235:01 MYT] HCM ACC	Helo request status of Malaysian Three Seven Zero.		

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1835:03 UTC [0235:03 MYT] KL ACC	Okay go ahead.		
1835:05 UTC [0235:05 MYT] HCM ACC	Do you have any information about it.		
1835:07 UTC [0235:07 MYT] KL ACC	Eer negative yet but we are still trying to ask from MAS whether there is anyway to contact the aircraft.		
1835:17 UTC [0235:17 MYT] HCM ACC	Aah Aah could you call your company company.		
1835:23 UTC [0235:23 MYT] KL ACC	Yeah yeah…we are talking with the…my my supervisor my supervisor is talking with the airlines right now whether we can call this aircfraft in any way maybe aah…there's another frequency for us … airlines frequency or what.		
1835:40 UTC [0235:40 MYT] HCM ACC	Okay should you have any information.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1835:42 UTC [0235:42 MYT] KL ACC	Yea… yea… will advise anyway have you check with other sector the next sector.		
1835:48 UTC [0235:48 MYT] HCM ACC	Okay negative		
1835:51 UTC [0235:51 MYT] KL ACC	Aah… no nobody nobody in contact with the aircraft aah okay okay alright		
		1850:16 UTC [0250:16 MYT] KL ACC	Lumpur.
		1850:18 UTC [0250:18 MYT] Singapore ACC	Lumpur estimate Korean Air Three Eight Five.
		1850:22 UTC [0250:22 MYT] KL ACC	Korean Air……okay Three Eight Five go.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1850:28 UTC [0250:28 MYT] Singapore ACC	Affirm.
		1850:29 UTC [0250:29 MYT] KL ACC	Go ahead.
		1850:31 UTC [0250:31 MYT] Singapore ACC	PADLI two zero one four flight level three five zero squawk four one six seven.
		1850:36 UTC [0250:36 MYT] KL ACC	Four one six seven flight level three five zero, PADLI two zero one four.
		1850:40 UTC [0250:40 MYT] Singapore ACC	Thank you.
		1906:35 UTC [0306:35 MYT] KL ACC	Singapore transfer Cebu Five Zero Two.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1906:39 UTC [0306:39 MYT] Singapore ACC	Five Zero Two go ahead.
		1906:41 UTC [0306:41 MYT] KL ACC	Eer... Papa Kilo one nine two five flight level request three six zero squawk two one four three.
		1906:50 UTC [0306:50 MYT] Singapore ACC	You said one nine two five flight level.
		1906:55 UTC [0306:55 MYT] KL ACC	Three six zero November Eight Eight Four squawk two one four three.
		1907:01 UTC [0307:01 MYT] Singapore ACC	Two one four three flight level three six zero Five Zero Two climb to flight level two niner zero.
		1907:09 UTC [0307:09 MYT] KL ACC	Thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1907:11 UTC [0307:11 MYT] Singapore ACC	And I have two for you.
		1907:12 UTC [0307:12 MYT] KL ACC	Okay.
		1907:14 UTC [0307:14 MYT] Singapore ACC	Malaysian Three Eight One.
		1907:16 UTC [0307:16 MYT] KL ACC	Yea.
		1907:18 UTC [0307:18 MYT] Singapore ACC	TAXUL two two zero seven flight level three five zero three one two seven.
		1907:23 UTC [0307:23 MYT] KL ACC	Three one two seven three five zero TAXUL two two zero seven next.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1907:31 UTC [0307:31 MYT] Singapore ACC	Asian Express One One Zero Nine.
		1907:34 UTC [0307:34 MYT] KL ACC	Go ahead.
		1907:36 UTC [0307:36 MYT] Singapore ACC	TAXUL two zero four zero flight level three five zero squawk three one three zero.
		1907:41 UTC [0307:41 MYT] KL ACC	Three one three zero three five zero SABTO two zero four zero Zero One Niner thank you.
		1907:46 UTC [0307:46 MYT] Singapore ACC	Thank you.
		1919:09 UTC [0319:09 MYT] KL ACC	Lumpur.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1919:10 UTC [0319:10 MYT] Bangkok ACC	Estimate Singapore Six Seven.
		1919:12 UTC [0319:12 MYT] KL ACC	Singapore Six Seven go ahead.
		1919:15 UTC [0319:15 MYT] Bangkok ACC	Kota Bahru two zero one eight flight level three five zero squawk one two one four and next revision Singapore Four Four Seven.
		1919:24 UTC [0319:24 MYT] KL ACC	Go ahead.
		1919:25 UTC [0319:25 MYT] Bangkok ACC	Time two zero one six.
		1919:29 UTC [0319:29 MYT] KL ACC	One six and Singapore Six Seven estimate two zero one eight level three five zero squawk one two one four.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		1919:36 UTC [0319:36 MYT] Bangkok ACC	Negative two zero zero eight.
		1919:38 UTC [0319:38 MYT] KL ACC	Two zero zero eight level three five zero one two one four.
		1926:36 UTC [0326:36 MYT] KL ACC	Lumpur.
		1926:37 UTC [0326:37 MYT] Bangkok ACC	Revision Singapore Six Seven.
		1926:39 UTC [0326:39 MYT] KL ACC	Yes.
		1926:40 UTC [0326:40 MYT] Bangkok ACC	Revise final three seven zero.
		1926:42 UTC [0326:42 MYT] KL ACC	Three seven zero two zero zero eight.

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1928:03 UTC [0328:03 MYT] Singapore ACC	Lumpur Singapore.
		1928:04 UTC [0328:04 MYT] KL ACC	Three transfer Papa Kilo for you first one Silk Air Five Zero Niner.
		1928:11 UTC [0328:11 MYT] Singapore ACC	Say again Silk Air.
		1928:12 UTC [0328:12 MYT] KL ACC	Five Zero Niner.
		1928:14 UTC [0328:14 MYT] Singapore ACC	Standby.
		1928:18 UTC [0328:18 MYT] Singapore ACC	Silk Air Five Zero Niner request the flight plan detail.
		1928:23 UTC [0328:23 MYT] KL ACC	Eer Yangon to Singapore Airbus Three Twenty.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1928:29 UTC [0328:29 MYT] Singapore ACC	Eer from where to Singapore.
		1928:31 UTC [0328:31 MYT] KL ACC	Aah Victor Yankee Yankee Yankee .
		1928:36 UTC [0328:36 MYT] Singapore ACC	Standby.
		1928:43 UTC [0328:43 MYT] Singapore ACC	I select (xxx) (xxx) [illegible] Victor Papa Kilo.
		1928:45 UTC [0328:45 MYT] KL ACC	Victor Papa Kilo two zero zero five flight level three niner zero squawk seven four zero two.
		1928:53 UTC [0328:53 MYT] Singapore ACC	Seven four zero two flight level three niner zero Victor Papa Kilo two zero zero five Silk Air Five Zero Nine is it.

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		1928:59 UTC [0328:59 MYT] KL ACC	Okay next Singapore Four Four Seven.
		1929:02 UTC [0329:02 MYT] Singapore ACC	Go ahead.
		1929:03 UTC [0329:03 MYT] KL ACC	Victor Papa Kilo two zero three niner flight level three niner zero squawk four seven five one.
		1929:12 UTC [0329:12 MYT] Singapore ACC	Four seven five one flight level three niner zero Victor Papa Kilo two zero three niner Singapore Four Four Seven.
		1929:18 UTC [0329:18 MYT] KL ACC	Last one Singapore Six Seven.
		1929:20 UTC [0329:20 MYT] Singapore ACC	Go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		1929:21 UTC [0329:21 MYT] KL ACC	Two zero two zero flight level three seven zero, squawk one two one four.
		1929:28 UTC [0329:28 MYT] Singapore ACC	One two one four, flight level three seven zero, Victor Papa Kilo two zero three zero, Singapore Six Seven.
		1929:33 UTC [0329:33 MYT] KL ACC	That's all for now thank you.
		1929:36 UTC [0329:36 MYT] Singapore ACC	And Xanadu Three Seven Seven request descend can I descend to flight level three six zero.
		1929:40 UTC [0329:40 MYT] KL ACC	Three six zero roger thank you.
1930:03 UTC [0330:03 MYT] HCM ACC	Kuala Lumpur Ho Chi Minh.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1930:05 UTC [0330:05 MYT] KL ACC	Ho Chi Minh okay aa… do you have any news on Malaysian Three Seven Zero.		
1930:10 UTC [0330:10 MYT] HCM ACC	Aaa… not yet.		
1930:11 UTC [0330:11 MYT] KL ACC	Okay can you check with the next FIR Hainan.		
1930:16 UTC [0330:16 MYT] HCM ACC	Okay we are checking now with Sanya.		
1930:18 UTC [0330:18 MYT] KL ACC	Okay I advise aa… I mean aa… according to the company aircraft should be around Hainan at this time.		
1930:28 UTC [0330:28 MYT] HCM ACC	Yes.		
1930:28 UTC [0330:28 MYT] KL ACC	Okay can you check whether.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
1930:30 UTC [0330:30 MYT] HCM ACC	What daa what daa the company they said aah.		
1930:32 UTC [0330:32 MYT] KL ACC	Company said according to the flight plan daa… the what we call the departure time they don't have any information they don't have any information.		
1930:45 UTC [0330:45 MYT] HCM ACC	That according to the flight plan route.		
1930:47 UTC [0330:47 MYT] KL ACC	Flight plan route aircraft should be around Hainan at this moment.		
1930:51 UTC [0330:51 MYT] HCM ACC	Yes but you still now they not yet in contact from the aircraft.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
1930:55 UTC [0330:55 MYT] KL ACC	Okay they don't have any information can you check with Hainan whether they have any radar contact with this aircraft or any other information radio or radar contact.		
1931:04 UTC [0331:04 MYT] HCM ACC	Yes okay I will check.		
1931:07 UTC [0331:07 MYT] KL ACC	Okay and then call us back can you inform Lumpur please.		
1931:11 UTC [0331:11 MYT] HCM ACC	Yes sure if we have any information .		
1931:13 UTC [0331:13 MYT] KL ACC	Okay.		
1931:13 UTC [0331:13 MYT] HCM ACC	We call you back thank you.		

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
1931:14 UTC [0331:14 MYT] KL ACC	Okay alright thank you		
		1934:37 UTC [0334:37 MYT] KL ACC	Yeah.
		1934:38 UTC [0334:38 MYT] Singapore ACC	Lumpur transfer China Eastern Five Zero Niner Four.
		1934:41 UTC [0334:41 MYT] KL ACC	Five Zero Niner Four go ahead.
		1934:44 UTC [0334:44 MYT] Singapore ACC	Victor Papa Kilo one niner four niner request flight level three four zero squawk two two one zero.
		1934:51 UTC [0334:51 MYT] KL ACC	Two two one zero six zero one nine four nine two eight zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1935:03 UTC [0335:03 MYT] Singapore ACC	Helo.
		1935:05 UTC [0335:05 MYT] Singapore ACC	Aa helo give again the level.
		1935:07 UTC [0335:07 MYT] KL ACC	Two eight zero initially.
		1935:08 UTC [0335:08 MYT] Singapore ACC	Two eight zero.
		1936:49 UTC [0336:49 MYT] Bangkok ACC	Yes.
		1936:50 UTC [0336:50 MYT] KL ACC	Transfer Kota Bahru China Eastern Five Zero Niner Four.
		1936:54 UTC [0336:54 MYT] Bangkok ACC	Go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1936:56 UTC [0336:56 MYT] KL ACC	Baba Victor Kilo Bravo two zero one three flight level three four zero squawk two two one zero.
		1937:02 UTC [0337:02 MYT] Bangkok ACC	You are very weak say again please.
		1937:04 UTC [0337:04 MYT] KL ACC	Helo okay aa… how do you read now.
		1937:06 UTC [0337:06 MYT] Bangkok ACC	Now better.
		1937:08 UTC [0337:08 MYT] KL ACC	Kota Bahru two zero one three flight level three four zero squawk two two one zero.
		1937:13 UTC [0337:13 MYT] Bangkok ACC	Two two one zero two zero one three thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1937:16 UTC [0337:16 MYT] KL ACC	Welcome.
		1944:00 UTC [0344:00 MYT] KL ACC	Lumpur.
		1944:02 UTC [0344:02 MYT] Singapore ACC	Lumpur revision Asian Express One Zero One Niner.
		1944:05 UTC [0344:05 MYT] KL ACC	Yes.
		1944:06 UTC [0344:06 MYT] Singapore ACC	Revise flight level three seven zero.
		1944:08 UTC [0344:08 MYT] KL ACC	Three seven zero copied.
		1944:11 UTC [0344:11 MYT] Singapore ACC	Thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1949:10 UTC [0349:10 MYT] KL ACC	Lumpur Sector Five aah Sector Three.
		1949:13 UTC [0349:13 MYT] Singapore ACC	Aa estimate for Thai Four Six Two.
		1949:16 UTC [0349:16 MYT] KL ACC	Thai Four Six Two go ahead.
		1949:19 UTC [0349:19 MYT] Singapore ACC	Estimate TIDAR two one one seven flight level three eight zero squawk one three two zero.
		1949:24 UTC [0349:24 MYT] KL ACC	One seven three eight zero two one one seven TIDAR Thai Four Six Two.
		1949:30 UTC [0349:30 MYT] Singapore ACC	Correct one three two zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1949:31 UTC [0349:31 MYT] KL ACC	One three two zero copied.
		1949:34 UTC [0349:34 MYT] Singapore ACC	Thank you.
		1952:06 UTC [0352:06 MYT] Bangkok ACC	Yeah.
		1952:06 UTC [0352:06 MYT] KL ACC	TIDAR estimate Thai Four Six Two.
		1952:11 UTC [0352:11 MYT] Bangkok ACC	Four Six Two go ahead.
		1952:12 UTC [0352:12 MYT] KL ACC	Two one one seven flight level three eight zero squawk one three two zero.
		1952:17 UTC [0352:17 MYT] Bangkok ACC	One three two seven and then.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		1952:20 UTC [0352:20 MYT] KL ACC	Aaa only one.
		1952:21 UTC [0352:21 MYT] Bangkok ACC	Copied.
		1952:22 UTC [0352:22 MYT] KL ACC	Okay thank you.
		2011:45 UTC [0411:45 MYT] KL ACC	Lumpur.
		2011:46 UTC [0411:46 MYT] Bangkok ACC	Estimate Singapore Three Two Five.
		2011:49 UTC [0411:49 MYT] KL ACC	Three Two Five go.
		2011:51 UTC [0411:51 MYT] Bangkok ACC	Kota Bahru two one one one flight level three niner squawk three zero zero six and then.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
		2012:00 UTC [0412:00 MYT] KL ACC	Two Zero go ahead.
		2012:01 UTC [0412:01 MYT] Bangkok ACC	Two zero two three flight level three seven zero squawk zero five one five and then Singapore Five One Seven.
		2012:08 UTC [0412:08 MYT] KL ACC	Go.
		2012:09 UTC [0412:09 MYT] Bangkok ACC	Two one three eight flight level three nine zero.
		2012:12 UTC [0412:12 MYT] KL ACC	Standby stnadby Singapore.
		2012:13 UTC [0412:13 MYT] Bangkok ACC	Singapore Two Five.
		2012:14 UTC [0412:14 MYT] KL ACC	Singapore Two Five go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	**DIRECT LINE COORDINATION COMMUNICATION** **KL ACC SECTOR 3+5 PLANNER** **CONTENT - MAS 370**	**TIME & SOURCE**	**DIRECT LINE COORDINATION COMMUNICATION** **KL ACC SECTOR 3+5 PLANNER** **CONTENT - OTHER FLIGHTS**
		2012:17 UTC [0412:17 MYT] Bangkok ACC	Helo.
		2012:18 UTC [0412:18 MYT] KL ACC	Yea Singapore Two Five go ahead.
		2012:20 UTC [0412:20 MYT] Bangkok ACC	Negative Singapore Two Five.
		2012:21 UTC [0412:21 MYT] KL ACC	Then.
		2012:22 UTC [0412:22 MYT] Bangkok ACC	Transfer.
		2012:25 UTC [0412:25 MYT] KL ACC	The callsign.
		2012:27 UTC [0412:27 MYT] Bangkok ACC	Singapore Five One Seven.

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2012:28 UTC [0412:28 MYT] KL ACC	Singapore.
		2012:30 UTC [0412:30 MYT] Bangkok ACC	Five One Seven.
		2012:31 UTC [0412:31 MYT] KL ACC	Five One Seven go ahead Kota Bharu.
		2012:34 UTC [0412:34 MYT] Bangkok ATC	Two one three eight three five zero zero four two five.
		2012:38 UTC [0412:38 MYT] KL ACC	Two one three eight three five zero squawk again.
		2012:42 UTC [0412:42 MYT] Bangkok ACC	Zero four two five.
		2012:43 UTC [0412:43 MYT] KL ACC	Zero four two five okay thank you.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		2012:46 UTC [0412:46 MYT] Bangkok ACC	Three nine zero.
		2012:49 UTC [0412:49 MYT] KL ACC	Three nine zero okay roger.
		2016:11 UTC [0416:11 MYT]	**Direct ringing until 2016:59 UTC [0416:59 MYT]**
		2016:59 UTC [0416:59 MYT] KL ACC	Halo.
		2017:01 UTC [0417:01 MYT] Singapore ACC	(xxx) (xxx) [illegible] Malaysian Three Eight One aircraft request direct to PIBOS.
		2017:06 UTC [0417:06 MYT] KL ACC	Direct PIBOS.
		2017:09 UTC [0417:09 MYT] Singapore ACC	Sorry sir.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2017:10 UTC [0417:10 MYT] KL ACC	Aproved.
		2017:12 UTC [0417:12 MYT] KL ACC	Halo.
		2017:15 UTC [0417:15 MYT] Singapore ACC	Halo.
		2017:16 UTC [0417:16 MYT] KL ACC	Yes PIBOS approved.
		2017:18 UTC [0417:18 MYT] Singapore ACC	Thank you.
		2017:19 UTC [0417:19 MYT] KL ACC	Three transfer for you.
		2017:21 UTC [0417:21 MYT] Singapore ACC	Okay go ahead please.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2017:23 UTC [0417:23 MYT] KL ACC	Singapore Three Four Five Papa Kilo.
		2017:27 UTC [0417:27 MYT] Singapore ACC	Three Four Five yes sir go ahead please.
		2017:29 UTC [0417:29 MYT] KL ACC	Two one three three flight level three niner zero squawk three zero zero six.
		2017:37 UTC [0417:37 MYT] Singapore ACC	Squawk three zero zero six two one three three Singapore Three Four Five.
		2017:45 UTC [0417:45 MYT] KL ACC	Affirm next.
		2017:47 UTC [0417:47 MYT] Singapore ACC	Go ahead.

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER
		2017:47 UTC [0417:47 MYT] KL ACC	Jet Airway Two Zero.
		2017:50 UTC [0417:50 MYT] Singapore ACC	Jet Airway wait a second aah…
		2017:59 UTC [0417:59 MYT] Singapore ACC	Jet Airway Two Zero Victor Papa Kilo.
		2018:02 UTC [0418:02 MYT] KL ACC	Two one four six flight level three seven zero squawk zero five one five.
		2018:09 UTC [0418:09 MYT] Singapore ACC	Two four five five.
		2018:11 UTC [0418:11 MYT] KL ACC	Zero five one five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2018:14 UTC [0418:14 MYT] Singapore ACC	My error there sorry about that zero five one five flight level.
		2018:21 UTC [0418:21 MYT] KL ACC	Three seven zero.
		2018:23 UTC [0418:23 MYT] Singapore ACC	VPK two one four six flight level three even zero Jet Airway Two Zero thank you next.
		2018:29 UTC [0418:29 MYT] KL ACC	Jet Airway squawk zero five one five.
		2018:33 UTC [0418:33 MYT] Singapore ACC	Jet Airway one fivethank you.
		2018:37 UTC [0418:37 MYT] KL ACC	Negative negative Jet Airway Two Zero squawk zero five one five.

TIME & SOURCE	CONTENT - MAS 370 DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	TIME & SOURCE	CONTENT - OTHER FLIGHTS DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER
		2018:44 UTC [0418:44 MYT] Singapore ACC	Jet Airway.
		2018:50 UTC [0418:50 MYT] Singapore ACC	Jet Airway Two Zero the transponder is zero five.
		2018:54 UTC [0418:54 MYT] KL ACC	One five.
		2018:55 UTC [0418:55 MYT] Singapore ACC	Zero five one five got it now and next.
		2018:59 UTC [0418:59 MYT] KL ACC	Singapore Five One Seven.
		2019:05 UTC [0419:05 MYT] Singapore ACC	Yes sir.
		2019:06 UTC [0419:06 MYT] KL ACC	Two one five eight flight level three niner zero squawk zero four two five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2019:14 UTC [0419:14 MYT] Singapore ACC	Zero four two five flight level three nine zero VPK two one five eight Singapore Five One Seven.
		2019:23 UTC [0419:23 MYT] KL ACC	Affirm thank you.
		2019:25 UTC [0419:25 MYT] Singapore ACC	Okay thank you.
		2020:19 UTC [0420:19 MYT] KL ACC	Yeah Lumpur.
		2020:20 UTC [0420:20 MYT] Singapore ACC	Lumpur very sorry this aah Singapore Five One Seven what is the transponder again I lost from my system.
		2020:27 UTC [0420:27 MYT] KL ACC	Eer Singapore Five One Seven Papa Kilo two one five eight.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2020:34 UTC [0420:34 MYT] Singapore ACC	Sir transponder code.
		2020:35 UTC [0420:35 MYT] KL ACC	Transponder zero four two five.
		2020:38 UTC [0420:38 MYT] Singapore ACC	Okay sir thank you very much.
		2020:39 UTC [0420:39 MYT] KL ACC	Alright.
		2036:14 UTC [0436:14 MYT] KL ACC	Helo.
		2036:15 UTC [0436:15 MYT] Singapore ACC	Lumpur transfer Xanadu Five Two Three.
		2036:20 UTC [0436:20 MYT] KL ACC	Xanadu Five Two Three go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2036:24 UTC [0436:24 MYT] Singapore ACC	Xanadu Five Two Three Victor Papa Kilo two two one seven flight level three nine zero squawk three six five one.
		2036:34 UTC [0436:34 MYT] KL ACC	Three six five one okay ni next.
		2036:40 UTC [0436:40 MYT] KL ACC	Only one aah.
		2036:40 UTC [0436:40 MYT] Singapore ACC	Just wait a second aah.
		2036:46 UTC [0436:46 MYT] Singapore ACC	Xanadu VPK two two one even.
		2036:49 UTC [0436:49 MYT] KL ACC	Okay only one naa.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2036:51 UTC [0436:51 MYT] Singapore ACC	Yes sir.
		2036:52 UTC [0436:52 MYT] KL ACC	Okay transfer Papa Kilo Gading Sari Five Thre Zero Four.
		2036:57 UTC [0436:57 MYT] Singapore ACC	Gading Sari Five Thre Zero Four go ahead sir.
		2037:02 UTC [0437:02 MYT] KL ACC	Two zero five four request three three zero squawk two one three five.
		2037:09 UTC [0437:09 MYT] Singapore ACC	Two one three five request flight level three three zero confirm.
		2037:12 UTC [0437:12 MYT] KL ACC	Affirm.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2037:14 UTC [0437:14 MYT] Singapore ACC	Okay climb to flight level two niner zero for Gading Sari Three Zero Four.
		2037:20 UTC [0437:20 MYT] KL ACC	Okay thank you.
		2037:21 UTC [0437:21 MYT] Singapore ACC	Thank you.
		2045:14 UTC [0445:14 MYT] KL ACC	Lumpur.
		2045:15 UTC [0445:15 MYT] Bangkok ACC	I got revision Singapore Five One Seven.
		2045:17 UTC [0445:17 MYT] KL ACC	Aah go ahead.
		2045:19 UTC [0445:19 MYT] Bangkok ACC	Two one three two.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2045:21 UTC [0445:21 MYT] KL ACC	Two one three two.
		2045:23 UTC [0445:23 MYT] Bangkok ACC	Thank you Bangkok.
		2045:37 UTC [0445:37 MYT] Singapore ACC	Singapore.
		2045:38 UTC [0445:38 MYT] KL ACC	Okay revision Singapore Five One Seven.
		2045:43 UTC [0445:43 MYT] Singapore ACC	Helo.
		2045:44 UTC [0445:44 MYT] KL ACC	Halo how do you read?
		2045:46 UTC [0445:46 MYT] Singapore ACC	Very weak.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2045:47 UTC [0445:47 MYT] KL ACC	Okay Singapore Five One Seven revise time two one five two..
		2045:52 UTC [0445:52 MYT] Singapore ACC	Two one five two and we are having some problem with zero four two five for his transponer.
		2045:58 UTC [0445:58 MYT] KL ACC	Yes.
		2045:59 UTC [0445:59 MYT] Singapore ACC	Reset zero four two six.
		2046:02 UTC [0446:02 MYT] KL ACC	Zero four two six okay calling you at zero four two six aah.
		2046:08 UTC [0446:08 MYT] Singapore ACC	Yes sir.

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		2046:09 UTC [0446:09 MYT] KL ACC	Alright thank you.
		2046:10 UTC [0446:10 MYT] Singapore ACC	Okay thank you.
		2103:09 UTC [0503:09 MYT] Singapore ACC	Singapore.
		2103:10 UTC [0503:10 MYT] KL ACC	Transfer Papa Kilo Gading Sari.
		2103:17 UTC [0503:17 MYT] KL ACC	No sound la over here.
		2103:20 UTC [0503:20 MYT] Singapore ACC	Gading Sari Three Zero Six go ahead.
		2103:22 UTC [0503:22 MYT] KL ACC	Two one one eight flight level three three zero squawk two.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2103:29 UTC [0503:29 MYT] Singapore ACC	Two one two two two one five eight requesting flight level three three zero for Gading Five Zero Six.
		2103:36 UTC [0503:36 MYT] KL ACC	Affirm.
		2103:38 UTC [0503:38 MYT] Singapore ACC	Climb to flight level two nine zero first.
		2103:43 UTC [0503:43 MYT] KL ACC	Okay two niner zero any transfer.
		2103:45 UTC [0503:45 MYT] Singapore ACC	Revision for you.
		2103:46 UTC [0503:46 MYT] KL ACC	Okay go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2103:47 UTC [0503:47 MYT] Singapore ACC	(xxx) (xxx) [illegible] one is revision of China Five Two Three.
		2103:52 UTC [0503:52 MYT] KL ACC	Five Two Three yes.
		2103:54 UTC [0503:54 MYT] Singapore ACC	It should be PADLI two two one seven.
		2103:58 UTC [0503:58 MYT] KL ACC	PADLI okay roger.
		2104:00 UTC [0504:00 MYT] Singapore ACC	And then the Thai Peace Niner Two zero.
		2104:04 UTC [0504:04 MYT] KL ACC	Nine Two Zero Thai Peace three letter word.
		2104:08 UTC [0504:08 MYT] Singapore ACC	And the Bravo Charlie Charlie Niner Two Zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		210411 UTC [0504:11 MYT] KL ACC	Aah okay clear.
		2104:14 UTC [0504:14 MYT] KL ACC	Victor Papa Kilo confirm.
		2104:17 UTC [0504:17 MYT] Singapore ACC	Two one yes sir.
		2104:19 UTC [0504:19 MYT] KL ACC	Go ahead.
		2104:20 UTC [0504:20 MYT] Singapore ACC	Victor Papa Kilo two one five two flight level two eight zero squawk two three four two.
		2104:27 UTC [0504:27 MYT] KL ACC	Two three four two roger and the you are calling from Singapore three P right.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2104:33 UTC [0504:33 MYT] Singapore ACC	Aah no is a overflight.
		2104:36 UTC [0504:36 MYT] KL ACC	Oo no I mean your you're your.
		2104:38 UTC [0504:38 MYT] Singapore ACC	The flight from Jakarta to Bangkok.
		2104:41 UTC [0504:41 MYT] KL ACC	I mean your number that mean that Singapore Sector Eight or Singapore Three P.
		2104:47 UTC [0504:47 MYT] Singapore ACC	Aah I am Singapore Sector Three.
		2104:49 UTC [0504:49 MYT] KL ACC	Sector Three aah okay because I got no (xxx) [illegible]
		2104:52 UTC [0504:52 MYT] Singapore ACC	(xxx) (xxx) [illegible]

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2104:53 UTC [0504:53 MYT] KL ACC	Alright.
		2106:32 UTC [0506:32 MYT] Bangkok ACC	Go ahead.
		2106:33 UTC [0506:33 MYT] KL ACC	Kota Bharu Thai Peace Niner Two Zero.
		2106:37 UTC [0506:37 MYT] Bangkok ACC	Thai Peace Nine Two Zero standby.
		2106:46 UTC [0506:46 MYT] Bangkok ACC	Go ahead.
		2106:47 UTC [0506:47 MYT] KL ACC	Kota Bharu two two one four flight levelthree eight zero squawk … helo.
		2107:29 UTC [0507:29 MYT] Bangkok ACC	Helo.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2107:30 UTC [0507:30 MYT] KL ACC	Okay Thai Peace Niner Two Zero.
		2107:33 UTC [0507:33 MYT] Bangkok ACC	Yes Kota Bahru two two one four two eight zero what is transponder.
		2107:38 UTC [0507:38 MYT] KL ACC	Two three four two.
		2107:39 UTC [0507:39 MYT] Bangkok ACC	Okay.
		2107:40 UTC [0507:40 MYT] KL ACC	Okay.
2109:13 UTC [0509:13 MYT] KL ACC	Lumpur.		
2109:14 UTC [0509:14 MYT] Singapore ACC	Lumpur aa I am calling on behalf of Hong Kong ACC.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2109:19 UTC [0509:19 MYT] KL ACC	Okay.		
2109:20 UTC [0509:20 MYT] Singapore ACC	They are requesting for aircraft Malaysian Three Seven Zero.		
2109:23 UTC [0509:23 MYT] KL ACC	Okay.		
2109:23 UTC [0509:23 MYT] Singapore ACC	Confirm you were in contact with the aircraft previously.		
2109:26 UTC [0509:26 MYT] KL ACC	Okay from our departure.		
2109:30 UTC [0509:30 MYT] Singapore ACC	Affirm.		
2109:31 UTC [0509:31 MYT] KL ACC	Aah… in contact until we transferred at IGARI.		

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
2109:35 UTC [0509:35 MYT] Singapore ACC	Hmm hmm.		
2109:36 UTC [0509:36 MYT] KL ACC	After that no contact we got the infor from IGARI aah they not in contact with the aircraft at… time er… after we transferred it the IGARI time was one seven two two.		
2110:01 UTC [0510:01 MYT] Singapore ACC	Okay.		
2110:01 UTC [0510:01 MYT] KL ACC	And and the Ho Chi Minh told us at around one negative contact with (xxx) (xxx) [illegible] one eight one zero.		
2110:16 UTC [0510:16 MYT] Singapore ACC	At one eight one zero Ho Chi Minh called you to say negative contact.		
2110:19 UTC [0510:19 MYT] KL ACC	Yes and we've been trying to check with Ho Chi Minh.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2110:24 UTC [0510:24 MYT] Singapore ACC	Aah aah.		
2110:25 UTC [0510:25 MYT] KL ACC	Of the aircraft because we check with eer the MAS operations they said they are not able to… aa… no comm with them.		
2110:41 UTC [0510:41 MYT] KL ACC	They.		
2110:41 UTC [0510:41 MYT] Singapore ACC	Confirm the Malaysian Airlines on the ground also no contact with Malaysian Three Seven Zero.		
2110:45 UTC [0510:45 MYT] KL ACC	Yes.		
2110:47 UTC [0510:47 MYT] Singapore ACC	Yes aah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2110:48 UTC [0510:48 MYT] KL ACC	Yes.		
2110:49 UTC [0510:49 MYT] Singapore ACC	Aah and the aircraft is no longer on your frequency one three four two five.		
2110:53 UTC [0510:53 MYT] KL ACC	Affirm at time one seven two two we transferred the aircraft to Ho Chi Minh.		
2111:00 UTC [0511:00 MYT] Singapore ACC	Aha at one seven two two was the aircraft still on radar.		
2111:04 UTC [0511:04 MYT] KL ACC	Affirm		
2111:07 UTC [0511:07 MYT] Singapore ACC	Okay.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2111:08 UTC [0511:08 MYT] KL ACC	So… aah or from aa… Hong Kong or… any update from Hong Kong.		
2111:13 UTC [0511:13 MYT] Singapore ACC	No Hong Kong is requesting er any update on this aircraft.		
2111:17 UTC [0511:17 MYT] KL ACC	Okay eer… if they are calling you again aa… can you update us.		
2111:26 UTC [0511:26 MYT] Singapore ACC	Okay copied.		
2111:27 UTC [0511:27 MYT] KL ACC	Okay thank you.		
		2129:55 UTC [0529:55 MYT] KL ACC	Singapore.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2129:58 UTC [0529:58 MYT] Singapore ACC	Lumpur.
		2129:59 UTC [0529:59 MYT] KL ACC	Yeah halo.
		2130:00 UTC [0530:00 MYT] Singapore ACC	Transfer for you Xanadu Six One correction Three Three One.
		2130:06 UTC [0530:06 MYT] KL ACC	Three Three One go ahead.
		2130:08 UTC [0530:08 MYT] Singapore ACC	Xanadu Three Three One TAXUL two two four four flight level three six zero squawk six three six six.
		2130:18 UTC [0530:18 MYT] KL ACC	Okay only one aaa.
		2130:20 UTC [0530:20 MYT] Singapore ACC	Yeah only one lah.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2130:21 UTC [0530:21 MYT] KL ACC	Alright thank you.
		2130:23 UTC [0530:23 MYT] Singapore ACC	Thank you.
2134:47 UTC [0534:47 MYT]	*Planner telephone ringing answered by AAT at 2134:47 UTC [0534:56 MYT]* ***This conversation was conducted in National Language that is Malay Language***		
2134:56 UTC [0534:56 MYT] AAT	Halo		
2134:57 UTC [0534:57 MYT] Sec 3+5 Planner	Yang tadi Malaysian Three Seven Zero tu eer… kau boleh follow dia punya radio for transmission dari departure terus sampai sampai kita… transferred boleh tak.		
2135:11 UTC [0535:11 MYT] AAT	Eh aah tak apa nanti kita tengok tengok kalau boleh bagi tahu la masa kita last contact.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2135:19 UTC [0535:19 MYT] Sec 3+5 Planner	Okay thank you.		
2144:59 UTC [0544:59 MYT] AAT	Helo		
2145:00 UTC [0545:00 MYT] Sec 3+5 Planner	Ya ni saya cakap sikit bagi pihak (xxx) [illegible] Malaysian Three Seven Zero tadikan boleh tengok eerdiapunya radar daripada dia departure depart dah pukul berapa pukul satu tujuh dari (xxx) (xxx) [illegible] ini abang nak kalau.		
2145:10 UTC [0545:10 MYT] AAT	Recording radar.		
2145:19 UTC [0545:19 MYT] Sec 3+5 Planner	Pukul satu kut.		
2145:20 UTC [0545:20 MYT] Sec 3+5 Planner	Dia nak tengok kut.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
2145:21 UTC [0545:21 MYT] AAT	Tak ini abang nak kalau.		
2145:35 UTC [0545:35 MYT] Sec 3+5 Planner	Aah.		
2145:47 UTC [0545:47 MYT] AAT	Kalau (xxx) (xxx) [illegible] bagi tengok.		
2145:51 UTC [0545:51 MYT] Sec 3+5 Planner	Supervisor (xxx)[illegible] tengok ta'boleh.		
2145:54 UTC [0545:54 MYT] AAT	Ta'dak eer.		
2145:56 UTC [0545:56 MYT] AAT	Ia duk lupa shaja.		
2145:58 UTC [0545:58 MYT] Sec 3+5 Planner	Orang dulu daripada pukul empat empat puluh lima.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2146:08 UTC [0546:08 MYT] Sec 3+5 Planner	Pukul dua belai lebih kurang pukul.		
2146:12 UTC [0546:12 MYT] Sec 3+5 Planner	ATC pukul pukul kejak ia.		
2146:19 UTC [0546:19 MYT] Sec 3+5 Planner	One six three zero dia lah kut.		
2146:21 UTC [0546:21 MYT] AAT	Duabelas local time ia.		
2146:23 UTC [0546:23 MYT] Sec 3+5 Planner	Local time hm local time.		
2146:24 UTC [0546:24 MYT] Sec 3+5 Planner	Duabelas tujuhbelas local time sampai lebih kurang dua jam macam itu shaja la.		
	END OF TELEPHONE CONVERSATION BETWEEN SECTOR 3+5 PLANNER AND AAT		

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2148:55 UTC [0548:55 MYT] HCM ACC	Ho Chi Minh.
		2148:56 UTC [0548:56 MYT] KL ACC	Okay Ho Chi Minh transfer Asia Express One Zero One Two.
		2149:01 UTC [0549:01 MYT] HCM ACC	Asia Express One Zero One Two go.
		2149:04 UTC [0549:04 MYT] KL ACC	IGARI Two Two Two Six request three Five Zero squawk two one five zero.
		2149:13 UTC [0549:13 MYT] HCM ACC	Asian Express One Zero One Two time IGARI two two two six flight level three five zero approved squawk two one five zero over.
		2149:23 UTC [0549:23 MYT] KL ACC	Okay thank you transfer three five zero.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2149:23 UTC [0549:23 MYT] HCM ACC	(xxx) (xxx) [illegible]
		2159:50 UTC [0559:59 MYT] KL ACC	*Sound of punching telephone number*
		2200:05 UTC [0600:05 MYT] Service Provider	*Nombor ya* *Telephone engaged tone from time 2200:05 UTC [0600:05MYT] - 2200:17 UTC [0600:17 MYT]*
		2200:21 UTC [0600:21 MYT] Singapore ACC	Lumpur confirm calling.
		2200:26 UTC [0600:26 MYT] KL ACC	Nothing disregard.
		2200:28 UTC [0600:28 MYT] Singapore ACC	Okay disregard.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2200:30 UTC [0600:30 MYT] KL ACC	*Telephone open line*
		2200:34 UTC [0600:34 MYT] KL ACC	*Sound of punching telephone number*
		2200:36 UTC [0600:36 MYT] Service Provider	*"Nombor yang anda dial tiada dalam perkhidmatan"* *The number you dialled is not in service*
		2200:46 UTC [0600:46 MYT] KL ACC	*Telephone open line*
		2201:19 UTC [0601:19 MYT] KL ACC	*Sound "too too too' until time 2201:23 UTC [0601:23 MYT]*
		2201:27 UTC [0601:27 MYT] KL ACC	*Telephone open line*
		2201:29 UTC [0601:29 MYT] KL ACC	*Sound of punching telephone number.*

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2201:36 UTC [0601:36 MYT] KL ACC	*Telephone engaged tone until 2201:40 UTC [0601:40 MYT]*
		2201:40 UTC [0601:40 MYT] KL ACC	*Telephone open line.*
		2201:45 UTC [0601:45 MYT] Service Provider	*Nombor yang anda dial tiada dalam perkhidmatan.*
		2201:55 UTC [0601:55 MYT] KL ACC	*Telephone open line and sound of punching telephone number until time 2202:06 UTC [0602:06 MYT].*
		2202:34 UTC [0602:34 MYT] KL ACC	*Telephone open line.*
		2203:00 UTC [0603:00 MYT] KL ACC	*Sound of punching telephone number.*
		2203:19 UTC [0603:19 MYT] KL ACC	*Sound of telepone ringing (voice) [illegible)*

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2203:48 UTC [0603:48 MYT] KL ACC	*Sound of music after the voice then sound of telephone ringing until 2204:11 UTC [0604:11 [MYT) cut-off tone until 2204:24 UTC [0604:24 MYT].*
		2204:29 UTC [0604:29 MYT] KL ACC	*Sound of punching telephone number .*
		2204:42 UTC [0604:42 MYT] KL ACC	*Telephone engaged tone until 2204:47 UTC [0604:47 MYT] voice [illegible] 2205:10 UTC [0605:10 MYT] telephone line cut off Redial at 2205:11 UTC [0605:11 MYT] At 2205:17 UTC [0605:17 MYT] music followed by phone ringing at 2205:26 UTC [0605:26 MYT] and phone cut off at 2205:46 UTC [0605:46 MYT].*
		2205:48 UTC [0605:48 MYT] KL ACC	Singapore.
		2205:49 UTC [0605:49 MYT] Singapore ACC	Aah Lumpur one estimate Fedex Five Three Four Three.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2205:53 UTC [0605:53 MYT] KL ACC	Five Three Seven Three.
		2205:56 UTC [0605:56 MYT] Singapore ACC	Five Three Four Three.
		2205:58 UTC [0605:58 MYT] KL ACC	Five Three Four Three go ahead.
		2206:00 UTC [0606:00 MYT] Singapore ACC	TAXUL two three one eight flight level two eight zero squawk three one two three.
		2206:05 UTC [0606:05 MYT] KL ACC	Three one two three two eight zero TAXUL two three one eight.
		2206:11 UTC [0606:11 MYT] Singapore ACC	Affirm and naa sir reference to Xanadu Five Two Three request descend.

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2206:18 UTC [0606:18 MYT] KL ACC	Xanadu Five Two Three level three four zero.
		2206:22 UTC [0606:22 MYT] Singapore ACC	Three four zero copied thank you Siera Bravo.
		2210:13 UTC [0610:13 MYT] KL ACC	*Sound of punching telephone number [foreign langguage then "Sorry the call that you (xxx) [illegible] mobile phone (xxx) [illegible].*
		2218:47 UTC [0618:47 MYT] Bangkok ACC	Lumpur please release Thai Peace Nine Two Zero to Bangkok now.
		2218:53 UTC [0618:53 MYT] KL ACC	Thai Peace Nine Two Zero (xxx) (xxx) [illegible]
		2218:57 UTC [0618:57 MYT] Bangkok ACC	Yeah yeah not contact yet.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2220:34 UTC [0620:34 MYT] Singapore ACC	Singapore.
		2220:35 UTC [0620:35 MYT] KL ACC	Singapore estimate Victor Papa Kilo Asian Express Five Eight Seven Six.
		2220:40 UTC [0620:40 MYT] Singapore ACC	Go ahead.
		2220:41 UTC [0620:41 MYT] KL ACC	Aah estimate Asian Express Five Eight Seven Six estimate Victor Papa Kilo two two three three requesting flight level three seven zero squawk two one zero one.
		2220:53 UTC [0620:53 MYT] Singapore ACC	Asian Express Five Eight Seven Six Victor Papa Kilo two two three three requesting flight level three seven zero squawk two one zero one climb to flight level two niner zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2221:03 UTC [0621:03 MYT] KL ACC	Two niner zero thank you.
		2221:05 UTC [0621:05 MYT] Singapore ACC	(xxx) [illegible] thank you Sierra Brabo.
		2223:36 UTC [0623:36 MYT] Singapore ACC	Lumpur.
		2223:37 UTC [0623:37 MYT] KL ACC	Yeah go ahead.
		2223:38 UTC [0623:38 MYT] Singapore ACC	Estimate Malaysian Two Six Three Seven.
		2223:42 UTC [0623:42 MYT] KL ACC	Malaysian Two Six go ahead.
		2223:44 UTC [0623:44 MYT] Singapore ACC	Three Seven PADLI two three five niner flight level three eight zero squawk zero four four two.

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2223:55 UTC [0623:55 MYT] KL ACC	Say again squawk.
		2223:57 UTC [0623:57 MYT] Singapore ACC	Zero four four two.
		2224:00 UTC [0624:00 MYT] KL ACC	Okay Malaysian Two Six Five Eight three three five one flight level three eight zero squawk zero four four two.
		2224:07 UTC [0624:07 MYT] Singapore ACC	Aah… negative PADLI two three five niner.
		2224:13 UTC [0624:13 MYT] KL ACC	Five niner okay Malaysian Two Six Five Eight PADLI two three five niner flight level three eight zero squawk zero four four two.
		2224:19 UTC [0624:19 MYT] Singapore ACC	Affirm and naa callsign is Maaysian Two Six Three Seven.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2224:25 UTC [0624:25 MYT] KL ACC	Three Seven.
		2224:27 UTC [0624:27 MYT] Singapore ACC	Affirm.
		2224:28 UTC [0624:28 MYT] KL ACC	Eer Malaysian Two Six Three Seven PADLI five niner, flight level three eight zero, squawk zero four four two.
		2224:36 UTC [0624:36 MYT] KL ACC	Affirm thank you sir Sierra Bravo.
		2232:03 UTC [0632:03 MYT] Unknown	Good morning mdm.
		2232:05 UTC [0632:05 MYT] KL ACC	Morning.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2232:06 UTC [0632:06 MYT] Unknown	(xxx) [illegible] cerntral reauest airspace release eight thounsand and below.
		2232:14 UTC [0632:14 MYT] KL ACC	(xxx) (xxx) [illegible]
		2232:17 UTC [0632:17 MYT] Unknown	Again airspace release eight thousand feet and below.
		2232:26 UTC [0632:26 MYT] KL ACC	Eight thousand.
		2232:28 UTC [0632:28 MYT] Unknown	Eight thousand feet and below.
		2232:31 UTC [0632:31 MYT] KL ACC	Ah (xxx) [illegible]

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2232:32 UTC [0632:32 MYT] Unknown	Okay aah.
		2232:44 UTC [0632:44 MYT] Unknown	Approve mdm.
		2232:46 UTC [0632:46 MYT] KL ACC	Yeah approve.
		2232:47 UTC [0632:47 MYT] Unknown	Thank you.
2233:23 UTC [0633:23 MYT] KL ACC	Lumpur Sector Three.		
2233:24 UTC [0633:24 MYT] Singapore ACC	Okay Lumpur is that just to check with you aaa, earlier on ah you guys call up regarding MalaysiaThree Seven Zero no contact.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2233:32 UTC [0633:32 MYT] KL ACC	Yes.		
2233:34 UTC [0633:34 MYT] Singapore ACC	Confirm now the aircraft in contact with anybody already.		
2233:37 UTC [0633:37 MYT] KL ACC	Aaa… I am not sure aaa… standby aaa…		
2233:40 UTC [0633:40 MYT] Singapore ACC	Okay.		
2233:43 UTC [0633:43 MYT] KL ACC	Lumpur IGARI.		
2233:45 UTC [0633:45 MYT] Singapore ACC	Okay Lumpur just to check with you earlier on regarding Malaysian Three Seven Zero when you guys say no contact aah confirm in contact with anyone already.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2233:54 UTC [0633:54 MYT] KL ACC	This one aircraft actually passed IGARI at time one seven two two.		
2234:00 UTC [0634:00 MYT] Singapore ACC	Passed IGARI at time one seven two two ya.		
2234:04 UTC [0634:04 MYT] KL ACC	Yea so we after IGARI after IGARI we transferred this aircraft to Ho Chi Minh and then after about fourteen or fifteen minutes like that Ho Chi Minh called us you know Sector Five Lumpur Sector Five asking aaa… whether we in contact with this aircraft I told the we already transferred you fourteen or fifteen minutes ago.		
2234:26 UTC [0634:26 MYT] Singapore ACC	Oh… but all the while until the full control you guys are in contact with the aircraft.		
2234:30 UTC [0634:30 MYT] KL ACC	No problem yeah.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2234:32 UTC [0634:32 MYT] Singapore ACC	Ooh.		
2234:33 UTC [0634:33 MYT] KL ACC	We transferred the aircraft at IGARI and then we thought the aircraft in contact with Ho Chi Minh but after fourteen to fifteen minutes they called us this aircraft never contact them and then they said they have a radar contact with this aircraft up until this BITOD position after BITOD only they said aircraft disappeared from their radar with no ADC everything cannot see the aircraft cannot contact the aircraft.		
2234:57 UTC [0634:57 MYT] Singapore ACC	Okay.		
2234:58 UTC [0634:58 MYT] KL ACC	And then aah that's all what we know laa.		
2235:00 UTC [0635:00 MYT] Singapore ACC	Okay that's all what you know laa okay thanks.		

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2235:03 UTC [0635:03 MYT] KL ACC	Okay.		
		2235:11 UTC [0635:11 MYT] KL ACC	Sector Three good morning.
		2235:13 UTC [0635:13 MYT] Unknown	(xxx) (xxx) [illegible]
		2235:22 UTC [0635:22 MYT] KL ACC	One two six three.
		2235:36 UTC [0635:36 MYT] KL ACC	Copied.
2236:28 UTC [0636:28 MYT] KL ACC	Yea go ahead … Ho Chi Minh.		
2236:30 UTC [0636:30 MYT] HCM ACC	Yes saahelo this is xx xx xx [name redacted] Supervisor in Ho Chi Minh may I talk to your supervisor please.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2236:36 UTC [0636:36 MYT] KL ACC	You want to talk to my supervisor aah hold on aah okay ah Can you wait a minute I call you back shortly.		
		2237:30 UTC [0637:30 MYT] Singapore ACC	Singapore.
		2237:33 UTC [0637:33 MYT] KL ACC	(xxx) [illegible]
		2237:34 UTC [0637:34 MYT] Singapore ACC	Singapore line check how do you read me.
		2237:36 UTC [0637:36 MYT] KL ACC	Read you strength five how do you read me.
		2237:38 UTC [0637:38 MYT] Singapore ACC	Read you strength two.
		2237:40 UTC [0637:40 MYT] KL ACC	Okay Singapore aa… one estimate.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2237:43 UTC [0637:43 MYT] Singapore ACC	Go ahead.
		2237:44 UTC [0637:44 MYT] KL ACC	Estimate Transmile Three One Five.
		2237:49 UTC [0637:49 MYT] Singapore ACC	Go ahead.
		2237:50 UTC [0637:50 MYT] KL ACC	Okay Victor Papa Kilo two two five four request flight level three three zero squawk two one one five.
		2237:58 UTC [0637:58 MYT] Singapore ACC	Transmile Three One Five okay Victor Papa Kilo two two five four request flight level three three zero squawk two one one five climb to flight level two niner zero.
		2238:10 UTC [0638:10 MYT] KL ACC	Yes.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2238:12 UTC [0638:12 MYT] Singapore ACC	Two estimates and one traffic information.
		2238:14 UTC [0638:14 MYT] KL ACC	Okay go with estimate.
		2238:17 UTC [0638:17 MYT] Singapore ACC	Estimate Malaysian Two Five Five One.
		2238:20 UTC [0638:20 MYT] KL ACC	Two Five Five One go.
		2238:24 UTC [0638:24 MYT] Singapore ACC	PADLI two three five six flight level three four zero squawk zero four six three.
		2238:33 UTC [0638:33 MYT] KL ACC	Aah
		2238:37 UTC [0638:37 MYT] Singapore ACC	Two three five six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2238:39 UTC [0638:39 MYT] KL ACC	Two three five six okay Malaysian Two Five Five One PADLI two three five six flight level three four zero squawk zero four six three.
		2238:48 UTC [0638:48 MYT] Singapore ACC	Read back correct and next Xanadu Three One Seven.
		2238:51 UTC [0638:51 MYT] KL ACC	Xanadu Three One Seven go ahead.
		2238:54 UTC [0638:54 MYT] Singapore ACC	Taxul zero zero zero eight flight level four zero zero squawk zero zero one five.
		2239:02 UTC [0639:02 MYT] KL ACC	Zero zero one five okay Xanadu Three One Seven Taxul zero zero zero eight flight level four zero zero squawk zero zero one five.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2239:12 UTC [0639:12 MYT] Singapore ACC	Read back correct one traffic information Pelita Five Five Zero.
		2239:20 UTC [0639:20 MYT] KL ACC	Okay aaa Pelita…… Five One Five.
		2239:27 UTC [0639:27 MYT] Singapore ACC	Five Five Zero.
		2239:28 UTC [0639:28 MYT] KL ACC	Okay Five Five Zero go ahead.
		2239:33 UTC [0639:33 MYT] Singapore ACC	Take-off from Halim to Matak estimating abeam Tioman two three four niner flight level one niner zero squawk two five six six.
		2239:45 UTC [0639:45 MYT] KL ACC	Pelita five five Zero Halim to Matak abeam Tioman two three four niner flight level one niner zero squawk two five six six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION — **KL ACC SECTOR 3+5 PLANNER**

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2239:57 UTC [0639:57 MYT] Singapore ACC	Affirm.
		2239:58 UTC [0639:58 MYT] Singapore ACC	And Lumpur.
		2239:59 UTC [0639:59 MYT] KL ACC	Yeah go ahead.
		2240:00 UTC [0640:00 MYT] Singapore ACC	Xanadu Two Three One request direct.
		2240:02 UTC [0640:02 MYT] KL ACC	Say again.
		2240:04 UTC [0640:04 MYT] Singapore ACC	Xanadu Two Three One anywhere direct.
		2240:06 UTC [0640:06 MYT] KL ACC	The the Three Three One standby.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2240:10 UTC [0640:10 MYT] Singapore ACC	Lumpur you are mumbling say again.
		2240:13 UTC [0640:13 MYT] KL ACC	Xanadu Three Three One.
		2240:14 UTC [0640:14 MYT] Singapore ACC	Helo.
		2240:17 UTC [0640:17 MYT] Singapore ACC	What man.
		2240:20 UTC [0640:20 MYT] Source Unknown	Lumpur.
		2240:32 UTC [0640:32 MYT] Source Unknown	Helo.
		2240:44 UTC [0640:44 MYT] KL ACC	Sector Three.

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2240:58 UTC [0640:58 MYT]	*Tone of direct telephone line ringing and answer by KL ACC at time 2241:09 UTC [0641:09 MYT].*
		2241:09 UTC [0641:09 MYT] KL ACC	Singapore.
		2241:13 UTC [0641:13 MYT] Singapore ACC	Singapore.
		2241:14 UTC [0641:14 MYT] KL ACC	Singapore just now Xanadu Three Three One direct PIBOS okay.
		2241:19 UTC [0641:19 MYT] Singapore ACC	Is okay (xxx) (xxx) [illegible] thank you.
		2241:39 UTC [0641:39 MYT] HCM ACC	Helo.
		2241:40 UTC [0641:40 MYT] KL ACC	Ho Chi Minh.

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2241:41 UTC [0641:41 MYT] HCM ACC	Yeah.
		2241:43 UTC [0641:43 MYT] KL ACC	One estimate.
		2241:46 UTC [0641:46 MYT] HCM ACC	Go ahead.
		2241:47 UTC [0641:47 MYT] KL ACC	Asian Express One Six Five Six IGARI two three one five request flight level three seven zero squawk two one five one.
		2241:58 UTC [0641:58 MYT] HCM ACC	Two one five one three seven zero two three one five Asian Express One Six Five Six.
		2242:04 UTC [0642:04 MYT] KL ACC	Asian Express One Six Five Six.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2242:08 UTC [0642:08 MYT] HCM ACC	Any transfer.
		2242:10 UTC [0642:10 MYT] KL ACC	Any transfer no aaaaflight level three seven zero sir.
		2242:15 UTC [0642:15 MYT] HCM ACC	Three seven zero okay approved.
		2242:18 UTC [0642:18 MYT] KL ACC	Three seven zero approved.
		2242:19 UTC [0642:19 MYT] HCM ACC	Yeah.
		2242:50 UTC [0642:50 MYT] KL ACC	Centre.
		2242:51 UTC [0642:51 MYT] Unknown source	(xxx) (xxx) ATC[illegible]

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		2242:52 UTC [0642:52 MYT] KL ACC	ATC Malaysian One Two Six Three cleared to Lumpur via (xxx) [illegible] flight level one six zero squawk zero three one six.
		2243:07 UTC [0643:07 MYT] Unknown source	(xxx) [illegible] Clear to Lumpur one six zero zero three one six.
		2244:18 UTC [0644:18 MYT] KL ACC	Calling tone of direct telephone line.
		2244:40 UTC [0644:40 MYT] KL ACC	Calling tone of direct telephone line stopped.
		2244:58 UTC [0644:58 MYT] KL ACC	Calling tone of direct telephone line.
		2245:32 UTC [0645:32 MYT] HCM ACC	Helo.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - MAS 370	TIME & SOURCE	DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER CONTENT - OTHER FLIGHTS
		2245:34 UTC [0645:34 MYT] KL ACC	Okay Ho Chi Minh.
		2245:35 UTC [0645:35 MYT] HCM ACC	Yes sir.
		2245:37 UTC [0645:37 MYT] KL ACC	One estimate.
		2245:39 UTC [0645:39 MYT] HCM ACC	Go ahead.
		2245:40 UTC [0645:40 MYT] KL ACC	Asian Express One Zero Five Eight IGARI two three two two flight level three five zero squawk two one two three.
		2245:53 UTC [0645:53 MYT] HCM ACC	Two three three two right.
		2245:56 UTC [0645:56 MYT] KL ACC	Two one two two for the squawk.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2245:59 UTC [0645:59 MYT] HCM ACC	No no no I (xxx) (xxx) [illegible]
		2246:01 UTC [0646:01 MYT] KL ACC	Okay affirm.
		2246:06 UTC [0646:06 MYT] HCM ACC	Flight level three five zero (xxx) [illegible] time two one three two and flight level three five zero.
		2246:13 UTC [0646:13 MYT] KL ACC	No aaa time is two three three two squawk is two one.
		2246:18 UTC [0646:18 MYT] HCM ACC	Two thirty three two the squawk two one two three and flight level three five zero is approved.
		2246:25 UTC [0646:25 MYT] KL ACC	Three five zero approved.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2246:27 UTC [0646:27 MYT] HCM ACC	Yes.
		2246:29 UTC [0646:29 MYT] KL ACC	(xxx) [illegible]
		2247:52 UTC [0647:52 MYT] KL ACC	Sector three.
		2247:57 UTC [0647:57 MYT] Singapore ACC	Singapore.
		2247:58 UTC [0647:58 MYT] KL ACC	Yes you call me Singapore.
		2248:01 UTC [0648:01 MYT] Singapore ACC	Singapore.
		2248:02 UTC [0648:02 MYT] KL ACC	Lumpur Sector Three you call me.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2248:03 UTC [0648:03 MYT] Singapore ACC	Go ahead.
		2248:04 UTC [0648:04 MYT] Singapore ACC	Negative.
		2248:05 UTC [0648:05 MYT] KL ACC	Okay disregard.
		2248:09 UTC [0648:09 MYT] KL ACC	Sector Three.
		2248:09 UTC [0648:09 MYT] Kuantan	Sector Three departure Malaysian One Two Six Three time four four six.
		2248:16 UTC [0648:16 MYT] KL ACC	(xxx) [illegible] climb.
		2248:37 UTC [0648:37 MYT] Kuantan	Kuantan.

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
		2248:38 UTC [0648:38 MYT] KL ACC	Kuantan eer Malaysian One Two Six Three initially climb to what level.
		2248:45 UTC [0648:45 MYT] Kuantan	Eer… just now you give final level on six zero.
		2248:48 UTC [0648:48 MYT] KL ACC	One six zero okay.
		2248:49 UTC [0648:49 MYT] Kuantan	Affirm.
2250:22 UTC [0650:22 MYT] KL ACC	Yeah Singapore		
2250:23 UTC [0650:23 MYT] Singapore ACC	Aaa…Lumpur morning this is the Watch Manager is your supervisor free.		
	.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2250:27 UTC [0650:27 MYT] KL ACC	My supervisor aa… is quite busy right time … right now anything.		
2250:31 UTC [0650:31 MYT] Singapore ACC	Okay with regard to the earlier callsign Malaysian Three Seven Zero.		
2250:35 UTC [0650:35 MYT] KL ACC	Okay.		
2250:36 UTC [0650:36 MYT] Singapore ACC	Yeah… Hong Kong is aah… just sent a AFTN to Singapore to help check they have sent out a detresfa.		
2250:43 UTC [0650:43 MYT] KL ACC	Okay.		
2250:43 UTC [0650:43 MYT] Singapore ACC	aircraft missing.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION **KL ACC SECTOR 3+5 PLANNER**

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2250:45 UTC [0650:45 MYT] KL ACC	Okay		
2250:46 UTC [0650:46 MYT] Singapore ACC	Yeah and aah I just call Ho Chi Minh to confirm Ho Chi Minh said Hong Kong aah got a call from aah from Beijing that aah still no contact with the aircraft aah… is there anyway to call the airline to contact them.		
2251:02 UTC [0651:02 MYT] KL ACC	Aaah.		
2251:03 UTC [0651:03 MYT] Singapore ACC	And try and establish contact on company frequency.		
2251:05 UTC [0651:05 MYT] KL ACC	We have been trying that since aa zero correction aaa… one eight something like that UTC.		
2251:13 UTC [0651:13 MYT] Singapore ACC	Aaa…		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2251:13 UTC [0651:13 MYT] KL ACC	Aaa straight away after Ho Chi Minh asked us a few minutes after that we already asked the airline to contact this airraft you know.		
2251:20 UTC [0651:20 MYT] Singapore ACC	Yeah… because at time two two three three aah Hong aaaactually this is from you aah.		
2251:28 UTC [0651:28 MYT] KL ACC	Two two three three is ah you follow the flight plan aircraft already … say again.		
2251:35 UTC [0651:35 MYT] Singapore ACC	I have a detresfa AFTN message sent by WMFC.		
2251:41 UTC [0651:41 MYT] KL ACC	WMFC is from us.		

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2251:42 UTC [0651:42 MYT] Singapore ACC	Yeah… that's right and ah the the… a… remark is missing detresfa aircraft.		
2251:52 UTC [0651:52 MYT] KL ACC	Hm…hm okay.		
2251:55 UTC [0651:55 MYT] Singapore ACC	Okay so aaa… can I just confirm that aaa Malaysia Airlines is still trying to establish contact.		
2252:04 UTC [0652:04 MYT] KL ACC	Yeah yeah we also trying to establish contact with this aircraft and this Malaysian Airlines already request earlier much much earlier since aah…aircraft reported missing by by Ho Chi Minh lah but until now no information about this aircraft.		
2252:24 UTC [0652:24 MYT] Singapore ACC	Okay but earlier on when aah over the point IGARI was it positive contact with your all.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2252:31 UTC [0652:31 MYT] KL ACC	At position IGARI we our procedure is we transferred the aircraft to Ho Chi Minh.		
2252:36 UTC [0652:36 MYT] Singapore ACC	Ho Chi Minh right.		
2252:38 UTC [0652:38 MYT] KL ACC	Ho Chi Minh yeah after IGARI is Ho Chi Minh control.		
2252:41 UTC [0652:41 MYT] Singapore ACC	Correct Ho Chi Minh said on their radar it wasn't positive.contact with them.		
2252:47 UTC [0652:47 MYT] KL ACC	Aaa… but earlier part actually got radar contact but the thing is no radio contact only lah.		
2252:55 UTC [0652:55 MYT] Singapore ACC	Radar contact but no radio contact.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2252:59 UTC [0652:59 MYT] KL ACC	Yeah yeah.		
2253:00 UTC [0653:00 MYT] Singapore ACC	Okay but IGARI is a suppose to be before IGARI is with you all radar is it.		
2253:06 UTC [0653:06 MYT] KL ACC	Yeah.		
2253:08 UTC [0653:08 MYT] Singapore ACC	That part is radar contact I mean that part is your radar contact.		
2253:12 UTC [0653:12 MYT] KL ACC	Radio and radar contact.		
2253:13 UTC [0653:13 MYT] Singapore ACC	Ooo okay but you all don't have radio contact with the aircraft at IGARI.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION

KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2253:19 UTC [0653:19 MYT] KL ACC	No after IGARI after transfer by right aircraft should be with Ho Chi Minh lah.		
2253:24 UTC [0653:24 MYT] Singapore ACC	Correct… no what I am trying to ask is before you all QSY to Ho Chi Minh was the aircraft in positive radio contact with you all also.		
2253:35 UTC [0653:35 MYT] KL ACC	Earlier before IGARI yes.		
2253:37 UTC [0653:37 MYT] Singapore ACC	Okay at point IGARI where you have to hand over aircraft to Ho Chi Minh.		
2253:41 UTC [0653:41 MYT] KL ACC	Okay that one I am not sure because that one is the radar man working at that time.		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION
KL ACC SECTOR 3+5 PLANNER

TIME & SOURCE	CONTENT - MAS 370	TIME & SOURCE	CONTENT - OTHER FLIGHTS
2253:46 UTC [0653:46 MYT] Singapore ACC	Okay I need your to help confirm that there was positive radio and radar contact.		
2253:54 UTC [0653:54 MYT] KL ACC	I will advise you aaa later because this one my supervisor is taking the playback tape now.		
2254:02 UTC [0654:02 MYT] Singapore ACC	Oh okay okay when he comes up can you give me a call please I am xxxxx *[name redacted]*		
2254:08 UTC [0654:08 MYT] KL ACC	xxxxx *[name redacted]* aah.		
2254:09 UTC [0654:09 MYT] Singapore ACC	Aah xxxxx… xxxxx *[name redacted]*		
2254:10 UTC [0654:10 MYT] KL ACC	xxxxx *[name redacted]*		

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
2254:10 UTC [0654:10 MYT] Singapore ACC	Okay thank you.		
		2256:40 UTC [0656:40 MYT] KL ACC	Yes.
		2256:41 UTC [0656:41 MYT] Singapore ACC	Confirm in contact Asian Express Five Zero Three Four
		2256:44 UTC [0656:44 MYT] KL ACC	Yeah.
		2256:44 UTC [0656:44 MYT] Singapore ACC	Okay thank you.
		2257:40 UTC [0657:40 MYT] Singapore ACC	Singapore.
		2257:40 UTC [0657:40 MYT] KL ACC	Estimate Victor Papa Kilo Asian Express One Six Niner Two.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2257:45 UTC [0657:45 MYT] Singapore ACC	Asian Express One Six Niner Two go ahead.
		2257:48 UTC [0657:48 MYT] KL ACC	Asian Express One Six Niner Two Victor Papa Kilo two three one seven request flight level three three zero squawk two one four seven.
		2257:56 UTC [0657:56 MYT] Singapore ACC	Asian Express One Six Niner Two Victor Papa Kilo two three one seven request flight level three three zero squawk two one four seven.
		2258:03 UTC [0658:03 MYT] KL ACC	Affirm.
		2258:03 UTC [0658:03 MYT] Singapore ACC	Climb two niner zero.
		2258:05 UTC [0658:05 MYT] KL ACC	Two niner zero thank you nut This Asian Five One One Zero.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2258:09 UTC [0658:09 MYT] Singapore ACC	Asian Express Five One One Zero go ahead
		2258:12 UTC [0658:12 MYT] KL ACC	Victor Papa Kilo two three one niner request flight level three seven zero squawk two one seven four.
		2258:19 UTC [0658:19 MYT] Singapore ACC	Asian Express Five One One Zero Victor Papa Kilo two three one niner request flight level three seven zero squawk two one seven four climb to flight level two seven zero.
		2258:29 UTC [0658:29 MYT] KL ACC	Two seven zero thank you.
		2258:31 UTC [0658:31 MYT] Singapore ACC	One revision Malaysian Two Six Three Seven.
		2258:33 UTC [0658:33 MYT] KL ACC	Two Six Three Seven go ahead.

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER		DIRECT LINE COORDINATION COMMUNICATION KL ACC SECTOR 3+5 PLANNER	
TIME & SOURCE	**CONTENT - MAS 370**	**TIME & SOURCE**	**CONTENT - OTHER FLIGHTS**
		2258:35 UTC [0658:35 MYT] Singapore ACC	Revise PADLI two three five six.
		2258:37 UTC [0658:37 MYT] KL ACC	Two three five six copied and thank you.
		2258:40 UTC [0658:40 MYT] Singapore ACC	Thank you.
			End of Direct Telephone Conversation Between KL ACC and Singapore ACC

END AT TIME 2300:00 UTC [0700:00 MYT]

Malaysia Time [MYT] - UTC + 8 hours
ICAO Airline Designator for Malaysia Airlines: MAS

I.C.A.O ANNEX9 APPENDIX 3

CARGO MANIFEST NBR 03 07MAR 15052 W7
OPERATOR MH MALAYSIA AIRLINES
MARKS OF NATIONALITY FLT/DATE MH 370 08MAR14
FROM KUL

BEIJING 07

			AKE 3372MH					
232 1200 73068	1	MANGOSTEEN		PER	1148	KULPEK	KLN	07
			AKE 3497MH					
232 1200 73068	1	MANGOSTEEN		PER	1128	KULPEK	KLN	07
			AKE 6442MH					
232 1066 49055	1	CONSOL		KEY QTC PPP	320	PENPEK	MH6803	07
			AKE 8535MH					
232 1200 73069	1	MANGOSTEEN		PER	1138	KULPEK	KLN	07
			AKE 90207MH					
232 1066 49058	1	CONSOL		KEY QTC PPP	326	PENPEK	MH6803	07
			AKE 90348MH					
232 1067 70855	67	CONSOL		SSR QTC B	463	PENPEK	MH6803	07
			AKE 90787MH					
232 1200 73068	1	MANGOSTEEN		PER	1152	KULPEK	KLN	07
			PMC 5871MH					
232 1067 70858	133	CONSOL		SSR QTC B	1390	PENPEK	MH6803	07
			PMC 61433MH					
232 1202 2382	4	CONSOL		B	26	KULPEK	PTM	07
232 1202 2404	1	CONSOL		B	6	KULPEK	PTM	07
232 1200 9141	13	CONSOL		B	2250	KULPEK	KLN	07
	18				2282			

TOTAL PCS 224 KGS 9947 6 SHPTS

I.C.A.O ANNEX9 APPENDIX 3

```
CARGO   M A N I F E S T    NBR 02                    07MAR 1356Z 5J
OPERATOR                   MH          MALAYSIA AIRLINES
MARKS OF NATIONALITY                     FLT/DATE  MH  370 08MAR14
FROM                       KUL
-----------------------------------------------------------------------

B E I J I N G                                                        07
-------------
                                    BULK
                                    ----
   ***EXPRESS HANDLING***
232 1187 3632    2 COURIER MATERIAL         EXP         6 KULPEK  MEW    07

-----------------------------------------------------------------------
TOTAL    PCS     2                            KGS       6        1 SHPTS
```

232 KUL 1200 7306

~~232-1200 7306~~

Shipper's Name and Address | Shipper's Account Number

POH SENG KIAN
79,BATU 6 1/4 KESANG
84000 . MUAR JOHOR
MALAYSIA

Not Negotiable
Air Waybill
Issued by

MALAYSIA AIRLINES
CARGO BERHAD

Copies 1, 2 and 3 of this Air Waybill are originals and have the same validity.

Consignee's Name and Address | Consignee's Account Number

BEIJING GUANGCHANGMING TRADING CO., LTD,18 HOUANDING DUAN,QING LILU
HOUNDINGCUN,ANDING ZHEN,DAXINGQU
BEIJING,CHINA

It is agreed that the goods described herein are accepted in apparent good order and condition (except as noted) for carriage SUBJECT TO THE CONDITIONS OF CONTRACT ON THE REVERSE HEREOF. ALL GOODS MAY BE CARRIED BY ANY OTHER MEANS INCLUDING ROAD OR ANY OTHER CARRIER UNLESS SPECIFIC CONTRARY INSTRUCTIONS ARE GIVEN HEREON BY THE SHIPPER, AND SHIPPER AGREES THAT THE SHIPMENT MAY BE CARRIED VIA INTERMEDIATE STOPPING PLACES WHICH THE CARRIER DEEMS APPROPRIATE. THE SHIPPER'S ATTENTION IS DRAWN TO THE NOTICE CONCERNING CARRIER'S LIMITATION OF LIABILITY. Shipper may increase such limitation of liability by declaring a higher value for carriage and paying a supplemental charge if required.

Issuing Carrier's Agent Name and City: "OWN"

Accounting Information/Also Notify: FREIGHT PREPAID

Agent's IATA Code | Account No.

Airport of Departure (Addr. of first Carrier) and requested Routing: KUAL LUMPUR , MALAYSIA

Reference Number | Optional Shipping Information

To	By First Carrier (Routing and Destination)	to	by	to	by	Currency	CHGS Code	WT/VAL PPD	WT/VAL COLL	Other PPD	Other COLL	Declared Value for Carriage	Declared Value for Customs
PEK	MH370/08MARCH2014					MYR		P		P			

Airport of Destination: BEIJING CHINA | Requested Flight/Date | Amount of Insurance | INSURANCE - If Carrier offers insurance, and such insurance is requested in accordance with the conditions thereof, indicate amount to be insured in figures in box marked "Amount of Insurance".

Handling Information: PLS CONTACT CNEE UPON ARRIVAL.TQ.PERISHABLE.

SCI

(For USA only) These commodities, technology or software were exported from the United States in accordance with the Export Administration Regulations. Diversion contrary to USA law prohibited.

No. of Pieces RCP	Gross Weight	kg lb	Rate Class	Commodity Item No.	Chargeable Weight	Rate / Charge	Total	Nature and Quantity of Goods (incl. Dimensions or Volume)
4	4566	K	Q		4566	10.25	46801.50	"FRESH MANGOSTEEN"
			SCR	6007				
4	4566						46801.50	

Prepaid	Collect	Other Charges
Weight Charge: 46801.50		FSC : 3652.80
Valuation Charge		ISS : 913.20
Tax		
Total other Charges Due Agent		
Total other Charges Due Carrier: 4566.00		
Total prepaid: 51367.50	Total collect	
Currency Conversion Rates	cc charges in Dest. Currency	
For Carriers Use only at Destination	Charges at Destination	Total collect Charges

Shipper certifies that the particulars on the face hereof are correct and that INSOFAR AS ANY PART OF THE CONSIGNMENT CONTAINS DANGEROUS GOODS, SUCH PART IS PROPERLY DESCRIBED BY NAME AND IS IN PROPER CONDITION FOR CARRIAGE BY AIR ACCORDING TO THE APPLICABLE DANGEROUS GOODS REGULATIONS.

POH SENG KIAN

Signature of Shipper or his Agent

POH SENG KIAN 79, Batu 6 1/4 Kesang 84000 Muar, Johor Tel: 016-665 2480

07march2014 KUALA LUMPUR JHG KUL
Executed on (Date) at (Place) Signature of Issuing Carrier or its Agent

232-1200 7306

ORIGINAL 1 (FOR ISSUING CARRIER)

~~Original 2 (For Consignee)~~ ~~232-10677085~~

232-10677085

232-10677085

Shipper's Name and Address — Shipper's Account Number 1000000

NNR GLOBAL LOGISTICS (M) SDN BHD
NO. 15, JALAN BATU MAUNG
DIS3PLEX FREE COMMERCIAL ZONE
AIRFREIGHT FORWARDERS WAREHOUSING CARGO
BATU MAUNG, PENANG 11960

Not negotiable
Air Waybill
Issued By
MALAYSIAN AIRLINE SYSTEM BERHAD
F, ADMIN BUILDING 1, MAS COMPLE
SULTAN ABDUL AZIZ SHAH AIRPORT. 4
SUBANG, SELANGOR DARUL EHSAN, MAL

Copies 1, 2 and 3 of this Air Waybill are originals and have the same validity

Consignee's Name and Address — Consignee's Account Number 10063400

JHJ INTERNATIONAL TRANSPORTATION CO LTD
BEIJING BRANCH
C/O NNR GLOBAL LOGISTICS (BEIJING) CO L
ROOM 302 LOGISTIC BLDG.
NO.10 TIANZHU ROAD, TIANZHU IND ESTATE

It is agreed that the goods described herein are accepted in apparent good order and condition (except as noted) for carriage SUBJECT TO THE CONDITIONS OF CONTRACT ON THE REVERSE HEREOF. ALL GOODS MAY BE CARRIED BY ANY OTHER MEANS INCLUDING ROAD OR ANY OTHER CARRIER UNLESS SPECIFIC CONTRARY INSTRUCTIONS ARE GIVEN HEREON BY THE SHIPPER, AND SHIPPER AGREES THAT THE SHIPMENT MAY BE CARRIED VIA INTERMEDIATE STOPPING PLACES WHICH THE CARRIER DEEMS APPROPRIATE. THE SHIPPER'S ATTENTION IS DRAWN TO THE NOTICE CONCERNING CARRIER'S LIMITATION OF LIABILITY. Shipper may increase such limitation of liability by declaring a higher value for carriage and paying a supplemental charge if required.

Issuing Carrier's Agent Name and City

NNR GLOBAL LOGISTICS (M) SDN BHD
NO. 15, JALAN BATU MAUNG
DIS3PLEX FREE COMMERCIAL ZONE

Accounting Information

<<< BDS 2.73 1516/FT >>>

FREIGHT : FREIGHT PREPAID
AIRPORT TO AIRPORT

Agent's IATA Code: 20-3-1232 | Account No.

Airport of Departure (Addr. of First Carrier) and Requested Routing: PENANG INTERNATIONAL

Reference Number | Optional Shipping Information

To	By First Carrier	to	by	to	by	Currency	CHGS Code	WT/VAL PPD	WT/VAL COLL	Other PPD	Other COLL	Declared Value for Carriage	Declared Value for Customs
KUL	MH	PEK	MH			MYR	PX	X		X		NVD	NCV

Airport of Destination: BEIJING | Requested Flight/Date: MH6803/7 MH370/8 | Amount of Insurance: 0

INSURANCE – If Carrier offers insurance and such insurance is requested in accordance with conditions on reverse thereof, indicate amount to be insured in figures in box marked "Amount of Insurance".

Handling Information: PLEASE NOTIFY CNEE IMMDY UPON ARRIVAL OF GOODS. ONE CONSOL POUCH ATTACHED.
SHIPPER DECLARATION FOR DGD NOT REQUIRED
'LITHIUM ION BATTERIES IN COMPLIANCE WITH SECT II OF P.I. 965'
EMERGENCY CONTACT TEL NBR 1-800-434-2300

SCI

No. of Pieces RCP	Gross Weight	kg lb	Rate Class / Commodity Item No.	Chargeable Weight	Rate / Charge	Total	Nature and Quantity of Goods (incl. Dimensions or Volume)
133	1990.0	K	Q GCR	1990.0	11.58	23044.20	CONSOLIDATED AS PER ATTACHED CARGO MANIFEST FREIGHT PREPAID
67	463.0	K	Q GCR	463.0	11.58	5361.54	PMC 5871 MH STC 133PKGS AND LOOSE 67 PKGS
							DIMS (CM) 60X 26X 22X 58 42X 36X 19X 9
200	2453.0				Totals	28405.74	

THE PACKAGE CONTAINS LITHIUM ION BATTERIES
THE PACKAGE MUST BE HANDLED WITH CARE AND
THAT A FLAMMABILITY HAZARDS EXIST IF THE
PACKAGE IS DAMAGED. SPECIAL PROCEDURES MUST
BE FOLLOWED IN THE EVENT THE PACKAGE IS
DAMAGED TO INCLUDE INSPECTION AND REPACKING IF NECESSARY

Prepaid	Weight Charge	Collect
28405.74		
	Valuation Charge	
	Tax	
	Total Other Charges Due Agent	
3676.74	Total Other Charges Due Carrier	
Total Prepaid		Total Collect
32082.48		
Currency Conversion Rates		cc Charges in Dest. Currency
For Carrier's Use only at Destination	Charges at Destination	Total Collect Charges

Other Charges: MY 2453.00 TC 291.60 XB 932.14

Shipper certifies that the particulars on the face hereof are correct and that insofar as any part of the consignment contains dangerous goods, such part is properly described by name and is in proper condition for carriage by air according to the applicable Dangerous Goods Regulations.

NNR GLOBAL LOGISTICS (M) SDN BHD

Signature of Shipper or his Agent

3/6/2014 — PEN — ANDELYN TEOH
Executed on (date) — at (place) — Signature of Issuing Carrier or its Agent

Original 2 – (For Consignee) 232-10677085

232 | KUL | 1202 2382 UTN:14 847 032267

232-1202 2382

Shipper's Name and Address — Shipper's Account Number: 7703

PANALPINA TRANSPORT (M) SDN BHD
LOT CTBGF 02&03 KLAS CARGO TERMINAL
KLAS CARGO COMPLEX KLIA
64000 SEPANG SELANGOR

Not Negotiable
Air Waybill
Issued by

~~MALAYSIAN AIRLINE SYSTEM BHD~~
33RD FLOOR, BANGUNAN MAS
50250 KUALA LUMPUR, MALAYSIA
MEMBER OF IATA

Copies 1, 2 and 3 of this Air Waybill are originals and have the same validity.

Consignee's Name and Address — Consignee's Account Number: 7230

CTS INTERNATIONAL ~~LOGISTICS CORP.~~
LIMITED BEIJING BRANCH ROOM E409
SOUTH BLD,ACLP INTL BLD,566SHUNPING
CN RD,SHUNYI DIST,BEIJING

~~FILE : 032267/7082~~

Issuing Carrier's Agent Name and City:
PANALPINA TRANSPORT (M) S/B-KLIA
LOT CTBGF 02&03 KLAS CARGO COMPLEX
KLIA,64000 SEPANG SELANGOR MALAYSIA

Accounting Information: FREIGHT PREPAID

VOLUME 0.194 M3

Agent's IATA Code: 20-3 0968/1501 — Account No.:

Airport of Departure (Addr. of First Carrier) and Requested Routing: KUL KUALA LUMPUR MY

Reference Number — Optional Shipping Information

To	By First Carrier	to	by	to	by	Currency	CHGS Code	WT/VAL PPD	COLL	Other PPD	COLL	Declared Value for Carriage	Declared Value for Customs
PEK	MAS					MYR	PP	X		X		NVD	NCV

Airport of Destination: BEIJING — Requested Flight/Date: MH 370/08 — Amount of Insurance: XXX

INSURANCE - If carrier offers insurance, and such insurance is requested in accordance with conditions on reverse hereof, indicate amount to be insured in figures in box marked "Amount of Insurance".

Handling Information: ENCL. CONSOL POUCH ATTCHD
PLS NTFY CNEE IMMED UPN ARRVL.
FINAL DESTINATION TIANJIN

SCI

No. of Pieces RCP	Gross Weight	kg lb	Rate Class / Commodity Item No.	Chargeable Weight	Rate / Charge	Total	Nature and Quantity of Goods (incl. Dimensions or Volume)
4	26.0	K	Q	33.0	13.66	450.78	CONSOLIDATION AS PER ATTACHED MANIFEST 2PCS 61x 36x 25 1PCS 37x 30x 26 1PCS 61x 36x 25
4	26.0	K				450.78	SLAC-00004/CONT. RIDER

Prepaid	Weight Charge	Collect	Other Charges
450.78			FSC 33.00 SSC 9.85

Valuation Charge

Tax

Total Other Charges Due Agent

Total Other Charges Due Carrier: 42.88

Shipper certifies that the particulars on the face hereof are correct and that insofar as any part of the consignment contains dangerous goods, such part is properly described by name and is in proper condition for carriage by air according to the applicable Dangerous Goods Regulations.

ON BEHALF OF THE SHIPPER
PANALPINA TRANSPORT (M) SDN BHD
SAIFUL
Signature of Shipper or his Agent

Total Prepaid: 493.66 — Total Collect

Currency Conversion Rates — CC Charges in Dest. Currency

AS AGENT OF CARRIER MAS
PANALPINA TRANSPORT (M) SDN BHD
07 MAR 2014
Executed on (date) — at (place) — Signature of Issuing Carrier or its Agent

For Carrier's Use only at Destination — Charges at Destination — Total Collect Charges

232-1202 2382

COPY 11 (EXTRA COPY)

232 KUL 1187 3632 | 232 1187 3632

Shipper's Name and Address

MALAYSIAN EXPRESS WORLDWIDE SDN BHD
NO 3 USJ16 2F
47630 UEP SUBANG JAYA
SELANGOR DARUL EHSAN
TE0380247875 FX0380247870 MS.ANUM

Air Waybill
Issued by
MALAYSIAN AIRLINE SYSTEM BERHAD
3RD FLR. ADMIN BLDG 1.MAS COMPLE
SAAS AIRPORT. 47200 SUBANG, MY

Copies 1, 2 and 3 of this Air Waybill are originals and have the same validity.

Consignee's Name and Address | Consignee's Account Number

UPS PARCEL DELIVERY(GUANGDONG)CO.,
BEIJING BRANCH
NO.3 ZAOYING RD.MAIZIDIAN CHAOYANG DISTRICT
BEIJING 100125 CHINA.
TEL: 65934088

It is agreed that the goods described herein are accepted in apparent good order and condition (except as noted) for carriage SUBJECT TO THE CONDITIONS OF CONTRACT ON THE REVERSE HEREOF. ALL GOODS MAY BE CARRIED BY ANY OTHER MEANS INCLUDING ROAD OR ANY OTHER CARRIER UNLESS SPECIFIC CONTRARY INSTRUCTIONS ARE GIVEN HEREON BY THE SHIPPER, AND SHIPPER AGREES THAT THE SHIPMENT MAY BE CARRIED VIA INTERMEDIATE STOPPING PLACES WHICH THE CARRIER DEEMS APPROPRIATE. THE SHIPPER'S ATTENTION IS DRAWN TO THE NOTICE CONCERNING CARRIER'S LIMITATION OF LIABILITY. Shipper may increase such limitation of liability by declaring a higher value for carriage and paying a supplemental charge if required.

Issuing Carrier's Agent Name and City
MALAYSIAN EXPRESS WORLDWIDE SDN BHD
KUL

Accounting Information/Also Notify
FREIGHT PREPAID
EXPRESS HANDLING UNIT(EHU)

Agent's IATA Code: 2037091 | Account No.: 0000000

Airport of Departure (Addr. of first Carrier) and requested Routing: KUALA LUMPUR

Reference Number | Optional Shipping Information

To	By First Carrier	Routing and Destination	to	by	to	by	Currency	CHGS Code	WT/VAL PPD	WT/VAL COLL	Other PPD	Other COLL	Declared Value for Carriage	Declared Value for Customs
PEK	MH370	08MAR					MYR		PP		PP		NVD	NCV

Airport of Destination	Requested Flight/Date	Amount of Insurance
BEIJING	MH370/08	XXX

INSURANCE - If Carrier offers insurance, and such insurance is requested in accordance with the conditions thereof, indicate amount to be insured in figures in box marked 'Amount of Insurance'.

HANDLING INFORMATION
EXP PLS NOTIFY CNEE UPON ARRIVALS

SCI

(For USA only) These commodities, technology or software were exported from the United States in accordance with the Export Administration Regulations. Diversion contrary to USA law prohibited.

No. of Pieces RCP	Gross Weight	kg lb	Rate Class / Commodity Item No.	Chargeable Weight	Rate / Charge	Total	Nature and Quantity of Goods (incl. Dimensions or Volume)
02	6.0			6.0	13.66		COURIER MATERIALS
						81.96	

Prepaid	Weight Charge	Collect	Other Charges
81.96			TC : 25.00
	Valuation Charge		FSC : 6.00
	Tax		SRC : 2.28
27.40	Total other Charges Due Agent		
8.28	Total other Charges Due Carrier		
117.64	Total prepaid	Total collect	
	Currency Conversion Rates	cc charges in Dest. Currency	
For Carriers Use only at Destination	Charges at Destination	Total collect Charges	

Shipper certifies that the particulars on the face hereof are correct and that INSOFAR AS ANY PART OF THE CONSIGNMENT CONTAINS DANGEROUS GOODS, SUCH PART IS PROPERLY DESCRIBED BY NAME AND IS IN PROPER CONDITION FOR CARRIAGE BY AIR ACCORDING TO THE APPLICABLE DANGEROUS GOODS REGULATIONS.

MALAYSIA EXPRESS WORLDWIDE SDN BHD

Signature of Shipper or his Agent

26FEB14 KUALA LUMPUR ANUM

Executed on (Date) at (Place) Signature of Issuing Carrier or its Agent

232 1187 3632

COPY 11 (EXTRA COPY)

232 | KUL | 1202 2404 UTN:14 847 032265 232-1202 2404

Shipper's Name and Address: PANALPINA TRANSPORT ~~(M) SDN BHD~~
LOT CTBGF 02&03 KLAS CARGO TERMINAL
KLAS CARGO COMPLEX KLIA
64000 SEPANG SELANGOR

Shipper's Account Number: 7703

Not Negotiable
Air Waybill
Issued by ~~MALAYSIAN AIRLINE SYSTEM BHD~~
33RD FLOOR, BANGUNAN MAS
50250 KUALA LUMPUR, MALAYSIA
MEMBER OF IATA

Copies 1, 2 and 3 of this Air Waybill are originals and have the same validity.

Consignee's Name and Address: CTS INTERNATIONAL ~~LOGISTICS CORP.~~
LIMITED BEIJING BRANCH ROOM E409
SOUTH BLD,ACLP INTL BLD,566SHUNPING
CN RD,SHUNYI DIST,BEIJING

Consignee's Account Number: 7230

~~FILE : 032265/7081~~

Issuing Carrier's Agent Name and City: PANALPINA TRANSPORT (M) S/B-KLIA
LOT CTBGF 02&03 KLAS CARGO COMPLEX
KLIA,64000 SEPANG SELANGOR MALAYSIA

Accounting Information: FREIGHT PREPAID

Agent's IATA Code: 20-3 0968/1501 | Account No.:

VOLUME 0.029 M3

Airport of Departure (Addr. of First Carrier) and Requested Routing: KUL KUALA LUMPUR MY

Reference Number | Optional Shipping Information

To	By First Carrier	Routing and Destination	to	by	to	by	Currency	CHGS Code	WT/VAL PPD	WT/VAL COLL	Other PPD	Other COLL	Declared Value for Carriage	Declared Value for Customs
PEK	MAS						MYR	PP	X		X		NVD	NCV

Airport of Destination	Requested Flight/Date	Amount of Insurance	INSURANCE
BEIJING	MH 370/08	XXX	INSURANCE - If carrier offers insurance, and such insurance is requested in accordance with conditions on reverse thereof, indicate amount to be insured in figures in box marked "Amount of Insurance".

Handling Information: ENCL. CONSOL POUCH ATTCHD
PLS NTFY CNEE IMMED UPN ARRVL.

SCI

No. of Pieces RCP	Gross Weight	kg lb	Rate Class	Commodity Item No.	Chargeable Weight	Rate / Charge	Total	Nature and Quantity of Goods (incl. Dimensions or Volume)
1	6.0	K	M		6.0	MIN.	75.00	CONSOLIDATION AS PER ATTACHED MANIFEST 1PCS 42x 42x 17
1	6.0	K					75.00	SLAC-00001/CONT. RIDER

Prepaid	Weight Charge	Collect
75.00		
	Valuation Charge	
	Tax	
	Total Other Charges Due Agent	
	Total Other Charges Due Carrier	
Total Prepaid 75.00		Total Collect
Currency Conversion Rates		CC Charges in Dest. Currency
For Carrier's Use only at Destination	Charges at Destination	Total Collect Charges

Other Charges

Shipper certifies that the particulars on the face hereof are correct and that insofar as any part of the consignment contains dangerous goods, such part is properly described by name and is in proper condition for carriage by air according to the applicable Dangerous Goods Regulations.

ON BEHALF OF THE SHIPPER :
PANALPINA TRANSPORT (M) SDN BHD
SAIFUL
Signature of Shipper or his Agent

AS AGENT OF CARRIER MAS
PANALPINA TRANSPORT (M) SDN BHD
07 MAR 2014
Executed on (date) at (place) Signature of Issuing Carrier or its Agent

232-1202 2404

COPY 11 (EXTRA COPY)

232-12009141

232 KUL 12009141

Shipper's Name and Address / Shipper's Account Number
KERRY LOGISTICS (MALAYSIA) SDN BHD - KUALA
LOT 844, 1ST FLOOR JLN SUBANG 7
TMN PERINDUSTRIAN SUBANG,
47500 SUBANG JAYA, SELANGOR D.E.
TEL: 60-3-80238266 FAX: 60-3-80238277

Not Negotiable
Air Waybill
Issued by
Malaysia Airline System Berhad
33RD FLOOR, MAS BUILDING,
JALAN SULTAN ISMAIL, KUALA LUMPUR,
FEDERAL TERRITORY, MALAYSIA
50250

Copies 1, 2 and 3 of this Air Waybill are originals and have the same validity.

Consignee's Name and Address / Consignee's Account Number
KERRY EAS LOGISTICS LIMITED
NO.21 XIAOYUN ROAD, CHAOYANG DISTRICT,
BEIJING 100027 CHINA
ATTN:MR DAVID ZHANG
TEL: 8610-84546956 FAX:8610-64647246

It is agreed that the goods described herein are accepted in apparent good order and condition (except as noted) for carriage SUBJECT TO THE CONDITIONS OF CONTRACT ON THE REVERSE HEREOF. ALL GOODS MAY BE CARRIED BY ANY OTHER MEANS INCLUDING ROAD OR ANY OTHER CARRIER UNLESS SPECIFIC CONTRARY INSTRUCTIONS ARE GIVEN HEREON BY THE SHIPPER, AND SHIPPER AGREES THAT THE SHIPMENT MAY BE CARRIED VIA INTERMEDIATE STOPPING PLACES WHICH THE CARRIER DEEMS APPROPRIATE. THE SHIPPER'S ATTENTION IS DRAWN TO THE NOTICE CONCERNING CARRIER'S LIMITATION OF LIABILITY. Shipper may increase such limitation of liability by declaring a higher value for carriage and paying a supplemental charge if required.

Issuing Carrier's Agent Name and City
INTERNATIONAL AIR TRANSPORT ASSOCIATION

Accounting Information
FREIGHT PREPAID

Agent's IATA Code: 20312481501
Account No.:

Airport of Departure (Addr. of First Carrier) and Requested Routing: KUALA LUMPUR

Reference Number | Optional Shipping Information

to	By First Carrier	Routing and Destination	to	by	to	by	Currency	CHGS Code	WT/VAL PPD	WT/VAL COLL	Other PPD	Other COLL	Declared Value for Carriage	Declared Value for Customs
PEK	MH						MYR	PP	P		P		NVD	NCV

Airport of Destination: BEIJING CAPITAL INTL
Requested Flight/Date: MH370/08
Amount of Insurance: XXX
INSURANCE - If carrier offers insurance, and such insurance is requested in accordance with the conditions thereof, indicate amount to be insured in figures in box marked "Amount of Insurance".

Handling Information
TOTAL: (13) PACKAGE(S) ONLY.
ONE POUCH OF DOCUMENT ATTACHED.

SCI

No. of Pieces RCP	Gross Weight	kg lb	Rate Class	Commodity Item No.	Chargeable Weight	Rate / Charge	Total	Nature and Quantity of Goods (incl. Dimensions or Volume)
13	2,250.0	K	Q		2,250	10.25	23,062.50	CONSOLIDATION DETAILS AS PER CARGO MANIFEST ATTACHED 38x31x13(CM)/2 43x30x25(CM)/5 105x95x105(CM)/1 105x95x118(CM)/1 105x95x140(CM)/1 105x95x144(CM)/1 105x95x150(CM)/1 105x95x161(CM)/1
13	2,250.0						23,062.50	

	Prepaid	Collect
Weight Charge	23062.50	
Valuation Charge		
Tax		
Total Other Charges Due Agent		
Total Other Charges Due Carrier	3108.00	
Total Prepaid / Total Collect	26170.50	
Currency Conversion Rates / CC Charges in Dest. Currency		
For Carriers Use only at Destination / Charges at Destination		

Other Charges
MYC:2250.00 SCC:855.00 CGC:3.00

Shipper certifies that the particulars on the face hereof are correct and that insofar as any part of the consignment contains dangerous goods, such part is properly described by name and is in proper condition for carriage by air according to the applicable Dangerous Goods Regulations.

KERRY LOGISTICS (MALAYSIA) SDN BHD - KUALA LUMPUR
Signature of Shipper or his Agent

06-MAR-2014 KUALA LUMPUR NAZROL NASIR
Executed on (date) at (place) Signature of Issuing Carrier or its Agent

Total Collect Charges

232-12009141

ORIGINAL 2 (FOR CONSIGNEE)

DVC-17957 1606 07MAR14

MALAYSIA AIRLINES

L O A D S H E E T   CHECKED BY   APPROVED   EDNO
ALL WEIGHTS IN KG   FAIZAL   02

FROM/TO FLIGHT   A/C REG VERSION   CREW   DATE   TIME
KUL PEK MH0370/08   9M-MRO J35Y245   2/10   07MAR14 1606

WEIGHT   DISTRIBUTION
LOAD IN COMPARTMENTS   14296 1/2500 2/4530 3/804 4/5885 5/577
0/0
PASSENGER/CABIN BAG   16790 222/3/2   TTL 227 CAB 0
PAX 10/215
TOTAL TRAFFIC LOAD   31086 BLKD 1/0
DRY OPERATING WEIGHT   143283
ZERO FUEL WEIGHT ACTUAL 174369 MAX 195044 L   ADJ

TAKE OFF FUEL   49100
TAKE OFF WEIGHT ACTUAL   223469 MAX 286897   ADJ

TRIP FUEL   37200
LANDING WEIGHT ACTUAL 186269 MAX 208652   ADJ

BALANCE AND SEATING CONDITIONS   LAST MINUTE CHANGES
DOI   59.07 DLI   57.29   DEST SPEC   CL/CPT + - WEIGHT
LIZFW   67.05 MACZFW   31.65
LITOW   70.05 MACTOW   33.78

STAB TO 03.9 MID
SEATING
0A/10 0B/127 0C/88

UNDERLOAD BEFORE LMC   20675   LMC TOTAL + -

LOADMESSAGE AND CAPTAINS INFORMATION BEFORE LMC

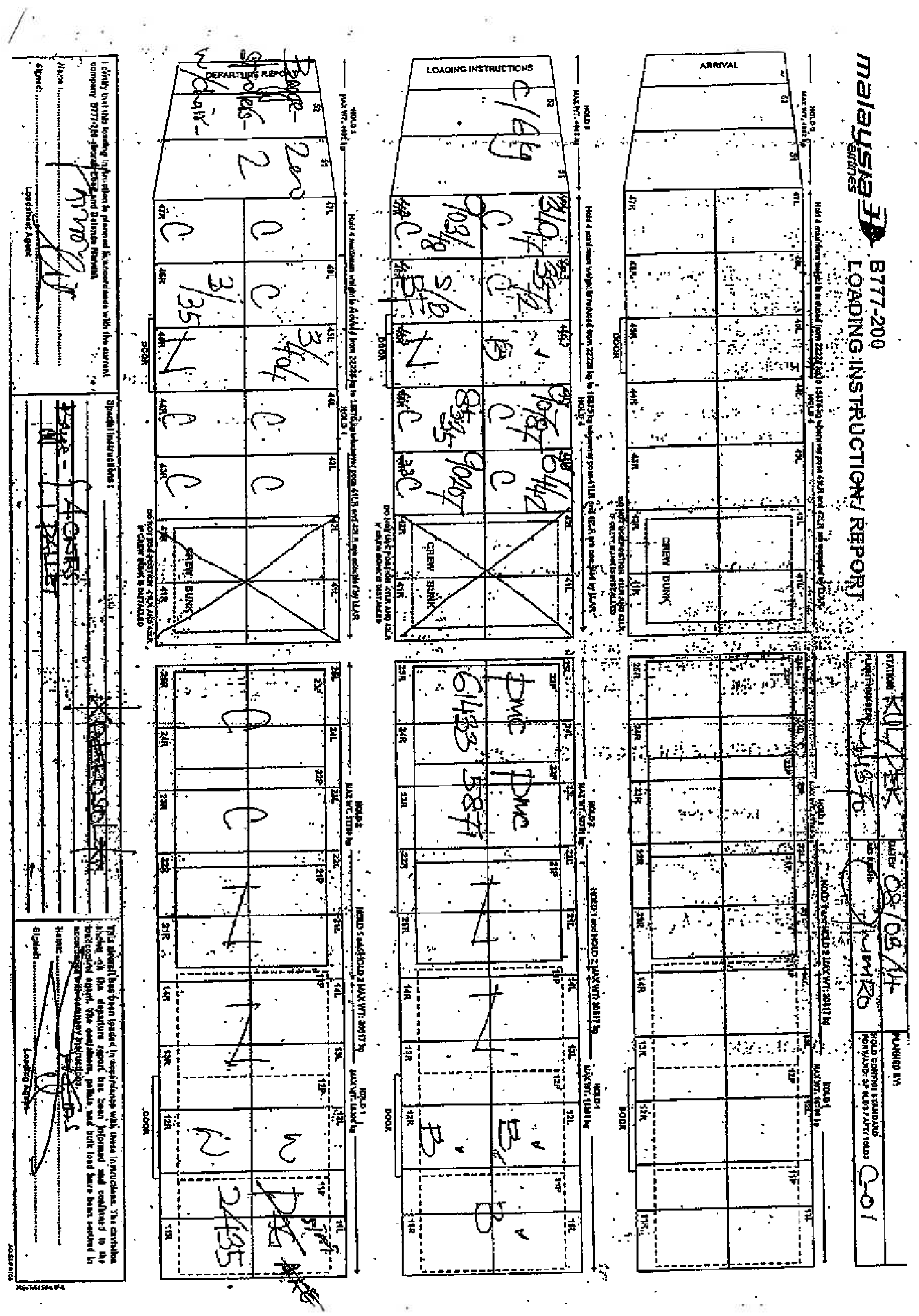
PANTRY B   4564/-01.0

*** CONNECTED TO CHECK-IN APPLICATION ***

WBC K8-45
EXP 20SEP14
NOTOC - YES

LDM
MH370/07. 9M-MRO. J35Y245. 2/10
PEK. 222/3/2.0. T14296. 1/2500. 2/4530. 3/804. 4/5885. 5/577
PAX/10/215. PAD/0/1. PER/41L. PER/41R. PER/43L. PER/44L

B3490. C10806. MNIL. ENIL


malaysia airlines
B777-200
LOADING INSTRUCTION / REPORT
ARRIVAL
LOADING INSTRUCTIONS
DEPARTURE REPORT
CREW BUNK
DOOR
Special Instructions:
Loadsheet Agent
Loading Agent

```
DVC-10329 1448 07MAR14

LOADING INSTRUCTION/REPORT  CONFIG          PREPARED BY        EDNO
ALL WEIGHTS IN KG     J35Y245               ELMI ZAMRI           01

FROM/TO FLIGHT    A-C/REG  D/V   VERSION   CREW   DATE    TIME
KULPEK MH 0370   9M-MRO  06/12  772        2/12   08MAR   1448

PLANNED LOAD
PEK  J 10 Y 218  C 010897 M 000000 B 004720 E 000000
JOINING SPECS PEK  PER/4 PER/4 PER/4 PER/4
TRANSIT SPECS
RELOADS

-----------------------------------------------------------
CPT  1.FLF MAX 015308                       ::CPT   TOTAL :
                                            ------------------
:11P                                                        :
:ONLOAD   PEK B/02000
:REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:12L                          :12R                          :
:ONLOAD   PEK B/00840         :ONLOAD   PEK B/00840
:REPORT                       :REPORT
-----------------------------------------------------------
CPT  2 FLA MAX 017780  1+2  033088          ::CPT  1 TOTAL :
                                            ------------------
:22P      PMC5871MH                                         :
:ONLOAD   PEK C/02110
:REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:23P      PMC61433MH                                        :
:ONLOAD   PEK C/02420
:REPORT
-----------------------------------------------------------
CPT  3 ALF MAX 003174                       ::CPT  2 TOTAL :
                                            ------------------
:33L      AKE6442MH           :33R      AKE90207MH          :
:ONLOAD   PEK C/00410         :ONLOAD   PEK C/00394
:REPORT                       :REPORT
-----------------------------------------------------------
CPT  4 ALC MAX 012701  3+4  015875          ::CPT  3 TOTAL :
                                            ------------------
:41L      AKE90787MH          :41R      AKE8535MH           :
:ONLOAD   PEK C/01242         :ONLOAD   PEK C/01228
:SPECS  PER                   :SPECS  PER
:REPORT                       :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:42L                          :                             :
:ONLOAD   PEK SS/00091        :ONLOAD
:REPORT                       :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:42L                          :                             :
:ONLOAD   PEK TB/00200        :ONLOAD
:REPORT                       :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:43L      AKE3372MH           :43R                          :
:ONLOAD   PEK C/01238         :ONLOAD   PEK FB/00840
:SPECS  PER                   :SPECS
:REPORT                       :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

```
:44L        AKE3497MH           :44R       AKE90348MH        :
:ONLOAD     PEK C/01218         :ONLOAD    PEK C/00540
:SPECS  PER                     :SPECS
:REPORT                         :REPORT
-----------------------------------------------------
CPT  5 ALA MAX 004082   +5  019957      ::CPT  4 TOTAL :
                                        ----------------------
:52         00000000000                                  :
:ONLOAD     PEK C/00006
:REPORT
-----------------------------------------------------
                                        ::CPT  5 TOTAL :
                                        ----------------------

SI

THIS AIRCRAFT HAS BEEN LOADED IN ACCORDANCE WITH THESE
INSTRUCTIONS AND THE DEVIATIONS SHOWN ON THIS REPORT. THE
CONTAINER/PALLETS AND BULK LOAD HAVE BEEN SECURED IN
ACCORDANCE WITH COMPANY INSTRUCTIONS.
                              SIGNATURE:

;

DVC-10329 1448 07MAR14
FLR
MH0370/08MAR14/KUL
;

DVC-10329 1448 07MAR14
EZFW MH 370/07MAR 9M-MRO J35Y245 02/12/00  KULPEK
PASSENGER              017015KG
BAGGAGE                003324KG
CARGO                  010806KG
MAIL                   000000KG
EQUIPMENT              000000KG
TR DEADLOAD            000000KG
TR PASSENGER           000000KG
TTL TRAFFIC LOAD       031145KG
J 010 Y 218
TTL PASSENGER          228
BW                     138919KG
WT ADJ                 004564KG
ADJ-DOW                143483KG
EST ZFW                174628KG OR 384989LB
*
;

DVC-10329 1448 07MAR14
EZFW MH 370/08MAR 9M-MRO J35Y245 02/12/00  KULPEK
PASSENGER              017015KG
BAGGAGE                003324KG
CARGO                  010806KG
MAIL                   000000KG
EQUIPMENT              000000KG
TR DEADLOAD            000000KG
TR PASSENGER           000000KG
TTL TRAFFIC LOAD       031145KG
```

131571 RCVD 07MAR14 1443Z
QX KULKJMH
.KULFGMH 071443 KUL/QF/4C90
U L D S A S S I G N E D T O F L I G H T 07MAR 1443Z QF
OTHERS ....
IRREGULARITIES AWB NBR ....
WEATHER GOOD / RAIN
IF RAIN SPECIFY TIME START.......... / END ....
PART02 END
SENT
KULKJMH KULKCMH HDQFEMH KULFWMH KULOCMH KULFOMH KULFGMH
**

190.0 175.0

131572 RCVD 07MAR14 1443Z
QX KULKJMH
.KULFGMH 071443 KUL/QF/4C90
U L D S A S S I G N E D T O F L I G H T 07MAR 1443Z QF

MH 370 08MAR 772 K U L UFL
FIRST UFL: 2243 07MAR14 QF LAST UFL:

P E K	PCS	VOL	WGT IN KGS SYST	ACTL	DEVIATION KGS	PERC
01*AKE 3372MH PER	1	6.9*	1148	1238	21	1.8
02*AKE 3497MH PER	1	6.8*	1128	1218	21	1.8
03*AKE 6442MH PPP QTC KEY	1	4.0*	320	410	21	6.5
04*AKE 8535MH PER	1	6.8*	1138	1228		0.0
05*AKE 90207MH PPP QTC KEY	1	4.0*	326	394	-18	-5.5
06 AKE 90348MH QTC SSR	67	2.8*	463	540	-9	-1.9
07*AKE 90787MH PER	1	6.9*	1152	1242	4	0.3
08*PMC 5871MH QTC SSR	133	10.0*	1990	2110		0.0
09 PMC 61433MH	18	8.6*	2282	2420	18	0.7
TOTAL	224	56.8	9947	10800	58	0.5

B U L K L O A D	PCS	VOL	WGT IN KGS SYST	ACTL	DEVIATION KGS	PERC
PEK	2	0.0*	6	6		0.0

EXS CN-11873632 2P/6.KG SEND BY VAN THRU EHUMGD**

*** POM BULK OP OKG ***

CHECKED BY............... APRON CHECKED............
NAME..................... NAME.....................

CONDITION OF CARGO AT BAY GOOD / TORN / DAMAGE / WET / LEAK
PART01 CONTINUED
SENT
KULKJMH KULKCMH HDQFEMH KULFWMH KULOCMH KULFOMH KULFGMH
**

02*AKE 3497MH PER	1	6.8*	1128	1218	81	1.8
03*AKE 6442MH PPP QTC KEY	1	4.0*	320	410	21	6.5
04*AKE 8535MH PER	1	6.8*	1138	1228		0.0
05*AKE 90207MH PPP QTC KEY	1	4.0*	326	394	-18	-5.5
06 AKE 90348MH QTC SSR	67	2.8*	463	540	-9	-1.9
07*AKE 90787MH PER	1	6.9*	1152	1242	4	0.3
08*PMC 5871MH QTC SSR	133	10.0*	1990	2110		0.0
09 PMC 61433MH	18	8.6*	2282	2420	18	0.7
TOTAL	224	56.8	9947	10800	58	0.5

BULK LOAD	PCS	VOL	WGT IN KGS SYST	ACTL	DEVIATION KGS	PERC
PEK	2	0.0*	6	6		0.0

EXS CN-11873632 2P/6.KG SEND BY VAN THRU EHUMGO**

*** POM BULK OP OKG ***

CHECKED BY...............
NAME.....................

APRON CHECKED............
NAME.....................

CONDITION OF CARGO AT BAY GOOD / TORN / DAMAGE / WET / LEAK
PART01 CONTINUED
SENT
KULKJMH KULKCMH HDQFEMH KULFWMH KULOCMH KULFOMH KULFGMH
**

131596 RCVD 07MAR14 1443Z
QX KULKJMH
.KULFGMH 071443 KUL/QF/4C90
SPECIAL LOAD NOTIFICATION TO CAPTAIN

FROM FLIGHT KUL MH 0370 — DATE 08MAR14 — A/C REG

NO RESTRICTED LOAD EX KUL

OTHER SPECIAL LOAD

TO	AWB	CONTENTS	PCS	QTY	IMP CODE	ULD	POS CODE
PEK	12007306	MANGOSTEEN	1	1128KG	PER	AKE 3497MH	...
PEK	12007306	MANGOSTEEN	1	1148KG	PER	AKE 3372MH	...
PEK	12007306	MANGOSTEEN	1	1138KG	PER	AKE 8535MH	...
PEK	12007306	MANGOSTEEN	1	1152KG	PER	AKE 90787MH	...

174 064

SI NIL

THERE IS NO EVIDENCE THAT ANY DAMAGED OR LEAKING PACKAGES &
CONTAINING DANGEROUS GOODS HAVE BEEN LOADED ON THE AIRCRAFT
AT THIS STATION

LOADED AS SHOWN CAPTAINS SIGNATURE

2

DVC-17957 1529 07MAR14
SPECIAL LOAD NOTIFICATION TO CAPTAIN PRE-FLIGHT 08:54

FROM	FLIGHT	DATE	A/C REG	PREPARED BY
KUL	MH 0370 /08	08MAR14	9M-MRO	MASGD

*** OTHER SPECIAL LOAD ***

TO	AWB NR	CONTENTS	PCS	QTY	IMP CODE	ULD	POS CODE
001.		MANGOSTEEN	0001	1128KG	PER		41L
PEK	12007306	MANGOSTEEN				AKE3497MH	
002.		MANGOSTEEN	0001	1152KG	PER		41R
PEK	12007306	MANGOSTEEN				AKE90787MH	
003.		MANGOSTEEN	0001	1148KG	PER		43L
PEK	12007306	MANGOSTEEN				AKE3372MH	
004.		MANGOSTEEN	0001	1138KG	PER		44L
PEK	12007306	MANGOSTEEN				AKE8535MH	

THERE IS NO EVIDENCE THAT ANY DAMAGED OR LEAKING PACKAGES CONTAINING DANGEROUS GOODS HAVE BEEN LOADED ON THE AIRCRAFT

LOADING SUPERVISOR
NAME AND SIGNATURE:

CAPTAIN
NAME AND SIGNATURE:

```
DVC-10329 1448 07MAR14

LOADING INSTRUCTION/REPORT  CONFIG          PREPARED BY       EDNO
ALL WEIGHTS IN KG      J35Y245              ELMI ZAMRI          01

FROM/TO FLIGHT    A-C/REG  D/V    VERSION   CREW   DATE    TIME
KULPEK MH 0370   9M-MRO  06/12  772         2/12   08MAR   1448

PLANNED LOAD
PEK  J 10 Y 218  C 010897 M 000000 B 004720 E 000000
JOINING SPECS PEK  PER/4 PER/4 PER/4 PER/4
TRANSIT SPECS
RELOADS
--------------------------------------------------------------
CPT  1 FLF MAX 015308                       ::CPT   TOTAL :

:11P                                                         :
:ONLOAD   PEK B/02000
:REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:12L                       :12R                              :
:ONLOAD   PEK B/00840      :ONLOAD   PEK B/00840
:REPORT                    :REPORT
--------------------------------------------------------------
CPT  2 FLA MAX 017780  1+2  033088          ::CPT  1 TOTAL :

:22P      PMC5871MH                                          :
:ONLOAD   PEK C/02110
:REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:23P      PMC61433MH                                         :
:ONLOAD   PEK C/02420
:REPORT
--------------------------------------------------------------
CPT  3 ALF MAX 003174                       ::CPT  2 TOTAL :

:33L      AKE6442MH        :33R      AKE90207MH              :
:ONLOAD   PEK C/00410      :ONLOAD   PEK C/00394
:REPORT                    :REPORT
--------------------------------------------------------------
CPT  4 ALC MAX 012701  3+4  015875          ::CPT  3 TOTAL :

:41L      AKE90787MH  M    :41R      AKE8535MH  M            :
:ONLOAD   PEK C/01242      :ONLOAD   PEK C/01228
:SPECS  PER                :SPECS  PER
:REPORT                    :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:42L                       :                                 :
:ONLOAD   PEK SS/00091 B   :ONLOAD
:REPORT                    :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:42L                       :                                 :
:ONLOAD   PEK TB/00200 B   :ONLOAD
:REPORT                    :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
:43L      AKE3372MH   M    :43R                              :
:ONLOAD   PEK C/01238      :ONLOAD   PEK FB/00840
:SPECS  PER                :SPECS
:REPORT                    :REPORT
. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . .
```

```
:44L      AKE3497MH              :44R      AKE90348MH       :
:ONLOAD   PEK C/01218            :ONLOAD   PEK C/00540
:SPECS  PER                      :SPECS
:REPORT                          :REPORT
-------------------------------------------------------
CPT  5 ALA MAX 004082   #5  019957      ::CPT  4 TOTAL :
                                        --------------------
:52       00000000000                                   :
:ONLOAD   PEK C/00006
:REPORT
-------------------------------------------------------
                                        ::CPT  5 TOTAL :
                                        --------------------

SI

THIS AIRCRAFT HAS BEEN LOADED IN ACCORDANCE WITH THESE
INSTRUCTIONS AND THE DEVIATIONS SHOWN ON THIS REPORT. THE
CONTAINER/PALLETS AND BULK LOAD HAVE BEEN SECURED IN
ACCORDANCE WITH COMPANY INSTRUCTIONS.
                     SIGNATURE:            2320

;

DVC-10329 1448 07MAR14
FLR
MH0270/08MAR14/KUL
;

DVC-10329 1448 07MAR14
EZFW MH 370/07MAR 9M-MRO J35Y245 02/12/00  KULPEK
PASSENGER              017015KG
BAGGAGE                003324KG
CARGO                  010806KG
MAIL                   000000KG
EQUIPMENT              000000KG
TR DEADLOAD            000000KG
TR PASSENGER           000000KG
TTL TRAFFIC LOAD       031145KG
J 010 Y 218
TTL PASSENGER          228
BW                     138919KG
WT ADJ                 004564KG
ADJ-DOW                143483KG
EST ZFW                174628KG OR 384989LB
;
;

DVC-10329 1448 07MAR14
EZFW MH 370/08MAR 9M-MRO J35Y245 02/12/00  KULPEK
PASSENGER              017015KG
BAGGAGE                003324KG
CARGO                  010806KG
MAIL                   000000KG
EQUIPMENT              000000KG
TR DEADLOAD            000000KG
TR PASSENGER           000000KG
TTL TRAFFIC LOAD       031145KG
```

```
PAGE  01                                                                    CC7NAM
 BSD: MH370/08MAR KUL
772/D      GTD/C1   POS/GATE BDT2335 SD0035 ED0035   SA0630    FT0555
PASSENGERS CHECKED-IN   : J10Y215
PASSENGERS BOARDED      : J10Y215
PASSENGERS NOT BOARDED  : J0Y0
NIL
```

IATA

Lithium Battery Guidance Document

Transport of lithium Metal and Lithium Ion Batteries

Revised for the 2014 Regulations

△ Introduction

This document is based on the provisions set out in the 2013-2014 Edition of the ICAO Technical Instruction for the Safe Transport of Dangerous Goods by Air and the 55th Edition of the IATA Dangerous Goods Regulations (DGR).

The purpose of this document is to provide guidance for complying with provisions applicable to the transport by air of lithium batteries as set out in the DGR. Specifically the document provides information on:

- Definitions;
- Classification (including classification flowcharts);
- Transport Conditions
- Exceptions;
- Special Provisions;
- Packaging provisions for lithium batteries;
- Prohibitions;
- Passenger Provisions; and
- Frequently Asked Questions

provisions of DGR 1.3.3.3 and 1.3.3.6 apply. If packages are assembled into an overpack the requirements for overpacks in DGR 8.1.6.9.3, Step 7 apply.

Note 3*: Until 31 March 2014 the shipper may , provide the information set out below on an air waybill or on an alternative transport documentation in lieu of using a Shipper's Declaration.*

When the transitional provisions are applied and an air waybill is used, the information required by 2, 3 and 4 below must be shown in the "Nature and Quantity of Goods" box of the air waybill and the air waybill must clearly identify the name and address of the shipper and of the consignee. Where an agreement exists with the operator, the shipper may provide the information by electronic data processing (EDP) or electronic data interchange (EDI) techniques. The information required is as follows and should be shown in the following order:

1) the name and address of the shipper and consignee;

2) UN 3480 or UN 3090, as applicable;

3) Lithium ion batteries PI 965 IB, or lithium metal batteries PI 968 IB;

4) the number of packages and the gross weight of each package.

3. Section II - Packing Instructions 965 – 970

"Small" Lithium ion and lithium metal cells and batteries that meet the Watt-hour or lithium content limits set out in Section II of PI 965 to PI 970 are only subject to certain parts of the DGR when shipped as cargo. The bulk of the requirements for these small lithium batteries are contained within the General Requirements at the start of each packing instruction which apply to all lithium batteries and then the specific requirements set out in Section II of each packing instruction, which are as follows:

(a) classification (DGR 3.9.2.6);

(b) limits on the quantity of lithium cells or batteries per package (Table II of the applicable packing instruction);

(c) strong outer packagings (see Section II of applicable packing instruction);

(d) marking and labelling of packages (Additional Requirements of Section II of the applicable packing instruction);

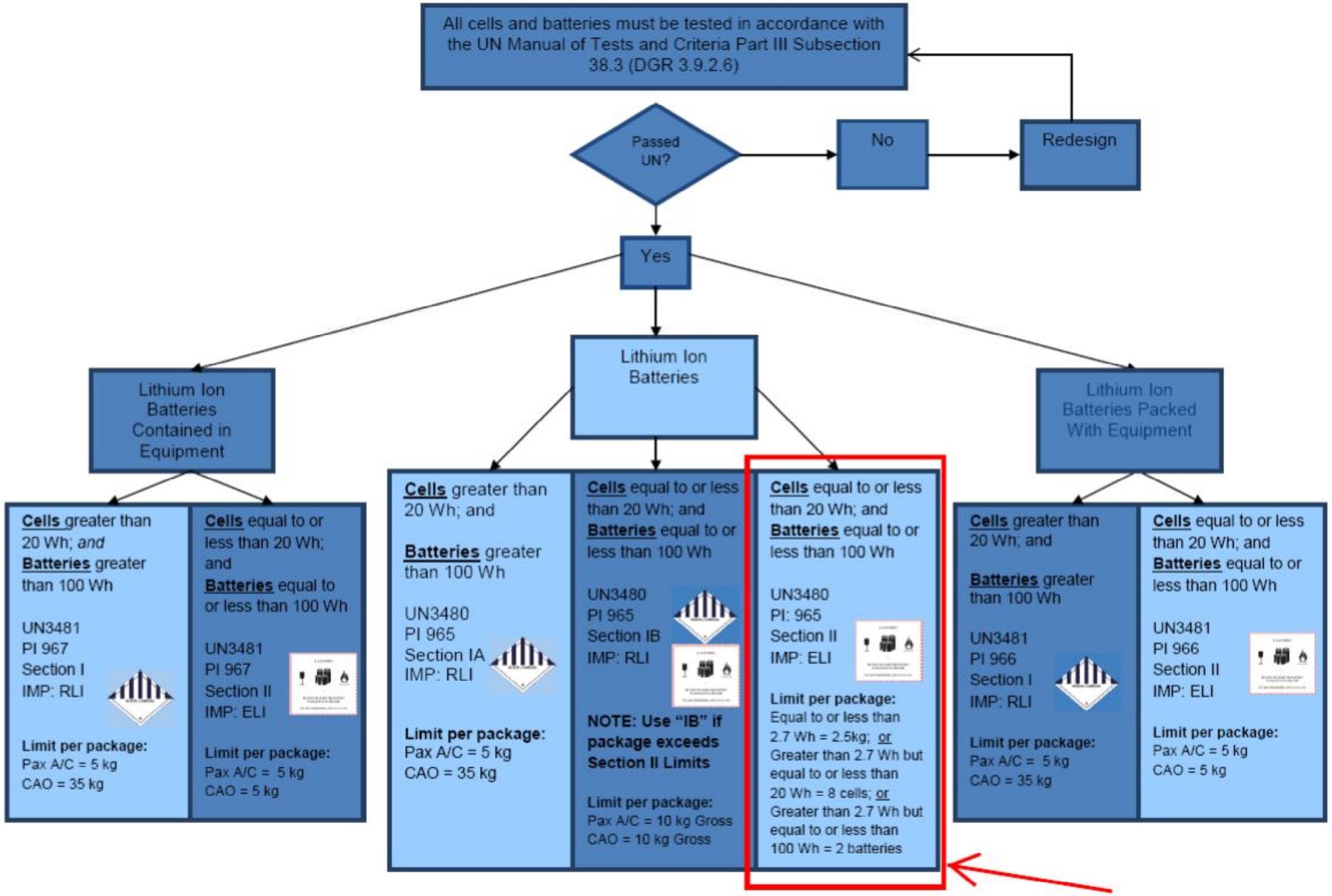
(e) the details of the consignment must be described (Additional Requirements of Section II of the applicable packing instruction).

Exceptions

Small lithium metal and lithium ion batteries are not subject to all of the provisions of the DGR provided that they comply with all of the requirements set out in Section II of Packing Instructions 965, 966 and 967 for lithium ion batteries and Section II of Packing Instructions 968, 969 and 970 for lithium metal batteries in the 55th Edition of the IATA DGR.

Packages containing lithium batteries, or lithium batteries contained in, or packed with, equipment that meet the provisions of Section II of these packing instructions are not required to have a Class 9 hazard label and there is no requirement for a Shipper's Declaration for Dangerous Goods for consignments of these batteries.

Classification Flowchart – Lithium Ion Batteries



APCS/Cargo Page 9 05/11/2013

*In red (Mangosteens and Lithium Ion Batteries carried together)

MANGOSTEEN				LITHIUM ION BATERRIES			
FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION	FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION
MH 376	01 JAN	232-11828622	KUL/PEK				
MH 370	02 JAN	232-11828795	KUL/PEK	MH 370	02 JAN	232-10629920	PEN/PEK
				MH 360	02 JAN	232-10638095	PEN/PEK
MH 370	03 JAN	232-11828806	KUL/PEK				
MH 370	03 JAN	232-11828795	KUL/PEK				
MH 370	04 JAN	232-11828810	KUL/PEK				
MH 370	05 JAN	232-11828821	KUL/PEK				
MH 370	06 JAN	232-11828832	KUL/PEK				
MH 370	07 JAN	232-11828843	KUL/PEK	MH 370	08 JAN	232-10638434	PEN/PEK
				MH 360	09 JAN	232-11843436	PEN/PEK
				MH 370	09 JAN	232-10638191	PEN/PEK
MH 360	10 JAN	232-11830976	KUL/PEK	MH 370	10 JAN	232-10638202	PEN/PEK
				MH 370	10 JAN	232-10630200	PEN/PEK
				MH 370	11 JAN	232-11812802	PEN/PEK
				MH 370	11 JAN	232-10630211	PEN/PEK
				MH 370	11 JAN	232-10638445	PEN/PEK
				MH 370	12 JAN	232-10630222	PEN/PEK
MH 370`	15 JAN	232-11828935	KUL/PEK	MH 370	15 JAN	232-10630454	PEN/PEK
				MH 370	15 JAN	232-10638106	PEN/PEK
MH 360	16 JAN	232-11879792	KUL/PEK				
MH 370	16 JAN	232-11851055	KUL/PEK	MH 370	16 JAN	232-10638375	PEN/PEK
MH 370	17 JAN	232-11851066	KUL/PEK	MH 370	17 JAN	232-10630476	PEN/PEK
				MH 370	17 JAN	232-10638526	PEN/PEK
MH 370	18 JAN	232-11879781	KUL/PEK	MH 370	18 JAN	232-10630480	PEN/PEK
MH 360	19 JAN	232-11879770	KUL/PEK				
MH 370	19 JAN	232-11851081	KUL/PEK				

MANGOSTEEN				LITHIUM ION BATERRIES			
MH 370	20 JAN	232-11851092	KUL/PEK	MH 370	20 JAN	232-10638810	PEN/PEK
MH 360	21 JAN	232-11879766	KUL/PEK	MH 360	21 JAN	232-11859105	PEN/PEK
MH 360	21 JAN	232-11880643	KUL/PEK	MH 360	21 JAN	232-11898445	PEN/PEK
MH 370	21 JAN	232-11865685	KUL/PEK				
MH 360	22 JAN	232-11884600	KUL/PEK				
MH 360	22 JAN	232-11884633	KUL/PEK				
MH 370	22 JAN	232-11865696	KUL/PEK				
MH 360	23 JAN	232-11880654	KUL/PEK				
MH 370	23 JAN	232-11865700	KUL/PEK				
MH 360	24 JAN	232-11775831	KUL/PEK				
MH 360	24 JAN	232-11831621	KUL/PEK				
MH 370	24 JAN	232-11865711	KUL/PEK	MH 370	24 JAN	232-10639053	PEN/PEK
MH 360	25 JAN	232-11831632	KUL/PEK				
MH 370	25 JAN	232-11865722	KUL/PEK	MH 370	25 JAN	232-10639064	PEN/PEK
MH 370	26 JAN	232-11828880	KUL/PEK				
MH 360	27 JAN	232-11831643	KUL/PEK				
MH 370	27 JAN	232-11828902	KUL/PEK				
MH 360	28 JAN	232-11831761	KUL/PEK				
MH 370	28 JAN	232-11828913	KUL/PEK				
MH 360	30 JAN	232-11831654	KUL/PEK				

MANGOSTEEN				LITHIUM ION BATERRIES			
FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION	FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION
				MH 360	09 FEB	232-11945894	PEN/PEK
				MH 370	12 FEB	232-10664054	PEN/PEK
				MH 370	15 FEB	232-10639193	PEN/PEK
				MH 370	15 FEB	232-10664080	PEN/PEK
				MH 370	16 FEB	232-10639204	PEN/PEK
				MH 370	16 FEB	232-10664091	PEN/PEK
				MH 370	16 FEB	232-10665395	PEN/PEK
				MH 370	17 FEB	232-10639215	PEN/PEK
				MH 370	18 FEB	232-11962786	PEN/PEK
				MH 370	20 FEB	232-10639510	PEN/PEK
				MH 370	20 FEB	232-10664334	PEN/PEK
				MH 370	21 FEB	232-10664345	PEN/PEK
				MH 370	21 FEB	232-10639532	PEN/PEK
				MH 370	22 FEB	232-10639543	PEN/PEK
				MH 370	23 FEB	232-10639554	PEN/PEK
				MH 360	25 FEB	232-10639775	PEN/PEK
				MH 370	26 FEB	232-10639086	PEN/PEK
				MH 370	26 FEB	232-10664603	PEN/PEK

MANGOSTEEN				LITHIUM ION BATERRIES			
FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION	FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN /DESTINATION
MH 370	03 MAR	232-12007413	KUL/PEK				
				MH 360	04 MAR	232-10676853	PEN/PEK
MH 370	05 MAR	232-11989176	KUL/PEK	MH 370	05 MAR	232-10677052	PEN/PEK
MH 360	06 MAR	232-12007671	KUL/PEK				
				MH 370	06 MAR	232-10677063	PEN/PEK
				MH 370	06 MAR	232-10664883	PEN/PEK
MH 370	07 MAR	232-12007295	KUL/PEK	MH 370	07 MAR	232-10677074	PEN/PEK
MH 370	09 MAR	232-12008441	KUL/PEK	MH 370	09 MAR	232-10677096	PEN/PEK
MH 360	10 MAR	232-12007332	KUL/PEK	MH 360	10 MAR	232-10677111	PEN/KUL
MH 370	10 MAR	232-12007321	KUL/PEK	MH 370	10 MAR	232-10677100	PEN/PEK
MH 360	12 MAR	232-12026136	KUL/PEK				
				MH 370	12 MAR	232-10677203	PEN/PEK
MH 370	13 MAR	232-12008905	KUL/PEK	MH 370	13 MAR	232-10677214	PEN/PEK
MH 360	14 MAR	232-12017250	KUL/PEK				
				MH 370	14 MAR	232-10677225	PEN/PEK
MH 318	15 MAR	232-11865976	KUL/PEK	MH 318	15 MAR	232-10677236	PEN/PEK
MH 318	16 MAR	232-12017412	KUL/PEK	MH 318	16 MAR	232-10677240	PEN/PEK
MH 318	16 MAR	232-11865980	KUL/PEK	MH 318	16 MAR	232-10665185	PEN/PEK
MH 318	16 MAR	232-12009163	KUL/PEK				
MH 318	17 MAR	232-11865991	KUL/PEK	MH 318	17 MAR	232-10677251	PEN/PEK
MH 360	17 MAR	232-11866046	KUL/PEK	MH 360	17 MAR	232-1067762	PEN/PEK
MH 318	19 MAR	232-11866050	KUL/PEK	MH 318	19 MAR	232-5652865	PEN/PEK
				MH 318	19 MAR	232-10680762	PEN/PEK
MH 318	20 MAR	232-11866061	KUL/PEK				
MH 318	21 MAR	232-11866035	KUL/PEK	MH 318	21 MAR	232-69867700	PEN/PEK
MH 318	22 MAR	232-11908116	KUL/PEK	MH 318	22 MAR	232-69868315	PEN/PEK
MH 318	23 MAR	232-11828865	KUL/PEK	MH 318	23 MAR	232-69907994	PEN/PEK

MANGOSTEEN				LITHIUM ION BATERRIES			
				MH 318	23 MAR	232-10680806	PEN/PEK
MH 318	25 MAR	232-11828924	KUL/PEK				
MH 318	26 MAR	232-11865921	KUL/PEK	MH 318	26 MAR	232-54905620	PEN/PEK
MH 318	27 MAR	232-11865932	KUL/PEK	MH 318	27 MAR	232-592064442	PEN/PEK
MH 318	28 MAR	232-11866002	KUL/PEK	MH 318	28 MAR	232-10681053	PEN/PEK
				MH 318	28 MAR	232-59207072	PEN/PEK
MH 318	29 MAR	232-11866013	KUL/PEK	MH 318	29 MAR	232-59242315	PEN/PEK
MH 318	30 MAR	232-11775901	KUL/PEK	MH 318	30 MAR	232-56872771	PEN/PEK
MH 318	30 MAR	232-11851173	KUL/PEK				
MH 318	31 MAR	232-11828666	KUL/PEK				
MH 360	31 MAR	232-11908105	KUL/PEK				

MANGOSTEEN				LITHIUM ION BATERRIES			
FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION	FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION
MH 360	01 APR	232-118851044	KUL/PEK				
MH 360	02 APR	232-12955795	KUL/PEK	MH 360	02 APR	232-10681344	PEN/PEK
MH 360	02 APR	232-11908061	KUL/PEK				
MH 318	02 APR	232-11851151	KUL/PEK				
MH 318	04 APR	232-11865943	KUL/PEK	MH318	04 APR	232-10677542	PEN/PEK
MH 318	04 APR	232-12955806	KUL/PEK				
MH 360	04 ARP	232-12955983	KUL/PEK				
MH 318	05 APR	232-12955810	KUL/PEK	MH 318	05 APR	232-10677553	PEN/KUL
MH 318	05 APR	232-11865954	KUL/PEK				
MH 318	06 APR	232-11070076	KUL/PEK				
MH 318	06 APR	232-12955821	KUL/PEK				
MH 318	07 APR	232-12955832	KUL/PEK				
MH 318	08 APRIL	232-11866024	KUL/PEK				
MH 318	09 APL	232-11908094	KUL/PEK				
MH 318	09 APR	232-12955854	KUL/PEK				
MH 318	10 APR	232-11908072	KUL/PEK	MH 318	10 APR	232-10681646	PEN/PEK
MH 318	11 APR	232-11851184	KUL/PEK				
				MH 318	12 APR	232-12976784	PEN/PEK
MH 318	13 APR	232-11908083	KUL/PEK				
MH 318	17 APR	232-12956053	KUL/PEK	MH 318	17 APR	232-10681952	PEN/PEK
				MH 318	18 APR	232-10681963	PEN/PEK
				MH 318	19 APR	232-10681974	PEN/PEK
				MH 318	19 APR	232-12977101	PEN/KUL
				MH 360	22 APR	232-10678136	PEN/PEK
				MH 318	25 APR	232-10682276	PEN/PEK
				MH 360	25 APR	232-10678161	PEN/PEK
				MH 360	25 APR	232-12992055	PEN/PEK
				MH 360	26 APR	232-12977565	PEN/PEK

MANGOSTEEN				LITHIUM ION BATERRIES			
FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION	FLIGHT NO	DATE	AIRWAYS BILL	ORIGIN/ DESTINATION
				MH 360	01 MAY	232-10682560	PEN/PEK
				MH 360	03 MAY	232-13053250	PEN/PEK
				MH 360	10 MAY	232-13053784	PEN/PEK
				MH 360	18 MAY	232-13053832	PEN/PEK
				MH 360	20 MAY	232-12582511	PEN/PEK
				MH 360	21 MAY	232-12582522	PEN/PEK
				MH 360	22 MAY	232-12582533	PEN/PEK
				MH 360	23 MAY	232-12594794	PEN/PEK
				MH 360	24 MAY	232-12594805	PEN/PEK
				MH 360	25 MAY	232-12977020	PEN/PEK
				MH 360	27 MAY	232-12594934	PEN/PEK
				MH 360	28 MAY	232-12582835	PEN/PEK
				MH 360	28 MAY	232-12594945	PEN/PEK
				MH 360	29 MAY	232-12582846	PEN/PEK
				MH 360	29 MAY	232-12594956	PEN/PEK
				MH 360	30 MAY	232-12582850	PEN/PEK
				MH 360	31 MAY	232-13144563	PEN/PEK

Report by J. Poupin, expert in Marine Biology *12 August 2015*

Expert report on the barnacles (Cirripedia Crustacea) attached to aircraft debris beached on Réunion Island

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Summary

- The crustacea attached to the flaperon are *Lepas (Anatifa) anatifera striata* de Graaf, 1952.
- This subspecies is strictly pelagic, and always lives on floating objects.
- It is cosmopolitan and disseminated in the world's oceans at tropical to temperate latitudes in waters at temperatures above 18-20°C.
- Rarely reported in the literature, this subspecies is specifically mentioned off Western Australia.
- The size of the larger specimens indicates that initial colonization may date back 15-16 months.
- The locations of the colonies of *Lepas* on the flaperon indicate that it floated with its ventral side facing upward.

Background

This expert appraisal was carried out as part of an assignment defined by a mission statement, dated 3 August 2015, by Mr. François Grangier, aviation expert designated as part of an investigation into an aircraft component that had drifted onto a beach in Réunion Island that might be a flaperon from the Boeing 777-200 on flight MH370. The chronology of events is as follows:

- 7-8 March 2014: disappearance of the Boeing 777-200 on flight MH370
- 29 July 2015: discovery of the Boeing flaperon on Réunion Island

Against this background, on Sunday, 9 August 2015, I carried out an assignment involving sampling and observation at the DGA / Toulouse, where the part was stored.

This report was written on 10-12 August 2015. It shows the results of my findings and observations, the aims of which were as follows:

- Identify the marine organisms attached to the flaperon and their origin
- Assess the immersion time of the flaperon, if possible in order to estimate the initial immersion point of the part in the ocean.

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Sampling conditions and methods (9 August 2015)

After it was found beached on Réunion Island (07/29/2015) the flaperon was taken to the premises of the DGA / Toulouse.

The observations and samples were carried out on Sunday, August 9 by Mr. Poupin with the help of DGA / Toulouse personnel, Messrs Plotka, Bordes and Hakenholz, i.e. 12 days after the part was found beached.

At first observation it appears that **the marine organisms attached to the flaperon were barnacles (Cirripedia Crustacea**) **of the Lepadidae family and of the *Lepas* genus**. No other organisms were found attached to the flaperon.

The colonies of barnacles dried with a fairly strong 'marine' odour. The calcareous valves of the organisms tended to crumble and easily fall off. The soft parts, feet and internal organs, were shrivelled and dried. Some individual barnacles had obviously been loosened. However, if the spread of the specimens on the part examined on Sunday August 9 is compared with its appearance at the time of its discovery on Réunion Island (see the video archives and media photos), there was no major loss of barnacles.

Examination of the colonies of barnacles on the part

A comprehensive examination of the part was performed first of all to identify the colonization points of the barnacles on the flaperon. The flaperon rested on its flat portion, the curved portion being visible only at the beginning of the examination. To observe the underside of the flaperon (flat portion), it was set on trestles to enable observation of the greater part of the flat "ventral" surface. The following observations were made:

- The barnacles attached more on the side and rear edges or on parts of the flaperon which were scratched or damaged, revealing the underlying composite material. The largest specimens were located on the left rear flare (Figure 1)
- The curved part (dorsal) had some disparate colonies of barnacles, especially on the right side. These specimens were small (Figure 2)
- The flat part of the flaperon (ventral) was colonized very little or not at all by the barnacles (Figure 3)

Cirripedia crustacea of the *Lepas* genus always live on objects floating in the sea. They are located in the water, just below the waterline of their support.

The observations made suggest that **the flaperon floated with its flat surface facing upward**, the domed part being submerged. Subsequent buoyancy tests are expected to confirm this point by checking that the parts that remain exposed to the air were much less colonized by the barnacles.

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Figure 1 - Fastening of barnacles more on the rough portions of the flaperon, from left to right and top to bottom: front left edge with the largest barnacles, small colonies on scratched areas of the dorsal side, colonies attached to the bare composite on the back edge, colony on a metal corner.

Figure 2 – Dorsal appearance of the flaperon, domed section, from left to right and top to bottom: left side, right side, front, dorsal-posterior view (small colonies of barnacles on the right).

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Figure 3 - Ventral appearance of the flaperon, flat part, from left to right and top to bottom: left side, right side, front ventral, rear ventral.

Sample collection

Two samples were taken of 10-30 attached specimens and kept in 95° alcohol (Figure 4):

- One from the left front angle (Fig. 4 left)
- The other from a rear edge (Fig. 4 right)

Figure 4: Location of 2 samples taken on 9 August 2015

To these two samples were added to two further lots of 10-30 specimens taken on 6 August by Mr. Hakenholz, one kept in 95° alcohol, the other in 10% formaldehyde.

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These four samples were taken by Mr. Poupin for further examination and preparation of this expert report.

Condition of the barnacles remaining on the flaperon

After being exposed to the air for several days, the colonies still attached to the flaperon were brittle with a tendency to "crumble" and fall off easily.

To facilitate the handling of the flaperon for the rest of the expert appraisal, so as to preserve the specimens not sampled, it was therefore decided, in agreement with Mr Grangier, to collect the remaining specimens, at least the largest colonies and most exposed to handling, and keep them dry in heat-sealed plastic bags.

Results of the expert appraisal by Mr. Poupin (10-12 August 2015)

Ascertainment of the species

The *Lepas* genus has 8 species listed in the World Register of Marine Species (WoRMS 2015):

1. *Lepas (Anatifa) anatifera* Linnaeus, 1758
2. *Lepas (Anatifa) anserifera* Linnaeus, 1767
3. *Lepas (Anatifa) australis* Darwin, 1851
4. *Lepas (Anatifa) beringiana* Pilsbry, 1911
5. *Lepas (Anatifa) hillii* Leach, 1818
6. *Lepas (Anatifa) pacifica* Henry, 1940
7. *Lepas (Anatifa) pectinata* Spengler, 1793
8. *Lepas (Anatifa) testudinata* Aurivillius, 1892

The species *L. anatifera* also comprises three sub-species, all mentioned in the Australian Biological Resources Study (ABRS, 2015):

1. *Lepas (Anatifa) anatifera anatifera* Linnaeus, 1758
2. *Lepas (Anatifa) anatifera dentata* Bruguière, 1789
3. *Lepas (Anatifa) anatifera striata* de Graaf, 1952

The examination was carried out under binocular microscope by observing the hard outer parts as well as the internal soft tissues that were still sufficiently well preserved. The reference works consulted were: Barnard (1924), Darwin (1842), Graaf (1952), McLaughlin (1980), and Relini (1987).

The terminology used for the morphology (e.g. capitulum) is taken from McLaughlin (1980) (Figure 5)

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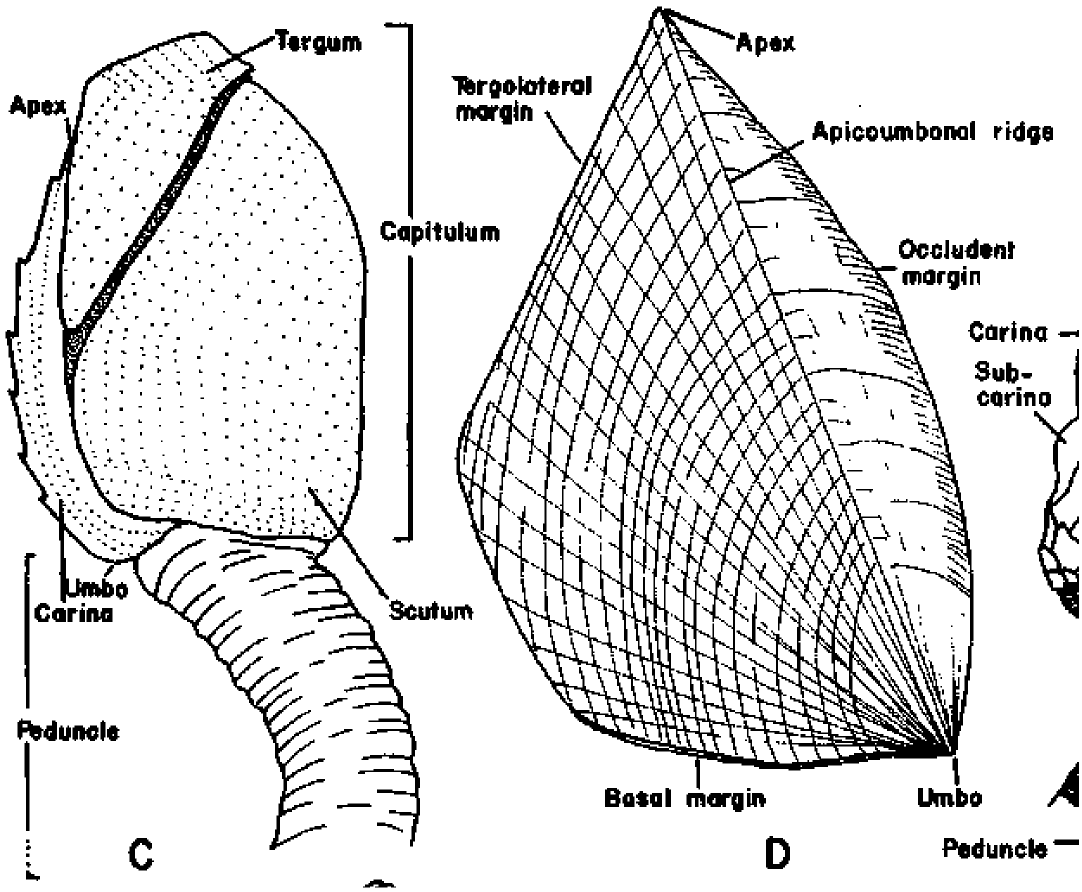

Figure 5 - External morphology of the plates of a Lepadidae according to McLaughlin (1980, fig. 17)

Graaf (1952) mentions that the external morphological characteristics, such as defined by Darwin (1852) to distinguish *L. anatifera* and *L. anserifera*, are highly variable and that the two species can therefore be confused. In his opinion, the only valid morphological criterion for recognizing these two species is the number of filamentary appendages on the soft parts (p. 1-2 *The valves of the capitulum of L. anatifera and L. anserifera are subject to a rather extreme variability ~ After these considerations it must be clear that in many cases only the number of the filamentary appendages can render a safe identification possible*).

According to the description by Graaf (1952) the **specimens attached to the flaperon belong to the subspecies *Lepas (Anatifa) anatifera striata* de Graaf, 1952**. In particular, the following characteristics mentioned by Graaf (1952) fully correspond the specimens examined (Figure 5):

Terga and scuta smaller than in the forma typica, more or less striated, especially the scuta. Scuta sometimes with a diagonal row of depressed quadrilateral marks of a brownish-green colour. Carina often more or less strongly dentated. Peduncle shorter than in the forma typica. Animals on the whole approaching Lepas anserifera in external appearance. Filamentary appendages two on each side as in the forma typical

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Figure 5 – Two specimens of Lepas (Anatifa) anatifera striata *de Graaf, 1952 from the flaperon. The different size (capitulum length of 36 mm, on the left, 19 mm, on the right) illustrates the variations of the radial streaks in this species.*

Geographical distribution

Like all of the *Lepas* genus, *L. (Anatifa) anatifera striata* is a cosmopolitan species. If *Lepas anatifera* has been frequently reported in the literature, this is not the case of the *striata* subspecies which was only described fairly late by Graaf (1952) and which has often been reported under the name *L. anatifera* in the broad sense, without specifying the subspecies.

It is therefore not possible to precisely define the geographical range of *L. (Anatifa) anatifera striata*, but it is known to be present in the temperate and tropical latitudes of the Atlantic, Indian and Pacific oceans.

It is interesting to note that one of the few formal records of this subspecies concerns Western Australia (ABRS, 2015).

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Ecology

L. (Anatifa) anatifera striata is a species that fastens in colonies onto floating objects of a very diverse nature, preferring their rough surfaces. The colony lives below the waterline near the surface. The species prefers water at a temperature above 18-20°C. The species is hermaphroditic, without being able to self-fertilize (Patel, 1959). The optimum reproduction temperature is between 18-25°C. Individuals are mature only 4-5 weeks after the first attachment and larvae can then be produced in large quantities.

The different size ranges observed on the flaperon, of which there were at least four (1-10 mm, 10-20 mm, 20-30 mm, > 30 mm), show that recolonization of the flaperon occurred from the first individuals that attached.

Size and Growth

The size of the specimens, measured as the maximum length of the capitulum, was between about 1 mm for the smallest specimens to 36 mm for the largest measured specimen.

The growth of *L. anatifera* barnacles was studied by Evans (1958) and Skerman (1958) with the data summarized by Thiel & Gutow (2005: 352, tab 17.). According to these authors, the growth of barnacles is rapid after the first colonization:

- The growth of the capitulum can reach 0.44-0.55 mm/day.
- The size of the capitulum at sexual maturity is 13-23 mm.
- Sexual maturity is reached after 30-37 days (4-5 weeks)

Growth data for the capitulum of a species of the *Lepas* genus (*L. anserifera*, very close to *L. anatifera*) by Evans (1958) are summarized in Table 1 (in grey).

Capitulum size (mm)	Days
8	8
21	40
25	107
36	*476*

Table 1 - Number of days required for different growths of the capitulum observed in barnacles of the Lepas genus (L. anserifera), very close to L. anatifera striata. The data in grey are taken from Evans (1958). The results in italics in the last row correspond to an extrapolation of the number of days required for growth of a size of 36 mm, estimating growth of the logarithmic type.

Evans' data (1958) are best adjusted for growth of the logarithmic type according to the equation:

$$\text{Capitulum size (mm)} = 6.7041 * \ln(\text{days}) - 5.333 \quad (r^2 = 0.9752)$$

By extrapolation, the colonization of the larger specimens (36 mm) on the flaperon dates back 476 days (Figure 6), i.e. 15-16 months.

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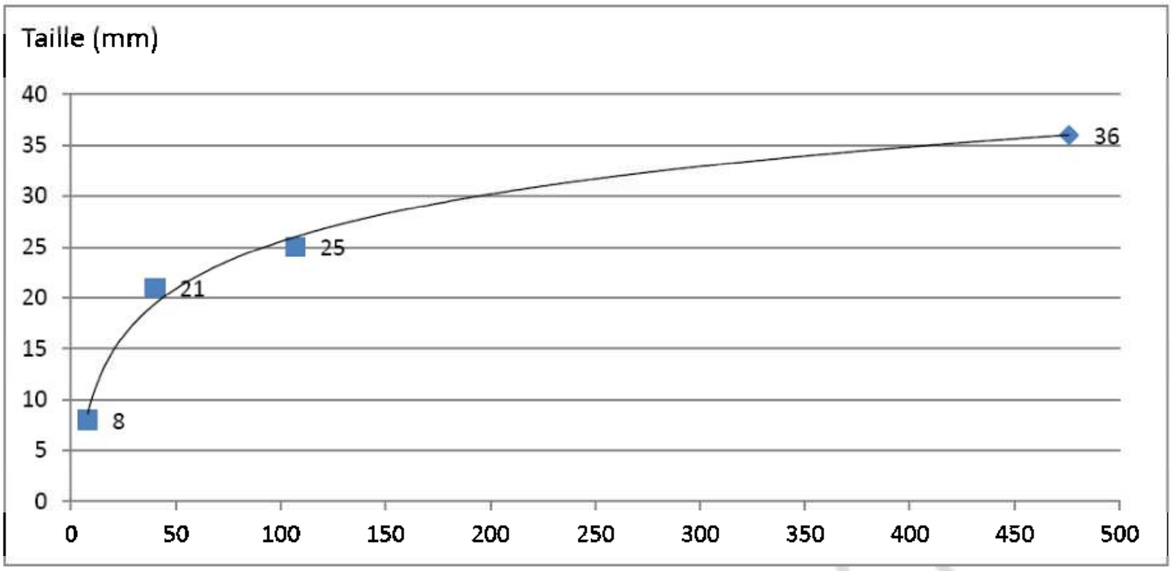

Figure 6 - Increase in size of the capitulum of a Lepas anserifera barnacle depending on the number of days (days 0-500). The first three points (squares) correspond to the literature data (see Evans, 1958). The last point (diamond) is extrapolated from the first three items of data by estimating logarithmic growth. The size of 36 mm corresponds to a growth period of 476 days, or 15-16 months.

The growth of the specimens stopped on the day of the discovery of the flaperon on Réunion Island, on 29/7/2015. The initial colonization therefore dates back to 10/04/2014, or 33-34 days after the disappearance of the Boeing 777-200 on flight MH370.

This estimate, although very approximate and based on limited data, reinforces the idea that this part could belong to the missing aeroplane.

Possible additional examinations

As part of this expert appraisal, I consulted my colleague and crustacean expert at the Western Australian Museum, whose contact details are as follows:

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Western Australian Museum

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Email: diana.jones@museum.wa.gov.au

Ms Jones is a recognized specialist for the barnacle group. Incidentally, she was chosen as the expert by the Australian Transport Safety Bureau in the case of flight MH370. She kindly provided me with her own expert appraisal, based on press photos.

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In broad terms, with the exception of the growth analysis in this report, her conclusions are similar to mine.

In addition, D. Jones suggested an analysis of the calcium deposits in order to establish the ratios of oxygen isotopes. This technique would make it possible to identify the temperature of the water after the barnacles became attached.

However, given the distributions of the surface temperature in the Indian Ocean (Figure 7), even if knowledge of the water temperature at the time of growth of the deposits were accurately known, it would help to identify the latitude with greater certainty but would provide little information about the longitude.

Not being an expert on this issue, I have forwarded her suggestion for further analysis. For information, a French laboratory that could perform this type of analysis is the 'PALEOCEAN' group of the LSCE in Gif-sur-Yvette (http://www.lsce.ipsl.fr/Phocea/Vie des labos/Ast/ast groupe.php?id groupe=13)

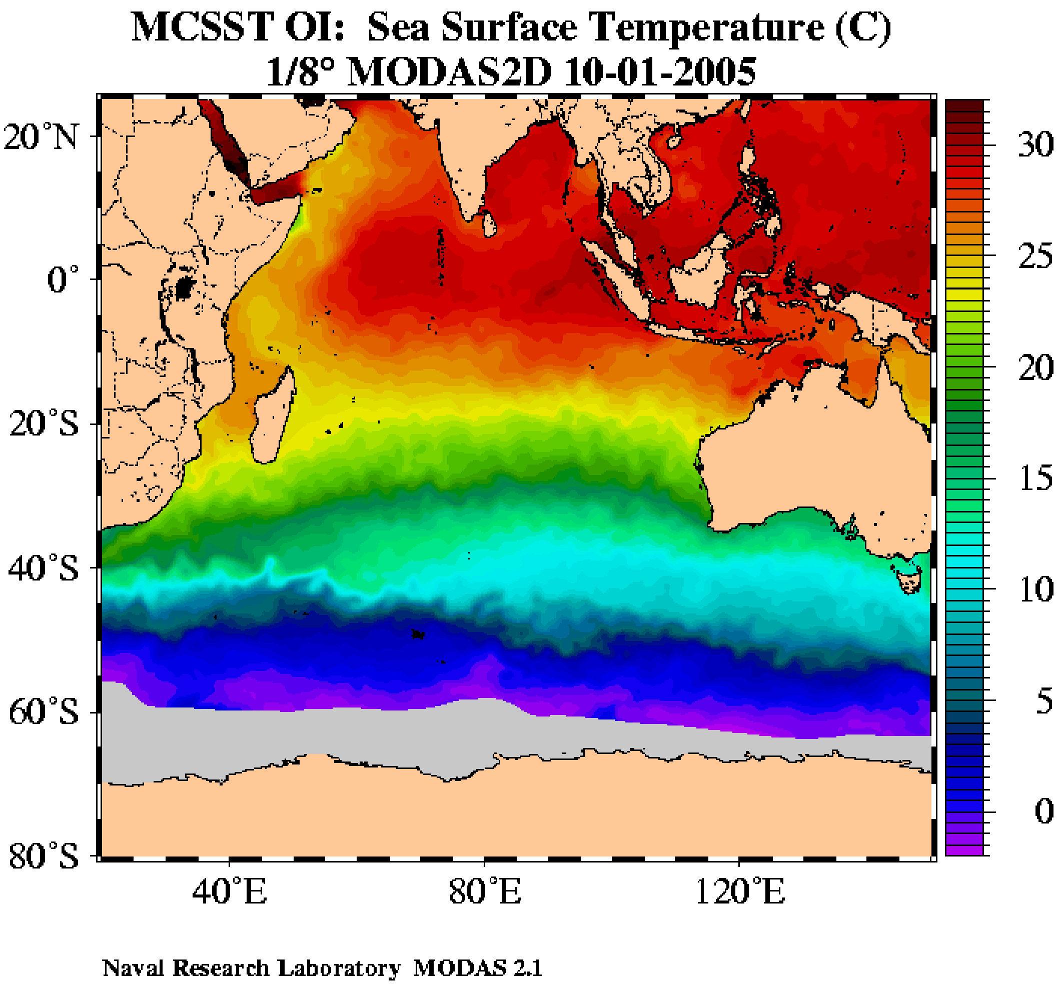

Figure 7 – An example of the distribution of surface temperatures in the Indian Ocean

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(42p)

Rapport d'expertise :

Estimation des températures de croissance des valves de cirripèdes fixés sur le flaperon du vol MH370 à partir de l'analyse de leur composition isotopique $^{18}O/^{16}O$.

Auteurs.

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Suite à une première prise de contact de Mme le juge d'instruction Carole Ramet avec le Dr Dominique Blamart, le LSCE a été mandaté par le Tribunal de Grande Instance de Paris (TGI) pour effectuer l'analyse isotopique des valves de cirripèdes trouvées sur le flaperon, afin d'estimer l'évolution de leurs températures de croissance.

Plan du rapport

Résumé

1- Contexte de l'étude et objectifs

2 - Matériel et méthode
- 2.1 Réception des cirripèdes du flaperon et description
- 2.2 Cirripèdes destinés à la calibration $^{18}O/^{16}O$-T
- 2.3 Stratégie d'échantillonnage
- 2.4 Méthodes analytiques

3 - Résultats
- 3.1 Imagerie et données minéralogiques
- 3.2 Calibration de la relation entre le rapport $^{18}O/^{16}$ des valves et leur température de formation
- 3.3 Variabilité des rapports $^{18}O/^{16}$ et températures de formation des valves analysées

4 - Conclusions

Références bibliographiques

Annexes :
- Personnes ayant participé à l'acquisition des données
- Personnes contactées dans le cadre de l'étude
- Tableaux des données

D257/3

Résumé

Le LSCE a été mandaté par le TGI de Paris pour tenter de reconstruire les températures de surface des eaux océaniques à travers lesquelles a transité le débris de flaperon du vol MH 370 retrouvé sur l'île de la Réunion en juillet 2015. A cet effet, nous avons mesuré le rapport isotopique $^{18}O/^{16}O$ des valves calcitiques des cirripèdes de l'espèce *Lepas anatifera* qui se sont fixés et développés sur le flaperon lors de son trajet dans l'Océan Indien. Pour cette expertise, 252 ont été effectuées par spectrométrie de masse au LSCE : 34 pour calibration, 198 mesures isotopiques sur 5 valves de cirripèdes adultes et 20 sur des valves de formes juvéniles.

Ne disposant d'aucune calibration de la relation $^{18}O/^{16}O$ – température pour la calcite de *Lepas anatifera*, nous avons dû établir cette calibration à l'aide de spécimens récents pour lesquels les conditions environnementales (température, salinité) étaient connues. Les spécimens australiens ont été fournis par le Dr Jones du Muséum d'Histoire Naturelle de Perth (Australie). Pour cette calibration, 34 analyses isotopiques ont été réalisées sur 6 valves provenant de 5 zones de prélèvements différentes dans l'Est de l'Océan Indien et autour de l'Australie. Cette base de données a été complétée par l'analyse de 20 petites valves d'individus juvéniles provenant du flaperon MH370 récupéré à la Réunion. Les résultats obtenus nous permettent de conclure que la composition isotopique de oxygène de la calcite sécrétée par *Lepas anatifera* reflète bien la température des eaux de surface.

Sur la base de cette calibration, nous avons ainsi converti en température les rapports $^{18}O/^{16}O$ obtenus sur les valves de cirripèdes du flaperon. Les différentes sources d'incertitudes ne nous permettent pas d'estimer les températures à mieux que ± 1°C.

Les deux résultats principaux sont les suivants :

1 - les températures de croissance enregistrées par les valves les plus petites (juvéniles) et par la frange terminale (ie. la plus récente) des grosses valves adultes (25,4 ± 1°C) sont cohérentes avec les températures observées au large de la Réunion. Ces résultats suggèrent que les cirripèdes ont fini de se développer dans des masses d'eaux dont les caractéristiques thermiques étaient similaires à celles des eaux proches de l'île de la Réunion, avant que le flaperon ne soit découvert ;

2 - au début de leur croissance, les cirripèdes les plus grands étaient baignés par des eaux dont la température était voisine de 28,5 ± 1°C. Les cartes de distribution des températures dans les mois qui précèdent la découverte du flaperon suggèrent que celui-ci a dérivé dans des masses d'eau situées à E-NE de l'île de la Réunion.

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Nous n'avons toutefois aucun élément permettant de déterminer avec certitude la durée de croissance des valves recueillies et donc la période couverte par les valves les plus développées. Néanmoins, d'après deux études expérimentales portant sur les vitesses de croissance des anatifes pélagiques (Evans, 1958, Inatsuchi et al., 2010), les valves (scutum) les plus grandes (20-25 mm) auraient pu se former sur une période de quelques mois seulement.

1 - Contexte de l'étude et objectifs

Le boeing 777 du vol MH370 de la Malaysia Airlines reliant Kuala Lumpur à Pékin et transportant 239 personnes est porté disparu depuis le 8 mars 2014. Jusqu'ici, aucun élément robuste n'a permis de définir avec précision la zone de disparition de l'appareil.

En juillet 2015, un débris de flaperon du vol MH370 a été découvert sur une plage de l'île de La Réunion. De nombreux cirripèdes se sont fixés sur ce flaperon lors de son séjour dans l'eau de mer. Une identification conduite par le Dr Poupin a montré qu'il s'agit de l'espèce *Lepas anatifera* (Linnée, 1758), cirripède pélagique (se développant sur des corps flottants). Cette espèce est présente au large de l'Australie et dans une large partie de l'Océan Indien.

Les cirripèdes sont des arthropodes qui vivent fixés sur un substrat dur ; leur corps est protégé par deux valves constituées d'éléments carbonatés articulés entre eux par des charnières organiques. La littérature scientifique est extrêmement pauvre en ce qui concerne la biologie et la géochimie des cirripèdes.

A notre connaissance, une seule étude a été publiée établissant un lien entre le rapport $^{18}O/^{16}O$ de la calcite et la température de croissance de cirripèdes. Ce travail porte sur une autre espèce que celle trouvée sur le flaperon : *Balanus aquila*, une espèce qui vit fixée sur les rochers dans la zone de battement des marées de l'océan Pacifique Est (Killingley & Newman, 1982). Les résultats de cette étude montrent que, comme pour les autres carbonates marins couramment étudiés dans notre laboratoire, le fractionnement isotopique lors des processus de calcification est bien dépendant de la température selon une équation du second degré de la forme :

$$T^{\circ} = C + B * (\delta^{18}O_c - \delta^{18}O_{sw}) + A^* ((\delta^{18}O_c - \delta^{18}O_{sw})^2 \quad (1)$$

où $\delta^{18}Oc$ représente l'écart relatif (en ‰) entre le rapport isotopique $^{18}O/^{16}O$ de la calcite biogène et un standard international (appelé PDB), et $\delta^{18}Osw$ représente le rapport isotopique $^{18}O/^{16}O$ de l'eau de mer, exprimé lui aussi en écart relatif (‰) par rapport à un standard d'eau de mer (appelé SMOW). Cette calibration peut être approximée par une relation linéaire entre la composition isotopique de l'oxygène et la température dans une gamme comprise entre 20 et 30°C.

Les résultats de Killingley et Newman (1982) sont tout à fait classiques en géochimie isotopique. Ils indiquent que le rapport $^{18}O/^{16}O$ des balanes dépend effectivement de la température des eaux de surface dans lesquelles ces cirripèdes ont vécu. La relation dépend étroitement de l'espèce considérée. Ils ne sont donc pas directement transposables à l'espèce *Lepas anatifera* qui s'est développée sur le flaperon.

Il était donc nécessaire d'établir directement l'existence d'une relation liant le rapport isotopique $^{18}O/^{16}O$ des valves calcitiques de *Lepas anatifera* à la température des eaux dans lesquelles ces animaux se sont développés et de la déterminer avec autant de justesse que possible.

La mission du LSCE comportait donc deux volets principaux :

- *établir une calibration de la relation $^{18}O/^{16}O$ – température de croissance pour la calcite de* Lepas anatifera ;
- *déterminer la composition isotopique $^{18}O/^{16}O$ des valves trouvées sur le flaperon du vol MH370 et, à l'aide de la calibration établie expérimentalement, estimer l'évolution des températures des eaux de surface lors de la croissance des cirripèdes pour tenter d'apporter des éléments nouveaux sur la zone de disparition de l'avion et/ou le trajet suivi par le flaperon, porté par les courants de surface.*

2 - Matériel et Méthodes

2.1 Réception des cirripèdes du flaperon et description

De très nombreux cirripèdes de l'espèce *Lepas anatifera* se sont développés sur le flaperon du vol MH370 lors de son séjour dans l'océan (Figure 1a). Ces cirripèdes ont été prélevés par le Dr Poupin et placés dans le scellé n°5 (Figure 1b et 1c). Ce matériel a été réceptionné au LSCE le 24 novembre 2015.

Le transport s'est effectué à température contrôlée (4°C). Les échantillons ont été placés immédiatement dans un réfrigérateur dont la température est également de 4°C. Les sacs d'échantillons n'ont été sortis du réfrigérateur que lors des échantillonnages ou pour les prises de photographies.

Les spécimens les plus grands se trouvaient dans les sachets des zones A1, A2, E1 et F1 du flaperon. La taille des valves les plus grandes (scutum) était de 25 mm, alors que les plus petits ne dépassaient pas 3 mm.

2.2 Cirripèdes destinés à la calibration $^{18}O/^{16}O$ – T

Pour déterminer la relation liant le rapport $^{18}O/^{16}O$ des valves à leur température de croissance, il était nécessaire de mesurer la composition isotopique de spécimens de *Lepas anatifera* dont les conditions de vie (température, salinité des eaux dans lesquelles ils ont vécu) étaient connues. A cette fin, nous avons contacté plusieurs biologistes, dont le Dr Poupin qui avait conduit, en août 2015, l'expertise des cirripèdes du flaperon du vol MH370.

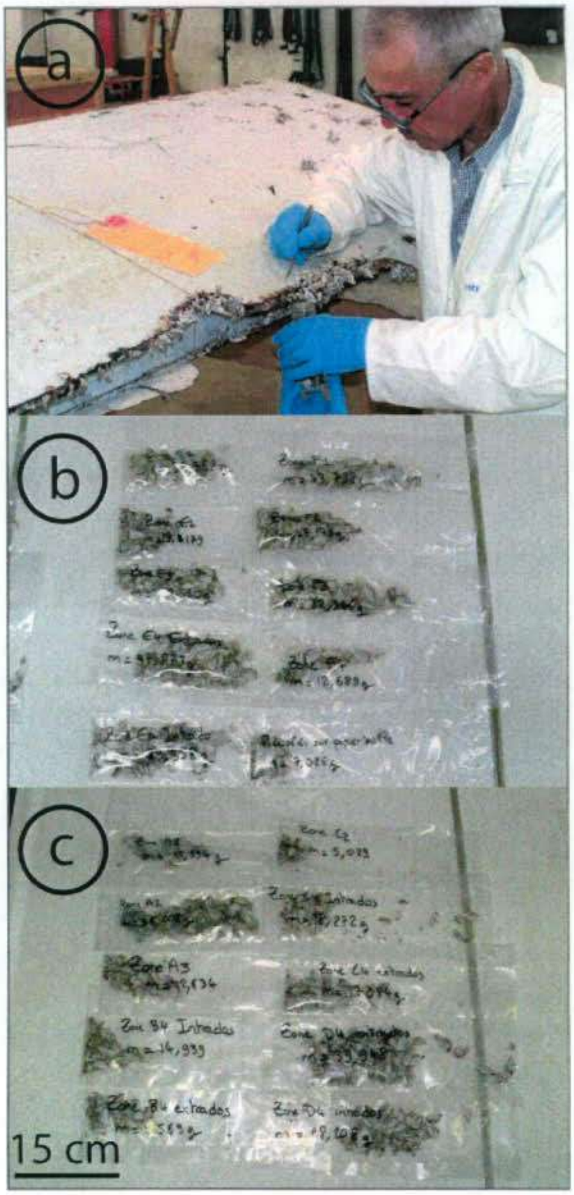

Figure 1 : a) collecte, par le Dr J. Poupin, des colonies de cirripèdes sur le flaperon du vol MH 370 de la Malaysia Airlines le 09 août 2015 à Toulouse ; b) et c) photographies des différents sachets contenant les échantillons de cirripèdes, constitutifs du scellé n°5 et annotés suivant la zone de collecte sur le flaperon.

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Une seule collection a pu nous permettre d'obtenir des spécimens provenant de plusieurs zones géographiques de l'Est de l'Océan Indien, couvrant une gamme de température assez large pour les besoins de la calibration et comportant des chroniques de température et de salinité bien documentées. Cette collection provient du Muséum d'Histoire Naturelle de Perth (Western Australian Museum, Australie), sous la direction du Dr. Jones.

Nous avons contacté le Dr Jones le 10 décembre 2015 pour obtenir des renseignements sur la collection et la disponibilité des spécimens. Malheureusement, en plein déménagement des collections, le Dr Jones n'a pu répondre favorablement à notre demande qu'à partir de février 2016. Une série d'échanges par courriels nous a permis de préciser les spécimens nécessaires à notre calibration.

En raison des règles contraignantes régissant les échanges de matériel biologique au niveau international, nous avons recherché un laboratoire agréé CITES (Convention sur le commerce international des espèces de faune et de flore sauvages menacées d'extinction) pour réceptionner les cirripèdes envoyés par le Dr Jones.

Les échantillons ont finalement été envoyés par le Dr Jones au Dr Laure Corbari du Muséum d'Histoire Naturelle (Paris) qui les a réceptionnés le 7 mars 2016. Dominique Blamart a pris en charge ces échantillons de calibration le 10 mars 2016 (Tableau 1, Figure 2). Les premières observations, le choix des spécimens et la mise au point du protocole expérimental ont commencé immédiatement. Les premières analyses isotopiques ont débuté à la fin du mois de mars et se sont terminées fin avril 2016.

2.3 Stratégie d'échantillonnage

Les analyses ont porté sur l'élément carbonaté principal (appelé scutum) de plusieurs valves de cirripèdes. La figure 3 présente les différentes pièces carbonatées constitutives de *Lepas anatifera* (photographie extraite du rapport de J. Poupin). De manière systématique nous avons choisi la valve droite pour réaliser les mesures isotopiques afin de rester cohérent dans le protocole d'échantillonnage.

Pour la population issue du flaperon, deux types de cirripèdes ont été sélectionnés :

- les plus petits, dont la taille maximale du scutum était < 10mm ; comme ils contiennent encore leurs parties molles, ils représentent des individus juvéniles dont l'arrimage sur le flaperon a été le plus tardif (c'est à dire le plus proche du moment de la découverte du débris),
- les plus grands, dont le scutum pouvait atteindre 25 mm ; ils représentent les individus les plus âgés, susceptibles de fournir les reconstructions

temporelles de température les plus longues au cours de la dérive du flaperon.

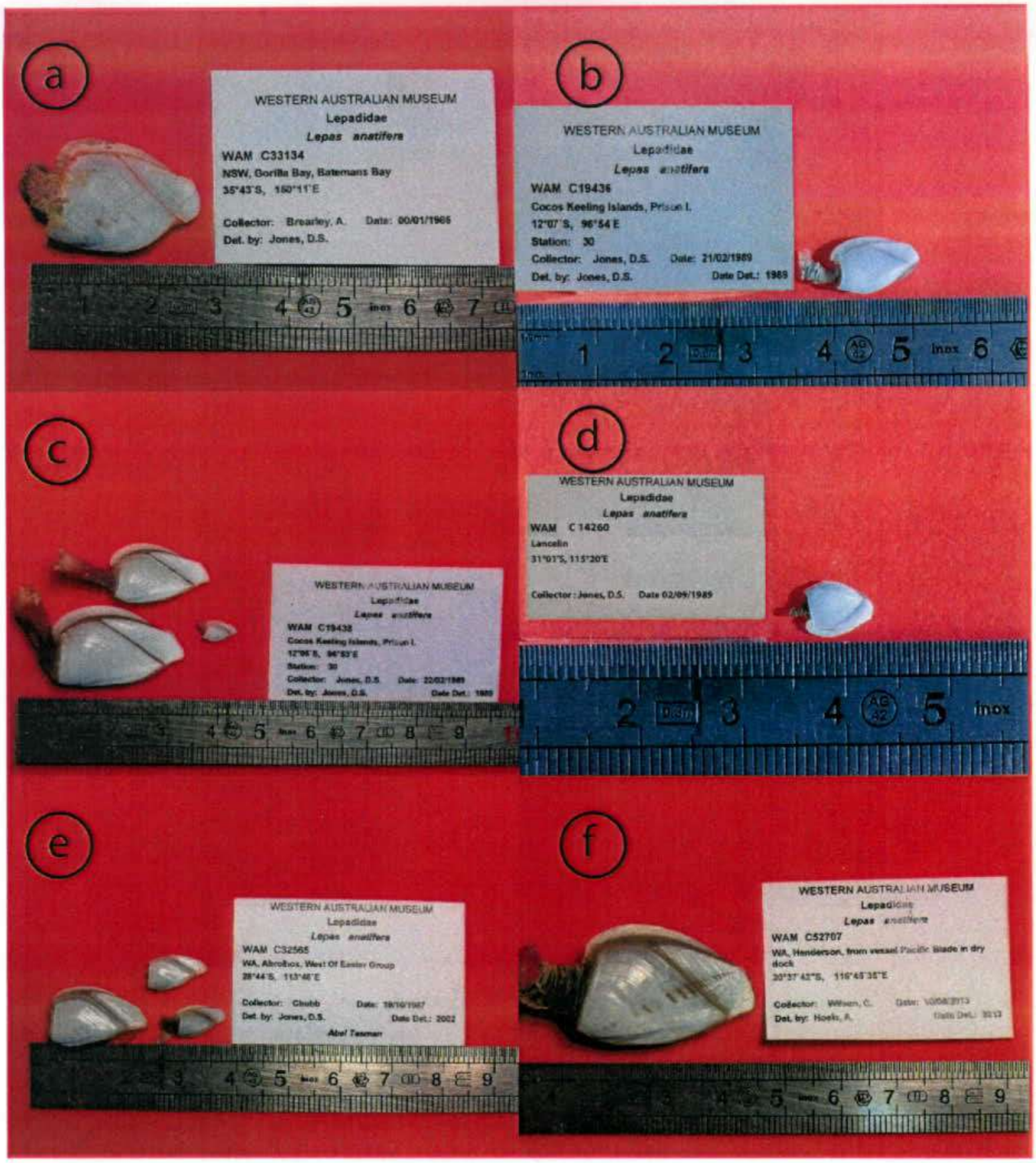

Figure 2 : Photographies (a à f) des échantillons provenant de la collection du Muséum d'Histoire Naturelle de Perth (Western Australian Museum, Australie) utilisés dans la calibration de la relation entre le rapport $^{18}O/^{16}O$ des valves de cirripèdes et leur température de formation.

Pour la sélection des plus petits individus, dans chaque sachet (sauf celui libellé « récupéré sur papier bulle »), nous avons procédé à un tirage au hasard de 3 petits spécimens parmi lesquels nous avons ensuite choisi un individu à analyser. Des mesures morphologiques ont été réalisées afin de détecter éventuellement une relation entre les valeurs de compositions isotopiques et la taille des spécimens. La longueur (L) du capitulum (correspondant au scutum plus le tergum, voir Figure 3) ainsi que sa largeur (l) ont été mesurées au pied-à-coulisse (Tableau 2).

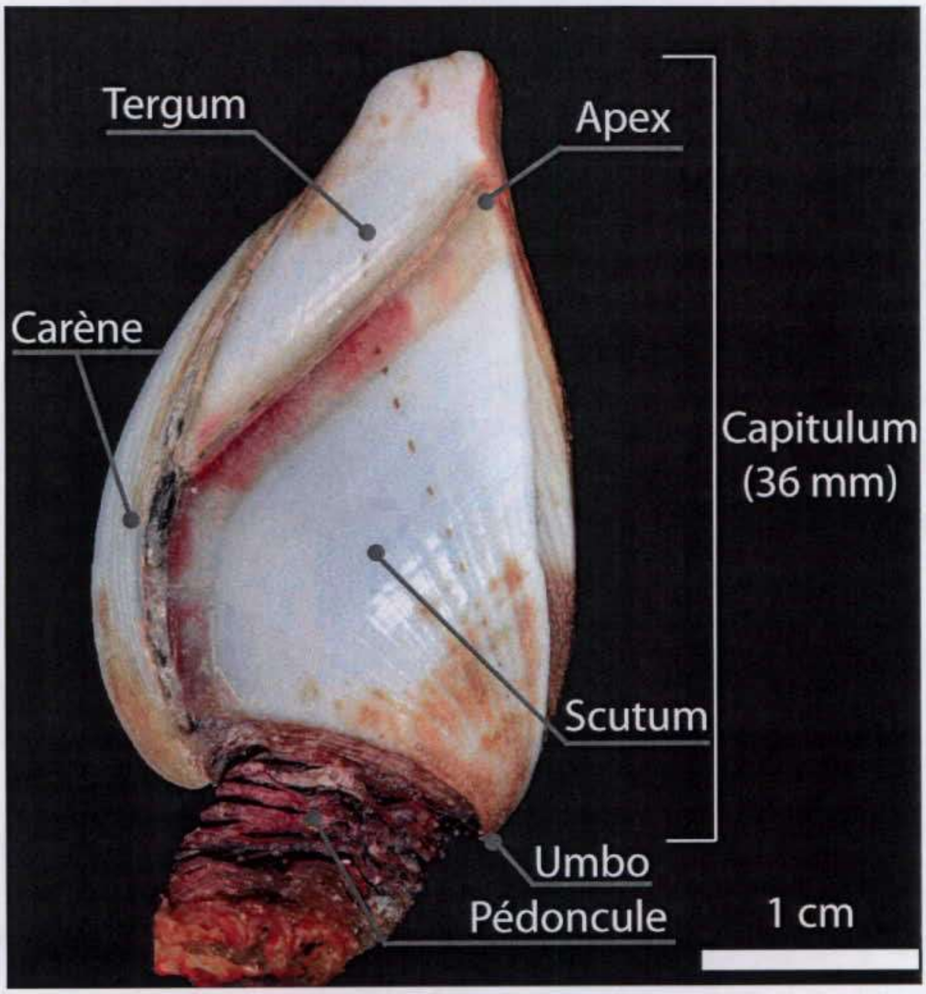

Figure 3 : Planche photographique de *Lepas anatifera* (photographie tirée du rapport du Dr J. Poupin) présentant les différentes pièces carbonatées constitutives de l'animal.

Pour les échantillons destinés à la calibration (spécimens envoyés par le Dr Jones) un à trois individus avaient été envoyés pour chaque site de prélèvement. Après observation macroscopique, référencement et prise de photographies (Figure 2), les analyses ont débuté le 30 mars 2016.

Pour chaque spécimen, les valves de cirripèdes ont été séparées et les parties molles de l'animal précautionneusement enlevées à l'aide d'un scalpel. La valve droite a ensuite été brossée délicatement sous l'eau pour enlever toute trace de résidu organique. En fin d'opération, chaque valve a été contrôlée pour sa propreté et nettoyée une seconde fois si nécessaire. Les valves n'ont été soumises à aucun traitement particulier (ni chimique, ni thermique) avant analyse isotopique.

La calcite qui constitue le scutum a ensuite été échantillonnée de deux manières :

(i) Pour les plus petites valves, nous avons broyé l'intégralité du scutum et homogénéisé la poudre obtenue afin d'obtenir une valeur isotopique représentative de l'ensemble de la valve ;

(ii) Pour les plus grands individus, nous avons procédé à un échantillonnage très précautionneux le long de l'axe principal du scutum, perpendiculairement aux stries de croissance, depuis, le crochet (appelé l'umbo) qui correspond à la partie la plus ancienne de la coquille, jusqu'à sa pointe la plus récente (appelée apex). Un tel échantillonnage était destiné à obtenir plusieurs points de mesure correspondant aux différentes étapes de croissance de la valve.

Une première grande valve a été échantillonnée à basse résolution spatiale (A1-2, Figure 4) à l'aide d'une micro-fraise de dentiste ainsi qu'avec une mini-disqueuse équipée d'un disque de 300µm d'épaisseur. Cet échantillonnage a été entrepris dans le but de déterminer la gamme de composition isotopique de la calcite et sa variabilité à l'échelle millimétrique.

Nous avons ensuite effectué un échantillonnage à haute résolution (entre 160 et 500 microns) sur plusieurs valves à l'aide d'un micro-échantillonneur de type Micromill (Newave-ESI Corporation). Cet échantillonneur, couplé à une loupe binoculaire, permet d'abraser la surface de l'échantillon à l'aide d'une pointe tournant à grande vitesse tout en connaissant la localisation précise du prélèvement. Cette technique d'échantillonnage très précise nécessite d'opérer le prélèvement perpendiculairement à une surface plane de l 'échantillon. Pour échantillonner les plus grosses valves incurvées, nous avons développé un système de cales réglables pour permettre les prélèvements représentatifs dans la zone de l'umbo où la concavité de la valve est très forte. Cette approche nous a permis d'obtenir une succession d'échantillons tout au long de l'axe principal de croissance, reflétant la formation progressive de la valve au cours du temps. Dans des conditions favorables, la meilleure résolution que nous ayons obtenue entre chaque prélèvement est comprise entre 160 et 180µm pour une extension latérale (le long d'un même ensemble de stries de croissance) comprise entre 1500 et 2500µm. La profondeur d'abrasion a fait l'objet de vérifications répétées ; d'une manière générale elle était comprise entre 50 et 150µm. Enfin un système de prélèvement par aspiration de la poudre de carbonate de calcium émise lors de l'abrasion nous a permis de collecter des échantillons de 50 à 100µg, sans contamination extérieure, en vue des analyses au spectromètre de masse.

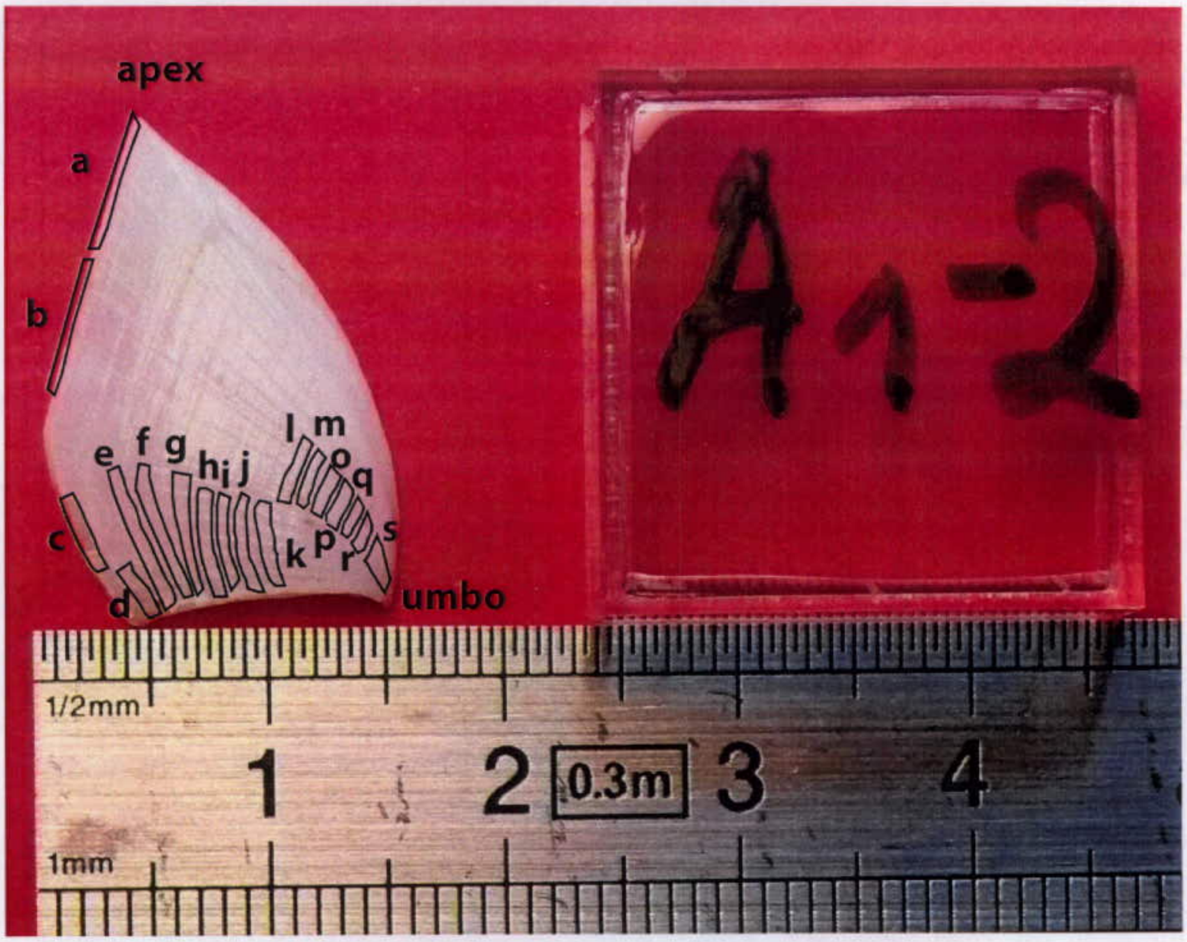

Figure 4 : Echantillonnage basse résolution du spécimen A1-2 dans le contexte de l'étude exploratoire de la variabilité de la composition isotopique de l'oxygène. Les zones a à s correspondent aux zones échantillonnées.

2.4 Méthodes analytiques

2.4.1. Analyse minéralogique

Préalablement aux analyses isotopiques, des analyses par spectroscopie infrarouge à transformée de Fourier ont été réalisées sur les poudres obtenues par broyage de quelques-uns des scutums échantillonnés. Ces analyses étaient destinées à déterminer la nature minéralogique des valves de *Lepas anatifera*. Nous avons ainsi vérifié que le carbonate de calcium était bien constitué de calcite (un carbonate de calcium rhomboédrique) sans présence d'aragonite (carbonate de

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calcium orthorhombique) qui présente un fractionnement isotopique pour l'oxygène différent de celui de la calcite.

L'appareil utilisé est un Spectro-Frontier Perkin-Elmer du Laboratoire Géosciences Paris-Sud (GEOPS). Après broyage de la totalité du scutum dans un mortier en agate et homogénéisation de la poudre obtenue, 1 à 2 milligrammes de matériel sont disposés sur la cellule d'illumination infrarouge. La déconvolution des spectres d'absorption qui permet de caractériser la nature minéralogique de l'échantillon a été réalisée à l'aide du logiciel Spectrum 10. Un exemple de spectre est présenté dans la figure 5.

2.4.2. Analyses au Microscope Electronique à Balayage (MEB)

Afin de visualiser l'agencement des couches successives de calcite déposées lors de la croissance des valves de *Lepas anatifera*, deux séances de microscopie électronique à balayage ont été programmées à GEOPS. Ces images ont été réalisées sur un microscope Phenom Prox permettant un grossissement de 80.000. Ce MEB possède aussi une sonde EDS (Energy Dispersive Spectroscopy) avec laquelle nous avons réalisé quelques spectres d'analyses chimiques confirmant la nature calcitique pure des valves de *Lepas anatifera*. Les stries de croissance sont bien visibles, ce qui a permis un échantillonnage représentatif des couches déposées au cours de la vie de l'animal.

2.4.3 Analyses des isotopes de l'oxygène par sonde ionique

Des processus biologiques complexes au moment de la cristallisation sont susceptibles de provoquer des variations importantes de composition isotopique indépendamment des conditions environnementales. Ils se traduisent par une grande variabilité des compositions isotopiques à l'échelle micronique. Pour s'assurer de l'absence de telles variations au sein de la valve de *Lepas anatifera*, des mesures *in situ* ont été réalisées à la sonde ionique au Centre de Recherche Pétrographique et Géochimique ((CRPG, UMR CNRS/UL 7358, Vandoeuvre-les-Nancy). La précision (proche de 1‰) des mesures réalisées par cet équipement ne permet pas une paléothermométrie fine. Les mesures effectuées sur la sonde ionique les 22, 23 et 24 février 2016 ont porté sur trois scutums des spécimens E1-G2, F1-G1 et E1-P1 ainsi qu'un targum du spécimen F1-G1. Tous confirment l'absence d'une grande variabilité à l'échelle micronique.

2.4.4 Analyses du rapport $^{18}O/^{16}O$ par spectrométrie de masse en phase gazeuse

Toutes les analyses isotopiques ont été réalisées au LSCE. Ces analyses ont été réparties en plusieurs séances, de décembre 2015 (travail exploratoire, basse résolution) à mi-mai 2016. Les dernières séances d'analyse ont porté à la fois sur les scutums échantillonnés à résolution micrométrique (Microdrill) ainsi que sur les cirripèdes reçus en mars 2016 et destinés à la calibration de la relation liant le rapport $^{18}O/^{16}O$ à la température des eaux dans lesquelles les valves de *Lepas anatifera* se sont développées.

Les deux spectromètres de masse utilisés sont un Optima VG-ISOTECH et un ISOPRIME 100 Elementar. Ces deux spectromètres sont rigoureusement intercalibrés. Ils permettent d'analyser des quantités de carbonate de calcium d'environ 100 microgrammes au minimum pour le premier et 50 microgrammes pour le second.

Les échantillons de calcite réagissent avec de l'acide phosphorique, dans une enceinte thermostatée. Le CO_2 produit est injecté dans le spectromètre de masse, en alternance avec un gaz CO_2 de référence. Les rapports $^{18}O/^{16}O$ sont exprimés en écarts relatifs (notation δ en ‰) par rapport à un standard calé sur l'échelle internationale PDB pour les carbonates (PeeDee Belemnite standard) et SMOW (Standard Mean Ocean Water) pour les compositions isotopiques de l'eau de mer. La reproductibilité externe du $\delta^{18}O$ estimée à l'aide de nombreuses mesures d'un standard $CaCO_3$ homogène, est de ± 0.05‰ (1 sigma), ce qui, exprimé en terme de température, correspond à une incertitude de 0,2°C.

3 - Résultats

3.1 Imagerie et données minéralogiques

Les mesures par FTIR confirment que les parties minérales des valves de *Lepas anatifera* trouvées sur le flaperon du vol MH370 sont constituées de carbonate de calcium ($CaCO_3$), sous sa forme calcite exclusivement (Figure 5). Ce résultat nous permet de poursuivre les analyses isotopiques en vue d'obtenir des estimations fiables de température.

Les données de microscopie électronique suggèrent que la croissance des valves de *Lepas anatifera* se réalise par dépôt successif de fines couches de calcite (Figure 6). Plusieurs échelles de structures et microstructures coexistent, allant du millimètre à la dizaine de microns. Les parties les plus marginales, qui correspondent latéralement à l'apex de la valve, sont les plus récentes et les plus fines. La croissance s'accompagne aussi d'un épaississement progressif de la coquille, par dépôt de carbonate sur la face interne des valves, plus marqué du côté de l'umbo (crochet initial marquant la partie la plus ancienne de la valve). Ces observations nous ont ainsi conduit à choisir un mode d'échantillonnage à haute résolution utilisant le Micromill, afin de collecter les couches les plus superficielles des spécimens. Cette stratégie permet de prélever la calcite déposée au cours du temps et de suivre l'évolution des températures de l'eau de mer au cours de la croissance de chaque individu.

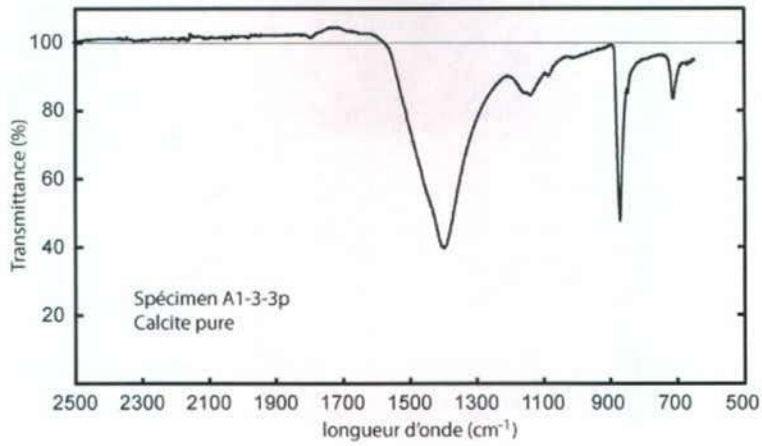

Figure 5 : Détermination de la nature minéralogique du spécimen A1-3-3p par spectrométrie infra rouge à transformée de Fourier (IRTF). Ce spectre est caractérisé par les bandes de vibration de la calcite (870 et 712 cm^{-1}). Il indique que l'échantillon est constitué de calcite pure.

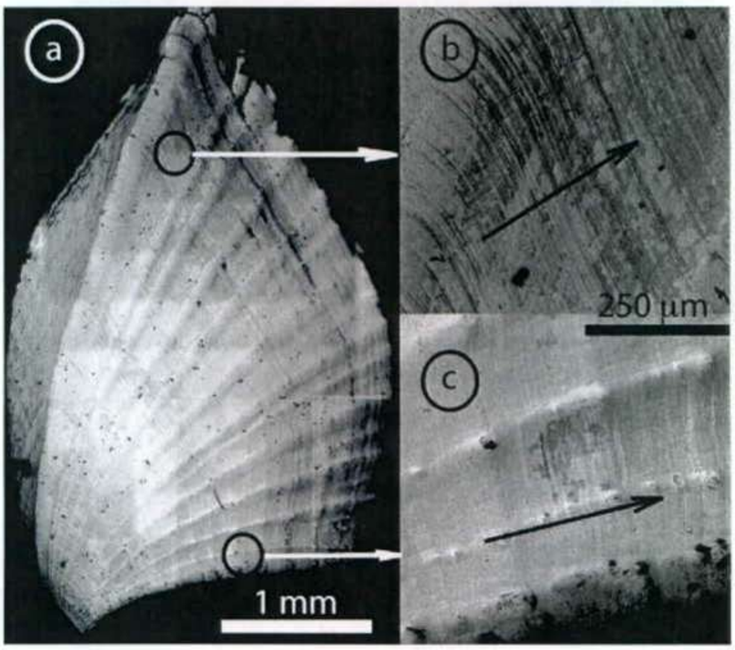

Figure 6 : Images MEB de la valve droite d'un specimen *Lepas anatifera* juvénile (échantillon E1-P1) avec a) une vue d'ensemble du spéciment, b) et c) vues correspondant respectivement à un agrandissement de la zone de l'apex et de la partie latérale de l'umbo. Les flèches noires indiquent le sens de la croissance. Ces photographies illustrent les différentes échelles d'organisation structurale de *Lepas anatifera*.

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3.2 Calibration de la relation entre le rapport $^{18}O/^{16}O$ des valves et leur température de formation

3.2.1 Calibration de la relation $\delta^{18}O_{SW}$ – salinité

Comme le montre l'équation des paléotempératures isotopiques (1), la composition isotopique $^{18}O/^{16}O$ de la calcite de *Lepas anatifera* dépend à la fois de la température de l'eau dans laquelle l'animal se développe, mais également de la composition isotopique de cette eau ($\delta^{18}O_{SW}$).

La composition isotopique de l'eau de mer de surface est régie par des processus de fractionnement isotopique associés aux différentes étapes du cycle hydrologique (évaporation, transport, précipitation). Il en résulte des relations linéaires régionales qui lient composition hydrologique et salinité de l'eau de mer en surface.

Le Dr Patrick de Deckker (Australian National University, Canberra) nous a fourni un ensemble de données de mesures du $\delta^{18}O$ des eaux de surface (Tableau 3) au large de l'Australie qui, associées aux données de salinité mesurées lors des campagnes de prélèvements, nous ont permis de déterminer empiriquement la relation linéaire liant $\delta^{18}O_{SW}$ et la salinité dans cette partie de l'Océan Indien (Figure 7).

$$\delta^{18}O_{SW}\ (‰) = 0{,}31 * \text{salinité} - 11.1 \qquad (2)$$

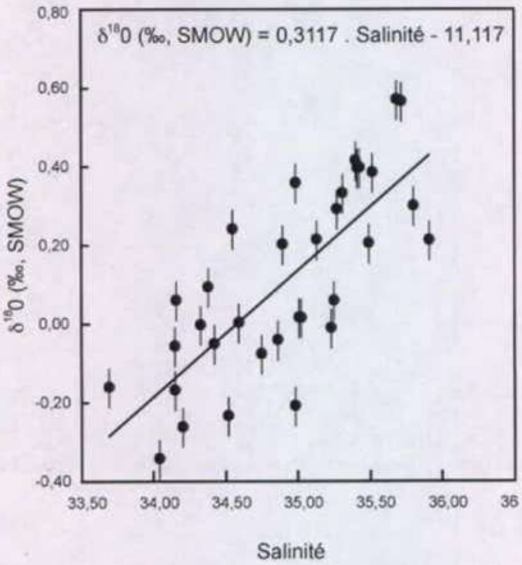

Figure 7 : Relation Salinité – $\delta^{18}O$ (‰, SMOW) pour des échantillons d'eau de surface de l'Océan Indien Est, collectés lors de la campagne océanographiques Francklin 02 (données non publiées, courtoisie du Pr P. de Deckker, Australian National University, Canberra).

Cette relation permet d'estimer le rapport $^{18}O/^{16}O$ de l'eau de mer avec un écart type de ±0,1‰ (à 1 sigma).

3.2.2 Calibration de la relation $^{18}O/^{16}O$ – température

Munis de la relation (2), et en utilisant les salinités mesurées aux sites de prélèvement des échantillons de *Lepas anatifera* destinés à la calibration, nous avons pu estimer le rapport isotopique des eaux dans lesquelles ces organismes s'étaient développés (Tableau 4) et d'établir une relation empirique entre le rapport $^{18}O/^{16}O$ de la calcite des valves et la température à laquelle elle se sont formées (Figure 8).

La relation linéaire obtenue est la suivante

$$T\ (°C) = -4{,}327 *(\delta^{18}O_{calcite} - \delta^{18}O_{SW} + 0{,}27) + 21{,}684 \quad (3)$$

où $\delta^{18}O_{calcite}$ représente la composition isotopique de la calcite (exprimé en ‰ dans l'échelle PDB), $\delta^{18}O_{SW}$ représente la composition isotopique de l'eau de mer (exprimé en ‰ dans l'échelle SMOW).

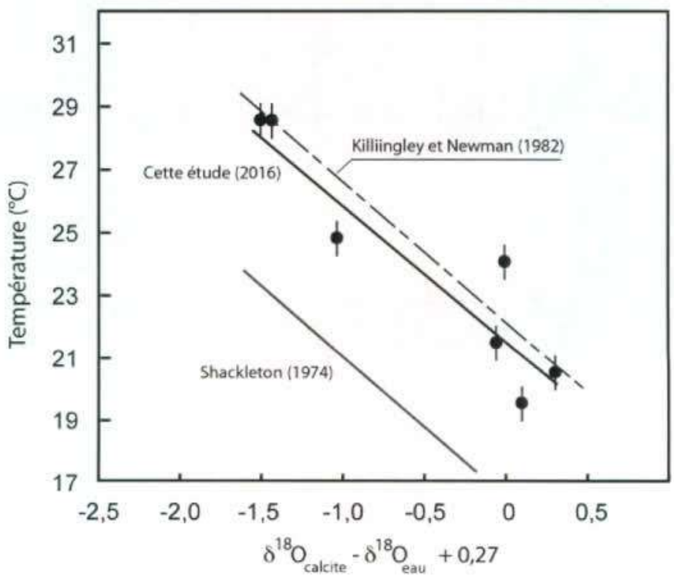

Figure 8 : Calibration des valeurs de composition isotopiques des valves de cirripèdes en fonction de la température de formation. Les points noirs représentent les valeurs que nous avons déterminées expérimentalement.
Pour comparaison, ont été ajoutées (i) la courbe de calibration de Shackelton (1974) utilisée classiquement en paléocéanographie pour les études portant sur les foraminifères, (ii) celle de Killingley et Newman (1982) obtenue sur l'espèce de cirripède *Balanus aquila*.

Nous avons utilisé cette relation pour calculer les températures de formation des valves de cirripèdes. Compte tenu des incertitudes analytiques sur la composition isotopique des valves et sur l'estimation de la composition isotopique de l'eau de mer, l'incertitude sur la reconstruction de la température de calcification des cirripèdes est d'environ ±1°C. Comme la température des eaux de surface de l'océan Indien présente des variations supérieures à 10°C (Figure 9), la précision des estimations de température permet d'apporter des informations significatives et de contraindre la zone dans laquelle le flaperon a dérivé pendant que les cirripèdes se développaient.

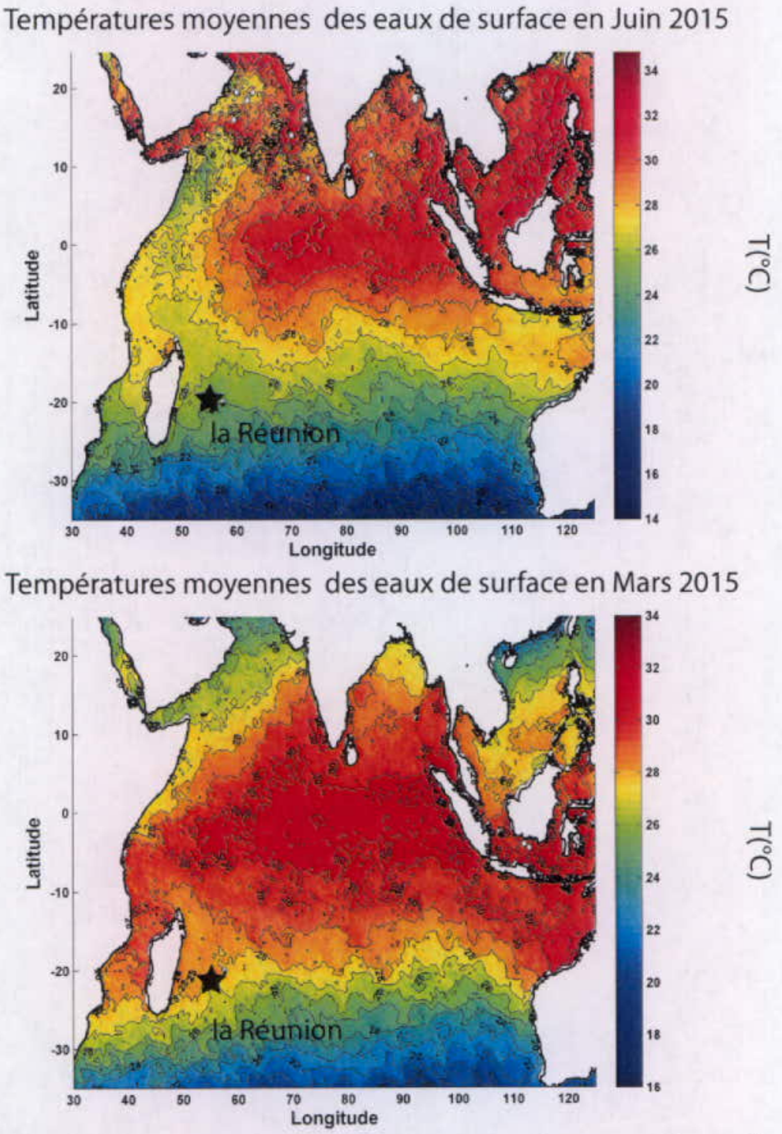

Figure 9 : Distribution des températures moyennes des eaux de surface de l'Océan Indien durant le mois de juin et de mars 2015. L'étoile noire représente l'ile de la Réunion.

3.3 $^{18}O/^{16}O$ des cirripèdes du flaperon : estimation des températures

3.31 Vérification de la cohérence des compositions isotopiques des cirripèdes collectés sur le flaperon

-Les données exploratoires ; spécimen A1-2.

Avant de commencer un échantillonnage haute résolution long et fastidieux, nous avons testé si effectivement les valves de cirripèdes enregistraient bien une variabilité isotopique susceptible de correspondre à un signal interprétable en terme de température. Nous avons donc échantillonné le spécimen A1-2 manuellement (Figure 4, Tableau 5). Les résultats des mesures isotopiques montrent que la gamme de variation est de l'ordre de 0,9‰, entre -1,92 et -1,08 ‰ vs PDB (Figure 10). Les valeurs isotopiques les plus positives (-1,08 ‰) correspondent aux zones périphériques de la valve, les plus récentes. Les valeurs les plus négatives ont été mesurées dans les zones plus anciennes contigües à la zone de l'umbo (la plus vieille). D'une manière globale, les valeurs de $\delta^{18}O$ montrent une tendance nette à l'augmentation depuis la zone contigües à l'umbo jusqu'à la périphérie.

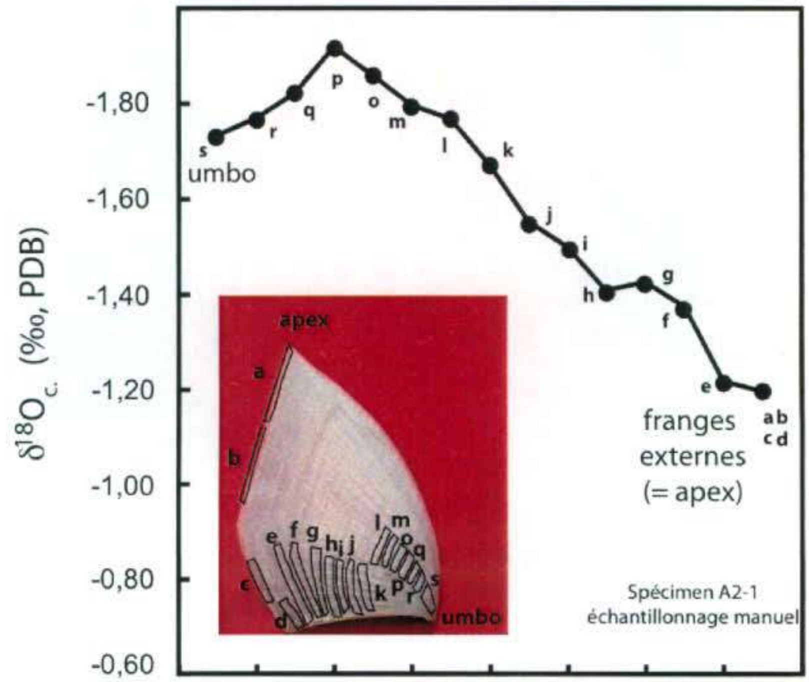

Figure 10 : Profil isotopique ($\delta^{18}O$, ‰ vs PDB) basse résolution du spécimen A1-2. A noter que la partie correspondant à l'umbo présente des valeurs $\delta^{18}O$ de plus négatives que celles correspondantes aux bords externes. Par convention l'échelle des ordonnées a été inversée dans toutes les figures avec $\delta^{18}O$ en ordonnées, ce qui permet de représenter un axe de température croissant vers le haut.

-Les petits spécimens

Nous avons analysé 20 petits spécimens (tableau 2 et tableau 4) provenant des différentes zones du flaperon. Les vitesses de croissance estimées par des études de biologistes (Evans 1958 ; Inatsuchi et al., 2010) nous conduisent à attribuer à ces spécimens juvéniles un âge pratiquement contemporain de l'échouage du flaperon. Si l'on considère la courbe de croissance proposée par le Dr. Poupin, alors ces spécimens auraient moins de 2 semaines d'existence. Les travaux expérimentaux d'Inatsuchi et al. (2010), qui portent sur la relation entre température de l'eau, nutriments et croissance des anatifes, sont également en accord avec cette estimation. La moyenne des compositions isotopiques $\delta^{18}O$ de ces échantillons est -1,06 ‰ avec un écart type de 0,15‰. Il n'y a pas de relation entre la taille des spécimens ou leur rapport longueur sur largeur et leurs compositions isotopiques $\delta^{18}O$. Nous considérerons donc que cette valeur moyenne de $\delta^{18}O$ correspond aux conditions thermiques des eaux de surface qui ont prévalues au large de l'ile de la Réunion le mois précédent la découverte du flaperon. En conséquence, les franges les plus externes de chaque individu analysé, trouvé vivant, quelle que soit sa taille, devraient avoir une valeur de $\delta^{18}O$ proche de -1,06 ± 0,15‰ (PDB). Nous avons systématiquement effectué cette vérification.

-Les spécimens de taille intermédiaires A2-G3 et A2-G4.

Ces deux échantillons ont une taille du scutum de 19 mm pour A2-G3 et de 16 mm pour A2-G4. Tous deux proviennent du sachet A et ont été analysés pour, d'une part tester la reproductibilité des profils isotopiques d'échantillons de taille comparable et, d'autre part, obtenir un enregistrement de $\delta^{18}O$ des valves couvrant une période plus longue que celle obtenue sur les petites valves.

Le spécimen A2-G3 a été analysé à haute résolution (Tableau 6, Figure 11).

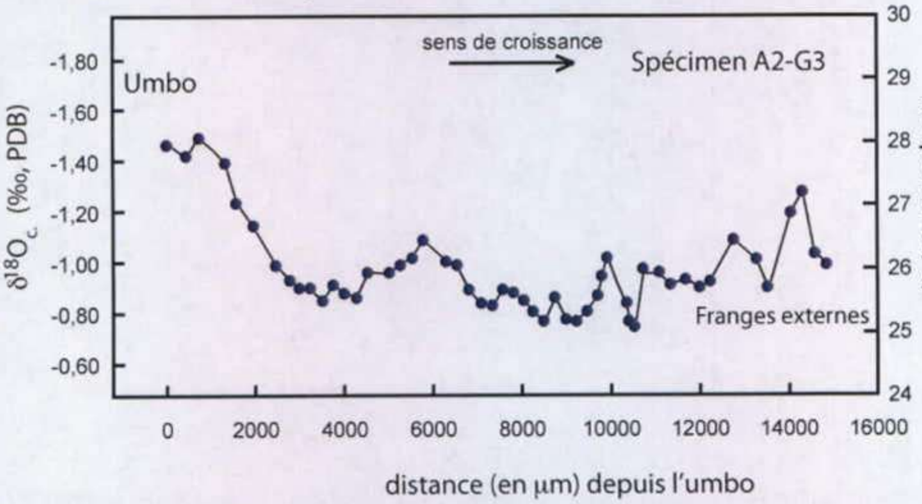

Figure 11 : Profil isotopique ($\delta^{18}O$, ‰ vs PDB) haute résolution et température de formation de la valve du spécimen A2-G3. On note que la partie correspondant à l'umbo s'est développée dans de eaux plus chaudes que les franges externes.

Les valeurs de $\delta^{18}O$ de ce spécimen sont comprises entre -1,50 et -0,78‰ (PDB). Les valeurs les plus négatives ont été mesurées dans les zones les plus anciennes contigües à la zone de l'umbo (la plus vieille). Les valeurs les plus élevées sont présentes dans les parties externes (les plus récentes) de la valve. Les valeurs augmentent de 0,7 ‰ entre la zone de l'umbo (~-1,45 ‰) vers la périphérie. Cette augmentation se réalise sur environ 1500µm de distance à proximité de l'umbo.

Le spécimen A2-G4 présente des valeurs de $\delta^{18}O$ (Tableau 7) comprises entre -1,43‰ et -0,96 ‰ (PDB). La valeur la plus négative se situe en position intermédiaire dans la valve. Ces valeurs se situent entre 3120 et 7380 µm de l'umbo dont la zone contigüe présente une valeur proche de -1,20‰ (PDB). Les valeurs isotopiques des bords les plus externes, les derniers 1000 µm, oscillent entre -1,13 et -0,96‰ (PDB) pour une moyenne de -1,04‰ (PDB) avec un écart type de 0.1‰. Ces valeurs sont similaires à celles obtenues pour les petits échantillons de cirripèdes et peuvent donc être considérées comme reflétant les conditions thermiques lorsque le flaperon a dérivé dans les eaux proches de l'ile de la Réunion.

La cohérence de l'ensemble de ces résultats isotopiques nous autorise à les exprimer en termes de température des eaux dans lesquelles les valves se sont développées (Figures 11, 12 et 13).

3.3.2 Obtention de profils longs sur grands spécimens

-A2-G1, échantillonnage haute résolution

Cet échantillon a été analysé à très haute résolution ; avec 77 échantillons (Figure 12, Tableau 8), il constitue la chronique isotopique la mieux documentée de cette expertise.

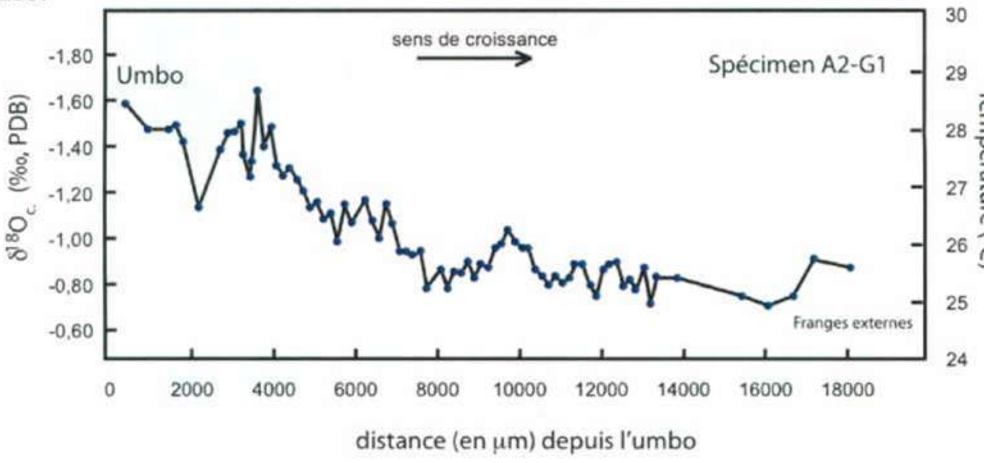

Figure 12 : Profil isotopique ($\delta^{18}O$, ‰ vs PDB) haute résolution et température de formation de la valve du spécimen A2-G1. A noter que la partie correspondant à l'umbo s'est développée dans des eaux significativement plus chaudes que les franges externes.

Les valeurs de $\delta^{18}O$ varient de -0,72 et -1,60 ‰ (PDB). Comme pour les échantillons précédents, nous observons que les valeurs les plus négatives correspondent aux zones proches de l'umbo, alors que les valeurs les plus positives correspondent aux zones les plus externes du spécimen. Entre l'umbo et 7850 µm, le profil obtenu, interprété en terme de température des eaux de surface de l'eau de mer (Figure 12) témoigne d'un refroidissement progressif d'environ 3°C au cours de la vie de l'animal. Cette diminution de température est significative compte tenu de l'incertitude expérimentale de ±1°C. Nos résultats montrent qu'au cours de la vie de l'animal, les températures ont diminue de manière plus ou moins régulière, passant d'environ 28,5 ± 1°C à 25,4 ± 1°C. Dans la seconde partie du profil, entre 7500 et 18180µm, les températures restent sensiblement constante (25,4 ± 1°C), dans la gamme des valeurs précédemment estimées pour les juvéniles qui se sont développés dans des eaux proches de l'île de la Réunion.

-Les valeurs $\delta^{18}O$ de la zone de l'umbo ; spécimen A2-G2

Afin de nous assurer de la bonne représentativité des températures élevées obtenues au voisinage de l'umbo de l'échantillon A2-G1, nous avons effectué une série d'analyses isotopiques sur le spécimen A2-G2 (Figure 13), de taille comparable à A2-G1.

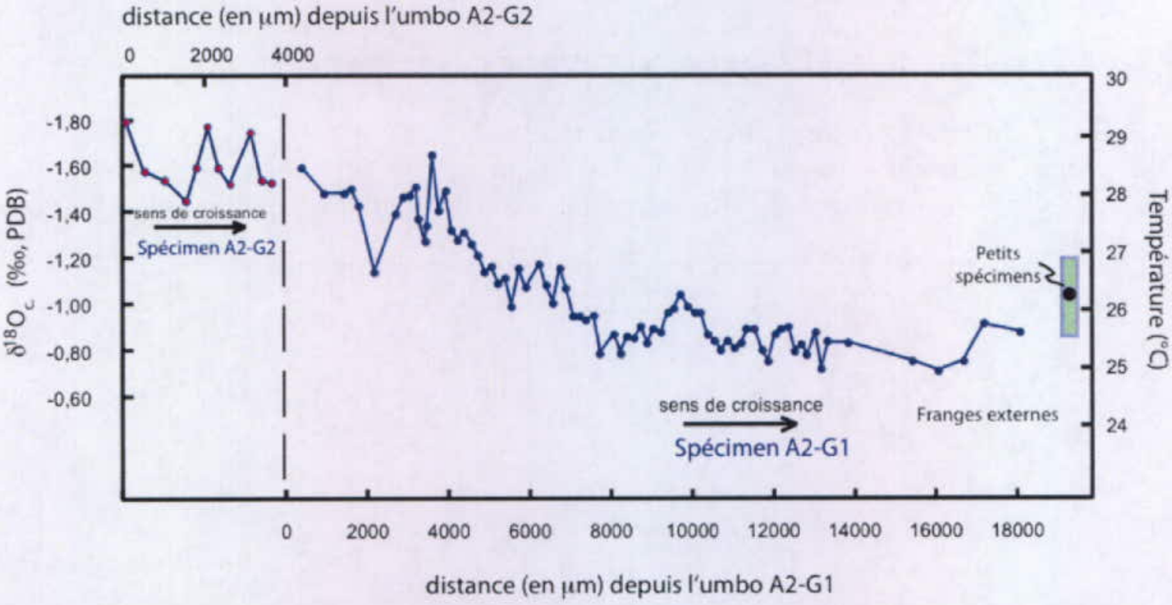

Figure 13: Synthèse des gammes de température déterminées à l'aide des différents profils isotopiques. Le profil isotopique haute résolution du spécimen A2-G1 constitue une référence de la variabilité des températures des eaux de surface à travers lesquelles a transité le flaperon. A titre de comparaison, sont représentés : (i) le profil de la partie proche de l'umbo du spécimen A2-G2 (ii) la gamme de variabilité enregistrée par les cirripédes juvéniles (boîte colorée). On notera que les deux plus grands spécimens (A1-G1 et A2-G2) ont commencé leur croissance dans des eaux dont les températures étaient proches de 28,5±1°C.

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Le profil isotopique couvre une distance d'environ 3500 µm à partir de l'umbo. Les valeurs de compositions isotopiques de l'oxygène (Tableau 9) et de températures sont comparables à celles obtenues au voisinage de l'umbo de l'échantillon A2-G1 (Figure 13).
Ces résultats indiquent que dans les quelques mois qui ont précédé l'échouage, le flaperon a dérivé progressivement depuis des eaux chaudes (29 ± 1°C) vers des eaux sensiblement plus froides (25,4 ±1°C) présentes près de l'île de la Réunion.

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4 Conclusions

L'ensemble de ces mesures, d'une grande cohérence, montre :

1 – Les cirripèdes de l'espèce *Lepas anatifera* enregistrent fidèlement la température des eaux de surface dans lesquelles ils se sont développés et ont sécrété leurs valves.

2 - les températures de croissance enregistrées par les valves les plus petites (juvéniles) et par la frange terminale (c'est à dire la plus récente) des grosses valves adultes (~ 25,4 ± 1°C) sont cohérentes avec les températures observées au large de la Réunion en mai - juin 2015. Ces résultats indiquent que les cirripèdes ont achevé leur développement, avant que le flaperon ne soit découvert, dans des masses d'eaux dont les caractéristiques thermiques étaient similaires à celles des eaux proches de l'île de la Réunion.

3 au début de leur croissance, les cirripèdes les plus grands étaient baignés par des eaux dont la température était voisine de 28,5 ± 1°C (Figure 13). La distribution des courants et les variations de températures dans les mois qui précèdent la découverte du flaperon (Figure 9) suggèrent que celui-ci a dérivé dans des masses d'eau situées à E-NE de l'île de la Réunion.

Nous n'avons toutefois aucun élément permettant de déterminer avec certitude la durée de croissance des valves recueillies et donc la période couverte par les valves les plus développées. Néanmoins, d'après deux études expérimentales portant sur les vitesses de croissance des anatifes pélagiques 58s, 1966, Inatsuchi et al., 2010), les valves (scutum) les plus grandes (20-25 mm) auraient pu se former sur une période de quelques mois seulement ce qui ne permettrait que de retracer la fin du trajet de dérive du flaperon dans l'Océan Indien.

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ANNEXES

- Tableaux de données
- Bibliographie
- Personnes impliquées dans l'acquisition des données.

Tableaux de données

Tableau 1 : Liste des échantillons de cirripèdes ayant servi à la calibration $^{18}O/^{16}O$-T et fournis par le Dr Jones (Muséum d'Histoire Naturelle de Perth, Australie).

Lieu	Echantillon	Latitude	Longitude	Prélèvement
Batemans Bay	C33134	35°43'S	150°11'E	00/01/1986
Cocos Islands, Home I.	C19436	12°06'S	96°53'E	22/02/1989
Cocos Islands, Prison I.	C19438	12°06'S	96°53'E	21/02/1989
Houtman Abrolhos	C32565	28°44'S	113°46'E	19/10/1987
Lancelin	C14260	31°01'S	115°20'E	02/09/1984
Henderson	C52707	20°37'S	116°45'E	10/08/2013

Tableau 2 : Longueur (L), largeur (l) données en millimètre et rapport L/l des petits cirripèdes provenant des différentes zones du flaperon du vol MH370.

Zone	N° Echantillon	Longueur Capitulum (mm)	largeur capitulum (mm)	L/l
Zone A1	A1-1	6,93	4,24	1,63
Zone A2	A2-1	4,93	3,26	1,51
Zone A3	A3-1	5,04	3,90	1,29
Zone B4 extrados	B4 extrados -1	6,36	3,75	1,70
Zone B4 intrados	B4 intrados -1	7,61	4,26	1,79
Zone C2	C2-1	6,90	4,11	1,68
Zone C4 extrados	C4 extrados -1	7,31	4,44	1,65
Zone C4 intrados	C4 intrados -1	5,79	3,70	1,56
Zone D4 extrados	D4 extrados -1	6,08	3,83	1,59
Zone D4 intrados	D4 intrados -1	5,79	3,70	1,56
Zone E1	E1-1	6,10	3,96	1,54
Zone E2	E2-1	6,76	3,94	1,72
Zone E3	E3-1	8,29	5,57	1,49
Zone E4 extrados	E4 extrados -1	4,12	2,85	1,45
Zone E4 intrados	E4 intrados -1	3,71	2,47	1,50
Zone F1	F1-1	6,24	4,04	1,54
Zone F2	F2-1	6,62	4,41	1,50
Zone F3	F3-1	4,97	3,13	1,59
Zone F4	F4-1	4,55	3,34	1,36
			moyenne	1,56
			écartype	0,12

Tableau 3 : Localisation, température, salinité et composition isotopique ($\delta^{18}O$) des eaux de surface collectées lors de la campagne océanographique Francklin 2. (Données non publiées fournies par le Dr P. Dedecker, ANU).

stations	Lat. S	Long. E	Température	Salinité	$\delta^{18}O$ (SMOW)
1	31,12	114,55	23,51	35,71	0,57
2	29,67	113,68	23,43	35,69	0,57
3	29,37	113,22	23,26	35,80	0,30
4	29,35	112,95	22,90	35,91	0,21
5	28,72	113,38	24,54	35,40	0,42
6	28,40	113,17	25,08	35,31	0,33
7	28,42	112,28	25,30	35,27	0,29
8	26,98	111,33	24,44	35,52	0,39
9	27,00	111,01	24,54	35,49	0,21
10	25,38	110,10	25,31	35,41	0,40
11	24,85	108,82	24,88	34,42	-0,05
13	24,48	108,51	24,85	35,43	0,40
15	23,73	108,53	25,39	35,23	-0,01
17	23,01	108,17	28,28	35,02	0,02
18	21,99	108,83	25,96	35,13	0,22
19	20,99	109,50	25,78	35,25	0,06
20	19,99	110,17	27,99	34,98	-0,21
21	19,42	110,51	28,13	35,01	0,02
22	18,00	110,50	28,55	34,75	-0,08
23	17,00	110,49	28,85	34,86	-0,04
25	15,00	110,48	29,07	34,15	-0,06
26	15,00	110,48	29,18	34,04	-0,35
27	13,00	110,47	29,55	34,20	-0,27
28	12,23	110,43	29,04	33,69	-0,17
29	12,18	111,51	28,95	34,55	0,24
31	12,25	112,73	29,08	34,59	0,01
32	12,08	114,45	28,93	34,16	0,06
34	13,02	114,07	29,53	34,38	0,10
35	14,60	113,51	29,50	34,52	-0,24
36	14,78	114,27	29,19	34,15	-0,17
38	16,92	113,33	29,53	34,99	0,36
39	16,92	114,83	29,87	34,89	0,20

Tableau 4 : Composition isotopique de l'oxygène (‰, PDB) des spécimens utilisés pour la calibration $\delta^{18}O$ carbonates (calcite) en fonction de la température.

Lieu		collection	Lat.	Long.
	Batemans Bay	00/01/1986	35°43'S	150°11'E
	Température= 22,4 ± 0,5°C			
	$\delta^{18}O$ SW estimé à 0,36 ‰			
			$\delta^{18}O$ (PDB, ‰)	
	C33134-L1		0,01	
	C33134-L2		0,06	
	C33134-L3		0,05	
	C33134-L4		0,09	
	C33134-L5		-0,18	
	moyenne		0,00	
	écartype		0,11	
	Cocos Islands Prison I.	22/02/1989	12°06'S	96°53'E
	Température= 28,5 ± 0,5°C			
	$\delta^{18}O$ SW estimé à -0,19‰		$\delta^{18}O$ (PDB, ‰)	
	C19438-L1-P1		-1,76	
	C19438-L1-P1		-1,90	
	C19438-L1-P1		-1,96	
	moyenne		-1,88	
	écartype		0,10	
	Cocos Islands Home I.	22/02/1989		
	Température= 28,5 ± 0,5°C			
	$\delta^{18}O$ SW estimé à -0,19‰			
			$\delta^{18}O$ (PDB, ‰)	
	C19436-L1		-2,23	
	C19436-L1		-1,96	
	C19436-L1		-1,78	
	C19436-L2		-1,73	
	C19436-L4		-2,09	
	moyenne		-1,96	
	écartype		0,21	

Tableau 4 (suite) : Compositions isotopique de l'oxygène (‰, PDB) des spécimens utilisées pour calibration $\delta^{18}O$ carbonates (calcite) en fonction de la température.

		collection	Lat.	Long.
Lieu	**Houtman Abrolhos.**	19/10/1987	28°44'S	113°46'E
	Température = 20,5 ± 0,5°C			
	$\delta^{18}O$ SW estimé à 0,33‰			
			$\delta^{18}O$ (PDB, ‰)	
	C32565 P1-3mm (bulk)		0,23	
	C32565 P2- L4		0,44	
	C32565 P2-L4 (duplicate)		0,34	
	C32565 P2-L5		0,50	
	C32565 P2-L5 (duplicate)		0,54	
	C32565 P2-bord externe		0,47	
	C32565 L-intermédiaire		0,31	
	C32565 L1-intermédiaire		0,30	
	C32565 intermédiaire		0,2	
	moyenne		0,35	
	écartype		0,13	
	Lancelin	02/09/1984	31°01'S	115°20'E
	Température = 19,8 ± 0,5°C			
	$\delta^{18}O$ SW estimé à 0,29‰			
			$\delta^{18}O$ (PDB, ‰)	
	C14260 J3mm		0,10	
	C14260 J3mm (duplicate)		0,03	
	C14260 J1mm		0,19	
	C14260 J5mm		0,14	
	C14260 J5mm (duplicate)		0,11	
	C14260 J5mm (triplicate)		0,13	
	moyenne		0,12	
	écartype		0,05	
	Henderson	10/08/2013	20°37'S	116°45'E
	Température = 24,2 ± 0,5°C			
	$\delta^{18}O$ SW estimé à 0,10‰			
			$\delta^{18}O$ (PDB, ‰)	
	C52707-L1-2		-0,02	
	C52707-L2		-0,12	
	C52707-L2		-0,11	
	C52707-L2		-0,25	
	C52707-L3		-0,30	
	C52707-L4		-0,22	
	moyenne		-0,17	
	écartype		0,10	

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Tableau 4 (suite) : composition isotopique de l'oxygène des spécimens utilisées pour la calibration $\delta^{18}O$ carbonates (calcite) en fonction de la température.

		collection	Lat.	Long.
Lieu	**La Réunion**	00/08/2015	21°10'S	55°30'E
	Température = 24,8 ± 1°C			
	$\delta^{18}O$ SW estimé à 0,26‰			
			$\delta^{18}O$ (PDB, ‰)	
	A1-P-0-B		-1,07	
	A2-P-0-B		-1,00	
	A3-P-0-B		-1,04	
	B4 extrados -P-0-B		-1,15	
	B4 intrados -P-0-B		-1,11	
	C2-P-0-B		-1,05	
	C4 extrados -P-0-B		-1,13	
	C4 intrados -P-0-B		-1,20	
	D4 extrados -P-0-B		-1,39	
	D4 intrados -P-0-B		-1,12	
	E1-P-0-B		-0,96	
	E2-P-0-B		-0,99	
	E3-P-0-B		-1,21	
	E4 extrados -P-0-B		-1,03	
	E4 intrados -P-0-B		-1,24	
	F1-P-0-B		-0,94	
	F2-P-0-B		-0,89	
	F3-P-0-B		-1,00	
	F4-P-0-B		-0,69	
	A1-P-0-B		-1,07	
	moyenne		-1,06	
	écartype		0,15	

Tableau 5 : composition isotopique de l'oxygène (‰, PDB) du spécimen A1-2. La colonne « moyenne »reporte la moyenne des résultats obtenus sur les prélèvements d'une même zone. L'échantillonnage a été réalisé manuellement à la fraise de dentiste et/ou par mini-disqueuse. Pour des raisons pratiques l'échantillonnage s'est réalisé des bords externes vers l'umbo (voir Figure 4 pour la localisation).

Spécimen	Ligne d'échantillon vers l'umbo	$\delta^{18}O$ (‰, PDB)	Moyenne $\delta^{18}O$
A1-2a	15	-1,29	
A1-2b	15	-1,08	
A1-2c	15	-1,15	
A1-2d	15	-1,26	-1,20
A1-2e1	14	-1,24	
A1-2e2	14	-1,27	
A1-2e3	14	-1,15	-1,22
A1-2f1	13	-1,23	
A1-2f2	13	-1,52	-1,38
A1-2g1	12	-1,32	
A1-2g2	12	-1,51	
A1-2g3	12	-1,45	-1,43
A1-2h1	11	-1,42	
A1-2h2	11	-1,40	-1,41
A1-2i1	10	-1,40	
A1-2i1	10	-1,58	
A1-2i2	10	-1,58	
A1-2i2	10	-1,43	
A1-2i3	10	-1,51	-1,50
A1-2j1	9	-1,55	-1,55
A1-2k1	8	-1,79	
A1-2k2	8	-1,56	-1,67
A1-2l1	7	-1,78	
A1-2l2	7	-1,75	-1,77
A1-2m1	6	-1,80	
A1-2m2	6	-1,80	
A1-2m3	6	-1,79	-1,80
A1-2o1	5	-1,83	
A1-2o2	5	-1,89	-1,86
A1-2p1	4	-1,92	-1,92
A1-2q1	3	-1,77	
A1-2q2	3	-1,88	-1,82
A1-2r1	2	-1,77	-1,77
A1-2 U1	1	-1,72	
A1-2 U2	1	-1,78	
A1-2 U3	1	-1,70	-1,73

Tableau 6 : composition isotopique de l'oxygène (‰, PDB) du spécimen A2-G3 échantillonné à haute résolution au Micromill et température estimée.

spécimen	Ligne d'échantillonnage	Distance en µm depuis l'umbo	δ18O (‰, PDB)	Température estimée (°C)
A2-G3	A2G3-3L28	0	-1,47	28,00
	A2G3-3L27	350	-1,42	27,78
	A2G3-3L26	600	-1,50	28,13
	A2G3-3L25	950	-1,45	27,91
	A2G3-3L24	1200	-1,40	27,70
	A2G3-3L23	1450	-1,25	27,05
	A2G3-3L22	1800	-1,16	26,66
	A2G3-3L19	2300	-1,02	26,05
	A2G3-3L18	2600	-0,96	25,79
	A2G3-3L17	2800	-0,93	25,66
	A2G3-3L16	3000	-0,93	25,66
	A2G3-3L15	3300	-0,88	25,45
	A2G3-3L14	3550	-0,94	25,71
	A2G3-3L13	3800	-0,91	25,58
	A2G3-3L12	4050	-0,89	25,49
	A2G3-3L11	4300	-0,99	25,92
	A2-G3-3L10	4750	-0,98	25,88
	A2-G3-3L9	5000	-1,02	26,05
	A2-G3-3L8	5250	-1,04	26,14
	A2-G3-3L7	5500	-1,11	26,44
	A2-G3-3L5	6000	-1,03	26,10
	A2-G3-3L4	6250	-1,01	26,01
	A2-G3-3L3	6500	-0,92	25,62
	A2-G3-3L2	6750	-0,87	25,41
	A2-G3-3L1	7000	-0,86	25,36
	A2-G3-2L15	7050	-0,87	25,41
	A2-G3-2L14	7230	-0,92	25,62
	A2-G3-2L13	7460	-0,91	25,58
	A2-G3-2L12	7690	-0,88	25,45
	A2-G3-2L11	7920	-0,83	25,23
	A2-G3-2L10	8150	-0,80	25,10
	A2-G3-2L9	8380	-0,89	25,49
	A2-G3-2L8	8610	-0,81	25,15
	A2-G3-2L7	8840	-0,80	25,10
	A2-G3-2L6	9070	-0,84	25,28
	A2-G3-2L5	9300	-0,90	25,53
	A2-G3-L18	9500	-1,05	26,18
	A2-G3-2L4	9700	-0,95	25,75
	A2-G3-2L3	9900	-0,87	25,41
	A2-G3-L17	10000	-0,80	25,10

Tableau 6 (suite) : composition isotopique de l'oxygène (‰, PDB) du spécimen A2-G3 échantillonné à haute résolution au Micromill et température estimée.

spécimen	Ligne d'échantillonnage	Distance en µm depuis l'umbo	$\delta^{18}O$ (‰, PDB)	Température estimée (°C)
A2-G3	A2-G3-2L2	10100	-0,78	25,02
	A2-G3-L16	10300	-1,02	26,05
	A2-G3-2L1	10300	-0,98	25,88
	A2-G3-L15	10600	-0,98	25,88
	A2-G3-L14	10900	-0,94	25,71
	A2-G3-L13	11200	-0,96	25,79
	A2-G3-L12	11500	-0,93	25,66
	A2-G3-L9+10	11750	-0,95	25,75
	A2-G3-L7+L8	12250	-1,11	26,44
	A2-G3-L6	12750	-1,03	26,10
	A2-G3-L5+L4	13000	-0,92	25,62
	A2-G3-L3	13500	-1,21	26,88
	A2-G3-L2	13750	-1,29	27,22
	A2-G3-L1-2	14000	-1,06	26,23
	A2-G3-L27+28+29	14250	-1,02	26,05

Tableau 7 : composition isotopique de l'oxygène (‰, PDB) du spécimen A2-G4 au Micromill et température estimée.

spécimen	Ligne d'échantillonnage	Distance en µm depuis l'umbo	$\delta^{18}O$ (‰, PDB)	Température estimée (°C)
A2-G4	A2-G4-L22	300	-1,13	26,53
	A2-G4-L21	870	-1,19	26,79
	A2-G4-L20	1700	-1,24	27,01
	A2-G4-L19	2425	-0,96	25,79
	A2-G4-L18	3120	-1,40	27,70
	A2-G4-L17	4225	-1,31	27,31
	A2-G4-L16	5120	-1,23	26,96
	A2-G4-L15	5970	-1,33	27,40
	A2-G4-L13+ L14	7380	-1,43	27,83
	A2-G4-L12	8375	-1,17	26,70
	A2-G4-L11	9840	-1,19	26,79
	A2-G4-L9	10780	-1,16	26,66
	A2-G4-L8	11350	-1,16	26,66
	A2-G4-L7	12130	-1,27	27,14
	A2-G4-L6	12980	-1,11	26,44
	A2-G4-L3	13190	-0,96	25,79
	A2-G4-L2	13530	-1,00	25,97
	A2-G4-L4+L5	13620	-1,13	26,53
	A2-G4-L1	14040	-1,07	26,27

Tableau 8 : composition isotopique de l'oxygène (‰, PDB) du spécimen A2-G1 échantillonné à haute résolution au Micromill et température estimée.

spécimen	Ligne d'échantillonnage	Distance en µm depuis l'umbo	$\delta^{18}O$ (‰, PDB)	Température estimée (°C)
A2-G1	A2-G1-2L1	500	-1,60	28,56
	A2-G1-2L3	1030	-1,49	28,09
	A2-G1-2L4	1530	-1,49	28,09
	A2-G1-2L5	1710	-1,51	28,17
	A2-G1-2L6	1890	-1,44	27,87
	A2-G1-2L8	2290	-1,15	26,62
	A2-G1-2L11	2815	-1,40	27,70
	A2-G1-2L12	2990	-1,47	28,00
	A2-G1-2L13	3140	-1,48	28,04
	A2-G1-2L14	3300	-1,52	28,22
	A2-G1-2L15	3360	-1,38	27,61
	A2-G1-2L16	3510	-1,28	27,18
	A2-G1-2L17	3560	-1,35	27,48
	A2-G1-2L18	3710	-1,66	28,82
	A2-G1-2L19	3860	-1,41	27,74
	A2-G1-2L20	4010	-1,50	28,13
	A2-G1-2L21	4175	-1,33	27,40
	A2-G1-2L22	4340	-1,29	27,22
	A2-G1-2L23	4505	-1,32	27,35
	A2-G1-2L24	4670	-1,27	27,14
	A2-G1-2L25	4835	-1,22	26,92
	A2-G1-2L26	5000	-1,15	26,62
	A2-G1-2L27	5165	-1,17	26,70
	A2-G1-2L28	5330	-1,10	26,40
	A2-G1-2L29	5495	-1,12	26,49
	A2-G1-2L30	5660	-1,00	25,97
	A2-G1-2L31	5831	-1,16	26,66
	A2-G1-2L32	5999	-1,08	26,31
	A2-G1-2L34	6336	-1,18	26,75
	A2-G1-2L35	6504	-1,09	26,36
	A2-G1-2L36	6672	-1,02	26,05
	A2-G1-2L37	6841	-1,17	26,70
	A2-G1-2L38	7009	-1,08	26,31
	A2-G1-2L39	7177	-0,96	25,79
	A2-G1-2L40	7345	-0,96	25,79
	A2-G1-2L41	7514	-0,94	25,71
	A2-G1-2L42	7682	-0,96	25,79
	A2-G1-2L43	7850	-0,80	25,10
	A2-G1-2L45	8180	-0,88	25,45
	A2-G1-2L46	8345	-0,80	25,10
	A2-G1-2L47	8510	-0,87	25,41
	A2-G1-2L48	8675	-0,86	25,36

Tableau 8 (suite) : composition isotopique de l'oxygène (‰, PDB) du spécimen A2-G1 échantillonné à haute résolution au Micromill et température estimée.

spécimen	Ligne d'échantillonnage	Distance en mm depuis l'umbo	$\delta^{18}O$ (‰, PDB)	Température estimée (°C)
A2-G1	A2-G1-2L49	8840	-0,91	25,58
	A2-G1-2L50	9005	-0,84	25,28
	A2-G1-2L51	9170	-0,90	25,53
	A2-G1-2L52	9335	-0,89	25,49
	A2-G1-2L53	9500	-0,97	25,84
	A2-G1-2L54	9665	-0,99	25,92
	A2-G1-2L55	9830	-1,05	26,18
	A2-G1-2L56	9995	-1,00	25,97
	A2-G1-2L57	10160	-0,97	25,84
	A2-G1-2L58	10325	-0,97	25,84
	A2-G1-2L59	10490	-0,88	25,45
	A2-G1-2L60	10655	-0,85	25,32
	A2-G1-2L61	10820	-0,81	25,15
	A2-G1-2L62	10985	-0,85	25,32
	A2-G1-2L63	11150	-0,82	25,19
	A2-G1-2L64	11315	-0,84	25,28
	A2-G1-2L65	11480	-0,90	25,53
	A2-G1-2L66	11645	-0,90	25,53
	A2-G1-2L67	11810	-0,81	25,15
	A2-G1-2L68	11975	-0,76	24,93
	A2-G1-2L69	12140	-0,88	25,45
	A2-G1-2L70	12305	-0,90	25,53
	A2-G1-2L71	12470	-0,91	25,58
	A2-G1-2L72	12635	-0,81	25,15
	A2-G1-2L73	12800	-0,83	25,23
	A2-G1-2L74	12965	-0,79	25,06
	A2-G1-2L75	13130	-0,89	25,49
	A2-G1-2L76	13295	-0,73	24,80
	A2-G1-2L77	13460	-0,84	25,28
	A2-G1-2L80	13955	-0,84	25,28
	A2-G1/L14+15	15530	-0,76	24,93
	A2-G1/L12+L13	16180	-0,72	24,76
	A2-G1/L10+L11	16780	-0,76	24,93
	A2-G1/L9	17290	-0,92	25,62
	A2-G1/L7+L8	18180	-0,89	25,49

Tableau 9 : composition isotopique de l'oxygène (‰, PDB) du spécimen A2-G2 échantillonné dans la zone de l'umbo au Micromill et température estimée.

spécimen	Ligne d'échantillonnage	Distance en µm depuis l'umbo	$\delta^{18}O$ (‰, PDB)	Température estimée (°C)
A2-G2	L21	250	-1,81	29,47
	L20+L19	750	-1,58	28,48
	L18+L17	1250	-1,54	28,30
	L16	1750	-1,44	27,87
	L15	2000	-1,60	28,56
	L14	2250	-1,78	29,34
	L13	2500	-1,59	28,52
	L12	2750	-1,52	28,22
	L11+L10	3250	-1,75	29,21
	L9	3500	-1,54	28,30
	L8->L3	3750	-1,52	28,22

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LABORATOIRE DES SCIENCES DU CLIMAT & DE L'ENVIRONNEMENT

Gif –sur-Yvette, le 20 juin 2016,

ATTESTATION SUR L'HONNEUR DE LA RÉALISATION DE l'ORDONNANCE DE COMMISSION D'EXPERT ORDONNÉ PAR LE TRIBUNAL DE GRANDE INSTANCE DE PARIS.

Nous, Dr. Dominique Blamart (HDR) et Dr. Franck Bassinot (HDR), chercheurs au Laboratoire des Sciences du Climat et de l'Environnement (LSCE) certifions sur l'honneur que nous avons réalisé l'intégralité de l'expertise demandée par le Tribunal de Grand Instance de Paris auprès du Centre National de la Recherche Scientifique dans le cadre de l'instruction portant sur la disparition du vol MH 370 de la Malaysian Airlines.

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MH370 – Search and debris examination update

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Addendum

Page	Change	Date
18	Correction to Figure 11 caption to remove inconsistency with report text on Page 17.	2 Dec 2016
All	Corrected erroneous page numbers.	18 Aug 2017

Executive summary

This report provides an update to the MH370 search area definition described in previous ATSB reports. It comprises further analysis of satellite data, additional end of flight simulations, a summary of the analysis of the right outboard wing flap, and preliminary results from the enhanced debris drift modelling.

For background information, please refer to the ATSB publications available online at www.atsb.gov.au/mh370:

- Definition of underwater search areas, 18 August 2014
- Flight Path Analysis Update, 8 October 2014
- Definition of Underwater Search Area Update, 3 December 2015.

The Australian Defence Science and Technology (DST) Group[1] conducted a comprehensive analysis of the Inmarsat satellite communications (SATCOM) data and a model of aircraft dynamics. The output of the DST Group analysis was a probability density function (PDF) defining the probable location of the aircraft's crossing of the 7th arc.

Details of this analysis and the validation experiments are available in the open source published book here: http://link.springer.com/book/10.1007/978-981-10-0379-0.

Additional analysis of the burst frequency offsets associated with the final satellite communications to and from the aircraft is consistent with the aircraft being in a high and increasing rate of descent at that time. Additionally, the wing flap debris analysis reduced the likelihood of end-of-flight scenarios involving flap deployment.

Preliminary results of the CSIRO's drift analysis indicated it was unlikely that debris originated from south of the current search area. The northernmost simulated regions were also found to be less likely. Drift analysis work is ongoing and is expected to refine these results.

1 Formerly the Defence Science and Technology Organisation (DSTO).

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7th arc burst frequency offset (BFO) analysis

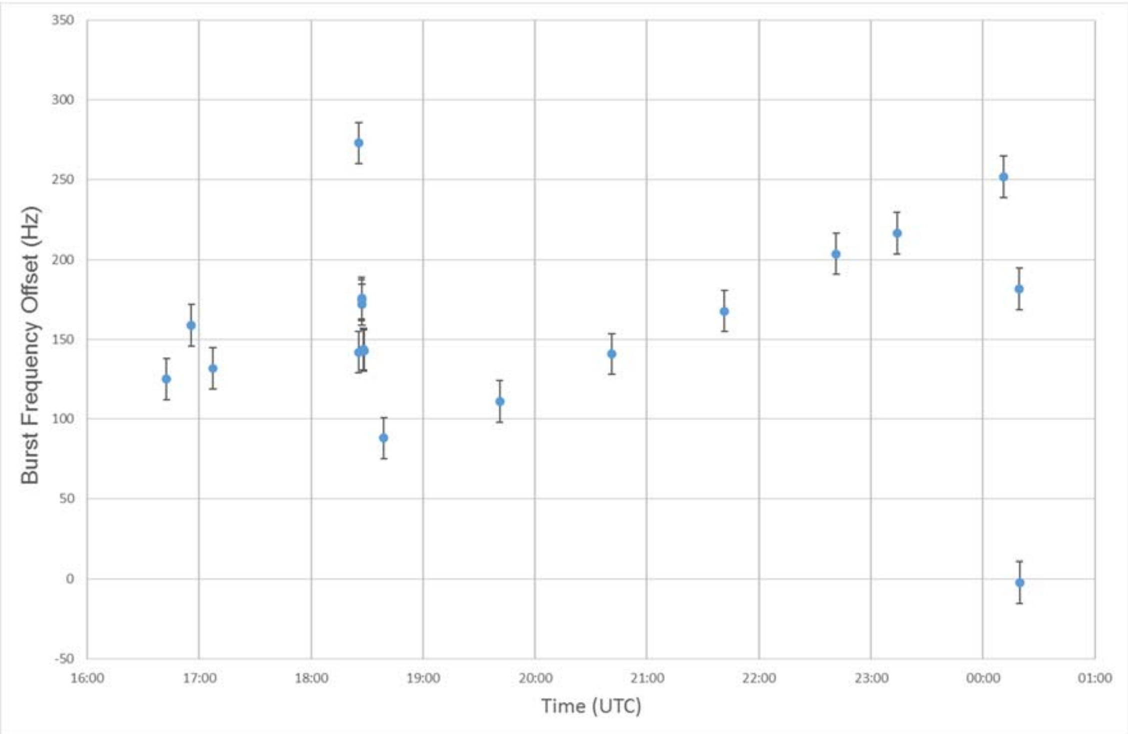
The final satellite communication (Satcom) transmissions between the Inmarsat Ground station and 9M-MRO occurred at 00:19 on the 8th March 2014. These transmissions were the aircraft logging on to the Satcom system, likely after an interruption to the power that supplies the satellite data unit (SDU) – an integral part of the Satcom system.

The ground station Satcom logs recorded the burst timing offset (BTO) and the burst frequency offset (BFO) for each received message. A complete explanation of the BTO and BFO is provided in the ATSB publication, *MH370 – Definition of Underwater Search Areas, August 2014*.

The BFO is a function of the Doppler shifts imparted on the communication signal due to the motion of the satellite and the aircraft. The relationship is more complicated than a direct Doppler calculation because the aircraft software contains Doppler compensation that offsets the Doppler shift due to the aircraft motion. Although the aircraft attempts to compensate for its own motion, it does this under the assumption that the communications satellite is in notional geostationary orbit and it does not include the vertical component of the aircraft velocity.

Analysis of the BFO value can provide information about the relative motion between the satellite and the aircraft. Figure 1 shows all the BFO recordings from 9M-MRO. The comprehensive analysis provided by the Defence Science and Technology (DST) Group (*Bayesian Methods in the Search for MH370*) indicated that the aircraft was likely on a southerly heading at 18:39. From that point until 00:11, all the solutions of the analysis showed a continuing southerly track.

Figure 1: Recorded BFO values throughout the flight

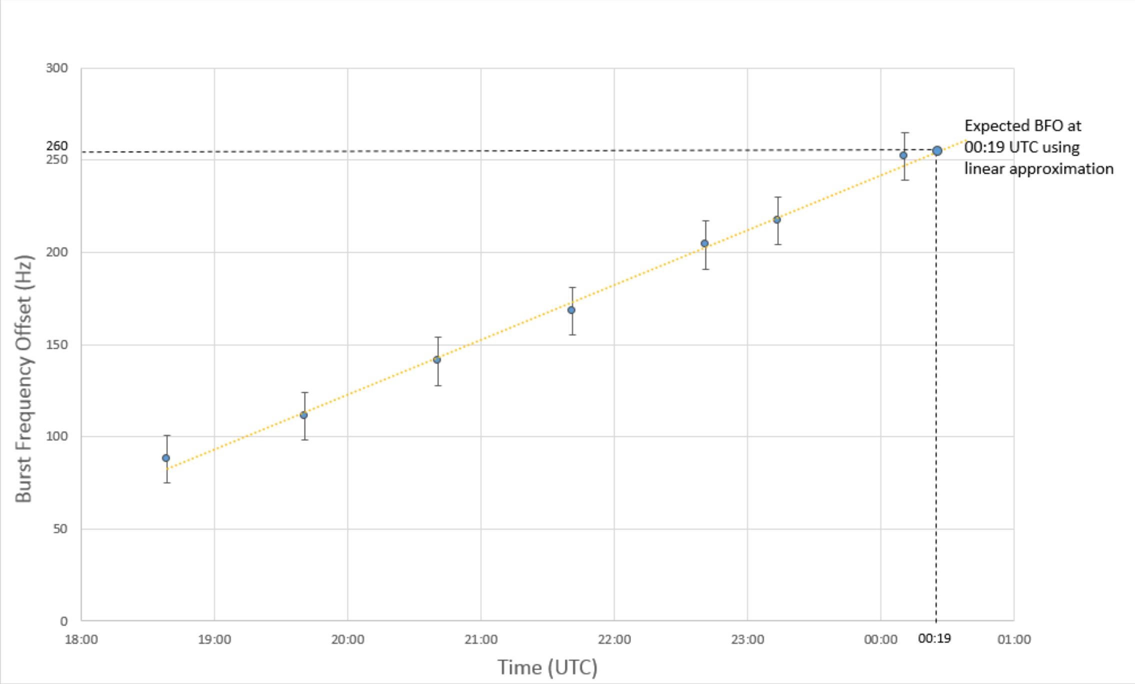


Source: ATSB

This graph illustrates the measured BFO recordings throughout the flight with the appropriate error bars on the measurements. After 18:39 the BFO values follow an approximately linear trend until the final two values at 00:19.

The trend of the BFO values from 18:39 until the 6th arc (00:11) is due to the change in location of the aircraft and can be linearly approximated (Figure 2). If this linear approximation is extrapolated to 00:19, and if neither the Satcom system nor the aircraft flight path were altered after 00:11, a BFO value of approximately 260 Hz would have been expected.

Figure 2: Linear approximation of the BFO values between 18:39 and 00:11



Source: ATSB

This graph illustrates 5 BFO values recorded between 18:39 and 00:11 and the linear approximation of the BFO at 00:19. The first 5 values correspond to the 2nd-6th arcs. During this time the aircraft is likely to be following a relatively constant southerly track. Continuing this linear trend to 00:19, a value of 260 Hz would be expected.

The recorded values of the BFO for the two messages at 00:19 were the following:

Table 1: Recorded BFO values at 00:19

Time	Burst Frequency Offset
00:19:29	182 Hz
00:19:37	-2 Hz

To explain this difference between the expected BFO value (260 Hz) and the recorded BFO values (Table 1), an examination was undertaken of the elements that contribute to the BFO.

This analysis includes a number of approximations, and the results should be interpreted as an approximate guide on the range of possible descent rates at the time of the last two SATCOM messages that were sent from 9M-MRO. DST Group intend to publish a more detailed version of the analysis in the near future. It should be noted that small refinements in the analysis may result in descent rate calculations that differ slightly from the values published here.

In the analysis it is assumed that there were no major changes to the satellite system between 00:11 and 00:19. Therefore the contributing elements consist of the:

- tolerance or error of the BFO
- direction of travel of the aircraft
- oven-controlled oscillator warm-up drift
- descent rate of the aircraft.

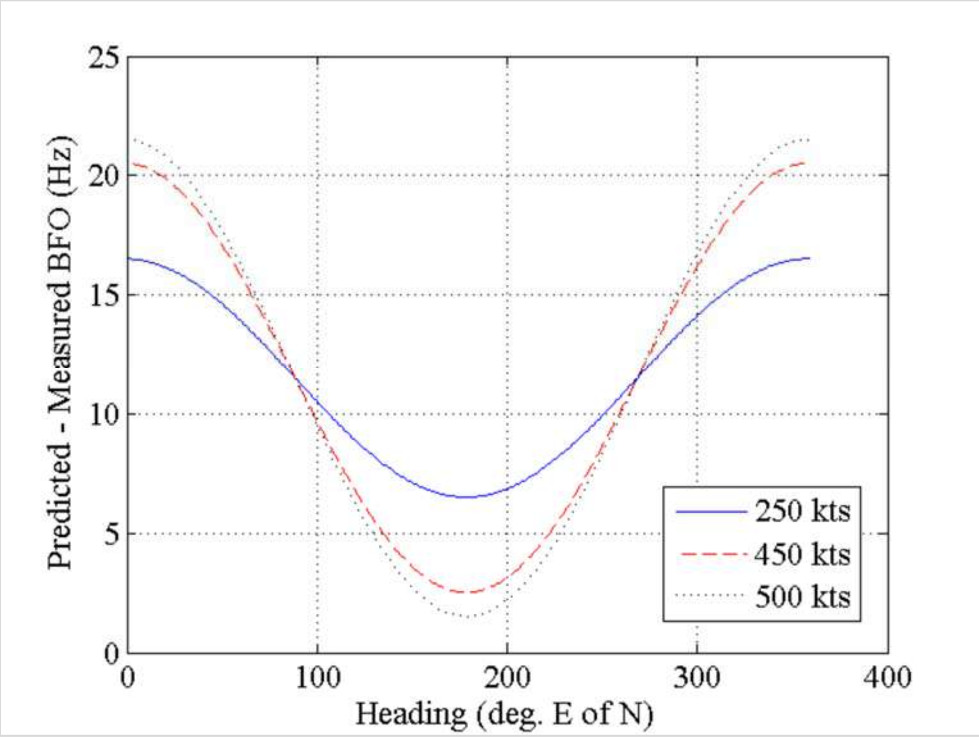
BFO tolerance or error

A statistical analysis of the BFO error from all the 20 previous flights of 9M-MRO identified that the distribution was approximately Gaussian (see DST Group book – link above) with a standard deviation of 4.3 Hz. ±3 standard deviations (12.9 Hz) is a conservative choice for the error.

Direction of flight

For any given speed, the estimated BFO differences can be plotted against the predicted heading of the aircraft (Figure 3). The maximum variation in the BFO differences based solely on change in direction is approximately 20 Hz.

Figure 3: Variation in estimated BFO differences at 00:19 for given track angles and groundspeed



Source: DST Group

This graph indicates that the lowest BFO differences, and therefore the closest to our measured values, would be attained for any given speed by continuing in a southerly direction.

Oscillator warm-up drift

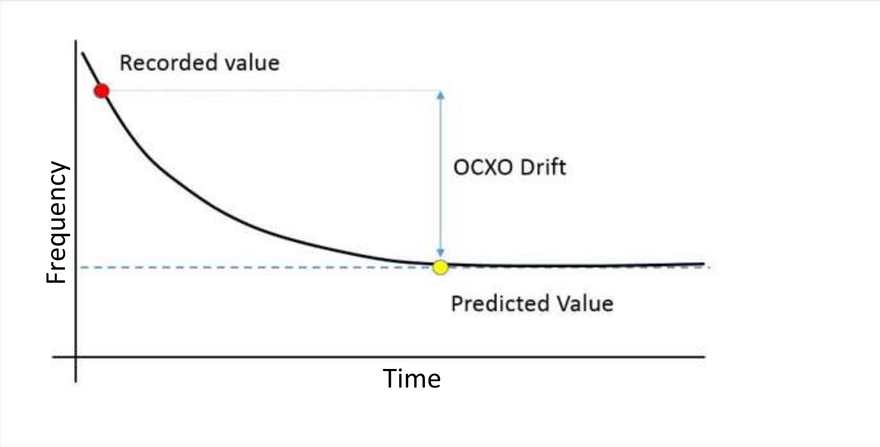
The oven-controlled crystal oscillator (OCXO) maintains the oscillator in the satellite data unit (SDU) at the design temperature. The performance of the OCXO in maintaining the correct temperature directly affects the transmitted frequency. When power is first applied to the SDU, the transient temperature variation associated with the OCXO warming-up causes a variation in the output frequency. This is referred to as warm-up drift.

To further understand this behaviour, the manufacturer of the SDU performed multiple power-up tests on several SDUs. It was observed that individual SDUs exhibit different warm-up drift characteristics. The differences were the magnitude of the frequency deviation, the time to reach steady state as well as the general shape of the curve.

Variations in the time in which the SDU (and OCXO) was not powered, prior to powering on, affected both the magnitude of the drift and the time taken for the frequency to stabilise, however the characteristic (or general shape of the curve) was not affected.

All available information indicated that, after power-up, the SDU in 9M-MRO exhibited a decay characteristic, represented in Figure 4. The values recorded shortly after power up would therefore be greater than the steady state value.

Figure 4: Representation of 9M-MRO SDU decaying warm-up characteristic (not to scale)



Source: ATSB

This graph illustrates the warm-up characteristic of the 9M-MRO SDU. After power is restored to the SDU, the OCXO drift results in BFO value being above the steady state value until the OCXO has stabilised.

The maximum OCXO drift value observed in the previous data of 9M-MRO was around 130 Hz and if the power interruption was sufficiently short, the OCXO drift could be negligible.

Descent rate

The remaining element to explain the difference in the predicted BFO value and the recorded BFO value is the descent rate of the aircraft. Analysis shows that at locations consistent with the search area and at the time of the last transmission, the descent rate affects the BFO value at -1.7 Hz per 100 ft/min.

Results of analysis

Due to the uncertainties associated with the end-of-flight scenario, it is not possible to define a specific descent rate from the recorded BFO values. Instead, using the limits of each contributing element, a range of possible descent rates, consistent with the recorded BFO values can be determined.

Case A and Case B below represent the boundary cases for the minimum descent rate and the maximum descent rate respectively. For each transmission at 00:19, Case A applies assumptions that reduce the required rate of descent to match the recorded BFO. Case B does the opposite and applies assumptions which increase the required rate of descent.

A. Minimum Descent Rate
   i. Southerly direction,
   ii. Maximum positive error of measured BFO for 00:19:29 and 00:19:37 (~ 13 Hz),
   iii. No OCXO drift – very short duration power interruption.

B. Maximum Descent Rate

i. Northerly direction,

ii. Maximum negative error on measured BFO at 00:19:29 and 00:19:37 (~ -13 Hz),

iii. Maximum OCXO drift – 130 Hz (as observed in other power-up logons of 9M-MRO).

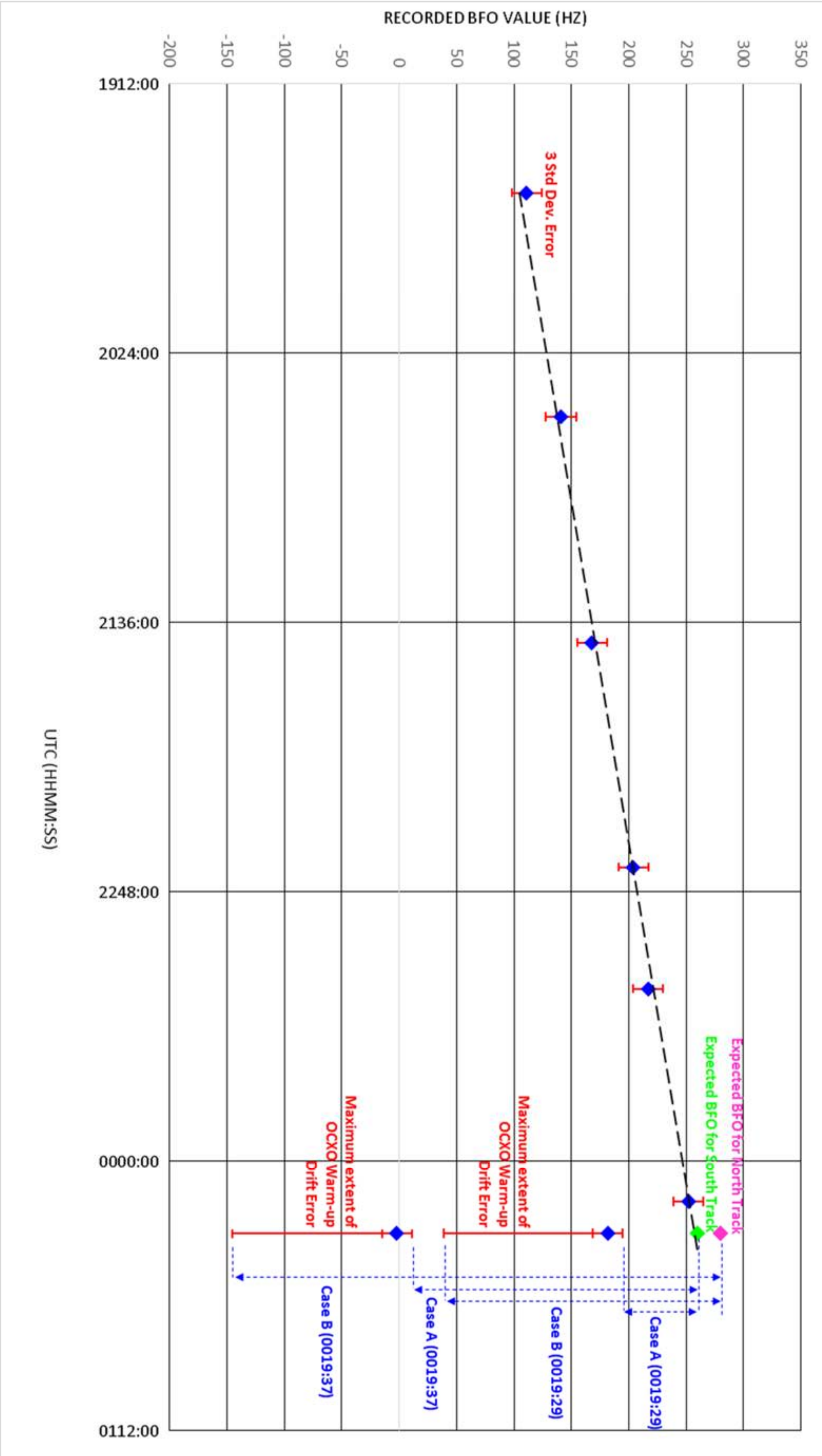
Table 2 and Figure 5 following provide the resulting descent rates based on cases above for the log-on request at 00:19:29 and the log-on acknowledge at 00:19:37.

Table 2: Derived descent rate boundary cases

00:19:29 log-on request	Case A (minimum)	Case B (maximum)
Predicted BFO level flight	260 Hz	280 Hz
Measured BFO	182 Hz	182 Hz
Possible error (3 std dev.)	13 Hz	-13 Hz
OCXO Drift	0 Hz	130 Hz
Derived descent rate	260- (182+13) = 65 Hz (65 / 1.7) *100 ≈ 3,800 ft/min	280 - (182 - 13 - 130) = 241 Hz (241 / 1.7) *100 ≈ 14,200 ft/min

00:19:37 log-on ACK	Case A (minimum)	Case B (maximum)
Predicted BFO level flight	260 Hz	280 Hz
Measured BFO	-2 Hz	-2 Hz
Possible error (3 std dev.)	13 Hz	-13 Hz
OCXO Drift	0 Hz	130 Hz
Derived descent rate	260-(-2+13) = 249 Hz (249 / 1.7) *100 ≈ 14,600 ft/min	280 - (-2 - 13 - 130) = 425 Hz (425 / 1.7) *100 ≈ 25,000 ft/min

Figure 5: Association of BFO differences to descent at 00:19



Source: ATSB

End of flight simulations

The ATSB report *MH370 – Definition of Underwater Search Areas, December 2015* outlined the previous simulations that the manufacturer had undertaken to assist in determining the aircraft's behaviour at the end of the accident flight.

In April 2016, the ATSB defined a range of additional scenarios for the manufacturer to simulate in their engineering simulator. Reasonable values were selected for the aircraft's speed, fuel, electrical configuration and altitude, along with the turbulence level.

The results of the simulation are presented in Figure 6. The results have all been aligned to the point two minutes after the loss of power from the engines. This is the theorised time at which the 7th arc transmissions would have been sent.

Figure 6: Results from simulated scenarios

Source: ATSB

This figure illustrates the resulting flight paths from the simulations performed by the manufacturer and aligned at a point consistent with when the final BTO transmission may have occurred.

The simulations were completed in the manufacturer's engineering simulator. The engineering simulator uses the same aerodynamic model as a Level D simulator used by the airlines. The simulator is not a full motion simulator but instead is used when a high level of system fidelity is required. The appropriate firmware and software applicable to the accident aircraft can be loaded.

The results of the simulations were that:

- The aircraft was capable of travelling rearwards (from the direction of travel) approximately 21 NM.
- Simulations that experienced a descent rate consistent with the ranges and timing from the BFO analysis generally impacted the water within 15 NM of the arc.
- In some instances, the aircraft remained airborne approximately 20 minutes after the second engine flameout.

- In an electrical configuration where the loss of engine power from one engine resulted in the loss of autopilot (AP), the aircraft descended in both clockwise and anti-clockwise directions.
- In some simulations, the aircraft exhibited phugoid motion[2] throughout the descent.
- Simulations that exhibited less stable flight resulted in higher descent rates and impact with water closer to the engine flameout location. In some simulations, the aircraft's motion was outside the simulation database. The manufacturer advised that data beyond this time should be treated with caution.
- Some of the simulated scenarios recorded descent rates that equalled or exceeded values derived from the final SATCOM transmission. Similarly, the increase in descent rates across an 8 second period (as per the two final BFO values) equalled or exceeded those derived from the SATCOM transmissions. Some simulated scenarios also recorded descent rates that were outside the aircraft's certified flight envelope.
- The results of the scenarios, combined with the possible errors associated with the BTO values indicate that the previously defined search area width of ±40 NM is an appropriate width to encompass all uncontrolled descent scenarios from the simulations.

The simulated scenarios do not represent all possible scenarios, nor do they represent the exact response of the accident aircraft. Rather, they provide an indication as to what response the accident aircraft may have exhibited in a particular scenario. As such, the results are treated with caution, and necessary error margins (or safety factors) should be added to the results.

It was not possible to simulate all likely scenario conditions due to the limitations of the simulator. Specifically, flight simulators are unable to accurately model the dynamics of the aircraft's fuel tanks. In the simulator, when the fuel tank is empty, zero fuel is available to all systems fed from the tank. However, in a real aircraft, various aircraft attitudes may result in unusable fuel (usually below engine/APU inlets) becoming available to the fuel inlets for the APU/engines. If this resulted in APU start-up, it would re-energise the AC buses and some hydraulic systems. This could affect the trajectory of the aircraft. Similarly, the left and right engines may also briefly restart, affecting the trajectory.

2 A long-period oscillation of pitch axis, perpetually hunting about level attitude and trimmed speed.

Drift modelling update

To assist with the underwater search for 9M-MRO, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) undertook an analysis of existing ocean data from the Global Drifter Program[3]. The analysis used the behaviour of drogued and undrogued drifters[4], as well as numerical simulations using ocean models. The purpose of this work was to trace any recovered debris to its likely point of origin. However, a drifter's geometry and buoyancy is not generally representative of aircraft debris and it was considered that the drift characteristics might also be different. To account for this difference, the CSIRO engaged in field work, studying how aircraft debris moves through the water compared to drifters, with regard to wind and ocean currents. This data was incorporated into numerical simulations in order to predict the drift behaviour of aircraft debris with more confidence.

As part of the ongoing field testing, the drift behaviour of replica flaperons and other recovered aircraft parts is being assessed. Replica flaperons were constructed with dimensions and buoyancy approximately equal to that of the recovered flaperon (Figure 7), which was float-tested during the detailed examinations in France. The replica flaperons were deployed into a bay for short term tests during various weather conditions. Longer term tests were then performed in the open ocean. For comparison, undrogued drifters were deployed alongside the flaperons. Drogued drifters were also used, because they move predominantly with the currents, as opposed to wind and waves. Data for currents was then able to be subtracted from the flaperons' drift data so that wind and wave behaviour could be assessed in isolation.

Figure 7: Flaperon recovered from Reunion Island on 29 July 2015

Source: Bureau d'Enquetes et d'Analyses (BEA)

Field tests demonstrated that the replica flaperons drift similarly to undrogued drifters:

- In low wind conditions, the flaperons move slightly faster than undrogued drifters due to the energy absorbed from waves.

[3] Visit www.aoml.noaa.gov/phod/dac/ for further details.

[4] A drifter is a satellite-tracked buoy which either has a subsurface sea anchor attached (drogued) or not (undrogued).

- In higher winds, the energy absorbed from waves was less significant, and the flaperons' behaviour was analogous to the undrogued drifters'.

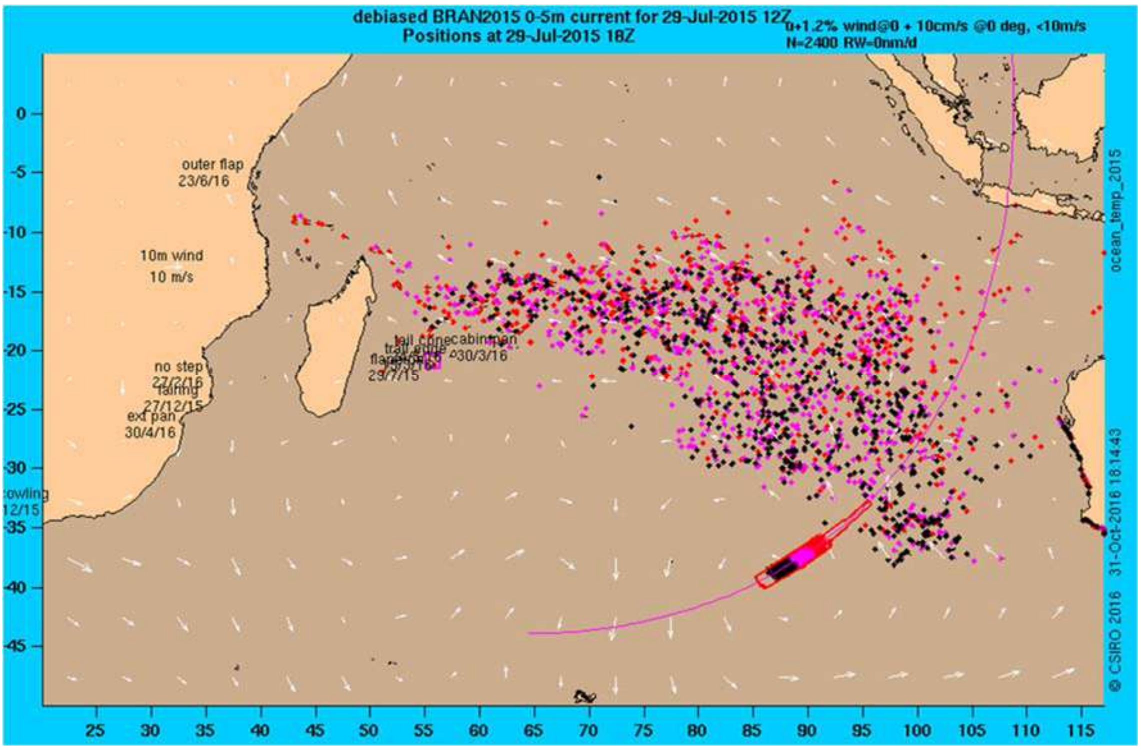
The replica flaperons presented their raised trailing edge to the wind, allowing waves to propel them in the wind direction. If waves tipped or turned the flaperons, the wind quickly reoriented them, so the direction of movement remained consistent.

Replicas of two other recovered items of debris drifted at a rate that was practically indistinguishable from undrogued oceanographic drifters in all wind conditions. Therefore, the trajectories of undrogued oceanographic drifters were valid for use in the analysis.

Preliminary results from the updated drift analysis indicated that the current search area was a possible origin for the recovered debris.

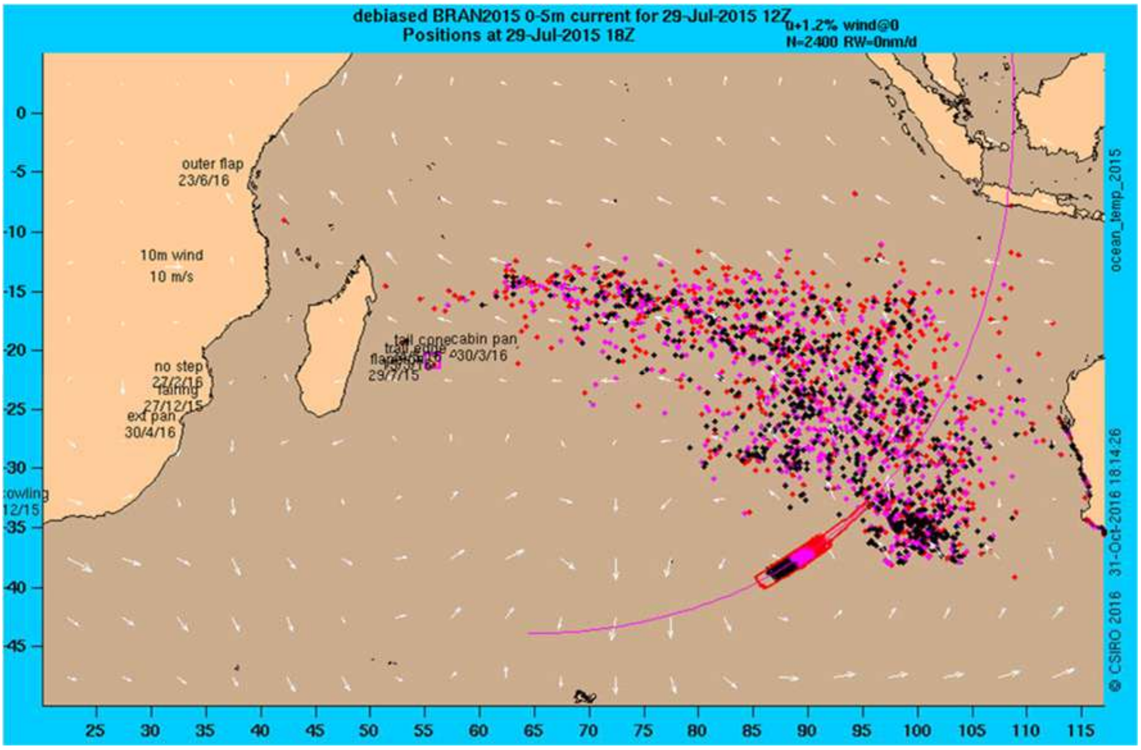
Using the collected field data, a new forward-tracking numerical simulation was performed. Within the simulation, flaperons were deployed on and around the current search area and allowed to drift freely. Results after 500 days of simulated drift are presented in Figure 8. For comparison, Figure 9 shows the results of a simulation where the original undrogued drifter model was used. By comparing the two figures, it can be seen that the flaperons generally moved further west within 500 days due to the extra speed at low winds.

Figure 8: Simulated location of flaperon-type drifters after 500 days



Source: CSIRO

Figure 9: Simulated location of undrogued drifters after 500 days



Source: CSIRO

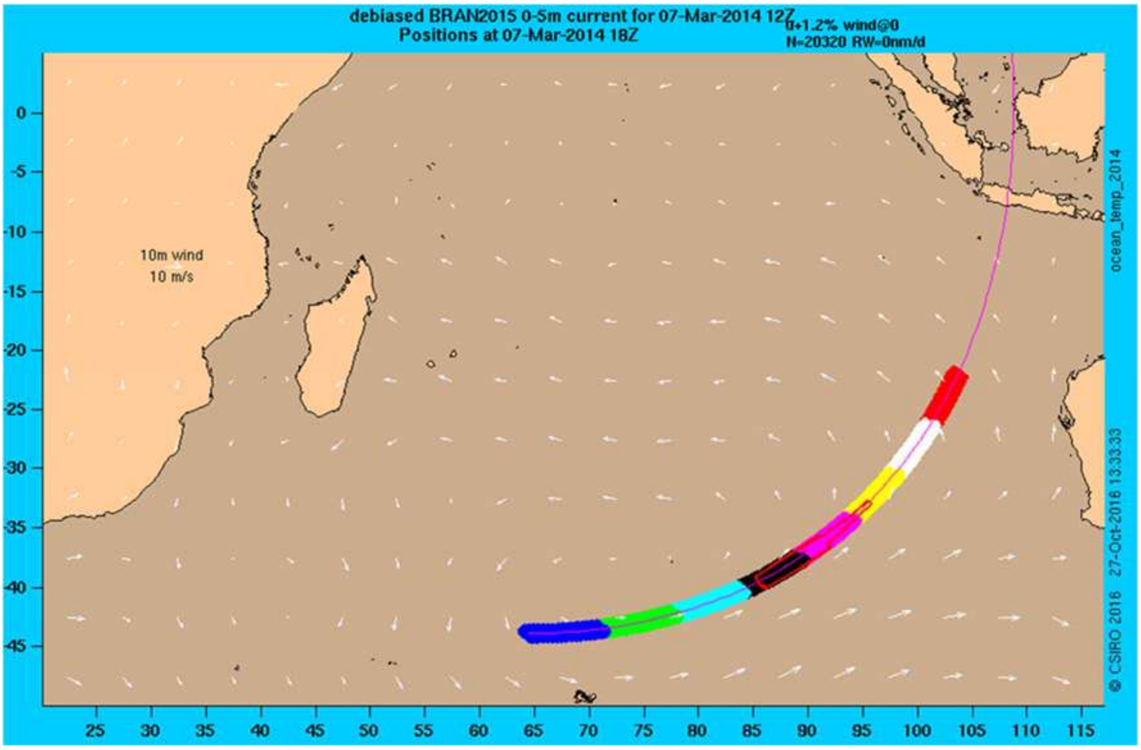
Small errors in the simulation can result in large divergences over time. As such, an examination of the debris behaviour in the first months after the accident was conducted.

Figure 10 illustrates the starting location of the simulated drifters along the 7th arc. After eight months of simulated drift (Figure 11), some initial conclusions can be drawn about the drifter's path with respect to debris discovered to date. A significant number of drifters arrived on the coast of Western Australia. Similarly, a number of drifters had arrived on the coast of Africa. The colour of each drifter identifies its starting location as marked along the arc.

- Drifters starting in the southern half of the current search area or below (dark blue, green, light blue) can be observed on and around the coast of Western Australia, with many drifting towards Tasmania. No debris has been discovered on the Australian coast. This indicates that a starting location within the current search area, or further north, is more likely.
- A significant number of red drifters have already reached the coast of Madagascar and mainland Africa. This is not consistent with the time at which debris was discovered. The first item of debris was not discovered on Reunion Island until 16 months after the accident. This suggests a reduced likelihood of debris originating from the northernmost areas shown in Figure 10 (red and white coloured regions).

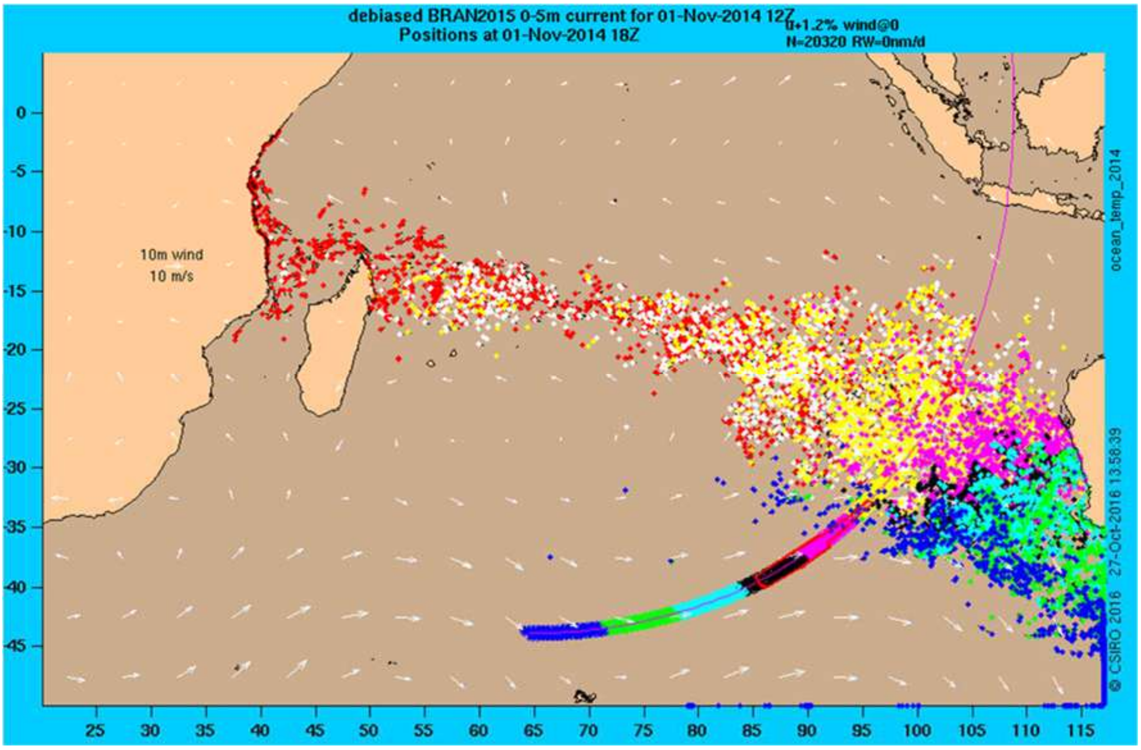
Refinement of the drift analysis is continuing. Flaperon replicas are currently deployed in the open ocean along with drogued and undrogued drifters, and replicas of smaller debris. This is to study the longer-term drift behaviour of the parts in conditions similar to those expected in the Indian Ocean. The long-term tests may provide additional improvement to the simulations and confidence in the backtracking results.

Figure 10: Simulated starting location of undrogued drifters



Source: CSIRO

Figure 11: Simulated location of undrogued drifters after 8 months



Source: CSIRO

A significant number of drifters from the light blue and green areas have made landfall on the West Australian coast. Similarly, drifters from the red and white areas have begun to make landfall on the African coastline. Neither are consistent with times and/or locations at which MH370 debris was discovered, therefore reducing the likelihood of debris originating from these locations.

Debris summary and analysis

Currently, more than 20 items of debris have been brought to the attention of and are of interest to the investigation team. The items have been located along the east and south coast of Africa, the east coast of Madagascar and the Islands of Mauritius, Reunion and Rodrigues in the Indian Ocean. A list of items recovered was published by the Malaysian investigation team and can be found at www.mh370.gov.my/index.php/en/.

The right flaperon has been examined by the French Judiciary and confirmed to have originated from 9M-MRO. Six further items of debris have previously been examined by the ATSB, comprising a:

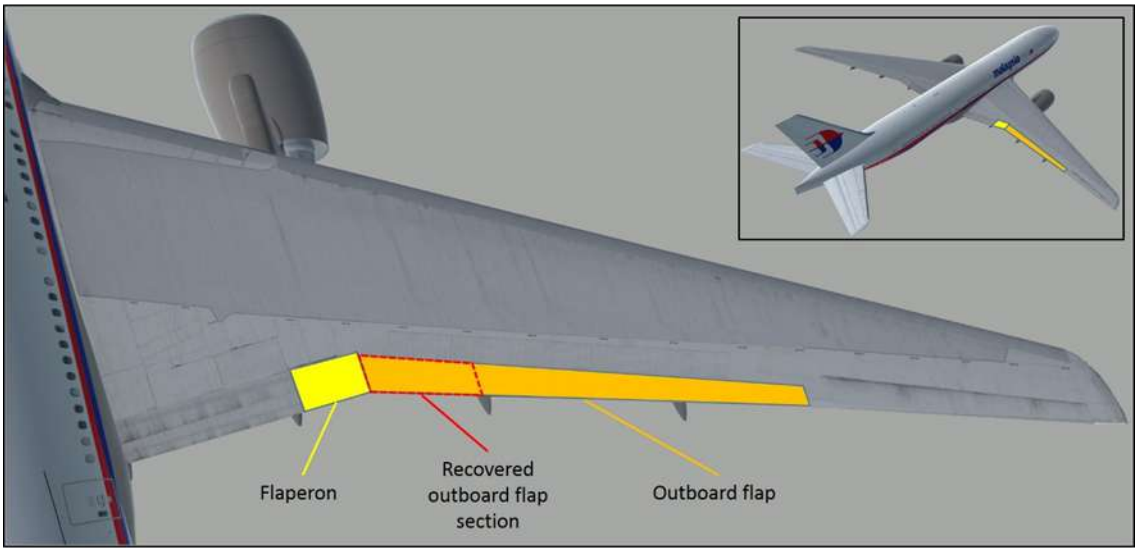
- section of the right outboard flap fairing
- panel section from the right horizontal stabiliser
- piece of engine cowling
- closet panel section from the closet adjacent to door R1
- inboard section of the right outboard flap
- trailing edge section of the left outboard flap.

Both flap sections had unique identification numbers that were able to be linked, through manufacturing records, to 9M-MRO. The remaining examined items were confirmed as Boeing 777 parts and had identifying features linking them to a Malaysian Airlines origin, however there were no unique identifiers to link the parts directly to 9M-MRO. The parts were therefore determined to have *almost certainly* originated from 9M-MRO, given that the likelihood of originating from another source is very remote. The ATSB debris examination reports are available at www.atsb.gov.au/mh370-pages/updates/reports/.

Outboard flap failure analysis

The recovered right, outboard wing flap section (Figures 12, 13 and 14) was examined for any evidence of interaction with mechanisms, supports and surrounding components that may indicate the state of flap operation at the time of fracture and separation from the wing. The purpose of the examination was to inform the end-of-flight scenarios being considered by the search team. The most significant items of evidence in relation to this are documented below.

Figure 12: Location of recovered outboard flap section



Source: DST Group (Modified by ATSB)

Figure 13: Inboard section of outboard flap

Source: ATSB

Figure 14: Inboard section of outboard flap (inverted)

Source: ATSB

Flap position

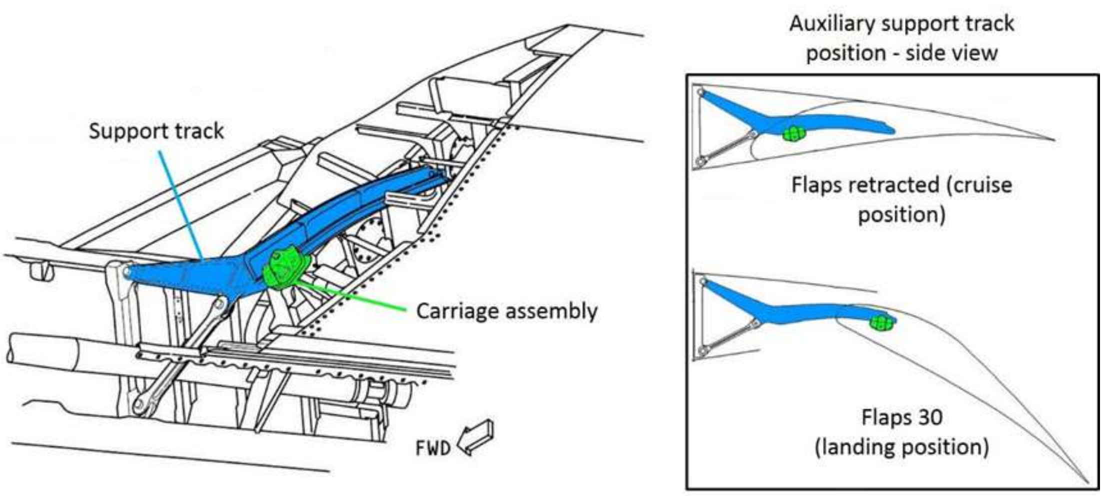
The trailing edge outboard wing flaps form part of the aircraft's high-lift control system and are deployed to alter the shape of the aircraft wing, improving lift at lower aircraft speeds during takeoff, approach and landing. The outboard wing flaps have defined stages of flap deployment between 'up' (retracted / cruise position) and 30-units of extension (landing position).

A fibreglass and aluminium seal pan is located at the inboard end of the outboard flap. It houses the inboard auxiliary support, comprising a deflection control track (support track) and carriage assembly. The support track is affixed to the rear of the wing. Using rollers in the carriage assembly, the inboard end of the flap is guided along the support track as the flap moves through its deflection range. The track is fully inserted into the flap in the 'up' position and progressively withdrawn from the flap as the flaps are deployed (Figure 15). The inboard auxiliary support track and carriage assembly were not present with the recovered debris.

Two adjacent aluminium stiffeners within the inboard seal pan area exhibited impact damage. The damage was significant because it was indicative of impact damage and the only component in the vicinity of the stiffeners, capable of independent movement within the seal pan, was the support track. Measurements of the support track position at the various stages of flap deployment, indicated that the track would have to be fully inserted into the flap in the retracted position to be adjacent to the damaged stiffeners (Figures 16, 17 and 18).

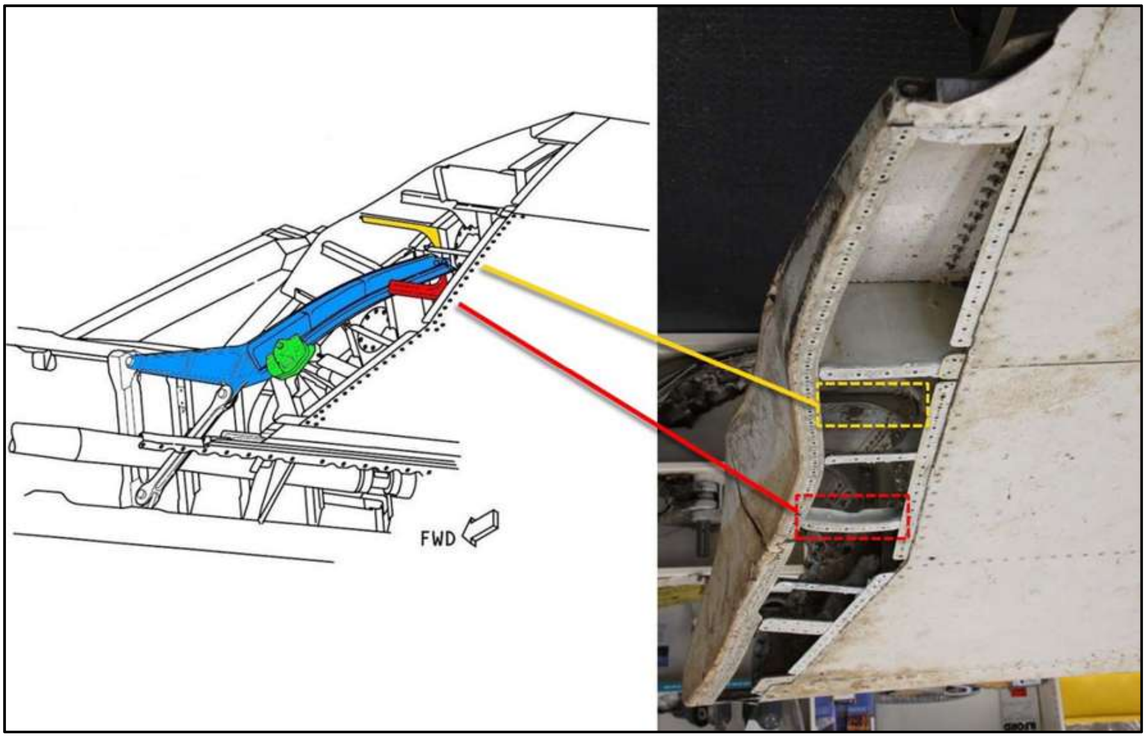
An outwards-fracture of the fibreglass seal pan initiated at a location adjacent to the damaged aluminium stiffeners (Figure 19). The damage was most likely also caused by impact from the support track. That damage provided further evidence of the support track position within the flap seal pan cavity, indicating that the flaps were retracted at the point of fracture and separation from the wing.

Figure 15: Outboard flap, inboard auxiliary support



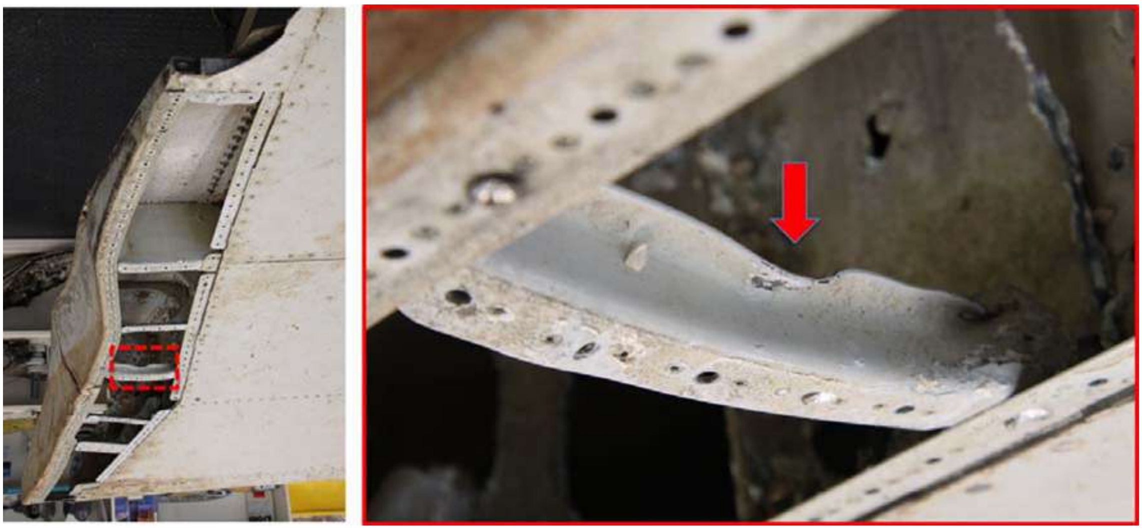
Source: Boeing (modified by ATSB)

Figure 16: Outboard flap location of damaged stiffeners within the seal pan cavity



Source: Boeing (modified by ATSB) / ATSB

Figure 17: Outboard flap, damaged stiffeners within the seal pan cavity



Source: ATSB

Figure 18: Outboard flap, damaged stiffeners within the seal pan cavity

Source: ATSB

Figure 19: Outboard flap, fractured seal pan (forward)

Source: ATSB

Contact damage between the flaperon and outboard flap

The flap seal pan was also fractured adjacent to the rear spar. The fracture resulted from external impact, puncturing the fibreglass and plastically deforming the supporting aluminium structure within the seal pan cavity (Figure 20). Comparable damage was noted at the outboard, rear spar and surrounding structure of the adjacent flaperon (Figure 21). It was noted that the two areas in question are aligned when the flaps are in the retracted position, with a significant offset existing at other stages of flap extension (Figure 22).

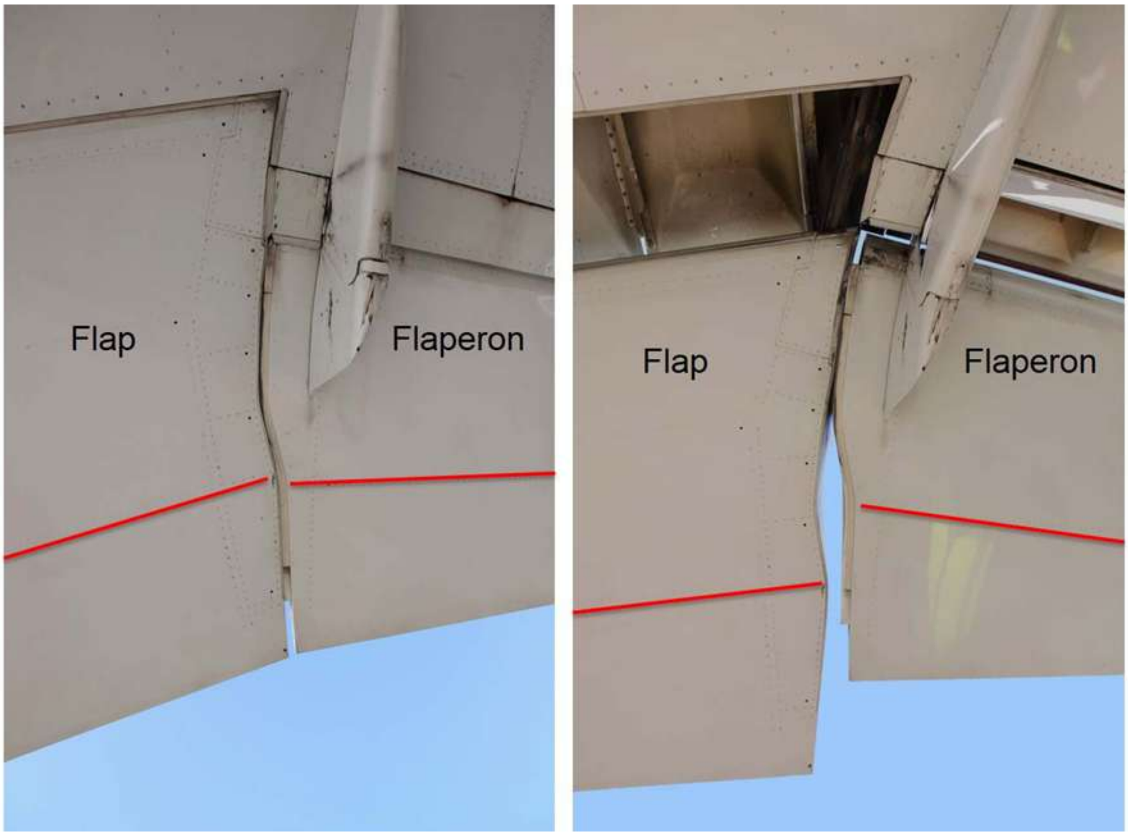
Figure 20: Outboard flap, fractured seal pan (aft)

Source: ATSB

Figure 21: Flaperon, outboard side damage

Source: Direction générale de l'armement / Techniques aéronautiques (modified by ATSB)

Figure 22: Flaperon and outboard flap from below, showing relative alignment of rear spar rivet line (highlighted) in the flaps retracted (left) and extended position (right)



Source: ATSB

Analysis

Damage to the internal seal pan components at the inboard end of the outboard flap was possible with the auxiliary support track fully inserted into the flap. That damage was consistent with contact between the support track and flap, with the flap in the retracted position. The possibility of the damage originating from a more complex failure sequence, commencing with the flaps extended, was considered much less likely.

With the flap in the retracted position, alignment of the flap and flaperon rear spar lines, along with the close proximity of the two parts, indicated a probable relationship between two areas of damage around the rear spars of the parts. This was consistent with contact between the two parts during the aircraft breakup sequence, indicating that the flaperon was probably aligned with the flap, at or close to the neutral (faired) position.

Numerous other discrete areas of flap damage were analysed. Some of the damage was consistent with the flaps in the retracted position, while other areas did not provide any useful indication of the likely flap position. It was therefore concluded that:

- The right outboard flap was most likely in the retracted position at the time it separated from the wing.
- The right flaperon was probably at, or close to, the neutral position at the time it separated from the wing.

Acknowledgements

The ATSB would like to acknowledge the following organisations for their input and continued assistance with the analysis:

- Air Accidents Investigation Branch (UK)
- Australian Bureau of Meteorology
- Australian Defence Science and Technology Group
- Boeing
- Commonwealth Scientific and Industrial Research Organisation
- Department of Civil Aviation, Malaysia
- Inmarsat
- Malaysian Airlines Berhad
- Malaysian Ministry of Transport
- National Transportation Safety Board (US)
- Thales.

Those involved have dedicated many hours outside of normal duties to advance the collective understanding of the event. The main focus has always been in finding the aircraft to assist the Malaysian investigation team and to bring closure to the families of the passengers and crew of MH370.

MOTOROLA SOLUTIONS

1700 Belle Meade Court,
Lawrenceville, GA, 30043,
USA

Certificate of Compliance

Certificate Number: 12GEM0185 Issue Date: 2012-09-12

The following produt(S) have been evaluated and tested to ensure compliance with the Fifth Revised Edition of the UN Manual of Tests and Criteria, Part III sub-section 38.3. Lithium Batteries. Specific test methods are given in the reference. Additional method implementation details are available in local test instructions available upon request. Test data is provided in the associated test data report filed under the same reference number as this certificate. The results obtained from this testing only relate to the actual products tested as described below.

Product Name: Beacon Battery

Part Numbers: PMNN4404BRT, PMNN4081B/BR/BC/BRC ✓ 1500 ah

Product Type: Pack, Small, Secondary

Product Description: The battery pack is a 7.4-volt (nominal) lithium ion battery assembly for use in Motorola communications equipment.

Original Manufacture Date: Sep-12

Associated Report Number(s): N/A

Tests Conducted:

- [x] T-1 Altitude Simulation (All)
- [x] T-2 Temperature Cycling (All)
- [x] T-3 Vibration (All)
- [x] T-4 Shock (All)
- [x] T-5 Short Circuit (All)
- [ ] T-6 Impact (Cells Only)
- [x] T-7 Overcharge (Packs Only)
- [ ] T-8 Forced Discharge (Cells Only)

Tested By: Brian Hodges
Date: 2012-09-12
Title: Technician(s)

Reviewed By: James Johnson
Date: 2012-09-12
Title: Laboratory Manager

Report Number: 13GEM0300

Page 1 of 1

MOTOROLA SOLUTIONS

1700 Belle Meade
Court, Lawrenceville,
GA, 30043, USA

Certificate of Compliance

Certificate Number: 13GEM0300 Issue Date: 2013.10.25

The following product(s) have been evaluated and tested to ensure compliance with the Fifth Revised Edition of the UN Manual of Tests and Criteria, Part III sub-section 38.3. Lithium Batteries and IATA PI-965. Specific test methods are given in the reference. Additional method implementation details are available in local test instructions available upon request. Test data is provided in the associated test data report filed under the same reference number as this certificate. The results obtained from this testing only relate to the actual products tested as described below.

Product Name: Minnow FM IP67 Li Ion
Product Type: Pack, Small, Secondary
Product Description:

Part Numbers: PMNN4073AR, PMNN4074AR

Original Manufacture Date: 2006.11.01

Associated Report Number(s): DT01-060922

Tests Conducted:

- ☑ T-1 Altitude Simulation
- ☑ T-2 Temperature Cycling
- ☑ T-3 Vibration
- ☑ T-4 Shock
- ☑ T-5 Short Circuit
- ☑ T-7 Overcharge
- ☑ Packaging Test per IATA PI-965

Tested By: Valerie Strain
Date: 2013.10.25
Title: Technician(s)

Reviewed By: James Johnson
Date: 2013.10.25
Title: Laboratory Manager

FCD-0968 - ESST Report of UN Transport Testing (Pack-Sec-SM)

Rev 15

Department of Civil Aviation Malaysia
No 27 Persiaran Perdana
Level 1-4, Block Podium A/B, Precinct 4
Federal Government Administration
Centre
62618 PUTRAJAYA MALAYSIA

TOPIC	:	DIRECTOR GENERAL DIRECTIVE NO 1A/2013 (AVSEC) PHYSICAL SECURITY SCREENING-ENHANCED
DURATION	:	EFFECTIVE 15TH JULY 2013
APPLICABILITY	:	ALL AIRCRAFT CARRIER AND GROUND HANDLERS OPERATING CARGO FROM MALAYSIA

In accordance with the power given under Regulation 198, Civil Aviation Regulation (Amendment) (No.3) 2011, Director General Civil Aviation Malaysia has the power to direct all aircraft carrier and ground handlers carrying air cargo from Malaysia to take necessary action as follow:-

1. All air cargo shall be subjected to physical security screening (as defined in ICAO Doc 8973, Chapter 13 item 13.6.5) before entering airside area or being loaded into an aircraft.

2. All screened air cargo shall be issued with a security status declaration, either in electronic format or in writing of the air carrier or ground handler or regulated agent (as defined in ICAO Doc 8973, Chapter 13 item 13.5.3.1) for documentation record and verification by the DCA Malaysia. The declaration shall be certified by supervisory level and above.

3. Exemption are given to as below:

   3.1 Known consignors or regulated agents certified by Department of Civil Aviation under Secure Freight Programme; and

   3.2 Item 13.6.10 (a)-(g), ICAO Doc 8973.

4. The above measures are pursuant to the Amendment 13 of ICAO Annex 17 – Security effective 15th July 2013; and

5. This Directive will be updated according to *ICAO Standard and Recomended Practices (SARPs).*

Date issue : 12 JULY 2013

DATO' AZHARUDDIN BIN ABDUL RAHMAN
DIRECTOR GENERAL
DEPARTMENT OF CIVIL AVIATION MALAYSIA

Department of Civil Aviation Malaysia
No 27 Persiaran Perdana
Level 1-4, Block Podium A/B, Precinct 4
Federal Government Administration Centre
62618 PUTRAJAYA MALAYSIA

TOPIC	:	DIRECTOR GENERAL DIRECTIVE NO 2/2013 (AVSEC) ON AIR CARGO TO AND TRANSHIPMENT IN MALAYSIA
DURATION	:	EFFECTIVE 15TH JULY 2013
APPLICABILITY	:	AIRCRAFT CARRIER AND GROUND HANDLERS

In according with the power that have been given under Regulation 198, Civil Aviation Regulation (Amendment) (No.3) 2011, the Director General of Civil Aviation Malaysia has the power to direct all aircraft carrier and ground handlers carrying air cargo to and transhipment in Malaysia to take necessary action as follow:-

1. All air cargo are subjected to appropriate security control, including screening prior to their being loaded onto an aircraft departing to Malaysia.

2. All operators shall not accept cargo unless the application of screening or other security controls is confirmed and accounted for by a regulated agent that is approved by an appropriate authority of origin country. Cargo which cannot be confirmed and accounted for by regulated agent or an entity that is approved by an appropriate authority shall be subjected to screening.

3. All cargo that has been confirmed prior to being loaded on an aircraft shall be issued with a security status, either in electronic format or in writing, which shall accompany the cargo for documentation checking and record by the operators or appointed agents and DCA Malaysia.

4. Transhipment cargo arriving by air from outside Malaysia not subjected to screening, provided they were;

   4.1 subjected to appropriate security controls against unauthorized interference at the origin and transhipment points, and

   4.2 accompanied by security status declaration.

5. The above measures are pursuant to the Amendment 13 of ICAO Annex 17 – Security which effective by 15th July 2013; and

6. This Directive will be updated in accordance with *ICAO Standard and Recomended Practices (SARPs) as required from time to time.*

Date issue : 12 JULY 2013

DATO' AZHARUDDIN BIN ABDUL RAHMAN
DIRECTOR GENERAL
DEPERTMENT OF CIVIL AVIATION MALAYSIA

QVC-17957 1529 07MAR14
SPECIAL LOAD NOTIFICATION TO CAPTAIN PRE-FLIGHT 08:54

FROM	FLIGHT	DATE	A/C REG	PREPARED BY
KUL	MH 0370 /08	08MAR14	9M-MRO	MASGO

*** OTHER SPECIAL LOAD ***

TO	AWB NR	CONTENTS	PCS	QTY	IMP CODE	ULD	POS CODE
001. PEK	12007306	MANGOSTEEN MANGOSTEEN	0001	1128KG	PER	AKE3497MH	41L
002. PEK	12007306	MANGOSTEEN MANGOSTEEN	0001	1152KG	PER	AKE90787MH	41R
003. PEK	12007306	MANGOSTEEN MANGOSTEEN	0001	1148KG	PER	AKE3372MH	43L
004. PEK	12007306	MANGOSTEEN MANGOSTEEN	0001	1138KG	PER	AKE8535MH	44L

THERE IS NO EVIDENCE THAT ANY DAMAGED OR LEAKING PACKAGES CONTAINING DANGEROUS GOODS HAVE BEEN LOADED ON THE AIRCRAFT

LOADING SUPERVISOR
NAME AND SIGNATURE:

CAPTAIN
NAME AND SIGNATURE:

KEMBARAN 9

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TEST REPORT

REPORT NO: STRIDE/TP/14-015

INSTITUT PENYELIDIKAN SAINS DAN TEKNOLOGI PERTAHANAN
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TEL: 603-60352121 FAX: 603-60352134

STRIDE

Job No: **OR/07-14**	**Date of Issue:** **May 2014**	Page **1** of **7**

Authority/Reference **KLIA rpt:3279/14 bth 8 April 2014**
For Test :-
Client's Details :-

Name : **Polis Di Raja Malaysia**
Address : **Jabatan Siasatan Jenayah, Ibu Pejabat Polis Di Raja Malaysia, Bukit Aman, 50560 Kuala Lumpur**
Tel No : **03 – 2266 6003**
Fax No **03 – 8776 9356**
Test Location: **600m Closed Firing Range and Ordnance Laboratory Weapon Technology Division STRIDE, Bt. Arang, Selangor**
Date Received: **29 Apr 2014**
Date of Test : **6 Mei – 7 Mei 2014**
Test Specifications : **Using Standard Operating Procedure and Equipments in 600m Closed Firing Ranges and Ordnance Laboratory**

Measuring /Test Equipment:
1. **Electrical Oven – Elba (Model EOT-0988)**
2. **Temperature Data Logger – TSH DOSHMANN**
3. **K-Type Thermocouple with Sensor**
4. **Scope Meter – Model Fluke 99 Series II**
5. **Digital Multimeter – Model Fluke 87 True RMS**
6. **Gas Detector - VelociCalc/Q-Trak 7575 – Model: 9565-X**
7. **Digital Camera – Nikon D7000**
8. **Video Camera – Sony HDR – XR520E**

Item Type: **Lithium Ion Battery (Motorola)**

Nature of Test: **Lab. Test – High Temperature Test**

Test Sample's Details:-

Manufacturer: **Motorola**
Origin: **Cell Origin Taiwan Finished in Malaysia**
Description: **MOTOROLA – Lithium Ion Battery Model: PMNN 4081BRC**

Quantity: **2 (Two) units**

Identification: **Barang Kes bertanda: MK31**
Barang Kes bertanda: MK32

Environmental Conditions During Test:

Ambient Temperature: **30 - 32 °C**
Relative Humidity: **81 % – 86 %**

Testers:

1. Mohd Jalis b. Md Jelas	Director I&E Tech. Div.
2. Osmera b. Ismail	Senior Research Officer
3. Kamsani b. Kamal	Research Officer
4. Azmi b. Minal	Research Officer
5. Mohd Fauzy b. Mohd Nor	Research Officer
6. Hanafiah b. Hussein	Research Officer
7. Muhammad Shahrir b. Saidin	Asst. Engineer
8. Muhamad Yusof b. Maulud	Asst. Engineer
9. Abdul Hakeem b. Selamat	Asst. Researcher
10. Rosly b. Othman	Skill Assistant

Prepared by :

(OSMERA BIN ISMAIL)
Senior Research Officer
Weapon Technology Division, STRIDE

Approved for Issue :

(HJ. MD ZAINI BIN ZAINAL)
Director
Weapon Technology Division, STRIDE

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TEST REPORT

REPORT NO: STRIDE/TP/14-015

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Job No: **OR/07-14**		Page **2 of 7**

REPORT OF HIGH TEMPERATURE TEST

TEST PREPARATION

Using non conductive base (hard wood), the test samples Barang Kes Bertanda: MK31 and Barang Kes Bertanda: MK32 was placed in an Electric Oven. All heat sensors (thermocouples) with their respective temperature meter and Gas Detector unit was also in placed. Optical Camera and Video Camera were used to record the test event. The test process were carefully timed and all event such as sample undergo bulging, fuming and to the point of eruption were carefully recorded and observed. The test sample was heated up from room temperature until 250 °C. The test were conducted in STRIDE 600m Close Firing Range. The test preparation footage are as below:

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FORM NO: FM PP(P) WTD 13-1	18 DEC 03

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TEST REPORT

REPORT NO: STRIDE/TP/14-015

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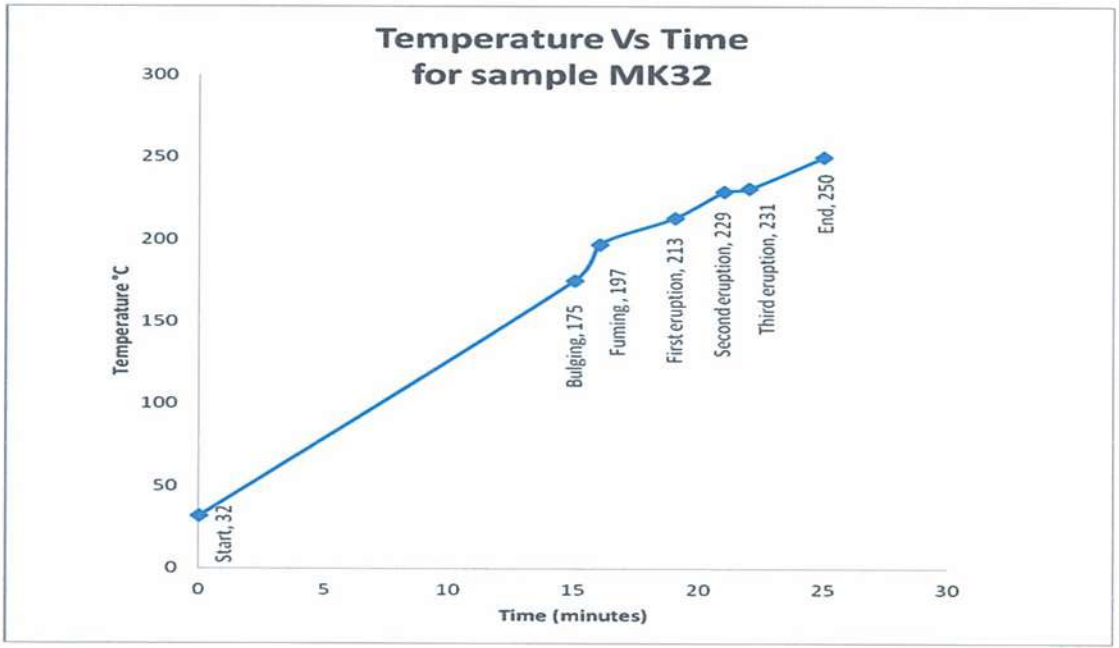
Job No: **OR/07-14**		Page 3 of 7

RESULTS

Test No. 1: Test Results On Barang Kes Bertanda: MK32

Test Date		6 May 2014 (start at 1435 hrs)	
Event Sequence	**Duration (Minutes)**	**Temperature Applied**	**Observation**
1	0	32°C	Starting
2	15	175°C	Sample surface starts bulging (observable)
3	16	197°C	Fuming starts to developed
4	19	213°C	The first eruption sound with thick fumes
5	21	229°C	The second eruption sound with thick fumes
6	22	231°C	The third eruption sound with thick fumes
7	25	250°C	Fumes continue but subside. Test end.



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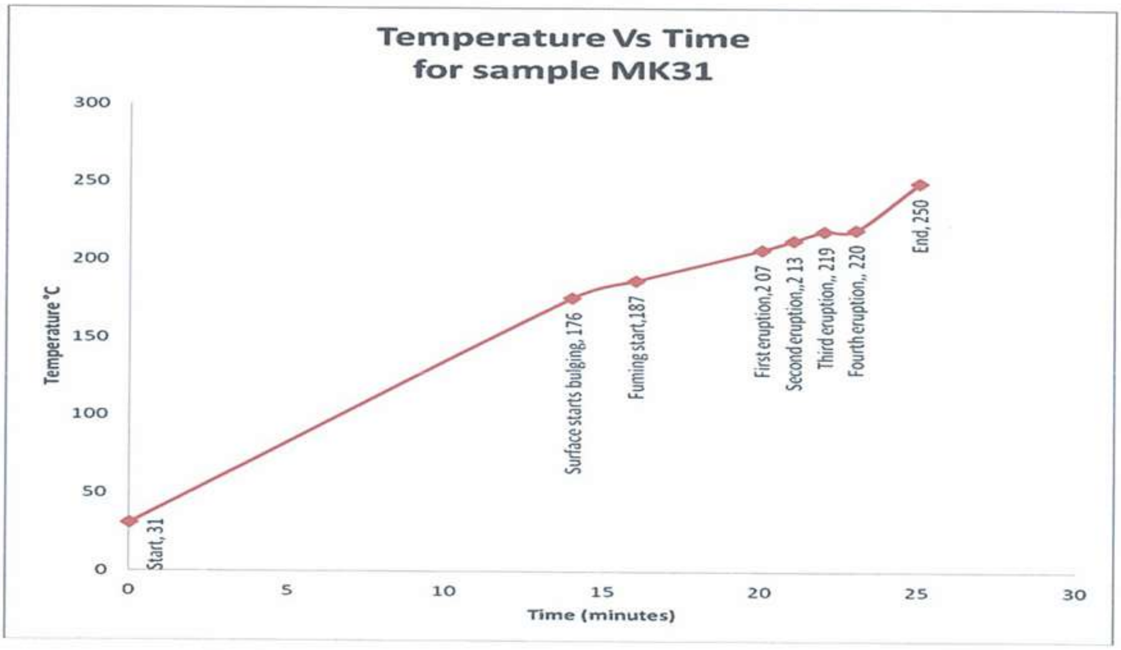
Job No: **OR/07-14**

RESULTS

Test No. 2: Test Results On Barang Kes Bertanda: MK31

Test Date		7 May 2014 (start at 1505 hrs)	
Event Sequence	**Duration (Minutes)**	**Temperature Applied**	**Observation**
1	0	31°C	Starting
2	14	176°C	Sample surface starts bulging (observable)
3	16	187°C	Fuming starts to developed
4	20	207°C	The first eruption sound with thick fumes
5	21	213°C	The second eruption sound with thick fumes
6	22	219°C	The third eruption sound with thick fumes
7	23	220°C	The fourth eruption sound with thick fumes
8	25	250°C	Fumes continue but subside, end test.



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TEST REPORT

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Job No: OR/07-14

RESULTS

Recorded Data for the rate of Carbon Monoxide (CO) and Carbon Dioxide (CO_2) gasses Release during High Temperature Test for Barang Kes Bertanda: MK31

Time	CO_2 (ppm)	CO (ppm)
15:27:07	404	0
15:27:12	408	0
15:27:17	406	0
15:27:22	401	0.3
15:27:27	400	0.2
15:27:32	399	0
15:27:37	401	0.2
15:27:42	404	0.6
15:27:47	414	0.9
15:27:52	434	0.6
15:27:57	463	0.3
15:28:02	448	0.2
15:28:07	431	0.2
15:28:12	434	0.9
15:28:17	458	6.8
15:28:22	464	17.8
15:28:27	471	28.6
15:28:32	471	43.2
15:28:37	467	115
15:28:42	448	176.5
15:28:47	433	134.5
15:28:52	433	89.4
15:28:57	430	56.2
15:29:02	432	38.2
15:29:07	438	30.4
15:29:12	438	25.9
15:29:17	434	25.2
15:29:22	429	23.4
15:29:27	425	20.5
15:29:32	426	20.7
15:29:37	429	24.1
15:29:42	420	24.5
15:29:47	426	19.7
15:29:52	429	16.7
15:29:57	433	15.7
15:30:02	437	14.4
15:30:07	438	16
15:30:12	437	20.5
15:30:17	425	19.4
15:30:22	435	14.3
15:30:27	435	12.5
15:30:32	424	12.8
15:30:37	420	14.5
15:30:42	422	14.5
15:30:47	423	11.9
15:30:52	423	9.5
15:30:57	425	7.9
15:31:02	419	7.6
15:31:07	415	9.2
15:31:12	421	10.2
15:31:17	424	9.5
15:31:22	424	8.4
15:31:27	427	7.4
15:31:32	430	8.2
15:31:37	422	8.8
15:31:42	427	7.7
15:31:47	429	6.3
15:31:52	422	5.6
15:31:57	422	5.1
15:32:02	427	4.9
15:32:07	437	4.8
15:32:12	433	4.8
15:32:17	429	4.6

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TEST REPORT

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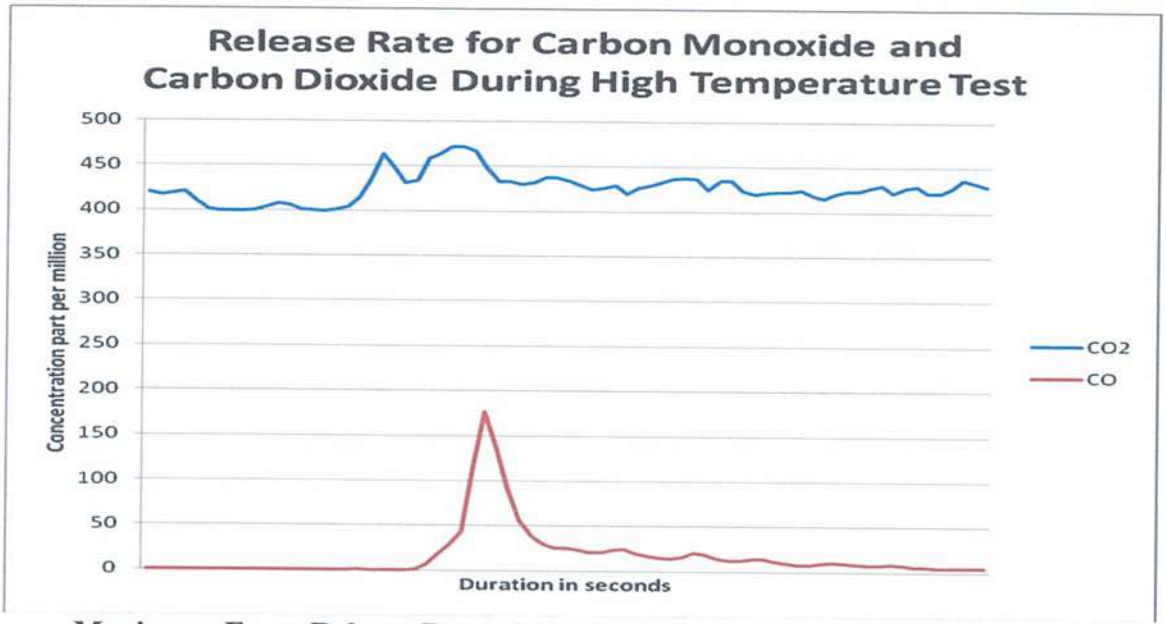
RESULTS



Maximum Fume Release Rate of Carbon Monoxide (CO) is 176.5 ppm
Maximum Fume Release Rate of Carbon Dioxide (CO_2) is 471 ppm

Test Conducted

Beginning of Test

During Testing

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TEST REPORT

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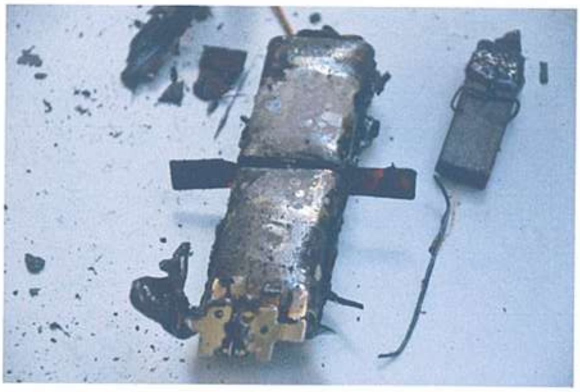

Left overs after High Temperature Test were applied to Barang Kes bertanda: MK32 of Lithium Ion Battery Model: PMNN 4081BRC

Findings and Conclusion

a. **It is found that both Barang Kes Bertanda: MK31 and Barang Kes Bertanda: MK32 experience 'Bulging' and then produced toxic fumes (such as Carbon Monoxide and Carbon Dioxide) if they are exposed to high temperature between 175 °C to 197 °C.**

b. **It is found that both Barang Kes Bertanda: MK31 and Barang Kes Bertanda: MK32 experience ruptured and then eruption (small explosion with released of fumes), if they are exposed to high temperature between 207 °C to 231 °C.**

END

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Report No. : STRIDE/MML/14/38

SCIENCE & TECHNOLOGY RESEARCH INSTITUTE FOR DEFENCE
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MINISTRY OF DEFENCE, MALAYSIA
KOMPLEKS UTAMA STRIDE, TAMAN BUKIT MEWAH FASA 9, 430000
KAJANG, SELANGOR. MALAYSIA
TEL: 603-87324400 FAX: 603-87338975

STRIDE

Job No: MML/14/38	**TEST CERTIFICATE**	Date of Issue: 19 May 2014 **Page 1 of 3**

Authority/Reference For Test :- **KLIA rpt:3279/14 bth 8 April 2014**

Client's Details :-

Name : **Polis Di Raja Malaysia**
Address : **Jabatan Siasatan Jenayah,**
Ibu Pejabat Polis Di Raja Malaysia,
Bukit Aman, 50560 Kuala Lumpur
Tel No : **03 – 2266 6003**
Fax No **03 – 8776 9356**
Test Location: **Mechanical Metrology Laboratory (Accredited), Instrumentation & Electronic Technology Division, STRIDE**

Date Received: **14 May 2014**

Date of Test : **15 May 2014**

Test Specifications : **Using Standard Physical Measurement Equipments**

Measuring /Test Equipment:
1. Verneer Caliper - Model: Mitutoyo 5671A
2. Weighing Balance – Mitter Toledo

Testers:
1. **Hanafiah bin Hussein** **Research Officer**
2. **Mohd Hasrol Hisam** **Asst. Researcher**

Item Type: **Lithium Ion Battery (Motorola)**

Nature of Test: **Lab. Test – Observation and Physical Test**

Test Sample's Details:-

Manufacturer: **Motorola**
Origin: **Cell Origin Taiwan**
Finished in Malaysia
Description: **MOTOROLA – Lithium Ion Battery**
Model: PMNN 4081BRC

Quantity: **2 (two) unit**

Identification: **Barang Kes bertanda: MK35**
Barang Kes bertanda: MK 36

-

Environmental Conditions During Test:

Ambient Temperature: **20°C**

Relative Humidity: **55 %**

Approved for Issue : ______________
Norkamizah Mohd Nor
(Head of Branch)

Approved Signatory : ______________
Hanafiah Hussein
(Lab. Manager)

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KAJANG, SELANGOR. MALAYSIA
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Job No: MML/14/38	Date of Issue: 19 Mei 2014	Page 2 of 3

RESULTS

OBSERVATION:

a. **Packed Set consist of the following components:**
   - **1 unit Dark Beige colour paper Casing (big box)**
   - **1 pc of Lithium Ion Battery product Specification information and Manual (in Chinese)**
   - **2 unit small paper box (not wrapped with air-tight plastics)**
   - **2 unit of Lithium Ion Battery (Barang Kes: MK35 and Barang Kes: MK 36) where both batteries were not wrapped with air-tight plastics.**

b. **It is observed that Barang Kes: MK35 and Barang Kes: MK 36 was packed separately in a white hard paper box. Both of this boxes that contain Barang Kes: MK35 and Barang Kes: MK 36 were then again packed in a bigger dark Beige colour paper casing (the photo footage below were referred).**

PHYSICAL TEST

A. White Card Paper Casing (small)

	Physical Dimension	Barang Kes : MK35	Barang Kes : MK 36
1.	Dimension of Li Ion Battery (LxWxH)	50.50 x 119.00 x 21.41cm	50.50 x 119.00 x 21.41cm
2.	Weight of Li Ion Battery	145.00 gm	145.62 gm
3.	Weight of Li Ion Battery + white box	155.75 gm	156.43 gm
4.	Dimension of White Box (LxWxH)	57.62 x 122.36 x 24.81cm	57.31 x 122.94 x 24.44cm
5.	Thickness of white paper	1.50mm	1.50mm

B. Dark Beige Colour Paper Casing (big)

1.	Dimension of Box (LxWxH)	132.06 x 136.47 x 34.170cm
2.	Total Weight (Beige box + 2 x Li Ion Battery and white box + 1 x Operating Manual document)	44.33 gm
3	Thickness of Beige Colour paper:	1.62 mm

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Job No: MML/14/38	Date of Issue: 19 Mei 2014	Page 3 of 3

Fig. 1: Top View of Li Ion Battery

a. Barang Kes Serial number.
b. 3 battery terminals
c. Motorola Trade Mark
d. Warning instruction (in Chinese)
e. Barr Code

Fig. 2 :Back View of Li Ion Battery

a. Barang Kes Serial number.
b. 4 battery terminals
c. Motorola Trade Mark

Fig. 3 : Li Ion Battery and battery casing

a. Barang Kes Serial Number (hand written).
b. 2x white small battery casing for each battery
c. 1x Beige colour casing
d. 2x Li Ion battery (1expose and 1 hidden in white casing)

- END -

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STRIDE

Job No: CSIE/BL/2014/21	**TEST CERTIFICATE**	Date of Issue: 15 May 2014 **Page 1 of 2**

Authority/Reference For Test :- **KLIA rpt:3279/14 bth 8 April 2014**

Client's Details :-

Name : ***Polis Di Raja Malaysia***
Address : **Jabatan Siasatan Jenayah,
Ibu Pejabat Polis Di Raja Malaysia,
Bukit Aman, 50560 Kuala Lumpur**
Tel No : **03 – 2266 6003**
Fax No **03 – 8776 9356**
Test Location: **Battery Laboratory (Accredited), Instrumentation & Electronic Technology Division, STRIDE**
Date Received: **14 May 2014**

Date of Test : **15 May 2014**

Test Specifications : **UL 2271**

Measuring /Test Equipment:
1. **Digital Multimeter – Model: Fluke 289**
2. **Test Rig 24 Hours Computerized Monitoring Lithium Ion Battery Performance**
3. **Simulate Load Resistor**
4. **Short Test Cable**
5. **Video Camera – Samsung Model: Note III N9000**

Testers:
1. **Hanafiah bin Hussein** — **Research Officer**
2. **Siti Robiah bt. Abdul** — **Senior Asst. Engineer**
3. **Mohd Yusof b. Maulud** — **Asst. Engineer**
4. **Maizurina bt. Kefli** — **Asst Researcher**

Item Type: **Lithium Ion Battery (Motorola)**

Nature of Test: **Lab. Test – Battery Capacity and Functional Test**

Test Sample's Details:-

Manufacturer: **Motorola**
Origin: **Cell Origin Taiwan
Finished in Malaysia**
Description: **MOTOROLA – Lithium Ion Battery
Model: PMNN 4081BRC**

Quantity: **10 (sepuluh) unit**

Identification: **Barang Kes: MK 27
Barang Kes: MK 28
Barang Kes: MK 29
Barang Kes: MK 30
Barang Kes: MK 31
Barang Kes: MK 32
Barang Kes: MK 33
Barang Kes: MK 34
Barang Kes: MK 35
Barang Kes: MK 36**

Environmental Conditions During Test:

Ambient Temperature: **20°C**

Relative Humidity: **55 %**

Approved for Issue : ____________________
Norkamizah Mohd Nor
(Head of Branch)

Approved Signatory : ____________________
Hanafiah Hussein
(Lab Manager)

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Report No. : STRIDE/BL/2014/21

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STRIDE

Job No: CSIE/BL/2014/21	TEST RESULTS	Date of Issue: 15 May 2014 **Page 2 of 2**

Identification	Storage Voltage	Percentage (%)
Barang Kes: MK 27 Barang Kes: MK 28 Barang Kes: MK 29 Barang Kes: MK 30 Barang Kes: MK 31 Barang Kes: MK 32 Barang Kes: MK 33 Barang Kes: MK 34 Barang Kes: MK 35 Barang Kes: MK 36	**All sample give same quantity of Storage Voltage as follows:** **From Outside of battery (4 Charging Terminal)** **Between terminal T1 & T3 Voltage measured is 7.3 V (up to 1 decimal)** **Between terminal T3 & T4 Voltage measured is 6.8 V (up to 1 decimal)** **From Inside of battery (3x Walkie talkie Terminal)** **Between terminal T1 & T3 Voltage measured is 7.6 V (up to 1 decimal)**	**For all sample the Average Storage capasity is about 60% from the original maximum Storage Voltage of 11 V.**

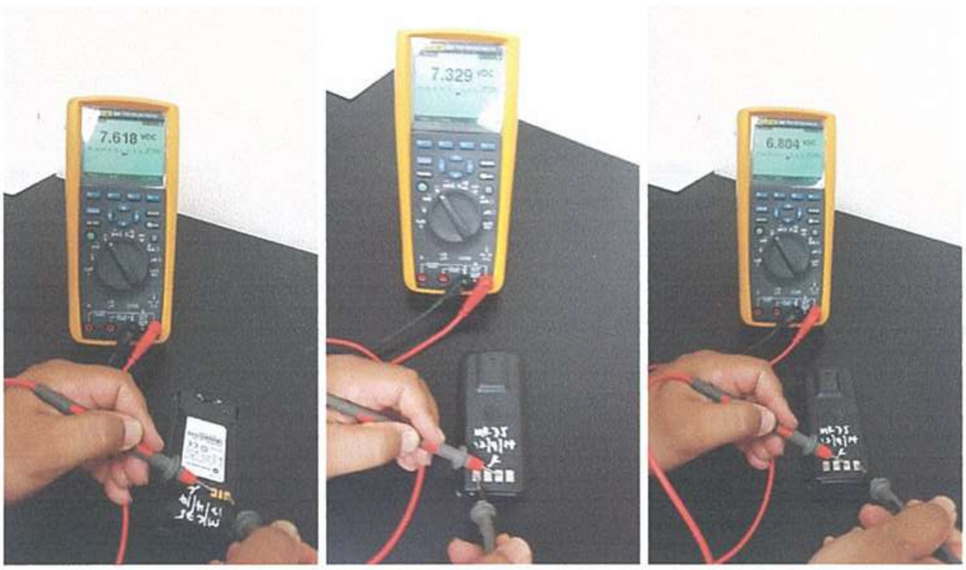

Fig. 1 : Functional Test of Sample Battery Capacity

- END -

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Job No: CSIE/BL/2014/22	TEST CERTIFICATE	Date of Issue: 15 May 2014 Page 1 of 2

Authority/Reference For Test :- **KLIA rpt:3279/14 bth 8 April 2014**

Client's Details :-

Name : **Polis Di Raja Malaysia**
Address : **Jabatan Siasatan Jenayah,
Ibu Pejabat Polis Di Raja Malaysia,
Bukit Aman, 50560 Kuala Lumpur**
Tel No : **03 – 2266 6003**
Fax No **03 – 8776 9356**
Test Location: **Electrical Laboratory (Accredited), Instrumentation & Electronic Technology Division, STRIDE**
Date Received: **29 Apr 2014**

Date of Test : **6 May – 7 May 2014**

Test Specifications : **UL 2271**

Measuring /Test Equipment:
1. **Digital Multimeter – Model: Fluke 289**
2. **Short Test Cable**
3. **Video Camera – Samsung Model: Note III N9000**

Testers:
1. **Hanafiah bin Hussein** — **Research Officer**
2. **Siti Robiah bt. Abdul** — **Senior Asst. Engineer**
3. **Mohamad Yusof b. Maulud** — **Asst. Engineer**
4. **Siti Selmah bt. Khalid** — **Senior Reserch Asst.**

Item Type: **Lithium Ion Battery (Motorola)**

Nature of Test: **Lab. Test – Spark and Short Circuit Test**

Test Sample's Details:-

Manufacturer: **Motorola**

Origin: **Cell Origin Taiwan
Finished in Malaysia**

Description: **MOTOROLA – Lithium Ion Battery
Model: PMNN 4081BRC**

Quantity: **1 (satu) unit**

Identification: **Barang Kes: MK 35**

Environmental Conditions During Test:

Ambient Temperature: **25 °C**

Relative Humidity: **62 %**

Approved for Issue : ____________________
Norkamizah Mohd Nor
(Head of Branch)

Approved Signatory : ____________________
Hanafiah Hussein
(Lab. Manager)

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Report. No. : **STRIDE/BL/2014/22**

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TEL: 603-87324400 FAX: 603-87338975

STRIDE

Job No: CSIE/BL/2014/22	Date of Issue: 15 May 2014	Page 2 of 2

PURPOSE OF TEST:

The Short Circuit Test was conducted to show that the Barang Kes: MK 35, is functioning and capable of giving out 'sparks' when the 2 opposite terminals of it were directly in contact (via connecting wire) due to presence of 60% of its storage voltage (but not to the extent of eruption).

Test Methodology

The test was conducted by using a piece of connection wire, when the 2 ends of the wire was allows to touch the 2 opposite battery terminals, the sparking light will be observed and follows with sound which indicate the sample battery is functioning and having reasonable storage voltage.

Figure 1:

The battery sample of Barang Kes: MK 35 was tested in a dark environment. This set up will be able for the tester to visually 'see' the minute sparks light clearly.

Test Result

Figure 2:

When touching the 2 opposite terminals of the sample test battery, it is clearly observed the light due to sparking and the sparking sound is also heard. (without explosion).

- END -

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KEMBARAN 15

TEST REPORT

REPORT NO:

SCIENCE & TECHNOLOGY RESEARCH INSTITUTE FOR DEFENCE
INSTRUMENTATION & ELECTRONIC TECHNOLOGY DIVISION
MINISTRY OF DEFENCE, MALAYSIA
KOMPLEKS UTAMA STRIDE, TAMAN BUKIT MEWAH FASA 9, 430000
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TEL: 603-87324400 FAX: 603-87338975

STRIDE

Job No: BTIE/2014/	Date of Issue: 25 April 2014	Page 1 of 2

Authority/Reference For Test :- KLIA rpt:3279/14 bth 8 April 2014

Client's Details :-

Name : ***Polis Di Raja Malaysia***
Address : Jabatan Siasatan Jenayah,
Ibu Pejabat Polis Di Raja Malaysia,
Bukit Aman, 50560 Kuala Lumpur
Tel No : 03 – 2266 6003
Fax No 03 – 8776 9356
Test Location: Metrology Mechanical Laboratory (Accredated),
Instrumentation & Electronic Technology Division, STRIDE

Date Received: 24 Apr 2014

Date of Test : 24 Apr 2014

Test Specifications : MPC5534 Microcontroller Data Sheet

Measuring /Test Equipment: N/A

Item Type: Freescale MPC5534 Microcontroller Chip

Nature of Test: Functional Observation

Test Sample's Details:-

Manufacturer: Freescale
Origin: Petaling Jaya Selangor, Malaysia
Description: Freescale Microcontroller Chip
Model: **MPC5534**

Quantity: One (1) unit

Identification: Barang Kes bertanda MK37

Testers:
Dr. Dinesh a/l Sathyamoorthy Research Officer

Environmental Conditions During Test: N/A

Prepared by

(DR. DINESH A/L SATHYAMOORTHY)
Research Officer
Radar & Geospatial Branch
Instrumentation & Electronic Technology Division
STRIDE

Approved for Issue :

(MOHD FAUDZI BIN MUHAMMAD)
Head, Radar & Geospatial Branch
Instrumentation & Electronic Technology Division
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FORM NO: FM PP(P) WTD 13-1	18 DEC 03

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KEMBARAN 15

TEST REPORT

REPORT NO:

SCIENCE & TECHNOLOGY RESEARCH INSTITUTE FOR DEFENCE
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TEL: 603-87324400 FAX: 603-87338975

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RESULTS

1. **Dimension of Chip (L x W) (Figure 1):** 1.70 cm x 1.70 cm

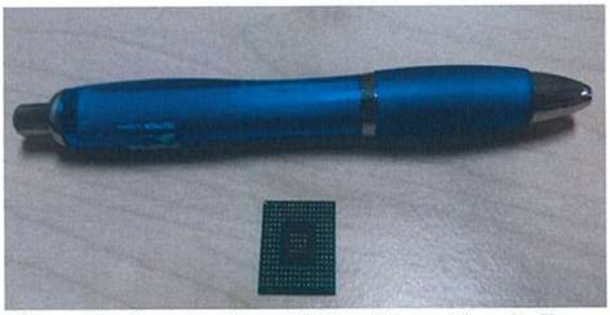

Figure 1: Comparison of the chip with a ballpen.

2. **Chip Holder (Figure 2):** Holds up to 90 chips.

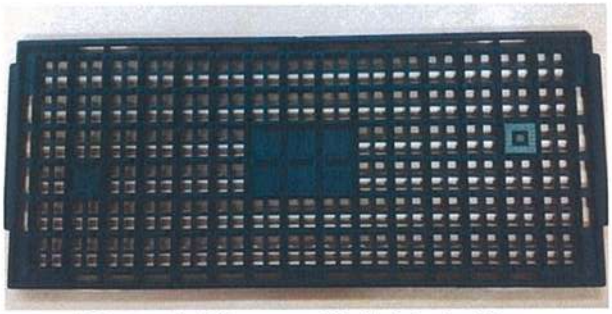

Figure 2: The provided chip holder.

3. **Chip Function:** According to the MPC5534 Microcontroller Data Sheet (http://cache.freescale.com/files/32bit/doc/data_sheet/MPC5534.pdf), the chip has **NO FUNCTIONAL CAPABILITIES UNLESS IT IS CONNECTED TO A VOLTAGE SUPPLY.**

- **END** -

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LAMPIRAN 19

CARBON MONOXIDE DANGER LEVELS

Levels of Carbon Monoxide are considered dangerous. The chart below shows the health effects of CO exposure.

Carbon Monoxide Concentration (parts per million)	Symptoms
50	No. adverse effects with 8 hours of exposure
200	Mild headache after 2-3 hours of exposure
400	Headache and nausea after 1-2 hours of exposure
800	Headache, nausea, and dizziness after 45 minutes; collapse and loss of consciousness after 1 hours of exposure
1,000	Loss of consciousness after 1 hour of exposure
1,600	Headache, nausea, and dizziness after 20 minutes of exposure
3,200	Headache, nausea, and dizziness after 5 - 10 minutes; collapse and loss of consciousness after 30 minutes of exposure
6,400	Headache and dizziness after 1-2 minutes; loss of consciousness and danger of death after 10-15 minutes of exposure
12,800	Immediate physiological effects, loss of consciousness and danger of death after 1-3 minutes of exposure

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KEMBARAN 8

TEST REPORT

REPORT NO:

	SCIENCE & TECHNOLOGY RESEARCH INSTITUTE FOR DEFENCE **PROTECTION & BIOPHYSICAL TECHNOLOGY DIVISION** **MINISTRY OF DEFENCE, MALAYSIA** KOMPLEKS INDUK STRIDE, TAMAN BUKIT MEWAH FASA 9, 43000 KAJANG, SELANGOR. MALAYSIA TEL: 603-87324400 FAX: 603-87335942	STRIDE

Job No: BTPB/2014/ 7010	**Date of Issue:** 28 **Mei 2014**	**Page 1 of 3**

Authority/Reference KLIA rpt:3279/14 bth 8 April 2014

For Test :-

Client's Details :-

Name : ***Polis Di Raja Malaysia***
Address : Jabatan Siasatan Jenayah,
Ibu Pejabat Polis Di Raja Malaysia,
Bukit Aman, 50560 Kuala Lumpur
Tel No : 03 – 2266 6003
Fax No 03 – 8776 9356
Test Location: Product Development Laboratory
Nutrition and Ration Branch
Protection & Biophysical
Technology Division, STRIDE
Date Received: 29 Apr 2014

Date of Test : 6 Mei – 7 Mei 2014

Test Specifications : -

Measuring /Test Equipment:
1. Blender – Model: National Model MX-491N
2. Waring Commercial Laboratory Blender
3. Distilled water
4. Beaker
5. Measuring Cylinder
6. Merck pH Indicator Strips
7. Mettler ToledoWeight Scales Model SB16001
8. Video Camera – Sony Model: EEZ-2

Item Type: Mangosteen fruits
Liquid from elastic sponge

Nature of Test:
i. Extraction of mangosteen juice and blended the whole mangosteen.
ii. Measuring the quantity of water trapped in the sponge use as a packaging absorber and cover for the plastic basket with lid.
iii. pH for the juice, the whole mangosteen and water trapped in the sponge.

Test Sample's Details:-

Manufacturer:

Origin: Mangosteen fruits and liquid from elastic sponge obtain from Syarikat Poh Seng Kian, No. 322, Batu 6 ¼ , Kesang 84000 Muar, Johor

Description:
1. 3 plastic basket with lid of mangosteen were brought back from Syarikat Poh Seng Kian.
2. The colour of the manggosteen were mixed with green colour when not ripe, dark red when half ripe and dark purple when ripe and they were packed according to their gred as determined by the size 2A, 3A and 4A.
3. Elastic sponge is a white color plastics foams used to cover the mangosteen fruit to maintain their freshness.

Quantity:
1. 3 x plastic basket with lid of mangosteen , each contain 55 -90 numbers of mangosteen fruit (or 8 kg weight each)
2. 3 x elastic sponge.

Identification:
i. Mangosteen Case 1,
ii. Mangosteen Case 2
iii. Mangosteen Case 3.
iv. Elastic Sponge: No. 1
v. Elastic Sponge: No. 2
vi. Elastic Sponge: No. 3

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KEMBARAN 8

TEST REPORT

REPORT NO:

SCIENCE & TECHNOLOGY RESEARCH INSTITUTE FOR DEFENCE
PROTECTION & BIOPHYSICAL TECHNOLOGY DIVISION
MINISTRY OF DEFENCE, MALAYSIA
KOMPLEKS INDUK STRIDE, TAMAN BUKIT MEWAH FASA 9, 43000
KAJANG, SELANGOR. MALAYSIA
TEL: 603-87324400 FAX: 603-87335942

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Job No: BTPB/2014/ 7010	Date of Issue: 7 Mei 2014	Page 2 of 3

Testers:

1. Dr. Aznida bt Yusuf @ Md Yusuf — Senior Research Officer
2. Mrs. Aznizah bt Ahmad — Research Officer
3. Mr. Mohd Badrolnizam bin Jamhari — Asst. Research Officer

Environmental Conditions During Test:
Ambient Temperature: 31°C
Relative Humidity: 62 – 66 %

Prepared by

(DR. AZNIDA BT YUSUF @ MD YUSUF)
Head, Nutrition and Ration Branch
Protection & Biophysical Technology Division, STRIDE

Approved for Issue :

(SALMAH BT MUDA)
Director
Protection & Biophysical Technology Division, STRIDE

RESULTS

1. The physical dimension (LxWxH) of mangosteen plastic basket with lid is 45cm x 32cm x 15cm.

2. The physical dimension (LxWxH) of elastic sponge inside the mangosteen plastic basket with lid is 44.5cm x 30.5cm x 0.8cm.

3. The total weight (plastic basket with lid, mangosteen fruits, soggy elastic sponge, wetted laminated white paper, plastic tapes) of each casing is 8.0 kg.

4. The number of mangosteen fruit is 80 - 90 pieces for grade 2A, 70 – 80 pieces for grade 3A and 55 – 65 pieces for grade 4A.

5. The total quantity of mangosteen juice prepared by BTPB is 201 ml, (which was tagged as BTPB 1, later was sent to Instrumentation and Electronic Technology Division for further test). The detailed extraction result were as follows:

   i. For mangosteen of grade 4A

      Number of mangosteen use is 6.
      Quantity of mangosteen juice is 107 ml.
      pH is 3

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ii. For mangosteen of grade 2A

Number of mangosteen use is 8.
Quantity of mangosteen juice is 94 ml.
pH is 3.

6. The quantity of liquid collected from 2 x elastic sponge is 310 ml, (which was later tagged as BTPB, 2 was sent to Instrumentation and Electronic Technology Division for further test),

7. The pH value of blended whole mangosteen is 4.

8. The pH value of liquid collected from elastic sponge is 6 ,

- END -

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