Islamic Republic of IRAN

Civil Aviation Organization

Accident Investigation Final Report

State File Number:	**A13940723EPMNE**
Type of Occurrence:	**Accident**
Date of Occurrence:	**Oct. 15th 2015**
Place of Occurrence:	**Near Mehrabad Airport**
Aircraft Type:	**B747-300**
Registration:	**EP-MNE**
Operator:	**Mahan Air**

Safety & Accident

Investigation Department

Date of Issue: 10 Oct 2016

Islamic Republic Of Iran

Civil Aviation Organization

Aircraft Accident Investigation Board

Final Report

Basic Information

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Date of occurrence: OCT 15th 2015

Place of occurrence: Near Tehran Mehrabad International Airport IR of Iran (inflight)

Aircraft Model: B747-300

Registration: EP-MNE

Operator: Mahan Air

Civil Aviation Organization of I.R. of Iran

(Aircraft Accident Investigation Board)

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Abbreviations:

AD	Airworthiness Directive
AMP	Aircraft Maintenance Program
APP	Approach
ATPL	Air Transport Pilot License
ATS	Air Traffic Service
CAMO	Continues Air Worthiness Management Organization
CAO	Civil Aviation Organization
CAT	Category
CSN	Cycles Since New
CVR	Cockpit Voice Recorder
DOC	Document
EGT	Engine Gas Temperature
ENG	Engine
F/C	Flight Cycles
F/H	Flight Hours
FAA	Federal Aviation Administration
FDR	Flight Data Recorder
FOD	Foreign Object Damage
GE	General Electric
GND	Ground
LPT	Low Pressure Turbine
HYD	Hydraulic
IRI	Islamic Republic Of Iran
LPT	Low pressure Turbine
PF	Pilot Flying
PNF	Pilot Non Flying
REV	Revision
RWY	Runway
SRM	Structural Repair Manual
TRN	Tehran
UTC	Coordinated Universal Time

SYNOPSIS:

Type of Aircraft: B747-300

Aircraft Registration: EP-MNE

Date of Occurrence: 03:49 UTC, 15 Oct 2015

Place of Accident: Inflight Near to Tehran Mehrabad Airport

Number of Flight Crew: 19

Number of Passengers: 422

Injuries: NIL

Fatality: NIL

Aircraft Damage: Substantial

Main Cause: lack of effective implementation of engine manufacture procedure

1. FACTUAL INFORMATION

1.1. History of the Flight:

On 15 Oct 2015, a Boeing 747-300, registered EP-MNE operated by MAHAN Airlines was scheduled for a flight from Mehrabad International Airport to Bandar Abbas airport within IR of IRAN territory. The aircraft with flight number 1095 was carrying 19 flight crew accompanied with 422 passengers. The aircraft upon departure from Tehran at (03:46UTC) and climbing on 7500ft experience engine failure. The evidences denotes that some seconds after aircraft departure the engine no. 3 was failed .The aircraft Engine #3 was damaged (due to uncontained engine failure), and some parts of the engine rear components detached and stroke to the engine #4 , as well as aircraft structure . the aircraft hydraulic systems no; 1, 3 and 4 were failed due to impact of thrown detached engine #3 parts. The pilot tried to take control of aircraft in spite of engine vibration and made emergency landing at Tehran at (04:23UTC).

Estimated Flight Path

1.2. Injuries to Persons:

There were neither fatalities nor injuries of passenger

Injuries	Crew	Passengers	Others
Fatal	0	0	0
Serious	0	0	0
Minor/None	19	422	

1.3. Damage to Aircraft:

The aircraft substantially damaged and it was out of Structural Repair Manual (SRM). The main damage on ENG.3 "REAR, LOW PRESSURE TURBINE" was completely detached. Some of ENG#3 detached parts hitting ENG#4 cowling and damaged it. Also FOD signs were seen on Fan Blades of Engine #4. Some of ENG #3 detached parts hitting the aircraft fuselage and caused some significant damages on low R/H wing surface & related fuel tanks and cutting on Hydraulic lines. Also some parts of landing gear doors were damaged.

1.4. Other Damages:

The ENG #3 "Rear, Low Pressure Turbine" parts damaged livestock located at the Tehran (Mehrabad International Airport) south west suburb.

The major parts of the engine were spread and found at following geographical locations:

35° 36 ′ 29.39″ N 51° 19 ′ 47.05″ E

35° 36 ′ 29.61″ N 51° 19 ′ 27.90″ E

35° 38 ′ 42.90″ N 51° 19 ′ 11.19″ E

1.5. Personnel Information:

There were 4 cockpit crew on board the aircraft including :pilot/copilot/ flight engineer(instructor)trainer / flight engineer-trainee (en-route check) as well as 15 flight attendants .

1.5.1 The Capitan (PF):

The pilot as flying pilot was 61 years old man with ATPL license No; 1637.

He has flying experience on B707, B727, and AIRBUS-A300 & A310 Aircraft. The details of his flying history are:

Total flying time	24500
Flying time in last 6 months on B747-300	111
Flying time in last 3 months	5
Flying time in last month	0
Flying time in last 72 hours	0
Flying time in last 24 hours	0
Flying time in current type	360
Last proficiency check (simulator)	15/05/2015
Last medical exam	01/02/2016
Last simulator	05/NOV/2015

1.5.2 The first officer (PNF) :

The copilot was 53 years old man with ATPL license No; 1513. He has flying experience on AIRBUS-A300 before this type of the aircraft. The details of his flying history are:

Total flying time	3783
Flying time in last 6 months on B747-300	94
Flying time in last 3 months	01:35
Flying time in last month	0
Flying time in last 72 hours	0

Flying time in last 24 hours	0
Flying time in current type	639
Last proficiency check (simulator)	15/05/2015
Last medical exam	10/02/2016
Last simulator	10/NOV/2015

1.6. Aircraft Information:

1.6.1 General Information

The accident airplane, EP-MNE, serial number 23480, manufacturing date 04-24-1986, with 20000 flight cycle life limit, had been operated and maintained continuously by Mahan Air until the accident. Mahan Air aircraft is subject to annual airworthiness renewal certificate (due date: 11-21-2015) from Iran Civil Aviation organization. This airplane's last airworthiness certificate was issued on 11-22-2014 and will be valid until 11-21-2017.

1.6.2 Maintenance operation

The Aircraft Last Periodic check was accomplished 4 days before accident Based on AMP REV.01, AMM REV.86, and SRM REV 119.

Mahan Air implements "A" check for every 600 cycles and "C" check for every 6000 cycles on this type.

According to CAMO records, last "A" check was done on 09-13-2015, F/H: 92754:40, F/C: 17679.

Last "C" check was done on 06-03-2014, F/H: 91366, F/C: 16760.

1.6.3 Engines

The airplane was equipped with four CF6-50E2 engines. This table shows related information of engines.

	ENG S/N	DATE OF EVENT	TFC	TFH
ENG1	517903	15/10/2015	18188	97483

ENG2	517702	15/10/2015	34657	48124
ENG3	530322	15/10/2015	13539	80988
ENG4	530450	15/10/2015	11910	57148

1.6.3.1 Related Airworthiness Directive:

The Federal Aviation Administration (FAA) issued Airworthiness Directive AD 2012-02-07 mandating inspections with guidance of related GE service bulletins which was concerning to LPT rotor stage 3 disks of this type of engine. This AD require inspections of high-pressure turbine (HPT) and LPT rotors, engine checks, and vibration surveys. According to this AD, a new lower life limit for the LPT rotor stage 3 disks is necessary. Due to some problems the operator did not implement this AD on the engine. It can be considered as the main cause of engine failure and accident.

1.7 Meteorological Information:

The Mehrabad International Airport weather report at date of accident was completely suitable for flight with no adverse effect on operation of the aircraft

1.8 Aids to Navigation:

The required Navigation systems at Mehrabad International Airport were completely operational.

1.9 Communications:

The related ATS Radio communication systems for Mehrabad International Airport Were Completely Operational.

APP & RADAR (TRN): 119.7,125.1,121.5,362.300,317.500,243.0 MHZ

, TWR (TRN): 118.1, 124.450,257.800.243.000 MHZ

, GND: 121.700, 121.900 ,275.800, 243.000 MHZ

1.10 Aerodrome Information:

Mehrabad International Airport (OIII) Located At: 354120N, 0511853E

Aerodrome Elevation: 3962ft

The airport is open for IFR/VFR flight at 24 HOURS.

Airport fire-fighting category is: CAT9

AIRPORT Active runway was: RWY 29L/11

RWY 29L/11: 3989*45 M

RWY 29R/11: 4030*60 M (under repairing at date of occurrence)

1.11 Flight Recorders:

The aircraft FDR/CVR were removed from the aircraft for investigation at the date of accident.

1.11.1 Flight Data Recorder:

FDR Manufacturer: HONEYWELL TYPE: SSFDR

PART NO.: 980-4700-042 s/n: 14423

FDR raw data read out was carried out in Iran and the data were provided to BEA FRANCE for more investigation. The data was analyzed by The BOEING DOC 747-AV-SD-LH_1-2 and toke advantages from DATA FRAME in form of "fgetb.xls" from AIR FRANCE with was received by German accident investigation Authority (BFU).The related report is available in the Appendices.

The FDR registered 17 flights.

FDR date shows:

During last 8 flights of aircraft (after engine #3 installation) there was abnormality in the engine (Concerning #3 Fan Vibration) during flight of the aircraft, but the pilots of the aircraft did not decide to turn back to the main base.

- After 3 minutes from departure, while aircraft was climbing out of 7500 to 76000 ft, EN. :#3 hot section was detached from engine and the rotating parts

were spread apart and some of them were entered into ENG. No. #4 inlet; and cause engine failure.

The pilot tried to restart the engine ENG. No. #4 at 8860 ft but it was not any response.

At the time of the problem, the hydraulic systems no; 1, 3 and 4 were failed and consequently aircraft inboard flight control empowering from hydraulic no; 1 was completely failed .

the pilot used FLAP 10 at the time of event , As the outboard flight control surfaces were empowered from hydraulic system no; 2; therefore for aircraft control and there was opportunity to save the aircraft and its occupants.

There were some deviations in aircraft altitude which were quiet normal during this critical situation.

The pilot could not use auto pilot (left side) due to HYD. #3 failure but did not use auto pilot (right side)

EPT.PITCH CONTROL COLUMN during whole flying time up to landing (during 37 minutes) was severely deviating within 4 degrees; it may be the cause of improper trimming, even though STAB TRIM was working properly but it caused passengers to suffer a lot from aircraft shakes.

1.11.2 Cockpit Voice Recorder:

The CVR (Solid state CVR) manufactured at FAIRCHILD (USA) was read out at BEA- FRANCE in the presence of CAO.IRI AAIB inspector. The CVR contains 30 minute audio files but did not refer to accident time.

The pilot reports denotes that 17 minutes after aircraft departure the engine no. 3 was failed But the pilot failed to pull out the Circuit Breaker (CB), therefore all data are removed inadvertently.

1.12 Wreckage and Impact Information:

The main damage on ENG#3 " REAR ,LOW PRESSURE TURBINE " was completely detached and as a result the engine exhaust section was detached

and fell into livestock (TEHRAN SUBURB) and about 10 KG. of engine parts were gathered from it .

Some of ENG#3 detached parts hitting ENG#4 and related fan blades an cowling of the engine were damaged.

Some of ENG#3 detached parts hitting the aircraft fuselage and caused some significant damage and some hydraulic lines were damaged.

The outer skin of right hand wing inboard fuel tank was damaged /raptured by thrown rotary parts of ENG#3 and consequently caused the leakage of the most fuel.

Inboard Damaged Engine

Detached Engine Part on Ground

1.13 Medical and Pathological Information:

There were not any significant observations concerning medical and pathological examination of the pilots.

1.14 Fire:

There was not any fire either during flight of after landing.

1.15 Survival Aspects:

As all aircraft occupants were in suitable condition, therefore there was not any action needed for aircraft passengers and flight crew concerning medical care or assistance. All passengers were disembarked via stair.

1.16 Tests and Research:

The NTSB report shows that similar occurrences and most of them were in those GE engines which have some difficulties in its low pressure turbine (LPT).High HPT imbalance causes secondary vibratory damage in the LPTR. The FAA ad no; 2012-02-07 required to replace related discs in appropriate time

1.17 Organizational and Management Information:

Mahan Air is registered airline in Iran and was stablished on 1992,

The company designation code is IRM and its ICAO registered code is: W5

Mahan Air is registered airline in the IR of Iran territory and has approved CAMO (based on CAO.IRI PART-M) and AMO (based on CAO.IRI PART-145).

1.17.1 Airport Ground Handling Service:

Airport Ground Handling Service for Mahan flight is provided by the "SAMAN Company "in defined airports in Iran.

1.18 Additional Information:

Although the following case was concerning to the flight accident but it is one finding and should be considered for future operation of similar aircraft at planned destination.

The destination of the aircraft was not properly selected (i.e: BANDAR ABBAS Airport) because this airport was not approved for CAT 7 fire-fighting protection operation based on ICAO standards.

1.19 Useful or Effective Investigation Techniques:

The investigation technique was adapted from ICAO DOC 9756 for detailed work performance of accident investigation team.

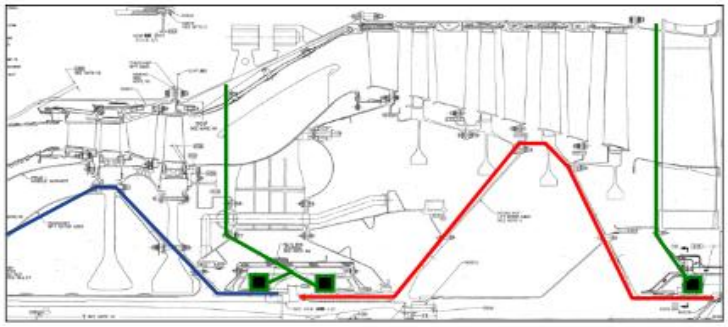
2-ANALYSIS:

2-1 Technical Analysis

2.1.1 Similar Engine Failures:

There were at least 8 similar engine failures in the worldwide operation of this type engine from 2008 according to manufacturer (GE Aviation) report. The manufacturer has researched about these occurrences and found common root cause and some corrective actions as Service Bulletins, Airworthiness Directives (AD).

Root Cause



High HPTR imbalance causes secondary vibratory damage in the LPTR

Loads are transmitted between the HP and LP systems through a common sump (#5R & 6R bearing sump)

LPT S3 blade-disk vibratory mode excited by HPTR imbalance:

- Bladed disk vibratory mode level just above engine ground idle

HCF crack initiates/propagates in LPT S3 disk forward spacer arm

Continued engine operations can lead to 360° crack and separation of LPT

The main related AD is 2012-02-07 which consists of following procedures to detect failures and preventative actions:

- *Bore scope Inspections (BSI) of High-Pressure Turbine (HPT) Rotor Stage 1 and Stage 2 Blades;*
- *Actions Required for Engines with Damaged HPT Rotor Blades;*
- *EGT Thermocouple Probe Inspections;*
- *EGT System Resistance Check Inspections;*
- *Ultrasonic Inspection (UI) of the LPT Rotor Stage 3 Disk Forward Spacer Arm Engine Core Vibration Survey;*
- *Initial and Repetitive FPI of LPT Rotor Stage 3 Disks;*
- *Removal of LPT* Rotor Stage 3 Disks
- *Installation Prohibition of Disk exceeds the new life limit of 6,200 CSN.*

2.1.2 Engine Failure consulting this accident:

The main problem which led to engine failure was vibration as a result of unbalance engine HPT module ,which caused crack propagation in ENG.#3 LPT.

The investigation team focused on the following more ADs orderly to reach the conclusion.

FAA AD 2010-06-15

FAA AD 2010-12-10

FAA AD 2012-02-07

FAA AD 2005-26-06

The operator of concerned aircraft showed the completed documents for compliance with ADs requirements. So research was applied to the related documents. According to General Electric descriptive report which was supported by the NTSB, the *FAA AD 2012-02-07* was issued as preventative action for this type of engine failure.

The history of EGN#3 SN; 530322 and its LPT rotor stage 3 DISK (P/N: 9061M23P10) were investigated. The CSN of this part at date of accident was: CSN: 10041Cycle; its service life was observed to 12600 cycles based on operator documents. More historical information of this disk is as followed:

- The disk had been installed on Engine S/N; 530376 while operator has bought the engine with condition of Accomplished all AD. When the FAA AD 2012-02-07 was applicable on the engine, the Mahan Air engineer took policy to prolong service time (3000 Cyc) of the disk to 12600 Cycle based on Paragraph m (ii) of AD context up to next engine shop. The record of AD accomplishment was recorded in engineering data.

❖ *Note: The Mahan Air was not supported by the Manufacturer due to involved embargo so could not buy related kit and modified new disk easy and tried to use the disk with specified mitigation in AD context and prolong Disk Service cycles.*

- The disk was removed due to vibration. About Mar 2015, after some adjustment this disk was installed on engine S/N; 517372 too. During operation on B747, this engine has encountered vibration. The disk was removed for the inspection.
- About May 2015, this disk was installed on engine S/N; 517862 . The Engine shop requested Operation test of the engine to evaluate Disk circumstances. During on wing operation on an A300, this engine showed vibration. Again the disk was removed for the inspection.

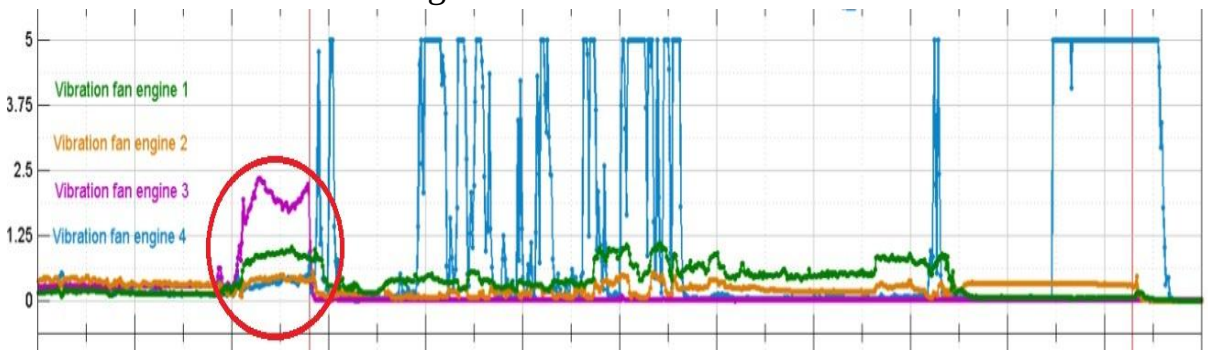
  - *Referring to Paragraph m (i) & n(1) of AD context , the installation of the disk with condition of over 10000 Cycles was prohibited but due to lack of information between Mahan Air engineering and Engine shop , the disk was installed on the engines.*
  - *There are lack communication of engine shop and engineering department to send feedback of engine situation to engineering department.*
  - *The engine shop personnel did not follow up for AD applicability for engine to refer & find out AD context for changing disk.*

- After ineffective inspection and maintenance, the disk was installed on accident engine with S/N; 530322 and stand by for engine request and operation.
- At 09 Oct 2015, the engine with 530415 was removed from #3 position of the aircraft N747, EP-MNE and accident engine with S/N; 530322 became on the aircraft.
- From 12 to 14 Oct 2015, the crew reported high vibration situation on #3 engine and some actions by technical persons were done on the engine same as: re-torqueing spinner, fan balancing… so the vibration was reduced momentary.
- The whole corrective actions were note effective finally uncontained engine failure was happened at the day of accident.

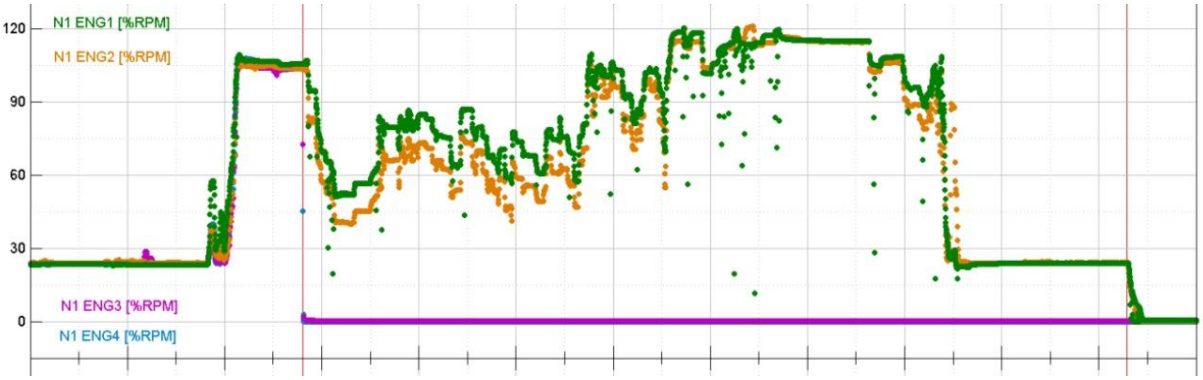
2.1.3 Engine#3 failure on FDR:

The engine #3 failure occurred about 3 minutes after take-off:

- From this time, engine #3 parameters N1 ENG#3, Engine 3 Fuel Flow, Vibration fan engine #3 and Vibration N1 ENG#3 are recorded to zero until the end of the flight



- Parameter EGT3 is recorded at about 983 until the end of the flight



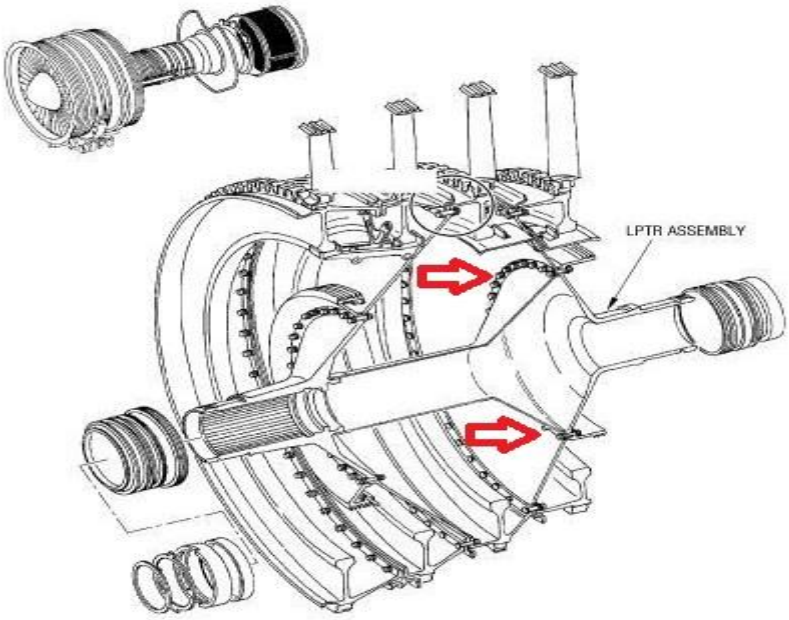
All engines N1 variation (loss of N1 in Eng#3&4 is obvious)

- Simultaneously, the parameters Engine 4 Fuel Flow and N1 ENG4 are also recorded to zero until the end of the flight. The other engine #4 parameters seem to be valid.
- The parameter Landing gear (Air/Gnd) is not consistent from about 20 minutes after take-off. This could be due to damage on landing gear position sensor / harness

2.1.4 Engine Damage:

Engine#3 LPT failure:

Because the LPT rotor spins rapidly, detachment of Disk#3 from its axis by centrifugal force resulted in radial propagation of defragments with high velocity. Therefore, LPT stage#3 is completely detached from the engine. Figure illustrates the LPT stage 3 with red arrows.



Cut away illustration of CF6-50 LPT disk#3 Location

This damage led in complete loss of thrust in engine#3.

Engine#4 FOD by engine#3 defragments:

Due to configuration of the aircraft engines, engine#4 is located closed to the engine 3. Hence, some defragments of engine#3 were thrown to the intake of engine#4; therefore there were sign of F.O.D in engine fan blade. The engine N1 dropped and there were continuous high fan vibration on this engine #4 within 17 minutes from EN#3 failure and during pilot trying to restart EN#4 N2 changes but the pilot couldn't restart the engine .

In addition some other defragments were impacted to engine#4 accessories including lines and harnesses. It increased the effect on this engine failure.

2-2 OPERATION ANALYSIS:

The flight has begun from Tehran Mehrabad airport (OIII) by engine starting on 03:11 UTC. On 03:46 UTC, Just after take-off, the engine #3 N1 vibrations was increased to 2.3 while other engines were stabilized vibration 0.4. The CVR containment shows that the pilot had experience on vibration before so he decided to continue the flight as custom latent condition. The #3 engine was

encountered failure while climbing 7500 ft. The thrown part of #3 engine caused FOD for Engine #4.

Following engine #3 and engine #4 failure, the pilot requested to maintain 8000 ft. altitude and requesting holding and air turn back to TRN (OIII) with no emergency declaring.

These technical tasks should be reviewed and done by the cockpit crew accordingly. It made a large pressure work on the pilots with required suitable times and their accuracy might save the aircraft and people on board.

1- *Declaring emergency and related coordination*
2- *Two Engine INOP check list*
3- *Two HYD systems INOP*
4- *Two generators INOP*
5- *Fuel Leak Procedure*
6- *Nose & Body gear steering INOP(RWY occupation, Tow track Coordination)*
7- *T/E flap extension*
8- *One pack air-condition operation*

These tasks should be declared by non-flying pilot, then accomplished by pilot& confirmed. All actions were supervised by both available flight engineers in the cockpit. Also they should take decision to return nearest aerodrome.

The hydraulic system description of B747 should be observed to determine the severity of the accident and analyze the operation of the systems.

B747 Hydraulic System Description			
HYD SYS 1	**HYD SYS 2**	**HYD SYS 3**	**HYD SYS 4**
Nose gear Steering **Inboard T/E flap** **LH OUTBD Elevator** **RH INBD elevator** **LH OUTBD Aileron** **LH INBD Aileron** **Normal Brake** **Upper Rudder**	**Spoiler2-3-10-11** **Alternate brake** **STAB Trim** **LH OUTBD Aileron** **LH INBD Aileron** **RH INBD Aileron** **RH INBD Elevator** **Upper Rudder** **Lower Rudder** **Autopilot 2(B)**	**Spoiler 1-4-9-12** **STAB Trim** **LH INBD Aileron** **Upper Rudder** **RH OUTBD Aileron** **LH INBD Elevator** **Autopilot 1(A)**	**Spoiler 5-6-7-8** **Wing Gear N. Brake** **outboard T/E flap** **Lower Rudder** **RH INBD Aileron** **RH OUTBD Aileron** **LH INBD Elevator** **RH OUTBD Aileron**

As the pilot has not initiated to retract 10 Deg. Flaps , therefore , there was an opportunity to maintain aircraft stability with access to outboard control surfaces empowering by No;2 Hydraulic System .

But PITCH & ROLL angle were not in their order condition and made inconvenience for passengers during these critical condition.

After leading the aircraft to the holding area, crew tried to restart the engine #4 but it was not successful. The pilot of aircraft decided to make landing in Tehran.

The pilots tried to use 1(A) autopilot system but due to HYD#3 failure, they could not active autopilot system however they did not try on autopilot 2(B).

Finally the aircraft has landed on RWY 29L of Mehrabad International Airport successfully and stopped on the Runway. The pilot has requested towing car for vacating the runway due to lack of nose gear steering system caused by HYD #1 system failure.

3- CONCLUSIONS:

3-1 Findings:

- ✓ The flight and cabin crewmembers were properly certificated and qualified under Iranian CAO regulations. No evidence indicated any preexisting medical or physical condition that might have adversely affected the flight crew's performance during the accident flight.
- ✓ The failure might be preventable via implementation of AD mentioned in section 2.1 of this investigation report.
- ✓ The procedure of delivering work scopes from Part-145 engineering to engine shop was not reliable to assure the receipt. It was not any responsible person to monitor the procedure and assure the receipt.

- ✓ There was not any transmittal form for communication between CAMO & Part-145. Therefore, issued ADs, SBs, or EOs was not officially delivered to part-145.
- ✓ Issuance of form-1 of engines after releasing from shop was prior to test cell. Hence, engine problem was not detectable at the time of issuance of form-1.
- ✓ The engine #3 vibration was already existed but the operator released the aircraft after some insufficient inspections.
- ✓ The engine LPT should be replaced based on related AD but the operator due to prolongation of its service life failed to modify engine at proper time. The lack of manufacturer Support helped this subject too.
- ✓ The pilot did not retract Flap 10, this action decrease severity of consequences and prevented fatal accident.

3-2 CAUSE of ACCIDENT:

IRI CAO Aircraft Accident Investigation Board determines the probable cause of this accident was the operator's fault to modify the ENG# 3 with AD requirement, and ineffective action for N1 Vibration which caused uncontained engine failure.

3-3 The contributing factors:

- In sufficient operator maintenance & engineering performance
- Lack of effective monitoring in operators line maintenance
- Lack of support for engine parts and mandatory information from the manufacturer
- Lack of effective monitoring in Mahan air concerning operation, training and technical divisions.

4-SAFETY RECOMMENDATIONS:

4.1 Previously Issued Recommendation Resulting from This Accident Investigation before Releasing the Final Report:

- *On 28 October 2015, because of Mahan Air(IRM) flight 1095 accident investigation, the CAO AAIB issued an urgent safety recommendation" prompt action" to all operators of Engine CF6-50C2 for the accomplishment of AD 2012-02-07 and immediately ordered them to check the operation of this type of engine in their fleets closely.*

- *Also, CAO AAIB sent a Safety Alert to the given operator for the effective training of the crew to introduce and monitor aircraft systems and take corrective actions during the failure of any systems.*

4.2 New Recommendations:

Because of this investigation, the CAO Aircraft Accident Investigation Board (AAIB) makes the following recommendations:

To the International Civil Aviation Organization (ICAO):

- The ICAO Air Navigation Commission (ANC) should recommend the Airworthiness Panel (AIRP) to review the situation of embargoed countries in respect of continuing airworthiness for receiving mandatory information from the State of Design and take corrective actions for implementing the standards of Annex 8, Chapter 4, by the Contracting States.

To the Civil Aviation Organization of the Islamic Republic of Iran (CAOIRI)

- ✓ To implement ICAO SARPS as well as its national CAOIRI regulations, to ensure the establishment of an effective engineering system in the air carriers to maintain aircraft airworthiness in a standard based level.
- ✓ To establish a system to monitor matching between operating aircraft category and airport characteristics .
- ✓ Require all aircraft operators to train pilots for the similar occurrences in the simulator for taking proper actions during the different course of the accident.

To the National Transportation Safety Board:

- ❖ To establish an analytical report for safety concerns about the effects of Embargo on civil aviation activities and deliver to the government of the United States to exempt Annex 8 standards related civil aircraft equipment from the embargo list for the improvement of the safety of civil flights.

To the Federal Aviation Administration:

To review the findings of this accident report and improve the context of the AD No. 2012-02-07 to prevent such diffeciencies between the engine operators.

- ➢ Remarks: the NTSB made the comment to the final report as followed which was not accepted by the AAIB:

"Concerning the NTSB recommendation, the requested action is beyond the scope of the NTSB's mission and we therefore believe it is not appropriate to propose this recommendation in the report. The U.S. government already makes an exception to the primary embargo specifically for safety of flight reasons and maintains a formal process for authorizing the participation of U.S. agencies and companies in these investigations consistent with our interest in maintaining global safety of flight."

5- Appendixes:

A: Flight Recorder Read out

B: FAA Airworthiness Directive

C: General Electric Analysis

Technical document

FDR decoding data
CVR read-out

Document ID:	**BEA2015-0656_tec01**
Date of occurrence:	15/10/2015
Place of occurrence:	Tehran Mehrabad International Airport (Islamic Republic of Iran)
Aircraft type:	BOEING - 747 - 300 - 3B3
Registration number:	**EP-MNE**
Equipment examined:	

CVR
Fairchild A100S
P/N : S100-0080-00
S/N : 00607

Circumstances :

The engine #3 sustained failure during take-off from Teheran airport.

Objectives of the examination

The objective is to:
- decode FDR data in engineering units
- perform a CVR readout to obtain audio files

Work performed:

- **FDR data processing**

FDR readout was performed by the Iranian authorities with the manufacturer (Honeywell) equipment. FDR raw data was sent to the BEA on 3rd November 2015.

Iran authorities informed the BEA that the acquisition unit – DFDAU – references were Teledyne P/N 2222601-6.

The dataframes used by the BEA to decode data were:
- file “FGETB.xls” provided by Air France, previous owner of the aircraft
- file “Boeing Doc 747-AV-SD-LH_1-2.pdf” provided by BFU

The FDR recorded more than 24 hours of data. The accident was recorded.

Engine #3 failure

The engine #3 failure occurred about 3 minutes after take-off :

- From this time, engine #3 parameters *N1 ENG3, Engine 3 Fuel Flow, Vibration fan engine 3 and Vibration N1 ENG3* are recorded to zero until the end of the flight
- Parameter *EGT3* is recorded at about 983 °C until the end of the flight

Simultaneously, the parameters *Engine 4 Fuel Flow* and *N1 ENG4* are also recorded to zero until the end of the flight. The other engine #4 parameters seem to be valid.

The parameter *Landing gear (Air/Gnd)* is not consistent from about 20 minutes after take-off. This could be due to damage on landing gear position sensor / harness.

Invalid parameters

The following parameters were found not valid :

- *Master warning* (recorded WARNING for all flights)
- *Gear_SELON_DW* (recorded UP for all flights)
- *Hyd sys low pressure* parameters (recorded LO PRESS for all flights)

Previous flights

Some abnormal values were recorded for engine #3 parameters during the 7 flights (approximately 13 flight hours) prior to the flight of the accident:

- parameter *Vibration fan engine 3* started to reach high values
- parameters *N1 ENG3* , *N2 ENG3*, *Engine 3 Fuel Flow* and *EGT3* were most of the time lower than for the other engines

FDR parameters are visible in the appendix “FDR plots” of this document.

- **CVR readout**

A visual inspection was performed. No physical damage was found. The technical seals were still in place and intact. It was decided to perform a direct readout.

The download for this kind of recorder is performed by analog acquisition. The readout requires opening the recorder to connect an adapter on one of the electronic boards to digitize simultaneously the recorded tracks.

Fig 1 – CVR opened

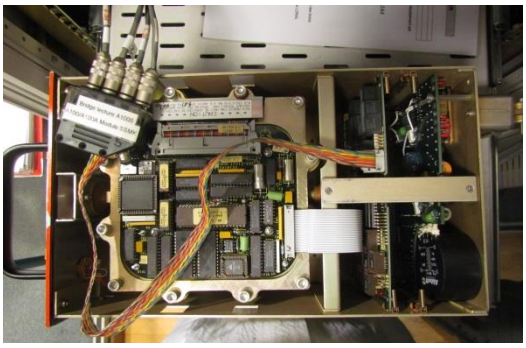


Fig 2 – CVR download

The download was successful. Four audio files with duration of 31 min 54 s were retrieved:

- EP-MNE_track 1.wav
- EP-MNE_track 2.wav
- EP-MNE_track 3.wav
- EP-MNE_track 4.wav

The tracks identification will be made later. The event was not present on the recordings.

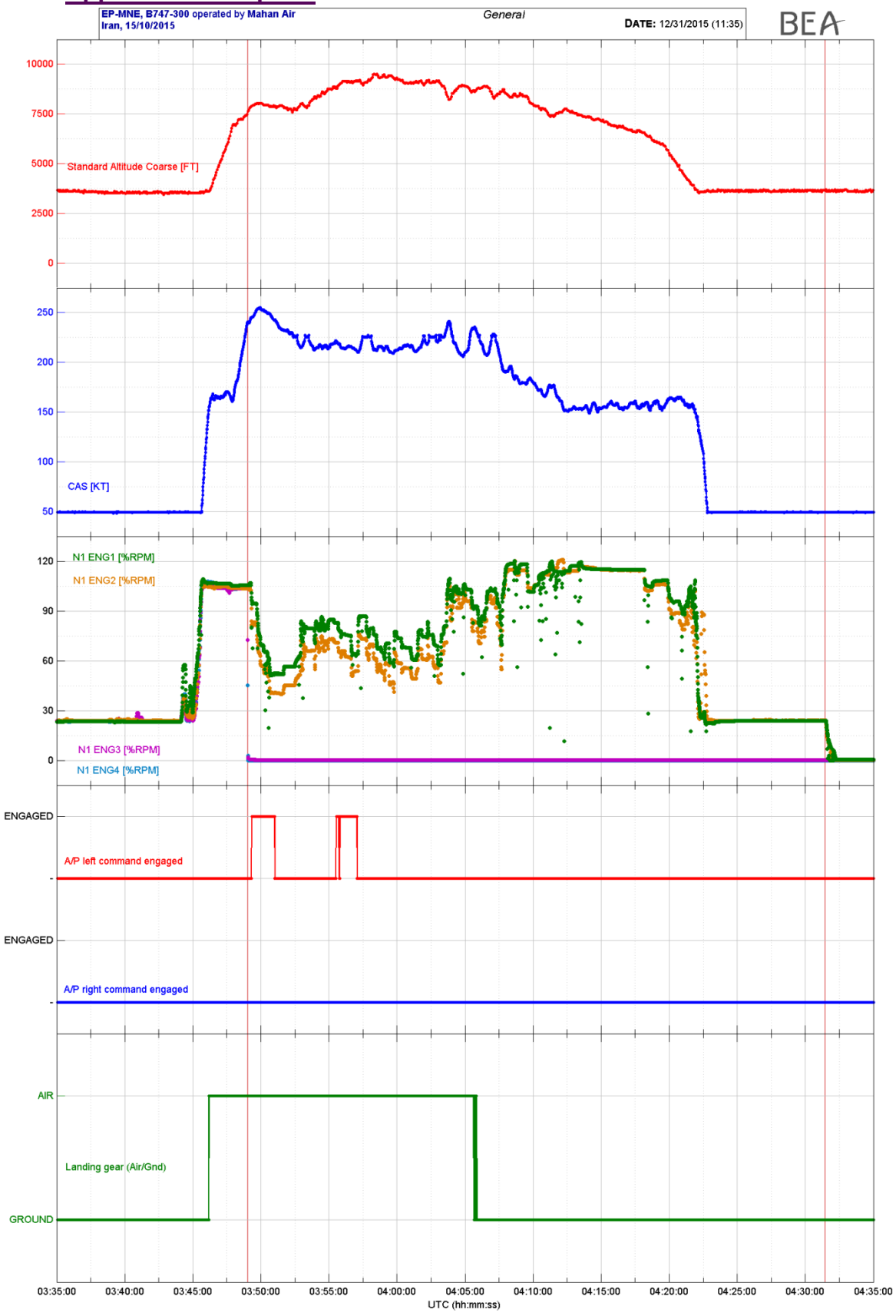
Results:

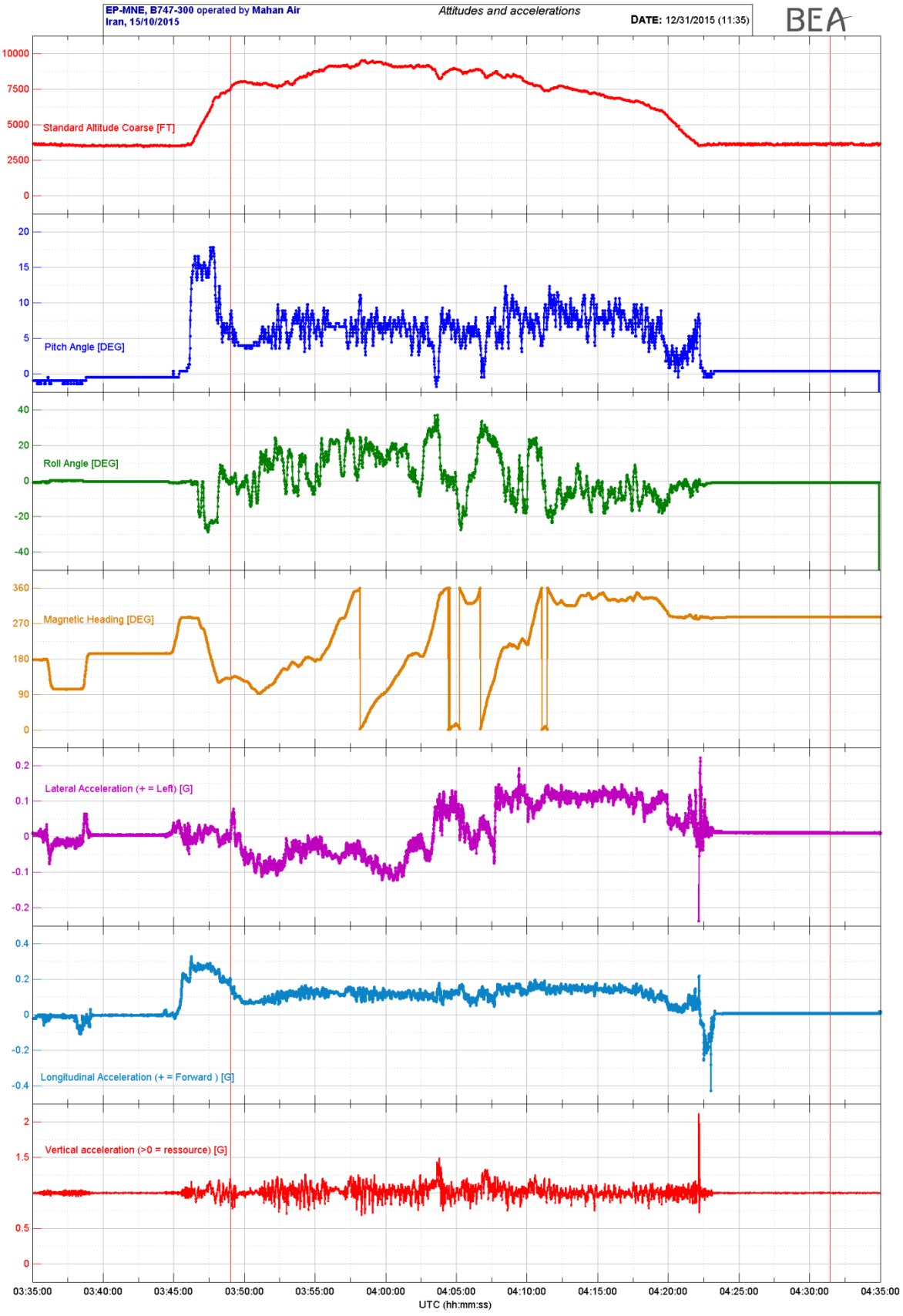
The accident was present in the FDR data but not in the CVR.

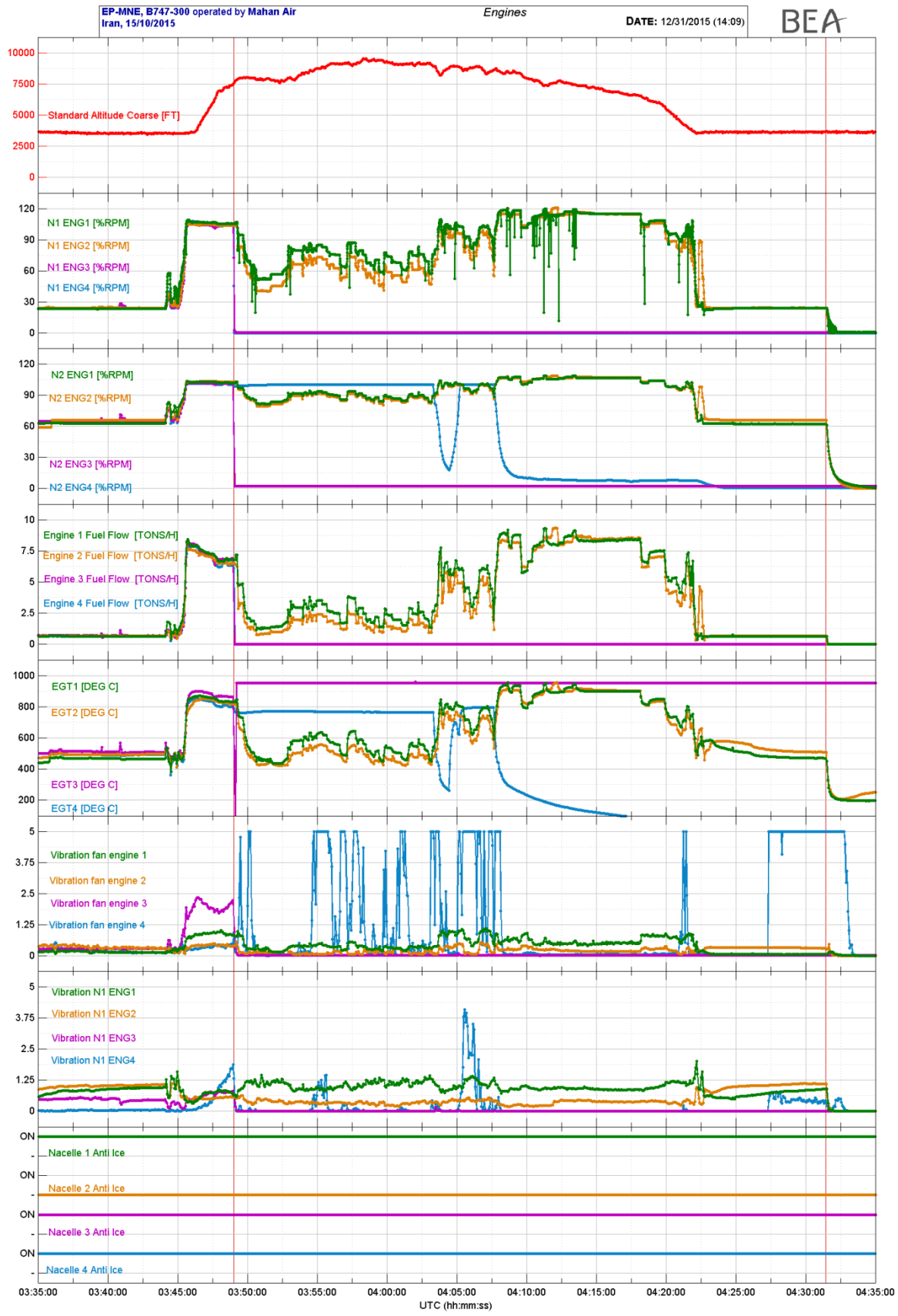
The BEA provided the Iranian authorities with the following documents :

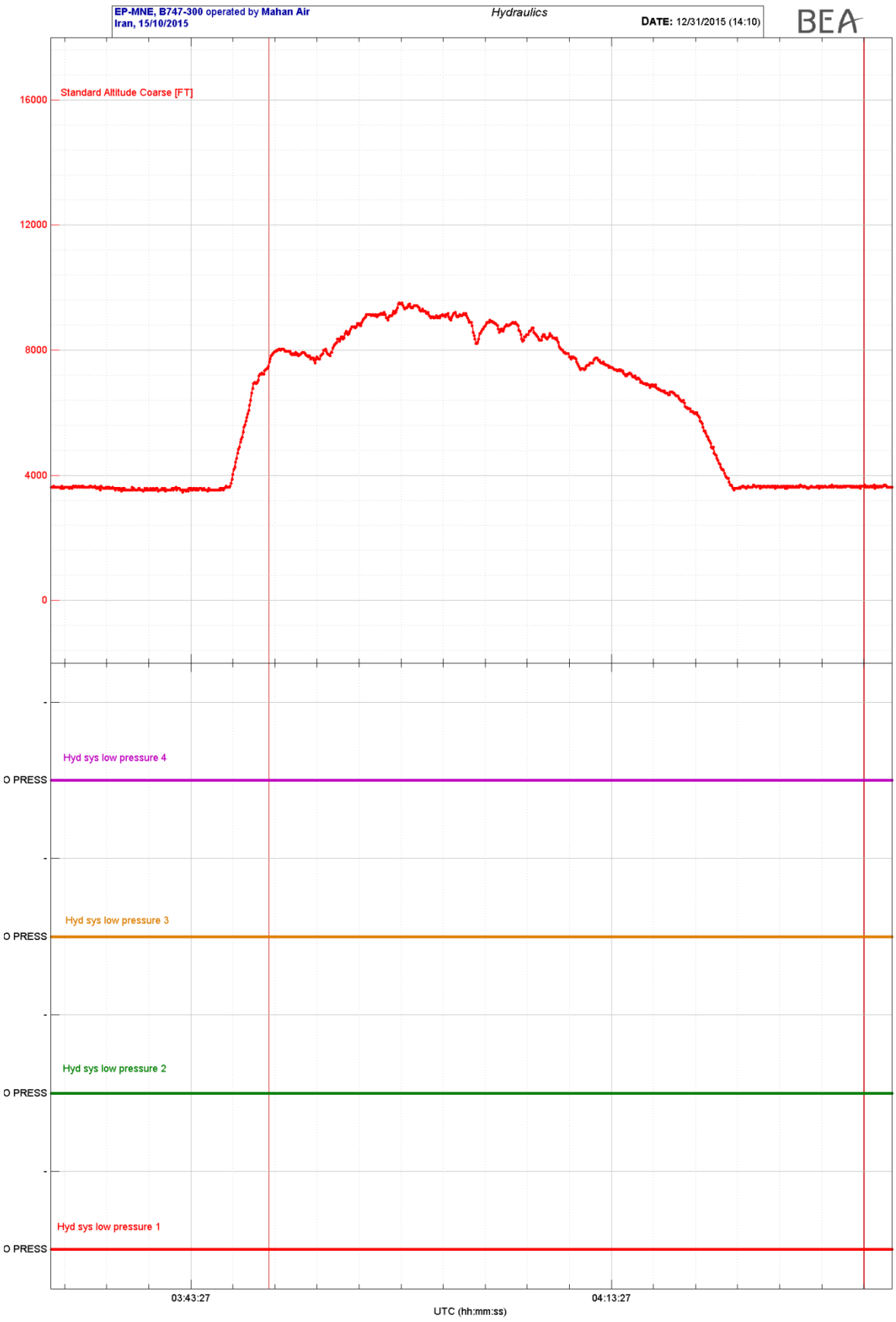
- FDR raw data (5625F1E0.TSC)
- FDR plots in tiff format
- FDR listings with all relevant parameters for the flight of the accident and all engine parameters for the last 17 recorded flights
- CVR wav files
- This report in electronic format

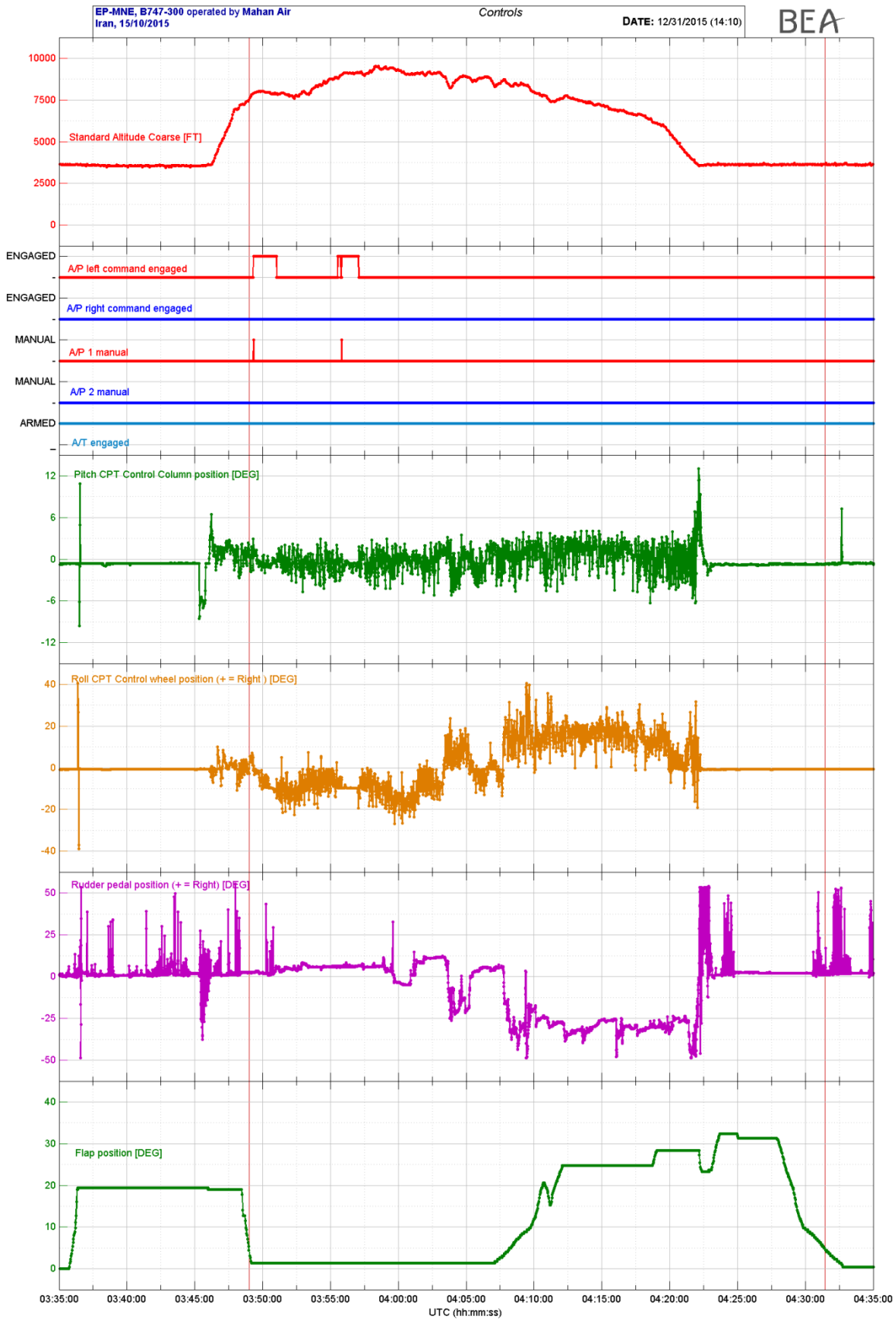
- ## Appendix : FDR plots

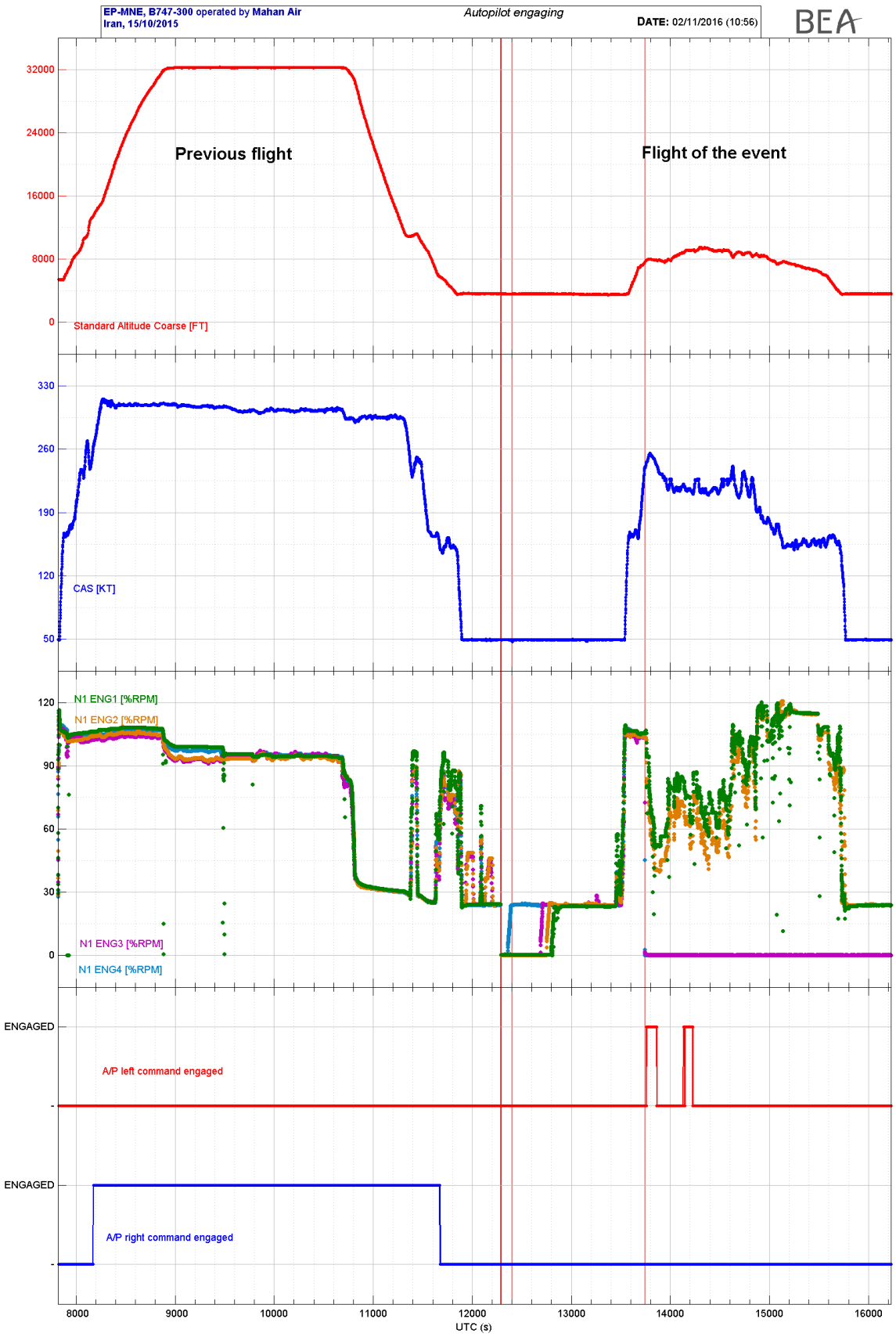


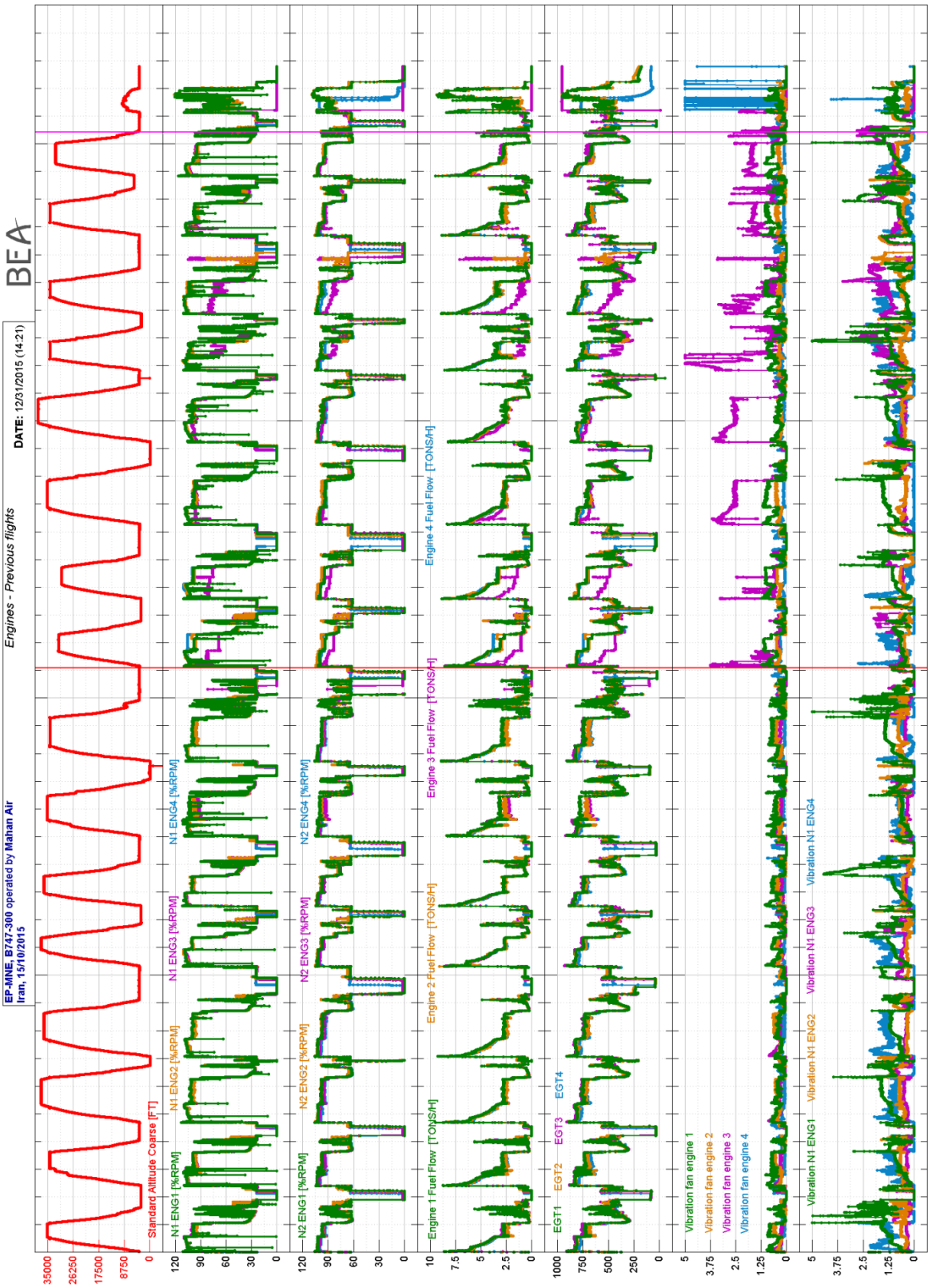












[Federal Register Volume 77, Number 20 (Tuesday, January 31, 2012)]
[Rules and Regulations]
[Pages 4650-4653]
From the Federal Register Online via the Government Printing Office [www.gpo.gov]
[FR Doc No: 2012-1953]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 39

[Docket No. FAA-2010-0068; Directorate Identifier 2010-NE-05-AD; Amendment 39-16930; AD 2012-02-07]

RIN 2120-AA64

Airworthiness Directives; General Electric Company Turbofan Engines

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: We are superseding two existing airworthiness directives (ADs) for General Electric Company (GE) CF6-45 and CF6-50 series turbofan engines with certain low-pressure turbine (LPT) rotor stage 3 disks installed. The existing ADs currently require inspections of high-pressure turbine (HPT) and LPT rotors, engine checks, and vibration surveys. This new AD retains the requirements of the two ADs being superseded, adds an optional LPT rotor stage 3 disk removal after a failed HPT blade borescope inspection (BSI) or a failed engine core vibration survey, establishes a new lower life limit for the affected LPT rotor stage 3 disks, and requires removing these disks from service at times determined by a drawdown plan. This AD was prompted by the determination that a new lower life limit for the LPT rotor stage 3 disks is necessary. We are issuing this AD to prevent critical life-limited rotating engine part failure, which could result in an uncontained engine failure and damage to the airplane.

DATES: This AD is effective March 6, 2012.

The Director of the Federal Register approved the incorporation by reference of a certain publication listed in this AD as of February 22, 2011 (76 FR 6323, February 4, 2011).

ADDRESSES: For service information identified in this AD, contact General Electric Company, GE-Aviation, Room 285, 1 Neumann Way, Cincinnati, OH 45215, phone: (513) 552-3272; email: geae.aoc@ge.com. You may review copies of the referenced service information at the FAA, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, MA. For information on the availability of this material at the FAA, call (781) 238-7125.

Examining the AD Docket

You may examine the AD docket on the Internet at http://www.regulations.gov; or in person at the Docket Management Facility between 9 a.m. and 5 p.m., Monday through Friday, except Federal holidays. The AD docket contains this AD, the regulatory evaluation, any comments received, and other information. The address for the Docket Office (phone: (800) 647-5527) is Document Management Facility, U.S. Department of Transportation, Docket Operations, M-30, West Building Ground Floor, Room W12-140, 1200 New Jersey Avenue SE., Washington, DC 20590.

FOR FURTHER INFORMATION CONTACT: Tomasz Rakowski, Aerospace Engineer, Engine Certification Office, FAA, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, MA 01803; phone: (781) 238-7735; fax: (781) 238-7199; email: tomasz.rakowski@faa.gov.

SUPPLEMENTARY INFORMATION:

Discussion

We issued a notice of proposed rulemaking (NPRM) to amend 14 CFR part 39 to supersede AD 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011) and AD 2011-18-01, Amendment 39-16783 (76 FR 52213, August 22, 2011). Those ADs apply to the specified products. The NPRM published in the Federal Register on October 19, 2011 (76 FR 64844). That NPRM proposed to retain the requirements of AD 2011-02-07 and AD 2011-18-01, except that reporting to the FAA would no longer be required and there would be an optional LPT rotor stage 3 disk removal after a failed HPT blade BSI or a failed engine core vibration survey. That NPRM also proposed to establish a new lower life limit for the LPT rotor stage 3 disk part numbers listed in Table 1 of the proposed AD, and proposed to require removing these disks from service at times determined by a drawdown plan.

Comments

We gave the public the opportunity to participate in developing this AD. The following presents the comments received on the proposal and the FAA's response to each comment.

Support for the NPRM as Written

One commenter, The Boeing Company, supports the NPRM (76 FR 64844, October 19, 2011) as written.

Request To Allow Credit for Vibration Surveys Performed in a Test Cell

One commenter, MTU Maintenance Hannover GmbH, requested that we add a paragraph that allows credit for performing vibration surveys in a test cell, as meeting the AD vibration survey requirements.

We agree. We added paragraph (k)(8) to the AD, which states "Vibration surveys carried out in an engine test cell as part of an engine manual performance run fulfill the vibration survey requirements of paragraphs (k)(2) through (k)(3) of this AD."

Request To Add a Requirement for Raw Exhaust Gas Temperature (EGT) Trend Data Point Exceedance

One commenter, Evergreen International Airlines, requested that we add a requirement that two consecutive raw EGT trend data point exceedances must be confirmed by a corresponding shift of other engine parameters to trigger the HPT blade BSI.

We partially agree. We agree that EGT system error should not force a BSI of turbine blades. But we disagree with troubleshooting the EGT raw data points once the EGT system error was ruled out. We added paragraph (o)(4) to the AD to state that, for the purposes of this AD, a raw EGT trend data point above the smoothed average is a confirmed temperature reading over the rolling average of EGT readings that is not a result of EGT system error. We also rearranged the wording in paragraph (iv) in Table 2 of the AD for clarification.

Correction to Engine Model CF6-50-E2D

Since we issued the NPRM (76 FR 67844, October 19, 2011), we discovered that, in applicability paragraph (c), engine model CF6-50-E2D was incorrect. We corrected it to read CF6-50E2B in the AD.

Conclusion

We reviewed the relevant data, considered the comments received, and determined that air safety and the public interest require adopting the AD with the changes described previously. We have determined that these minor changes:

Are consistent with the intent that was proposed in the NPRM (76 FR 64844, October 19, 2011) for correcting the unsafe condition; and

Do not add any additional burden upon the public than was already proposed in the NPRM.

We also determined that these changes will not increase the economic burden on any operator or increase the scope of the AD.

Costs of Compliance

We estimate that this AD will affect 387 CF6-45 and CF6-50 series turbofan engines installed on airplanes of U.S. registry. We also estimate that it will take about 8 work-hours to perform the HPT blade inspection, 6 work-hours to perform a vibration survey, 4 work-hours to perform an ultrasonic inspection, 2 work-hours to perform an EGT resistance check, 1 work-hour to perform an EGT thermocouple inspection, and 7 work-hours to clean and perform an fluorescent-penetrant inspection of the LPT rotor stage 3 disk for each engine. The average labor rate is $85 per work-hour. The cost estimate for the work just described was covered in the two ADs we are superseding. For this AD, we estimate that a replacement LPT rotor stage 3 disk prorated part cost is $75,000. Based on these figures, we estimate the total cost of this AD to U.S. operators to be $29,025,000.

Authority for This Rulemaking

Title 49 of the United States Code specifies the FAA's authority to issue rules on aviation safety. Subtitle I, Section 106, describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the Agency's authority.

We are issuing this rulemaking under the authority described in Subtitle VII, Part A, Subpart III, Section 44701, "General requirements." Under that section, Congress charges the FAA with promoting safe flight of civil aircraft in air commerce by prescribing regulations for practices, methods, and procedures the Administrator finds necessary for safety in air commerce. This

regulation is within the scope of that authority because it addresses an unsafe condition that is likely to exist or develop on products identified in this rulemaking action.

Regulatory Findings

We have determined that this AD will not have federalism implications under Executive Order 13132. This AD will not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government.

For the reasons discussed above, I certify that this AD:

(1) Is not a "significant regulatory action" under Executive Order 12866,

(2) Is not a "significant rule" under DOT Regulatory Policies and Procedures (44 FR 11034, February 26, 1979),

(3) Will not affect intrastate aviation in Alaska, and

(4) Will not have a significant economic impact, positive or negative, on a substantial number of small entities under the criteria of the Regulatory Flexibility Act.

List of Subjects in 14 CFR Part 39

Air transportation, Aircraft, Aviation safety, Incorporation by reference, Safety.

Adoption of the Amendment

Accordingly, under the authority delegated to me by the Administrator, the FAA amends 14 CFR part 39 as follows:

PART 39–AIRWORTHINESS DIRECTIVES

1. The authority citation for part 39 continues to read as follows:

Authority: 49 U.S.C. 106(g), 40113, 44701.

§ 39.13 [Amended]

The FAA amends § 39.13 by removing airworthiness directive (AD) 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011) and AD 2011-18-01, Amendment 39-16783 (76 FR 52213, August 22, 2011), and adding the following new AD:

2012-02-07 General Electric Company: Amendment 39-16930; Docket No. FAA-2010-0068; Directorate Identifier 2010-NE-05-AD.

(a) Effective Date

This airworthiness directive (AD) is effective March 6, 2012.

(b) Affected ADs

This AD supersedes AD 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011) and AD 2011-18-01, Amendment 39-16783 (76 FR 52213, August 22, 2011).

(c) Applicability

This AD applies to General Electric Company (GE) CF6-45A, CF6-45A2, CF6-50A, CF6-50C, CF6-50CA, CF6-50C1, CF6-50C2, CF6-50C2B, CF6-50C2D, CF6-50E, CF6-50E1, CF6-50E2, and CF6-50E2B turbofan engines, including engines marked on the engine data plate as CF6-50C2-F and CF6-50C2-R, with any of the low-pressure turbine (LPT) rotor stage 3 disk part numbers listed in Table 1 of this AD installed.

Table 1–Applicable LPT Rotor Stage 3 Disk Part Numbers

9061M23P06	9061M23P07	9061M23P08	9061M23P09	9224M75P01
9061M23P10	1473M90P01	1473M90P02	1473M90P03	1473M90P04
9061M23P12	9061M23P14	9061M23P15	9061M23P16	1479M75P01
1479M75P02	1479M75P03	1479M75P04	1479M75P05	1479M75P06
1479M75P07	1479M75P08	1479M75P09	1479M75P11	1479M75P13
1479M75P14	N/A	N/A	N/A	N/A

(d) Unsafe Condition

This AD was prompted by the determination that a new lower life limit for the LPT rotor stage 3 disks listed in Table 1 of this AD is necessary. We are issuing this AD to prevent critical life-limited rotating engine part failure, which could result in an uncontained engine failure and damage to the airplane.

(e) Compliance

Comply with this AD within the compliance times specified, unless already done.

(f) Borescope Inspections (BSI) of High-Pressure Turbine (HPT) Rotor Stage 1 and Stage 2 Blades

For the BSIs required by paragraphs (f)(1), (f)(2), and (f)(3) of this AD, inspect the blades from the forward and aft directions. Inspect all areas of the blade airfoil. Your inspection must include blade leading and trailing edges and their convex and concave airfoil surfaces. Inspect for signs of impact, cracking, burning, damage, or distress.

(1) Perform an initial BSI of the HPT rotor stage 1 and stage 2 blades within 10 cycles after the effective date of this AD.

(2) Thereafter, repeat the BSI of the HPT rotor stage 1 and stage 2 blades within every 75 cycles since last inspection (CSLI).

(3) Borescope-inspect the HPT rotor stage 1 and stage 2 blades within the cycle limits after the engine has experienced any of the events specified in Table 2 of this AD.

(4) Remove any engine from service before further flight if the engine fails any of the BSIs required by this AD.

Table 2–Conditional BSI Criteria

If the engine has experienced:	Then borescope-inspect:
(i) An exhaust gas temperature (EGT) above redline.	Within 10 cycles.
(ii) A shift in the smoothed EGT trending data that exceeds 18 °F (10 °C), but is less than or equal to 36 °F (20 °C).	Within 10 cycles.
(iii) A shift in the smoothed EGT trending data that exceeds 36 °F (20 °C)	Before further flight.
(iv) Two consecutive raw EGT trend data points that exceed 18 °F (10 °C), but is less than or equal to 36 °F (20 °C), above the smoothed average.	Within 10 cycles.
(v) Two consecutive raw EGT trend data points that exceed 36 °F (20 °C) above the smoothed average	Before further flight.

(g) Actions Required for Engines With Damaged HPT Rotor Blades

For those engines that fail any BSI requirements of this AD, before returning the engine to service:

(1) Remove the LPT rotor stage 3 disk from service; or

(2) Perform a fluorescent-penetrant inspection (FPI) of the inner diameter surface forward cone body (forward spacer arm) of the LPT rotor stage 3 disk as specified in paragraphs (l)(1)(i) through (l)(1)(iii) of this AD.

(h) EGT Thermocouple Probe Inspections

(1) Inspect the EGT thermocouple probe for damage within 50 cycles after the effective date of this AD or before accumulating 750 CSLI, whichever occurs later.

(2) Thereafter, re-inspect the EGT thermocouple probe for damage within every 750 CSLI.

(3) If any EGT thermocouple probe shows wear through the thermocouple guide sleeve, remove and replace the EGT thermocouple probe before further flight, and ensure the turbine mid-frame liner does not contact the EGT thermocouple probe.

(i) EGT System Resistance Check Inspections

(1) Perform an EGT system resistance check within 50 cycles from the effective date of this AD or before accumulating 750 cycles since the last resistance check on the EGT system, whichever occurs later.

(2) Thereafter, repeat the EGT system resistance check within every 750 cycles since the last resistance check.

(3) Remove and replace, or repair any EGT system component that fails the resistance system check before further flight.

(j) Ultrasonic Inspection (UI) of the LPT Rotor Stage 3 Disk Forward Spacer Arm

Within 75 cycles after the effective date of this AD, perform a UI of the forward spacer arm of the LPT rotor stage 3 disk. Use Appendix A of GE Service Bulletin (SB) No. CF6-50 S/B 72-1312, Revision 1, dated October 18, 2010, paragraph 4. except for paragraph 4.(12), to do the UI.

(k) Engine Core Vibration Survey

(1) Within 75 cycles after the effective date of this AD, perform an initial engine core vibration survey.

(2) Use about a one-minute acceleration and a one-minute deceleration of the engine between ground idle and 84% N2 (about 8,250 rpm) to perform the engine core vibration survey.

(3) Use a spectral/trim balance analyzer or equivalent to measure the N2 rotor vibration.

(4) If the vibration level is above 5 mils Double Amplitude then, before further flight, remove the engine from service.

(5) For those engines that fail any engine core vibration survey requirements of this AD, then before returning the engine to service:

(i) Remove the LPT rotor stage 3 disk from service; or

(ii) Perform an FPI of the inner diameter surface forward spacer arm of the LPT rotor stage 3 disk as specified in paragraphs (l)(1)(i) through (l)(1)(iii) of this AD.

(6) Thereafter, within every 350 cycles since the last engine core vibration survey, perform the engine core vibration survey as required in paragraphs (k)(1) through (k)(5) of this AD.

(7) If the engine has experienced any vibration reported by maintenance or flight crew that is suspected to be caused by the engine core (N2), perform the engine core vibration survey as required in paragraphs (k)(1) through (k)(5) of this AD within 10 cycles after the report.

(8) Vibration surveys carried out in an engine test cell as part of an engine manual performance run fulfill the vibration survey requirements of paragraphs (k)(2) through (k)(3) of this AD.

(l) Initial and Repetitive FPI of LPT Rotor Stage 3 Disks

(1) At the next shop visit after the effective date of this AD:

(i) Clean the LPT rotor stage 3 disk forward spacer arm, including the use of a wet-abrasive blast, to eliminate residual or background fluorescence.

(ii) Perform an FPI of the LPT rotor stage 3 disk forward spacer arm for cracks and for a band of fluorescence. Include all areas of the disk forward spacer arm and the inner diameter surface forward spacer arm of the LPT rotor stage 3 disk.

(iii) Remove the disk from service before further flight if a crack or a band of fluorescence is present.

(2) Thereafter, clean and perform an FPI of the LPT rotor stage 3 disk forward spacer arm, as specified in paragraphs (l)(1)(i) through (l)(1)(iii) of this AD, at each engine shop visit that occurs after 1,000 cycles since the last FPI of the LPT rotor stage 3 disk forward spacer arm.

(m) Removal of LPT Rotor Stage 3 Disks

Remove LPT rotor stage 3 disks listed in Table 1 from service as follows:

(1) For disks that have fewer than 3,200 flight cycles since new (CSN) on the effective date of this AD, remove the disk from service before exceeding 6,200 CSN.

(2) For disks that have 3,200 CSN or more on the effective date of this AD, do the following:

(i) If the engine has a shop visit before the disk exceeds 6,200 CSN, remove the disk from service before exceeding 6,200 CSN.

(ii) If the engine does not have a shop visit before the disk exceeds 6,200 CSN, remove the disk from service at the next shop visit after 6,200 CSN, not to exceed 3,000 cycles from the effective date of this AD.

(n) Installation Prohibition

(1) After the effective date of this AD, do not install or reinstall in any engine any LPT rotor stage 3 disk that exceeds the new life limit of 6,200 CSN.

(2) Remove from service any LPT rotor stage 3 disk that is installed or re-installed after the effective date of this AD, before the disk exceeds the new life limit of 6,200 CSN.

(o) Definitions

(1) For the purposes of this AD, an EGT above redline is a confirmed over-temperature indication that is not a result of EGT system error.

(2) For the purposes of this AD, a shift in the smoothed EGT trending data is a shift in a rolling average of EGT readings that can be confirmed by a corresponding shift in the trending of fuel flow or fan speed/core speed (N1/N2) relationship. You can find further guidance about evaluating EGT trend data in GE Company Service Rep Tip 373 "Guidelines For Parameter Trend Monitoring."

(3) For the purposes of this AD, an engine shop visit is the induction of an engine into the shop after the effective date of this AD, where the separation of a major engine flange occurs; except the following maintenance actions, or any combination, are not considered engine shop visits:

(i) Induction of an engine into a shop solely for removal of the compressor top or bottom case for airfoil maintenance or variable stator vane bushing replacement.

(ii) Induction of an engine into a shop solely for removal or replacement of the stage 1 fan disk.

(iii) Induction of an engine into a shop solely for replacement of the turbine rear frame.

(iv) Induction of an engine into a shop solely for replacement of the accessory gearbox or transfer gearbox, or both.

(v) Induction of an engine into a shop solely for replacement of the fan forward case.

(4) For the purposes of this AD, a raw EGT trend data point above the smoothed average is a confirmed temperature reading over the rolling average of EGT readings that is not a result of EGT system error.

(p) Previous Credit

(1) A BSI performed before the effective date of this AD using AD 2010-06-15, Amendment 39-16240 (75 FR 12661, March 17, 2010) or AD 2010-12-10, Amendment 39-16331 (75 FR 32649, June 9, 2010) or AD 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011) within the last 75 cycles, satisfies the initial BSI requirement in paragraph (f)(1) of this AD.

(2) A UI performed before the effective date of this AD using AD 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011) or GE SB No. CF6-50 S/B 72-1312, dated August 9, 2010 or GE SB No. CF6-50 S/B 72-1312 Revision 1, dated October 18, 2010, satisfies the inspection requirement in paragraph (j) of this AD.

(3) An engine core vibration survey performed before the effective date of this AD using AD 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011) or GE SB No. CF6-50 S/B 72-1313, dated August 9, 2010 or GE SB No. CF6-50 S/B 72-1313 Revision 1, dated October 18, 2010, within the last 350 cycles, satisfies the initial survey requirement in paragraphs (k)(1) through (k)(5) of this AD.

(4) An FPI of the LPT rotor stage 3 disk forward spacer arm performed before the effective date of this AD using AD 2011-18-01, Amendment 39-16783 (75 FR 52213, August 22, 2011), within the last 1,000 flight cycles of the LPT rotor stage 3 disk, satisfies the initial inspection requirements in paragraphs (l)(1)(i) through (l)(1)(iii) of this AD.

(q) Alternative Methods of Compliance (AMOCs)

(1) AMOCs previously approved for AD 2010-06-15, Amendment 39-16240 (75 FR 12661, March 17, 2010) are not approved for this AD. However, AMOCs previously approved for AD 2010-12-10, Amendment 39-16331 (75 FR 32649, June 9, 2010), AD 2011-02-07, Amendment 39-16580 (76 FR 6323, February 4, 2011), or AD 2011-18-01, Amendment 39-16783 (76 FR 52213, August 22, 2011) are approved for this AD.

(2) The Manager, Engine Certification Office, may approve alternative methods of compliance for this AD. Use the procedures found in 14 CFR 39.19 to make your request.

(r) Related Information

(1) For more information about this AD, contact Tomasz Rakowski, Aerospace Engineer, Engine Certification Office, FAA, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, MA 01803; phone: (781) 238-7735; fax: (781) 238-7199; email: tomasz.rakowski@faa.gov.

(2) For service information identified in this AD, contact General Electric Company, GE-Aviation, Room 285, 1 Neumann Way, Cincinnati, OH 45215, phone: (513) 552-3272; email: geae.aoc@ge.com. You may review copies of the referenced service information at the FAA, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, MA. For information on the availability of this material at the FAA, call (781) 238-7125.

(s) Material Incorporated by Reference

(1) You must use the following service information to do the UIs required by this AD, unless the AD specifies otherwise. The Director of the Federal Register approved the incorporation by reference (IBR) under 5 U.S.C. 552(a) and 1 CFR part 51 of the following service information on July 22, 2011: General Electric Company Service Bulletin No. CF6-50 S/B 72-1312 Revision 1, dated October 18, 2010.

(2) For service information identified in this AD, contact General Electric Company, GE-Aviation, Room 285, 1 Neumann Way, Cincinnati, OH 45215, phone: (513) 552-3272; email: geae.aoc@ge.com.

(3) You may review copies of the service information at the FAA, Engine & Propeller Directorate, 12 New England Executive Park, Burlington, MA. For information on the availability of this material at the FAA, call (781) 238-7125.

(4) You may also review copies of the service information that is incorporated by reference at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call (202) 741-6030, or go to: http://www.archives.gov/federal-register/cfr/ibr_locations.html.

Issued in Burlington, Massachusetts, on January 20, 2012.

Peter A. White,
Manager, Engine & Propeller Directorate,
Aircraft Certification Service.

This program and elements of the investigations are currently under the authority of the foreign Safety and Regulatory agencies, as well as the US FAA and NTSB. This data shall not be shared without authorization from the NTSB, FAA and GE Aviation.

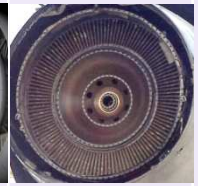
CF6-50 LPT Stage 3 Disk Separations

October 2015 Event Update

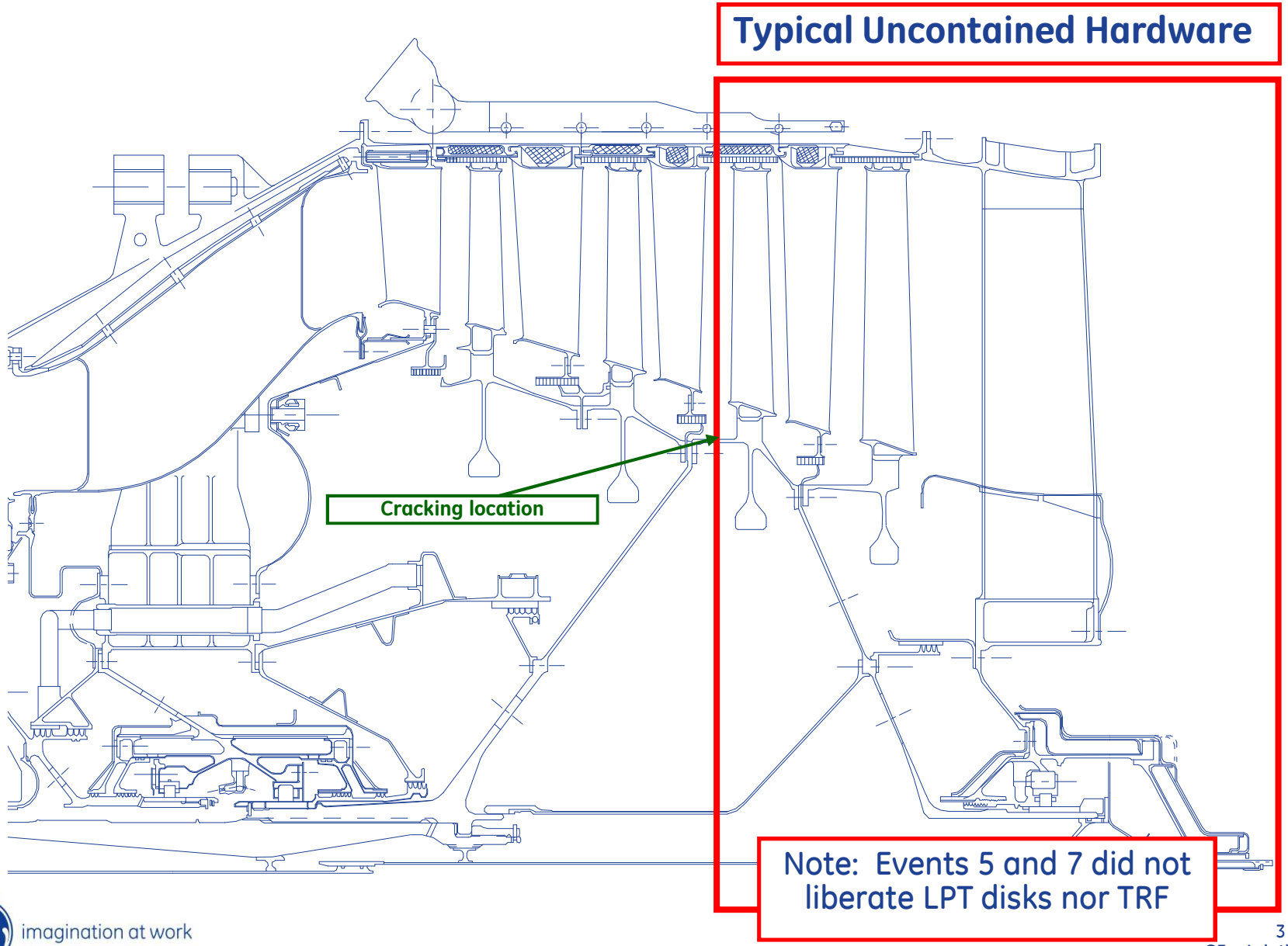
Ken Wolski
Investigator and Consulting Technologist
Accident Investigation and Fire Safety
GE Aviation – Flight Safety, Reliability and Human Factors

imagination at work

CF6-50 LPT Stage 3 Disk Separation Event History

Event #	1	2	3	4	5	6	7	8	9
Event Date	07/04/2008	03/26/2009	12/17/2009	04/10/2010	05/26/2010	07/17/2010	09/24/2010	06/18/2012	10/15/2015
Operator	Phuket A/L	Arrow Cargo	JETT8	ACT	MNG Cargo	Phuket A/L	Southern Air	Mahan Air	Mahan Air
Event Location	Saudi Arabia	Brazil	Singapore	Bahrain	Turkey	Egypt	Germany	Saudi Arabia	Iran
CAAM Level	2A / 2H	2A / 2H / 1B	2A / 2H	2A / 2D / 2G	2C	2A	**3A** / 2A	1B / 2H / ?? 2A or 3A	**3A** / 2A / 2H / 1B
Aircraft Type	B747-300	DC10-30F	B747-200F	A300B4F	A300b4F	B747-300	B747-300	B747-300	B747-300
Engine Pos.	**4**	2	4	2	2	**4**	3	4	3
ESN	455-898	455-278	517-816	517-671	455-771	530-200	517-856	517-669	530-322
Aircraft Tail	**HS-VAC**	N526MD	JA8172	TC-ACE	TC-MNC	**HS-VAC**	N758SA	EP-MND	EP-MNE
Investigative Teardown	No	Yes May 2009	Yes July 2010	Yes July 2010	Yes July 2010	No	No	TBD	TBD
Post Event Finding									
Significant Shop Findings	HPT distress & high calculated imbalance	HPT distress, high imbalance, EGT system distress	HPT distress, high calculated imbalance	High HPT imbalance	High HPT imbalance	n/a	n/a	TBD	TBD

LPT Separation



Previous Engine Event Findings

Event #1 ESN 455-898 (B747, Position 4)

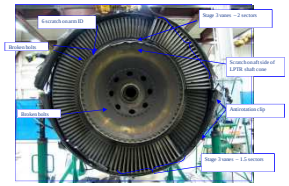
LPT

Engine Cowling

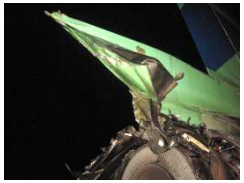
LPT S3 & S4 Disk

TRF & Centerbody

Event #2 ESN 455-278 (DC10, Position 2)



LPT



Engine Cowling

LPT S3 & S4 Disk

TRF & Centerbody

Event #3 ESN 517-816 (B747, Position 4)

LPT

Engine Cowling

Not Recovered
Lost at Sea

LPT S3 & S4 Disk

Not Recovered
Lost at Sea

TRF & Centerbody

Previous Engine Event Findings

Event #4 ESN 517-671 (A300B4, Position 2)

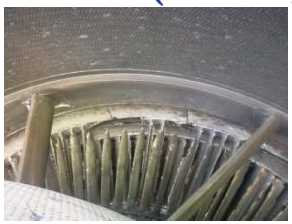
LPT

Engine Cowling

LPT S3 & S4 Disk

TRF & Centerbody

Event #5 ESN 455-771 (A300B4, Position 2) **771 (A300B4, Position 2)**



LPT

Engine Cowling

LPT S3 & S4 Disk

TRF & Centerbody

Event #6 ESN 530-200 (B747, Position 4)

LPT

Engine Cowling

LPT S3 & S4 Disk

TRF & Centerbody

Previous Engine Event Findings

Event #7 ESN 517-856 (B747, Position 3)

LPT

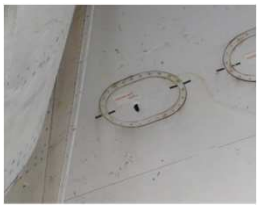
Engine Cowling

LPT S3 & S4 Disk

TRF & Centerbody

Event #8 ESN 517-669 (B747, Position 4)

LPT



Aircraft Damage

LPT S3 & S4 Disk

TRF & Centerbody

Event #9 ESN 530-322 (B747, Position 3)

LPT

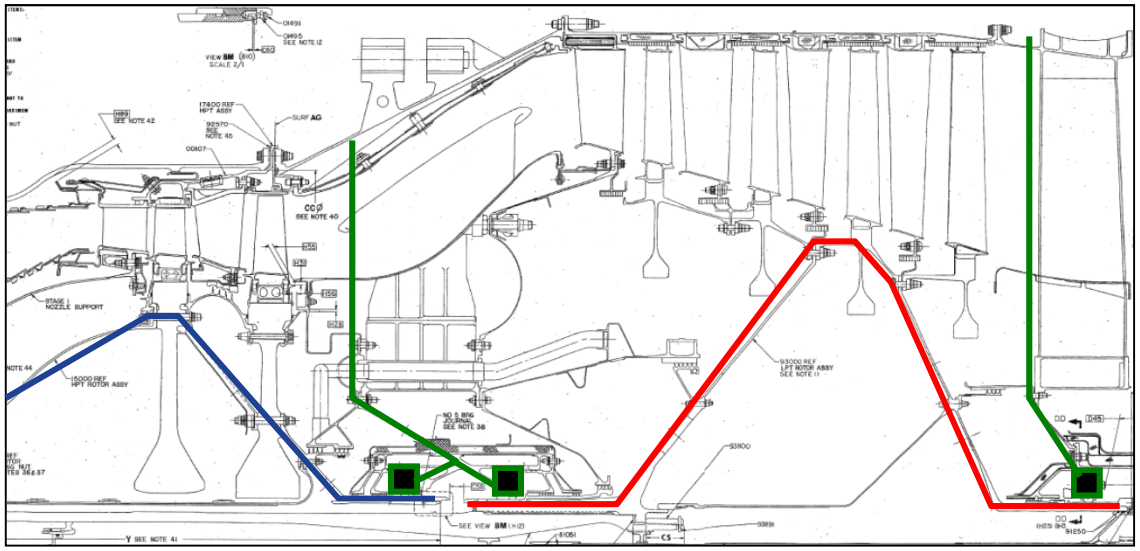
Engine Cowling

Aircraft Damage

TRF & Centerbody

TRF & Centerbody

Root Cause



High HPTR imbalance causes secondary vibratory damage in the LPTR

Loads are transmitted between the HP and LP systems through a common sump (#5R & 6R bearing sump)

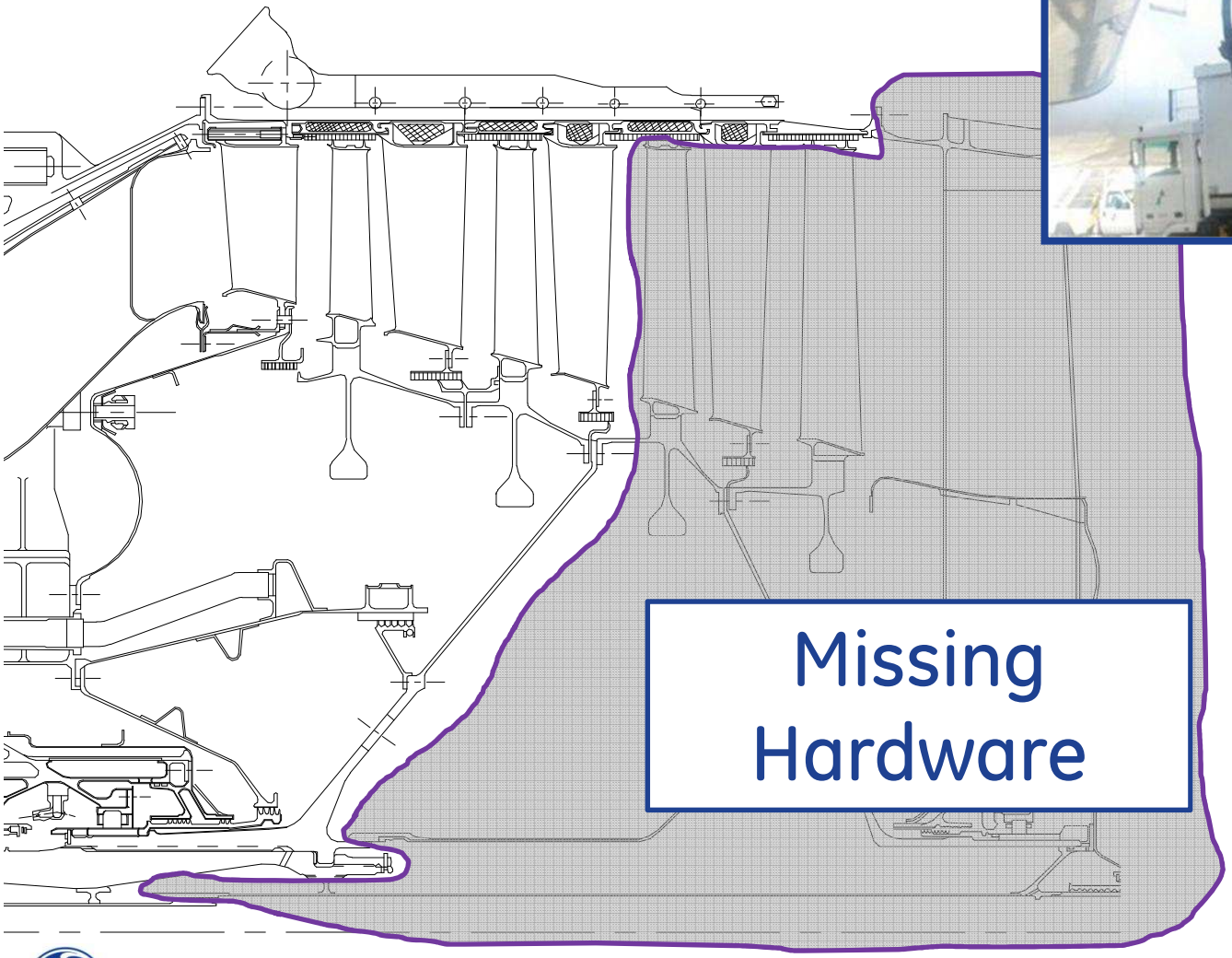
LPT S3 blade-disk vibratory mode excited by HPTR imbalance:

- Bladed disk vibratory mode level just above engine ground idle

HCF crack initiates/propagates in LPT S3 disk forward spacer arm

Continued engine operations can lead to 360° crack and separation of LPT

Event # 9 – Mahan Air



Event # 9 – Mahan Air – Aircraft Damage

Containment Programs Summary

On-wing containment

SB 72-1307 R1 – 75 cycle BSI + mx program

Issued 11/25/2009 R1 Issued 5/10/2010

SB 72-1312 R1 – On-wing ultrasonic inspection of LPTR S3 disk

Issued 8/9/2010 R1 Issued 10/18/2010

SB 72-1313 R1 – On-wing vibration survey for HPTR imbalance

Issued 8/9/2010 R1 Issued 10/18/2010

Shop program

SB 72-1309 R1

Issued 6/3/2010 R1 Issued 8/8/2011

Every shop visit:

- *Piece-part FPI of LPT stage 3 disk, or*
- *USI inspection of LPT S3 disk at assembled engine*

FAA Airworthiness Directive 2012-02-07

Issued 01/11/2012

- *Established a new lower life limit on old design stage 3 disk*
- *Introduces a draw down plan for the removal of the old design disks from service*

Final Corrective Action Summary

LPT Stage 3 Disk re-design

- SB 72-1315 R1 – New redesign LPT stage 3 disk
  Issued 5/24/2011 R1 Issued 6/30/2011
- SB 72-1318 – Repetitive on wing EGT system check for engines with new redesign disk
  Issued 5/24/2011
- SB 72-1317 – Repetitive on wing BSI of HPT Blades at 450 cycles for engines with new redesign disk
  Issued 5/24/2011
- SB 72-1316 – Repetitive on wing vibration test for engines with new redesign disk
  Issued 5/24/2011