ACCIDENT REPORT

ACCIDENT

occurred to the Boeing B737-800AS aircraft

registration marks EI-DYG

Rome Ciampino airport

November 10th 2008

NOTE : This is an English unofficial translation by

AVIATION ACCIDENTS

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OBJECTIVE OF THE SAFETY INVESTIGATION

The National Agency for Flight Safety (ANSV), established by Legislative Decree 25 February 1999 n. 66, identifies with the civil aviation safety investigation authority of the Italian State, pursuant to art. 4 of the EU regulation n. 996/2010 of the European Parliament and of the Council of 20 October 2010. **It independently conducts safety investigations.**

Every accident and every serious inconvenience caused to a civil aviation aircraft is subject to safety investigation, within the limits set by the combined provisions set out in paragraphs 1 and 4 of the art. 5 of EU regulation no. 996/2010.

A safety investigation refers to a set of operations including collection and analysis data, the drawing up of conclusions, the determination of the cause and/or of concurrent factors and, where appropriate, the formulation of safety recommendations.
The only objective of the safety investigation is to prevent future accidents and inconvenience, not in attributing fault or liability (Article 1 (1) of the EU Regulation n. 996/2010). Consequently, it is conducted independently and separately from investigations (such as that of the judicial authority) aimed at ascertaining fault or responsibility.
The safety investigation is conducted in compliance with the provisions of Attachment 13 to International Civil Aviation Convention (signed in Chicago on 7 December 1944, approved and enforced in Italy by legislative decree 6 March 1948, n. 616, ratified with the law 17 April 1956, n. 561) and by the EU regulation no. 996/2010.
Each safety investigation concludes with a report prepared in an appropriate form to the type and the gravity of the accident or of the serious inconvenience. It may contain, where appropriate, safety recommendations, which consist of a proposal formulated for prevention purposes. **A safety recommendation does not in itself constitute a presumption of fault or an assignment of responsibility for an accident, a serious inconvenience or an inconvenience (Article 17, paragraph 3, EU regulation No. 996/2010).**
The report guarantees the anonymity of those involved in the accident or in the serious drawback (Article 16 (2) of EU Regulation No. 996/2010).

NB The incident that was the subject of this investigation report took place prior to the entry into force of the EU regulation no. 996/2010. The related investigation (already called "technique") was consequently applied to the related investigation previous legislation the aforementioned EU regulation no. 996/2010.

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GLOSSARY

(A): Airplanes.
AAIU (Ireland): Air Accident Investigation Unit, Irish Investigation Authority for Safety of civil aviation.
AAL: Above Aerodrome Level, above the airport level.
ACC: Area Control Center or Area Control, Regional Control Center or Region Control.
ADIRS: Air Data Inertial Reference System.
ADIRU: Air Data Inertial Reference Unit.
AFDS: Autopilot Flight Director System.
AGL: Above Ground Level, above ground level.
AIP: Aeronautical Information Publication, Publication of aeronautical information.
ALD: Actual Landing Distance.
ALS: Approach Lighting System, approach light system.
AM: Italian Air Force.
AMSL: Above Mean Sea Level, above average sea level.
ANSV: National Agency for Flight Safety.
AOA: Angle of Attack, angle of attack.
AOC: Air Operator Certificate, Air Operator Certificate (COA).
A/P: AutoPilot, autopilot.
APP: Approach control office or Approach control or Approach control service approach or approach control or approach control service.
ARP: Airport Reference Point.
ASDA: Accelerate-Stop Distance Available, distance available for acceleration-stop.
A/T: Autothrottle, automanetta.
ATC: Air Traffic Control, air traffic control.
ATPL: Airline Transport Pilot License, pilot pilot license.
ATS: Air Traffic Services, air traffic services.
AW: Acoustic Warning, alarm horn.
BCU: Bird Contol Unit, bird control unit.
BEA: Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile, Investigative Authority French for civil aviation safety.
BIRDTAM: Bird To Air Man, NOTAM related to avifauna.
BRIEFING: preventive description of maneuvers or procedures.
CAS: Computed Air Speed.
CAT I, CAT II, CAT III: categories of instrument approach.
CAVOK: Ceiling and Visibility OK, visibility, clouds and present time better than values or values prescribed conditions.
CDP: High Pressure Compressor Discharge Pressure.
CDS: Common Display System.
CHECK LIST (also written **CHECKLIST**): list of controls.
COCKPIT: cockpit.
CPL: Commercial Pilot License, commercial pilot license.
CPT: Captain, commander.
CRM: Crew Resource Management, is defined as the effective use by the crew of flight, of all available resources, in order to ensure efficient and safe flight operations.
CTA: air traffic controller.
CVR: Cockpit Voice Recorder, communications recorder, voices and noises in the cockpit.
DCA: Airport district management.
DH: Decision Height, decision height.
DME: Distance Measuring Equipment, distance meter apparatus.
DOC: document.
DOT: measure of deviation from a descent or route path.
DU: Display Unit.
EASA: European Aviation Safety Agency, European Aviation Safety Agency.
EEC: Electronic Engine Control, electronic engine control.

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EFIS: Electronic Flight Instrument System, integrated onboard instrumentation system electronic.
EGT: Exhaust Gas Temperature, engine exhaust gas temperature.
ENAC: National Agency for Civil Aviation.
ENAV SPA: National Society for Flight Assistance.
FAA: Federal Aviation Administration, US Civil Aviation Authority.
FADEC: Full Authority Digital Engine Control, automatic parameter control system e performance of an aeronautical engine.
F/C: Flight Cycle, operating cycles.
FCOM: Flight Crew Operating Manual.
FCTM: Flight Crew Training Manual.
FD: Flight Director.
FDMAS: Flight Data Management Automated System.
FDR: Flight Data Recorder, analogue flight data recorder.
F/H: Flight Hours, flight hours.
FI: Flight Instructor, flight instructor.
FL: Flight Level, flight level.
FMA: Flight Mode Annunciator.
FMC: Flight Management Computer.
FMS: Flight Management System.
FO: First Officer, first officer (co-pilot).
FPL: Flight Plan, flight plan.
FT: Foot (unit), unit of measure, 1 ft = 0.3048 meters.
GND: Ground, soil.
GPWS: Ground Proximity Warning System, ground proximity warning system.
G/S: Glide Slope (or GP, Glide Path), descent path (component of the ILS system).
GS: Ground Speed, ground speed.
HPA: Hectopascal, unit of measurement of the pressure equal to about a thousandth of atmosphere.
HPC: High Pressure Compressor, high pressure compressor.
IAS: Indicated Air Speed, indicated speed with respect to air.
IATA: International Air Transport Association.
ICAO / OACI: International Civil Aviation Organization, Civil Aviation Organization international.
IDLE: position of the levers that control the engine power corresponding to the minimum speed.
IFR: Instrument Flight Rules, instrument flight rules.
ILS: Instrument Landing System, instrument landing system.
IR: Instrument Rating, instrumental flight qualification.
ISA: International Standard Atmosphere.
JAA: Joint Aviation Authorities.
KT: Knot (knot), unit of measure, nautical mile (1852 meters) per hour.
LDA: Landing Distance Available, distance available for landing.
LE: Leading Edge.
LOC: Localizer, locator (component of the ILS system).
MCT: Max Continuous Thrust, continuous maximum thrust.
MDA: Minimum Descent Altitude.
MEP: Multi Engine Piston, enabling to drive multi-engine aircraft with an alternative engine.
METAR: Aviation routine weather report, routine meteorological observation message.
MHZ: Megahertz.
MSA: Minimum Sector Altitude, minimum sector altitude.
MTOM: Maximum Take Off Mass, maximum takeoff mass.
ND: Navigation Display.
NDB: Non-Directional Beacon radio, adirectional beacon.
NM: Nautical Miles, nautical miles (1 nm = 1852 meters).
NNC: Not Normal Checklist.
NOTAM: Notice To Air Men, notices for personnel interested in flight operations.
NTSB: National Transportation Safety Board, US Safety Investigation Authority of transport.
OCA: Obstacle Clearance Altitude.
OCH: Obstacle Clearance Height.

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OM: Operations (or Operating) Manual.
OM: Outer Marker, external marker.
PA: Public Address, a communication system for passengers.
PAPI: Precision Approach Path Indicator, optical slope indicator for approaching precision.
PF: Pilot Flying, pilot that drives the controls.
PFD: Primary Flight Display, main flight data screen.
PM: Pilot Monitoring, also called, alternatively, PNF.
P/N: Part Number.
PNF: Pilot Not Flying, pilot assisting the PF.
QNH: altimetric adjustment to read the altitude of the airport on the ground.
RA: Radio Altimeter (or Radar Altimeter), radio altimeter.
RLD: Required Landing Distance.
RPM: revolutions per minute.
RWY: Runway, runway.
SEP: Single Engine Piston, enabling to drive single-engine aircraft with engine alternative.
SITUATIONAL AWARENESS: the perception of the environmental elements is defined as such a certain interval of space and time, an understanding of their meaning and projection of their state in the immediate future.
SMS: Safety Management System.
SMYD: Stall Management Yaw Damper.
S / N: Serial Number.
SOC: Operational Safety and flight control.
RUNWAY THRESHOLD (**THR**): the beginning of the part of the runway that can be used for landing.
SOP: Standard Operating Procedures.
SRGC: Safety Recommendation of Global Concern.
SRUR: Safety Recommendation of Union-wide Relevance.
STAR: Standard Instrument Arrival, standard instrumental arrival.
SV: Synthetic Voice, audio warning with a synthetic voice.
T / B / T: ground-airplane-ground radio communications.
TE: Trailing Edge.
HEAD: term to identify the initial part of a runway.
THR: Threshold, see "threshold" of the runway.
TODA: Take-Off Distance Available, distance available for take-off.
TO / GA or TOGA: Take Off / Go Around.
TORA: Take-Off Run Available, run available for take-off.
T/R: Thrust Reverse, thrust reverser.
TRI: Type Rating Instructor, instructor for the type rating.
TWR: Aerodrome Control Tower, Airport Control Tower.
TWY: Taxiway, route of circulation or taxiway.
UOC: Current operations office.
UTC: Universal Time Coordinated, coordinated universal time.
VFR: Visual Flight Rules, visual flight rules.
VHF: Very High Frequency (from 30 to 300 MHz), very high frequency (from 30 to 300 MHz).
VMC: Visual Meteorological Conditions, visual meteorological conditions.
VNL: limitation on the medical certificate: the person concerned must have corrective glasses for near vision and bring a pair of spare glasses.
VOR: VHF Omnidirectional radio Range, omnidirectional beacon in VHF.
VREF: Velocity of Reference, reference speed for landing.
VS: Vertical Speed, vertical speed.
VVF: Firefighters.
WOW: Weight on Wheel, the weight of the aircraft on the landing gear.

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FOREWORD

The accident occurred on 10 November 2008, at 06.56 '(07.56' local), on the Rome Ciampino airport and involved the aircraft type B737-8AS registration marks EI-DYG.
On 10 November 2008, at 05.30 ', the aircraft Boeing 737-8AS EI-DYG took off from Frankfurt Hahn airport (EDFH) to Rome Ciampino (LIRA), with 166 passengers and 6 crew members on board.
When approaching the destination airport, in a very short final, collided with a big flock of starlings.
At the sighting of the birds, the crew interrupted the landing procedure and performed a go-around maneuver, but both engines did not deliver the needed thrust for the maneuver; as a result, the aircraft rapidly lost speed and altitude and impacted heavily the runway. In the ground run, the left main landing gear was detached from its own anchorages and the lower part of the fan cowl of the left engine came into contact with the runway.
The aircraft continued its run on the ground until it was completely stopped, at the height of threshold RWY 33.
The 6 crew members and the 166 passengers carried out the evacuation of the aircraft without further inconveniences.
The ANSV was informed of the incident immediately after the event by ENAV SpA and has carried out an operational inspection at the accident site on the day of the event with a own team of investigators.
The ANSV has sent the notification of the event concerned, in accordance with the international law (Annex 13 to the International Civil Aviation Convention), to the following subjects: ICAO, NTSB, BEA, AAIU.
NTSB, BEA, and AAIU accredited their representatives in the investigation conducted by ANSV.
The significant delay in the publication of this report is unfortunately due to one side, to the cessation from the service of the various investigators, who, over time, have alternated in the role of investigators in charge (that is, coordinators of the investigation), on the other, to the known critical understaffing of ANSV.

All times shown in this investigation report, unless otherwise specified, are expressed in UTC time (Universal Time Coordinated), which, at the date of the event, corresponded to local time minus 1h.

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CHAPTER I - INFORMATION ON FACTS

1. GENERAL

Here will be explained the objective elements collected during the safety investigation.

1.1. HISTORY OF THE FLIGHT

On 10 November 2008, at 05.30 ', the aircraft Boeing 737-8AS reg. marks EI-DYG, ATC callsign RYR41CH, took off from Frankfurt Hahn airport (EDFH) bound to Rome Ciampino (LIRA), with 166 passengers on board and 6 crew members.

The flight took place without any significant event until the approach to the destination airport.

The aircraft established the first radio contact with the TWR of Ciampino, communicating of being at 9 NM from the runway and established on ILS for RWY 15.

The aircraft, regularly authorized and configured, continued to land, when, in a very short final, collided with a large flock of birds (afterward identified in starlings).

The crew aborted the landing procedure, performing a go-around.

With both engines that did not deliver the necessary thrust and the flight set-up for the climb, the aircraft quickly lost speed and altitude, impacting heavily the runway near the "AC" taxiway.

After the first contact with the runway, which occurred with the main landing gear regularly extended and with the lower part of the tail section of the fuselage, the left main carriage, during the landing run, detached from its anchorages and the lower part of the fan cowl of the left engine came in contact with the runway.

The aircraft stopped near the threshold of RWY 33.

The fire-fighting equipment immediately reached the aircraft and the fire brigade sprayed extinguishing foam around, especially in the area in where the engine's fan cowl had come into contact with the runway.

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Subsequently, the Captain ordered the disembarkation of the passengers and the crew through a ladder from the front right door, to which was added, at a later time, activation and use of the right rear door slide.

1.2. INJURIES

Injuries	Crew	Passengers	Total on board	Other
Fatal				
Serious				
Minor	2	6	8	
None	4	160	164	
Total	6	166	172	

1.3. DAMAGES TO THE AIRCRAFT

The left main landing gear was torn from its anchors, with its main leg that perforated out of the wing.
The fan cowl of the left engine was in contact with its lower part with the runway, the panels (doors) of the reverse thrust were in open position.
The lower part of the fuselage, in the tail sections, showed evident signs of creep and deformation of the structure due to contact with the runway.
There were also undulations of deformation of the floor structure of the passenger cabin.
On the radome and on the front of the fuselage, the leading edge of the axles, belly of the flaps, engine fan cowls and landing gears, no less than 86 impact points of birds have been identified.
On the engines fan blades, they were visible huge and numerous organic debris and bird feathers.

1.4. OTHER DAMAGES

Six passengers and two crew members have suffered back pains following the disembarkation from the aircraft and, after being visited at the "First Aid Rome Airports " at Ciampino airport, were transferred, with an ambulance, at hospital centers for further investigations.

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1.5. INFORMATION RELATING TO CREW

1.5.1.Flight crew

Captain

General:	male, 44 years of age, Belgian nationality.
License:	ATPL (A) valid.
Ratings:	B737 300-900, FI (A), TRI (A), TMG, SEP (land).
Other ratings:	TRI (A) B737 300-900.
Other qualifications:	radiotelephony in English.
Recurrent checks:	B737 300-900 carried out on 10.7.2008.
Medical check:	first-class medical certificate, with VNL limitation.

Flight experience of the Captain: the pilot was employed, as commander, at the aircraft operator involved in the aircraft's accident, for about 3 years. Previously he had been hired by another operator on the same type of aircraft B737, becoming familiar also with the Rome Ciampino airport.
The commander had a TRI qualification on aircraft type B737 300-900, although he did not have any instructional duties with the operator involved in the event. At the time of the accident, he had total flight activity of 9883h, of which 6045h on aircraft type B737.
The flight of the accident was, for the commander, the first of the day.
The commander was on his second day of service: he had, in fact, up to the previous day 5 days rest period.

First officer

Generality:	male, 23 years of age, Dutch nationality.
License:	CPL (A) valid.
Ratings:	B737 300-900, SEP (land), MEP (land), ME IR (SPA), ME IR (MPA).
Other qualifications:	radiotelephony in English.
Recurrent checks:	B737 300-900 carried out on 26.10.2008.
Medical check:	first-class medical certificate valid.

First officer's flight experience: the pilot was employed as the first officer by the aircraft operator involved in the accident, for about 6 months (May 2008).
The pilot had obtained the commercial pilot license of aircraft on 3 April 2008 and had taken the theoretical exam for the license of a pilot of an aircraft line to a JAA Member State. The pilot had subsequently achieved the qualification on type B737 300-900 on 24 April 2008, about 7 months before the accident. At the time of the

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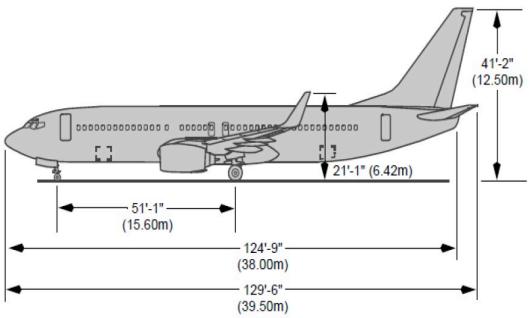
accident, he had a total flying activity of 600h, of which about 400h on standard aircraft B737.

During the investigation, it was found that for the First Officer was the first flight of the day.
The first officer was on his third day of service after having enjoyed a rest period.

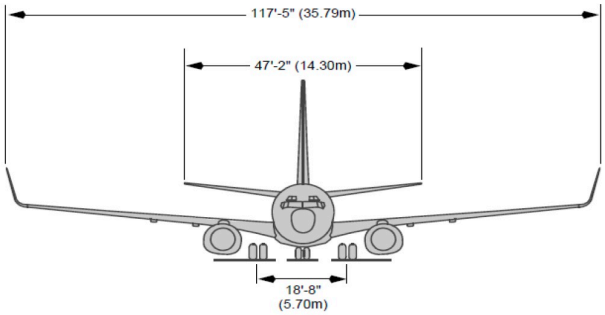
1.6. AIRCRAFT INFORMATION

1.6.1.General pieces of information

The aircraft B737-800AS (AS identifies the name of the operator) is built by Boeing Company and is an aircraft used for commercial transport, low wing equipped with winglets, with mainly metallic structure and retractable tricycle landing gear; the aircraft is equipped with two turbofan engines CFM56-7B26 / 3.
Its dimensions are shown in the two following figures; the MTOM is equal to 74.990 kg.



Picture 1 : longitudinal dimensions



Picture 2 : B737-800 front and vertical dimensions

1.6.2.Specific information

Aircraft

Manufacturer:	Boeing Company, Seattle (USA).
Template:	737-8AS.
Building number:	33639.
Year of construction:	2008.
Registration:	EI-DYG.
Certificate of registration:	Irish Aviation Authority, n. 4959 of March 25, 2008.
Operator:	Ryanair Limited.
Airworthiness certificate:	Irish Aviation Authority, n. 2328, 25 March 2008.
Certificate of airworthiness review:	Irish Aviation Authority, ARC n. 2328, expiry 24 March 2009.
Total hours of the airframe:	2419 F / H.
Total cycles:	1498 F / C.
Hours from last inspection:	152 F / H 100 F / C (check C, October 27, 2008).

Compliance of technical documentation with current legislation/directives: yes.

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Engines

Manufacturer: CFM.

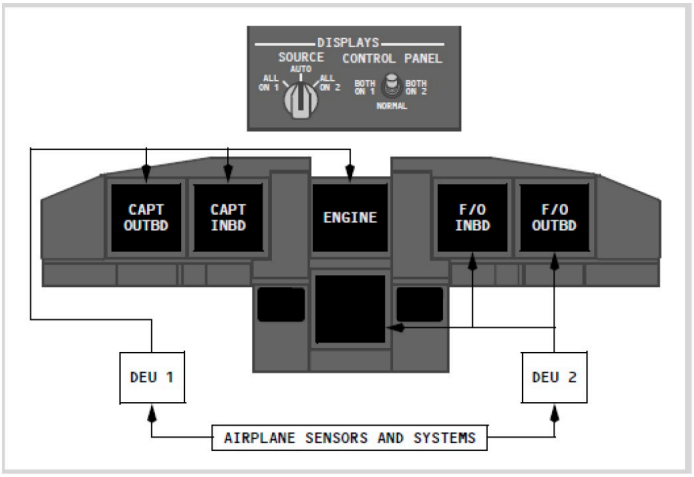
Model: CFM56-7B26 / 3.

Engine	S/N	Year of construction	Date of installation	Total hours (TSN)	Hours since last revision (TSO)	Hours since last scheduled maintenance	Hours since last non scheduled maintenance
1	896379		March 2008	2419 h	2419 h		
1	896379		March 2008	2419 h	2419 h		

1.6.3.Additional information

Systems available on board

The B737-8AS is an aircraft equipped with EFIS instrumentation. The CDS provides the information to the crew through six DU units consisting of a flat panel and liquid crystal panels. The 4 units placed in front of the pilot's area the PFD and the ND. The 2 units placed centrally are the primary indications of the engines (upper unit) and the indications of engines and onboard systems (lower unit).



Picture 3 : six DU units.

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The navigation system includes FMS, GPS (two receivers), ADIRS (two platforms independent), radio navigation system (one ADF, two DME, two ILS, marker beacon, two VORs), transponders and weather radar.
The integrated FMS allows centralized control of the aircraft flight path as well as performance parameters. The FMC is the heart of the system and performs the computation for navigation and for the performance of the aircraft, providing control and control commands guide. The commands for navigation are sent to autothrottle, autopilot and flight director.
The aircraft is certified for ILS operations in CAT II-III with automatic landing (autoland).

Go-Around mode

The AFDS provides indications for FLYING the go around in the "GO AROUND" mode ".

This mode (GA) is activated by pressing one of the two TO / GA switches positioned on the throttles (figure 4). If both autopilots are disarmed, the go around manual F / D mode, under the following conditions:
- in flight under 2000 feet RA;
- in flight above 2000 feet RA, with flaps not in UP or G / S captured position;
- not in T / O mode.

At the first pressure of one of the two TO / GA switches:
- the A/T (if armed) switches to GA and increases the thrust to the value of N1 reduced go around, such as to generate 1000/2000 feet/minute of climb rate;
- the A/T engaged mode annunciation on the FMA indicates GA;
- the AP (if inserted) switches off;
- the pitch mode switches to TO / GA and the pitch engaged mode annunciation on the FMA indicates TOGA;
- the F/D pitch controls 15 degrees nose up until reaching the climb rate programmed, then controls the speed to be reached for each flap selection with reference to the MAX T / O weight;
- the F/D roll controls the ground path of the approach at the time of activation;
- the command airspeed cursor is positioned at the airspeed target for the position of the present flaps configuration.

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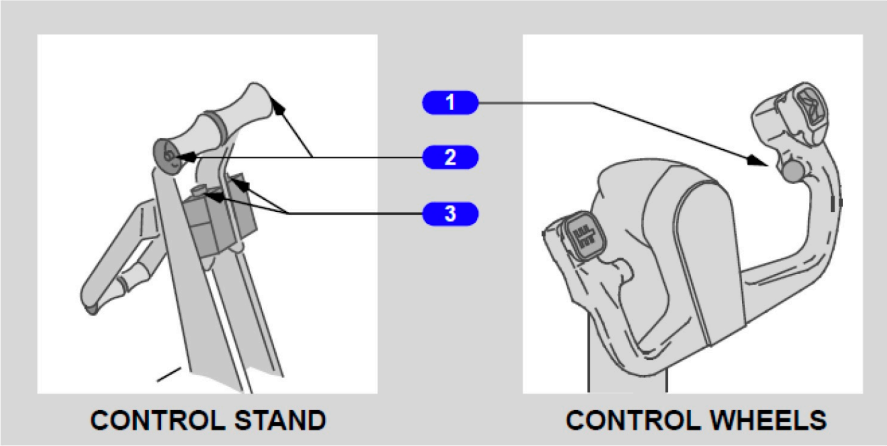
at the second press of one of the two TO / GA switches (if the A / T is inserted and after the A / T has reached the reduced go around thrust):

- the A / T advances to the N1 limit of full go-around N1.



Picture 4 : Go-around pushbutton

Flap system

Below is a brief description of the flap system extracted from the Boeing 737-8AS FCOM, vol. 2.

"Flaps and Slats. The flaps and slats are high lift devices decrease stall speed during takeoff, low-speed maneuvering and landing. LE devices consist of flaps and eight slats: two flaps inboard and four slats outboard of each engine. Slats extend to form a sealed or slotted leading edge depending on the TE flap setting. The TE devices consisting of double slotted flaps inboard and outboard of each engine. [omissis].

TE flap positions 1-15 provide increased lift; positions 15-40 provide increased lift and drag. Flap positions 30 and 40 are normal landing flaps positions.

To prevent excessive structural loads from increased Mach at higher altitude, flap extension above 20,000 feet should not be attempted.

Flap and Slat Sequencing. LE devices and TE flaps are normally extended and retracted by hydraulic power from system B. When the FLAP lever is in the UP detent, all flaps and LE devices are commanded to the retracted or up position. Moving the FLAP lever aft allows selection of flap detent positions 1, 2, 5, 10, 15, 25, 30 or 40. The LE devices deployment is sequenced as a function of TE flaps deployment.

When the FLAP lever is moved from the UP position to the 1, 2, or 5 positions, the TE flaps extend to the commanded position and the LE:

- flaps extended to the fully extended position
- slats extend to the extended position.

When the FLAP lever is moved beyond the 5 positions, the TE flaps extend to the commanded position and the LE:

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• flaps remain at the fully extended position
• slats extend to the fully extended position.
The LE devices sequence is reversed upon retraction.
Mechanical gates hinder inadvertent FLAP lever movement beyond flaps 1 for one engine inoperative go-around and flap 15 for a normal go-around. "

Photo 1: a flap control lever

Stall Warning System

Below is a brief description of the Stall Warning System, extracted from the Boeing 737-8AS FCOM, vol. 2.
«Natural stall warning (buffet) usually occurs at a speed prior to stall. In some configurations, the margin between the stall and the natural stall warning is less than desired.
Therefore, an artificial stall warning device, a stick shaker, is used to provide the required warning.
The stick warning "stick shaker" consists of two eccentric weight motors, one on each control column. They are designed to alert the pilots before a stall develops. The warning is given by vibrating both control columns. The system is armed in flight at all times. The system is deactivated on the ground.
Two independent, identical stall management yaw damper (SMYD) computers determine when a stall warning is required based upon:

• alpha vane angle of attack outputs
• ADIRU outputs
• anti-ice controls
• wing configurations
• air/ground sensing
• thrust
• FMC outputs.

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The SMYD computers provide outputs for all the stall warning to include stick shaker and signals to the pitch limit indicator and airspeed displays and the GPWS wind shear detection and alert. "

Automatic DH / MDA achievement warning system

Below is an excerpt from the Boeing 737-8AS FCOM, vol. 2, related to DH / MDA Callouts.

«The GPWS provides height-based callouts set by the Captain's Minimums selector.

Callouts are based on radio altitude when the MINS is set to RADIO.

Callouts are based on barometric altitude when the MINS selector is set to BARO:

- DH / MDA plus 100 feet - PLUS HUNDRED
- at DH / MDA - MINIMUMS. ».

Advisory Information: Normal configuration landing distance

The QRH of the B737, in the section relating to the Performance In flight, shows a table, that is of help ("Advisory Information") to determine the Landing Distance in different conditions (table 1).

ADVISORY INFORMATION

Normal Configuration Landing Distances

Flaps 40

Dry Runway

	LANDING DISTANCE AND ADJUSTMENT (M)											
	REF DIST	WT ADJ	ALT ADJ	WIND ADJ PER 10 KTS		SLOPE ADJ PER 1%		TEMP ADJ PER 10°C		VREF ADJ	REVERSE THRUST ADJ	
BRAKING CONFIGURATION	60000 KG LANDING WEIGHT	PER 5000 KG ABOVE/ BELOW 60000 KG	PER 1000 FT ABOVE SEA LEVEL	HEAD WIND	TAIL WIND	DOWN HILL	UP HILL	ABV ISA	BLW ISA	PER 10 KTS ABOVE VREF40	ONE REV	NO REV
MAX MANUAL	860	55/-45	15/25	-30	110	10	-10	15	-15	65	15	30
MAX AUTO	1070	60/-55	20/30	-40	135	5	-5	25	-25	95	0	0
AUTOBRAKE 3	1485	100/-95	35/50	-65	225	5	-5	40	-40	160	0	0
AUTOBRAKE 2	1910	140/-135	55/70	-90	315	25	-30	50	-50	175	35	35
AUTOBRAKE 1	2115	165/-160	65/85	-105	370	50	-60	60	-60	160	155	205

- Reference distance is for sea level, standard day, no wind or slope, VREF40 approach speed and two engine detent reverse thrust.
  Max manual braking data valid for auto speedbrakes. Autobrake data valid for both auto and manual speedbrakes.
  For max manual braking and manual speedbrakes, increase reference landing distance by 55 m.
  Distances for GOOD, MEDIUM, and POOR are increased by 15%.
  Includes distance from 50 ft above threshold (305 m of air distance).
  *For landing distance at or below 8000 ft pressure altitude, apply the STD adjustment. For altitudes higher than 8000 ft, first apply the STD adjustment to derive a new reference landing distance for 8000 ft then apply the HIGH adjustment to this new reference distance.

Table 1 : configurations and corrections for Landing distance

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Considering the mass of the aircraft landing at 61,100 kg, a component of 5-node tailwind, a Vref speed of 10 knots, a temperature of about 10 ° C under the ISA, dry runway, max manual braking, use of T / Rs and a height on the 100 foot threshold (50 feet above the expected glide path), the Landing Distance it is about 1341 m.

1.7. METEOROLOGICAL INFORMATION

The weather bulletins in force at the time of the accident did not detect particular anomalies or critical issues related to weather conditions in progress at the time accident. In fact, they were characterized by the absence of clouds and visibility of more than the 10 kilometers (CAVOK), calm wind, a temperature of 7 ° C and QNH of 1029 hPa.

Metar/Speci

```
_ 100855 METAR LIRA 100845Z 02004KT CAVOK 10/08 Q1029=
_ 100825 METAR LIRA 100815Z 02002KT CAVOK 08/07 Q1029=
_ 100755 METAR LIRA 100745Z 02003KT CAVOK 07/06 Q1029=
_ 100725 METAR LIRA 100715Z 02002KT CAVOK 07/06 Q1029=
_ 100655 METAR LIRA 100645Z 06004KT CAVOK 07/06 Q1029=
_ 100624 METAR LIRA 100615Z 06004KT CAVOK 07/06 Q1029=
_ 100554 METAR LIRA 100545Z 05003KT CAVOK 07/06 Q1028=
_ 100525 METAR LIRA 100515Z 05004KT CAVOK 08/07 Q1028=
```

Local time was UTC 1 hour and the event occurred in conditions daytime. The sun has risen at 5.53'14 ".

1.8. NAVIGATION ASSISTANCE

This section contains the most interesting information concerning aid available for air navigation and its state of efficiency.

1.8.1.Aid for air navigation and landing

The Ciampino airport has the following radio assistance:

- VOR / DME ROM 110.80 MHz / CH45X;
- ILS LOC RWY15 CIA 109.90 MHz;
- GP 333.80 MHz;
- NDB Urbe URB 285.00 KHz.

The Ciampino airport, for RWY 15, is equipped with ALS CAT approach lights has PAPI placed on the right side of the runway with a 3 ° angle.

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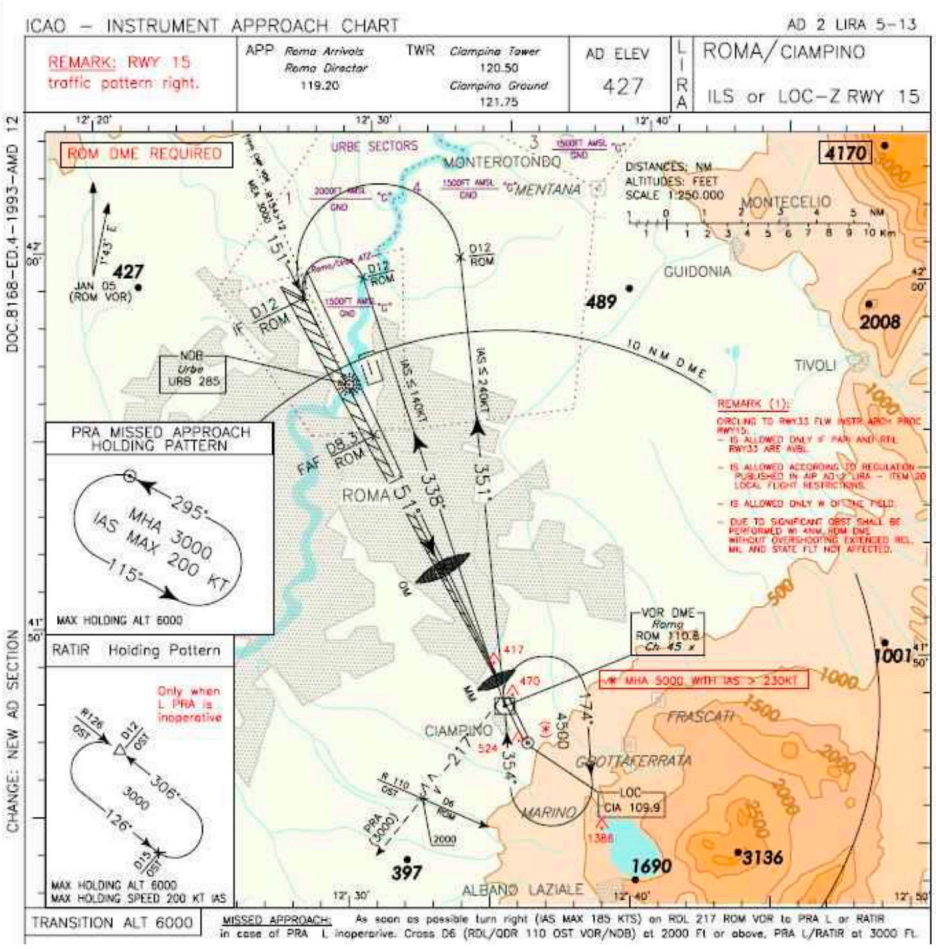
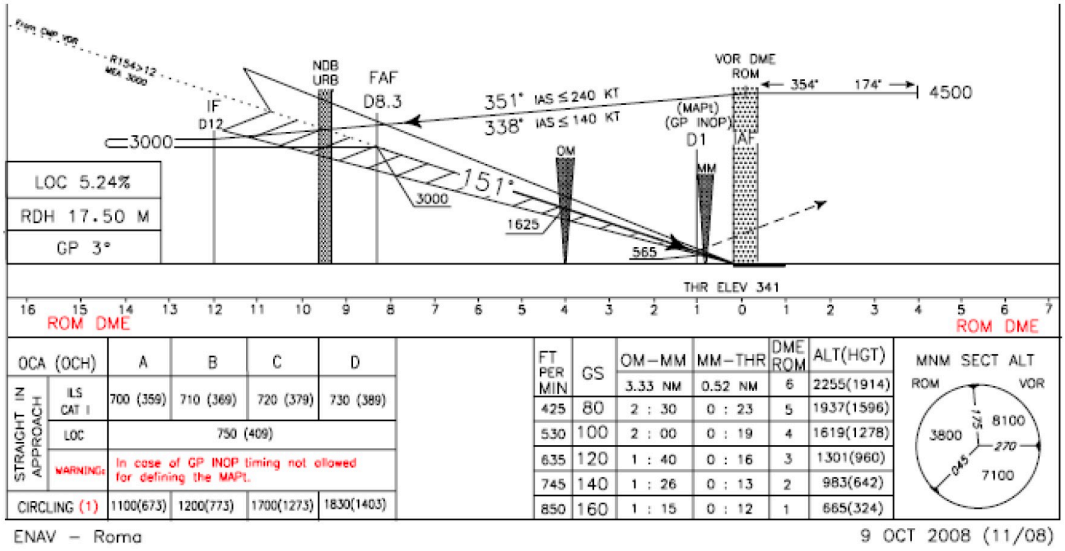
The instrumental runway (ILS) is the RWY 15. The procedure carried out in the flight of the accident is the ILS-Z RWY 15 (CAT I). The minimum of the procedure for the "C" category are the following: 720 feet OCA, corresponding to 379 feet OCH. The THR is placed at 341 feet AMSL.



Picture 5 : LIRA ILS-Z RWY15



Picture 6 : LIRA ILS Z RWY 15 glideslope

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1.9. COMMUNICATIONS

This paragraph contains the most interesting information concerning the means available for communications and their status of efficiency.

The flight with the radio station RYR41CH had maintained regular radio communications with the various ATS units under whose responsibility it progressively passed.
At the date of the event, the approach control service was managed, as is still the case, by Arrivals sector of Rome ACC (complex of several configurable control units in relation to the traffic situation) of ENAV SpA ; in the circumstance, the particular control unit who was responsible for the last ATS entity for handling the flight before of its handover to the TWR of Ciampino (managed by the Italian Air Force), it was the unit named TN EAST, frequency 127.950 MHz.
The T/B/T and telephone communication systems managed by ENAV SpA were found synchronized with the radar data recording system and with the common time base automatically updated to UTC time.
The T/B/T and telephone communication systems managed by the Italian Air Force and served by the TWR had a manual update at UTC time: this determined a time misalignment of about 17 seconds ahead with the time base of the systems of ENAV SpA.
The synchronization between the two-time bases has therefore been realized through the comparison of the different times to which common telephone communications between the TWR and the APP, extrapolated and transcribed with reference to the schedules of the two different systems of communication. The time base used for this report is the resulting one from the processing of data downloaded from the FDR of the aircraft, which was misaligned for an excess of a minimum value of about 3 seconds with the time base of the systems of communication and radar of ENAV SpA
Therefore the schedules of the transcripts of the T/B/T and telephone communications below reported have reference times normalized at the time of the FDR.

1.9.1.Mobile service

The RYR41CH flight carried out a regular approach to the Ciampino airport through the authorization to the ILS Z RWY 15 procedure issued by the Arrivals sector (unit TN EAST); the latest T / B / T communication that the CTA entertained with the crew of the aircraft ranged between 06.52'28 "and 06.52'36" and contained the request for confirmation of the stabilization of the aircraft on ILS RWY 15, which they followed the position information and the instruction on the transfer of radio contact with the subsequent ATS entity, ie the TWR of Ciampino (frequency 120,500 MHz).

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ACC: «Ryanair 41CH confirm established?».

RYR41CH: «Affirmative.».

ACC: «41CH position URBE, number one, TOWER 1205, good morning.».

RYR41CH: "1205."

RYR41CH established the first radio contact with Ciampino TWR at 06.52'47 ", confirming that it is completely stabilized on ILS for RWY 15 and providing its distance according to the indications of the VOR DME Rome (ROM); followed the authorization by TWR to land.

RYR41CH: «Ciampino good morning, Ryanair 41CH fully established ILS 15, distance nine miles. "

TWR: «Ryanair 41CH Ciampino good morning to you, number one approaching field on ILS Z, CAVOK, temperature seven, QNH 1029, the wind is calm and you are cleared to land runway one five. "

RYR41CH: "Cleared to land one five, Ryanair 41CH, thank you."

Regarding the accident, about 1 hour and ½ before this happened, took place two exchanges of radio communications between the TWR and the personnel responsible for bird control (BCU) of the airport operator on the UHF frequency 417.750 MHz.

The first exchange of communications took place at 05.21'15 ".

BCU: «Ciampino Tower from bird control».

TWR: «Go ahead.»

BCU: "Good morning Torre, I start the inspection as planned, affecting the area of maneuver excluding the runway. "

TWR: "Good morning, report when clear."

BCU: «Received.».

At 05.55'26 ", when the inspection was completed, the second exchange of communications took place.

BCU: «Ciampino Tower from bird control».

TWR: «Go ahead.»

BCU: «Inspection has been completed, the area is clear».

TWR: «Received, thanks.»

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At 06.56'10 "the first contact of the aircraft took place with the ground, just to the west of the RWY, at abeam the TWY "AC", with the dynamics already described; the aircraft stopped completely, after having crawled on the runway, near the RWY threshold 33, 25 seconds later.

Coinciding with the crash of the aircraft on the runway, the TWR, after having anyway activated by telephone the alerting of the emergency vehicles immediately after having acquired evidence of the impact effects with the flock of birds and observed the first contact with the ground by the aircraft, made a general call to all vehicles potentially listening on UHF frequency 417.750 MHz:

TWR: "To all stations, to all stations, Boeing 738 incident at the end of the runway."

With the aircraft stopped in the position described, at 06.56'48 "the last TBT communication that took place was between the crew of the aircraft and the TWR, in which the crew communicated having a problem and having to keep the runway occupied:

«RYR41CH is ... Is maintaining ... on the runway, MAYDAY.».

Following this last communication, TWR reassured the crew about the alerting of the rescue and the arrival of the vehicles.

1.9.2.Fixed service

The following is the original format of the FPL message, taken from FDMAS of ENAV SpA, issued for flight RYR41CH, with scheduled departure from Frankfurt Hahn airport (EDFH) at 05.30 'and expected to arrive at Rome airport Ciampino (LIRA) after an hour and thirty minutes, integrated with the indication of the speed, of the flight level and required route.

```
                          ***  ENAV  S.p.A.  ***                    20/11/08
                ** FLIGHT DATA MANAGEMENT AUTOMATED SYSTEM **       14:12:12
                   **      NATIONAL FLIGHT INQUIRY      **

Flight   Eobt Dep  Arr  Act   Tas Lev Fr Rebuilt Route                Org Typ
RYR41CH 0530 EDFH LIRA B738  460 370 IS UN850 UM727 UL995             A   F
 Aftn Message
 ZCZC IDX8704 091800
 FF LIIRZEZX LIMMZQZX LIRAZPZX LIRRZQZX
 091801 EBBDZMFP
 (FPL-RYR41CH-IS
 -B738/M-SRWY/S
 -EDFH0530
 -N0460F370 RUDUS5S RUDUS Z738 NOKDI Y163 NATOR UN850 ODINA UM727
 AMTEL UL995 BOL·
 -LIRA0130
 -OPR/RYR DOF/081110 ORGN/RPL)
 NNNN
```


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As anticipated in the previous paragraph, with the aircraft that was still decelerating in runway, the TWR activated the crash alarm and followed the emergency procedure with the notice to all the foreseen operators, first of all the health emergency services of the manager, those of the military authority and the Fire Brigade, with whom the first was established telephone contacts, respectively, at 06.56'16 ", 06.56'25" and 06.56'26 ".

1.9.3. Transcription of communications

The transcription of T/B/T and telephone communications is reported in the previous two subparagraphs.

1.9.4. Recorded arrivals and departures at Ciampino airport and ATC service

On November 10, 2008, before the accident occurred to the aircraft operating the flight RYR41CH, 16 movements were already registered on arrival and departure at the airport of Ciampino, of which 8 before and during the above inspection by the BCU and 8 after that this inspection had been completed: under no circumstances were any anomalies recorded in the operational activity connected with the possible presence of birds.

The 8 movements recorded after the inspection by the BCU were subdivided into 5 departures and 3 arrivals.

At 06.45 'there was a change to the TWR position between the two CTAs: the one going off duty from the night shift and the morning shift one.

No exceptional condition was recorded with respect to the operating routine and the regular management made it possible to record the ordinary functionality check, with the organizations in charge of emergency alert systems, which the CTA TWR upright exercised through 4 advance notice calls between 06.46'37" and 06.47'32 ".

The last movement recorded before the accident referred to a Saab 340 (turbopropeller), landed on RWY 15 just before reporting, at 06.52'06 ", on the frequency of the GND, while clearing the runway from TWY AD, that is 41 seconds before RYR41CH made his first call on the frequency of Ciampino TWR.

International regulations (ICAO DOC 4444 "Air Traffic Management", to which reconnect the ATS Operating Manuals in force) that oversee the performance of specifications TWR functions provides the following:

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«7.1.1.1 Aerodrome control towers shall issue information and clearances to aircraft under air traffic on and in the vicinity of an aerodrome with the object of collision (s) between:

a) aircraft flying within the designated area of the control tower, including the aerodrome traffic circuits;
b) aircraft operating on the manoeuvring area;
c) aircraft landing and taking off;
d) aircraft and vehicles operating on the manoeuvring area;
e) aircraft on the manoeuvring area and obstructions on that area.

7.1.1.2 Aerodrome controllers shall maintain a continuous watch on all flight operations on and in the vicinity of an aerodrome as well as vehicles and personnel on the maneuvering area. A Watch will be maintained by visual observation, augmented in low visibility conditions by an ATS surveillance system when available. [omissis]. "

The aforementioned international regulation also states the following:
«7.4.1.4.1 In the event the aerodrome controller, after take-off or a landing clearance has been issued, becomes aware of a runway incursion or the imminent occurrence or the existence of any obstruction on or close to the runway likely to appropriate action must be taken as follows:

a) cancel the take-off clearance for a departing aircraft;
b) instruct to landing aircraft to execute a go-around or missed approach;
c) in all cases inform the aircraft of the runway incursion or obstruction and its location in relation to the runway.

Notes – Animals and flocks of birds may constitute an obstruction with regard to runway operations. In addition, an aborted take-off or a go-around performed after touchdown may expose the airplane to the risk of overrunning the runway. Moreover, a low-altitude missed approach may expose the airplane to the risk of a tail strike. Pilots may, therefore, have to exercise their judgment in accordance with Annex 2, 2.4, concerning the authority of the pilot-in-command of an aircraft. ».

1.10.AIRPORT INFORMATION

Rome Ciampino Airport (IATA CIA, ICAO LIRA) is located southeast of Rome, just outside the perimeter of the Grande Raccordo Anulare, and falls partially in the territory of Municipality of Ciampino, and partially in the Municipality of Rome.

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It borders on the Northside with Capannelle racecourse, on the East side with the town of Ciampino, on the south and west sides with the Appia Antica park.

Photo 2 : Ciampino airport (from Google Earth)

The Rome Ciampino airport, at the time of the accident, had the status of "airport military open to civil traffic ". From the AIP Italia publication in force at the date of the incident were the following characteristics:

- ARP coordinates: 41 ° 47'58 "N 012 ° 35'50" E;
- direction and distance from the city: SSE, 6.5 NM;
- allowed traffic: IFR and VFR;
- reference code Annex I4 ICAO for flight infrastructure: 4E;
- category of airport fire service: CAT 8 ICAO supplied by the VVF (the military service firefighting will intervene in case of emergency according to the availability of the time, staff training and intervention plans if necessary subscribed at a local level).

Runway, in bituminous conglomerate, having the following characteristics:

- dimensions in meters: 2207.5 x 47;
- TORA / TODA / ASDA / LDA RWY 15: 2207.5 m;
- numerical designation: 15-33;
- magnetic orientation: 151 ° -331 °;
- runway tested elevation 15: 341.4 feet;
- runway tested elevation 33: 427.2 feet;
- longitudinal slope: 1.17%;
- strip size in meters: 2327.5 x 226.

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The RWY preferential for take-off and landing is 15.
Regarding Ciampino airport, AIP Italia, in the "additional information" section, it only reports the presence of gray crows on the entire airport grounds and during the whole year.
The NOTAMs in force did not contain any warning concerning the presence of birds on the Ciampino airport.

Birds removal procedure at Ciampino airport

The legislation concerned, at the date of the accident, was identified mainly with the following sources: circular ENAC APT-01A of 30.5.2007, concerning "Directive on procedures to be adopted for the prevention of impact risks with birds at airports"; the Airport manual, ed. 2 May 2007, limited in particular to the section "MOV/11/Plan to reduce the risk of impact with birds". Here we are also referring to the ordinance n. 6/2003 of 24.6.2003 of ENAC - Rome Ciampino airport district, as supplemented on 5 August 2003, containing, in attachment, the "Procedure for the removal of birds from the areas of maneuver of the Rome-Ciampino airport ", even if it is legitimate to doubt the validity of the same, at least those parts governed by the related legislation on the matter.

The circular ENAC APT-01A (later replaced by the circular ENAC APT-01B of December 23, 2011) preliminarily indicated that, from the provisions of the national legislation, there was evidence of an obligation to the airport operator, to carry out appropriate containment actions to prevent the risks of impact aircraft with birds on the airports concerned and to limit their gravity, based on a risk assessment.

The circular concerned provided that the operator of an airport open to traffic commercial:

- report to ENAC every bird strike event;
- elaborated and transmitted to ENAC, annually, a statistics of the events of bird strike;
- prepare naturalistic environmental research in the foreseen cases.

The mandatory events were the following events:

- impact (or presumed impact) ascertained by the navigating personnel;
- reporting of impact (or presumed impact) received by ATS service operators;
- damage to the aircraft reported by the maintenance staff as damage related to impact with a bird;
- recovery of bird carcasses or remains on the runway or in the area included within 60 meters from the center line;

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- effects on the conduct of the flight (go-around, rejected take-off) due to the presence of birds as an evasive maneuver.

The "expected cases" mentioned above, for which it was necessary to prepare the type research environmental naturalistic, concerned the circumstance that in the previous 12 months were verified on the airport even one of the following events:

a) impacts of birds with aircraft of 5 every 10,000 or more movements (within the height limit of 300 feet);
b) multiple impacts or ingestion of birds (within the 300-feet height limit);
c) impact with birds that have caused damage to the aircraft (within the height limit of 300 feet);
d) repeated observations of birds that by number and concentration were able to cause events referred to in points b) and c).

In the event that the research had highlighted the existence of a bird's risk level strike "dangerous" for air traffic (the circular does not provide, however, a definition of "Dangerous"), the airport manager was obliged to define a specific prevention and control Plan, taking into account the guidelines of to the circular APT-01A.

This research would have been sent to ENAC, which would then have communicated any comments to the manager. In the event that the ENAC had agreed with the existence of the level of bird strike risk reported in the research, the management company should have provided for the preparation and application of a specific prevention and control plan. This Plan should have been subsequently sent to ENAC for the evaluation and approved by the latter in the context of the certification process of the airport.

After 12 months from the implementation of the measures envisaged by the plan, the management company would have due to prepare a risk assessment based on the impacts of the period considered, compared with those of the same period of the previous two years, proposing, in the case of a decrease in the number and/or severity of the impacts had not been detected, an adaptation of the measures taken; the Prevention and Control Plan, as well as congruently amended, should have been retransmitted to ENAC for evaluation and approval.

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To implement the prevention and control plan, the circular provided for the establishment of a Bird Control Unit (BCU), whose activity was to be defined in the prevention and control Plan, as it would not have had to intervene only in the moment of the removal, but would have had to exercise continuous vigilance on the airport grounds and disturbance of the fauna in such a way as to cause it to be considered the airport unpleasant and unsafe place.

The organization of the BCU, in terms of staffing and resources, should have to be sized according to the characteristics of the airport.
Point 7 of the circular in question provided that the verification of the implementation by the airport manager, as provided for by the Prevention and Control Plan, was carried out as part of the inspection activity of the competent airport directorate of ENAC, from as indicated by the circular in question was a requirement for the certification of the airport and for the maintenance of the same.

Regarding the risk assessment activities carried out by the airport operator over the years immediately preceding the event, the events and data are shown below more significantly related to the bird strike phenomenon.

In 2003, a B737-400 landing in Ciampino, had an impact with a flock of starlings, a few meters from the contact with the runway: the event had been taken into consideration in the analysis on avifauna conducted by the airport manager.

The naturalistic-environmental research and the observation activity conducted by the manager in the following years, as described in the 2008 annual report on the bird strike situation, pointed out that, between 2004 and 2008 (up to the date of the EI-DYG incident), the number of impacts related to the number of movements ranged from 3.16 to 1.36 per 10,000 movements.

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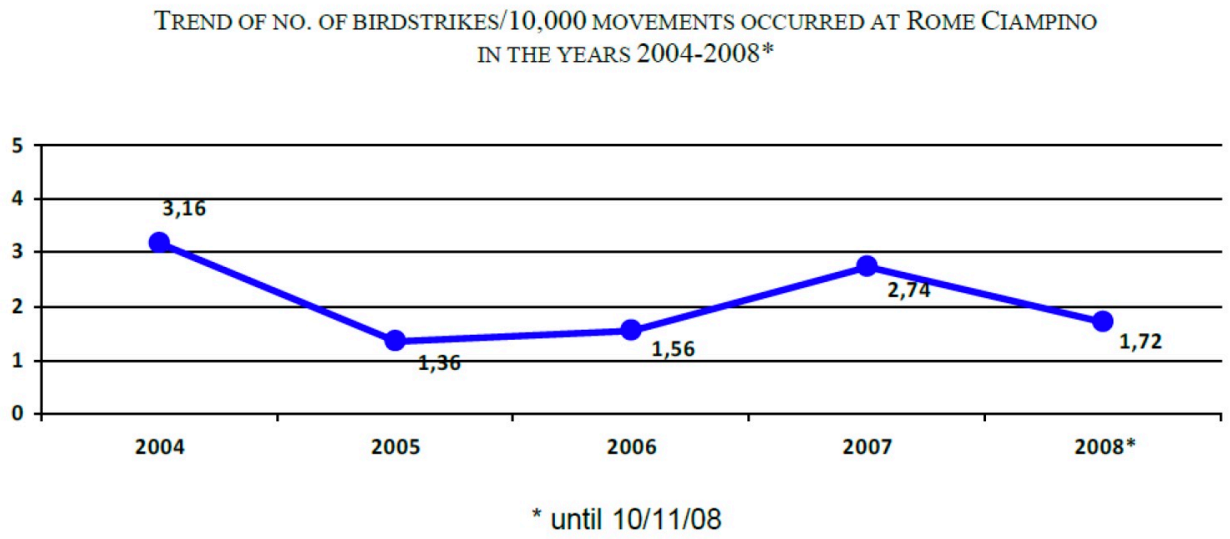
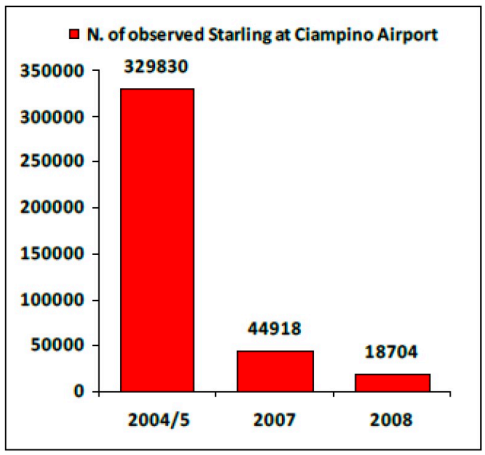


Picture 7 : birds impact trends from 2004 to 2008 (ADR, Report on Birdstrike Situation at Ciampino - GB Pastine airport, 19-11-2008)

On the basis of data relating to this activity, in 2005, the operator had completed the abatement selective of 11 maritime pine trees, which were located near the terminal and the parking area.

Photo 3 : Pines knocking down (areas in red)



Picture 8 : presence of starlings 2004/2008

From the study published by the airport manager immediately after the accident (precisely on 19.11.2008) it is clear that the same manager, in defining the risk for the planning of an adequate bird removal system, had held in consideration, in addition to the above, also the fact that, from a comparison of the same periods of the years 2007 and 2008, the presence of birds (in particular of the starlings) at Ciampino airport was decreased by about 56%.

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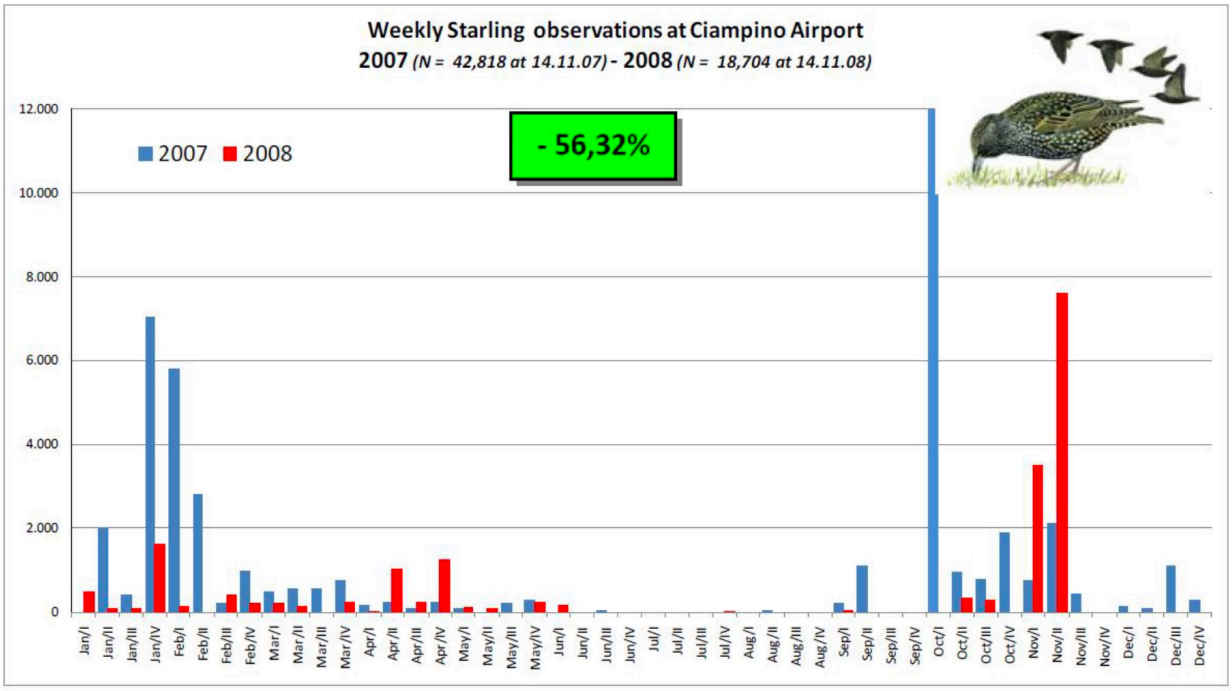

Picture 9 : weekly comparison of the presence of starlings between 2007 and 2008

On these studies, observations and conclusions, the manager consequently implemented a plan for bird removal, which was then included in the Airport Manual.

The Airport Manual, ed. 2 May 2007, in force at the date of the accident, states, in the forewords, that its main purpose is to define as the airport manager must fulfill its tasks in order to guarantee the conditions for proper management airport and safety of operations.

In particular, within the Manual in question, the aforementioned part MOV / 11 contained the Plan to reduce the risk of impact with birds, of which the following are reported highlights.

The objective of the Plan was to define the flow of information as well as responsibilities and the operative modalities for the monitoring activities of the avifauna, in order to guarantee the constant surveillance of the flight areas and avoid the presence of birds and therefore the risk of bird strike.

The subjects involved in the activity envisaged by the Plan were as follows: SOC Operational Safety (BCU); SOC Flight control; Civil Aviation Authority; TWR Air Force; SMS; SEC Headquarters of Ciampino service.

The inspections had to be carried out by the Operational Safety personnel who, through the BCU, carried out bird control and removal, according to what prescribed in the circular ENAC APT-01 (in another part of the same Plan the reference, however, it is at APT-01A), with a 24-hour service schedule.

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Inspections for the presence of birds in the area of the movement were carried out with a vehicle equipped with removal systems and radio system to guarantee a constant contact with TWR.

The type of inspections could be of three types:

a) scheduled checks (which, during the winter period, involved the following periods: dawn, about 1.00 pm, sunset);
b) checks on request;
c) verification following reporting of presumed impact.

The removal systems to be used for the removal were the following: pistol loaded with blanks; Scarecrow megaphone; acoustic signals mounted on cars.
The operating procedure provided that inspections were carried out by verifying the presence of birds on the runway, on the taxiways or in the immediate vicinity, reporting the presence/absence of birds on the appropriate form "Inspection birds card Ciampino ". In the event that the presence of birds had been detected, they would have been used the devices mentioned, depending on their location and the type of birds.
The employee would have maintained control of the affected area, continuing the actions up complete reclamation/removal, thus writing the significant data (position, number, bird type, means of removal used) on the appropriate form ("Ciampino Bird Inspection Sheet") and sending the form to the Airport Management.

In case of persistence of birds in the affected area, the worker would have requested the support of another car and report the situation to the supervisor
Operational safety, and, having detected the situation, would have activated the more appropriate scaring devices. At the end of the operation, he would have notified the TWR the successful removal of the birds from the flight area.
At the end of the last daily inspection, the Operational Safety supervisor would have entered the data for all inspections in the "Presence monitoring/bird impacts Ciampino ". In the event that the presence of the birds had been such as to compromise the Safety of operations and it could not be guaranteed that they would be removed, the Operational Safety Supervisor would have informed TWR and the SOC manager and/or the technical Operational Safety; the latter would contact the available ENAC officer, for the purpose of evaluating the penalties of flight infrastructures and to coordinate the possible issue of BIRDTAM. Received information regarding penalties, these were communicated to TWR.

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In the absence of the SOC manager and/or the Operational Safety technician, the employee would have had to contact the Ciampino airport service chief, which would have activated in accordance with the above.
For inspections requested by TWR / Flight control, both generic and presumed impact, the employee should have proceeded as planned, providing the TWR all the necessary information.
In the event of an impact with the finding of the remains of the bird/s, it was expected to be compiled both the "Ciampino birds inspection card", and the "Bird Strike Reporting" ENAC card Form ", in addition to the verification of the conditions of the aircraft concerned, by taking, if necessary, photo and collecting the remains of the bird for the identification of the species.
In the case of remains of the bird/s not found, the compilation of the "Ciampino Birds Inspection Sheet", specifying a negative result.

With regard to the order no. 6/2003 of 24.6.2003 of the ENAC-Circumscription Rome Ciampino airport, on which full force at the date of the accident is however legitimate doubt (even if it is included among the normative references referred to by the "MOV/ 11/Plan to reduce the risk of impact with birds"), we limit ourselves to observe that the same, among the persons required to report to the TWR the "only sighting" of bird, it contemplated multiple persons, including e.g. even the pilots, police, Carabinieri, etc.

Scheduled inspections of the day before the accident and day accident

The first two scheduled inspections (dawn and 1:00 pm) of the day before the accident they did not detect any presence of birds.
On the evening of the day preceding the incident, a scheduled inspection took place (sunset) with starting time 16.25 'and closing time 17.00', which had detected the presence a number of about 1000 starlings, placed on the grass, which affected the C2B and C3A and 300 starlings placed on the grass in the C1B and C1A sectors.

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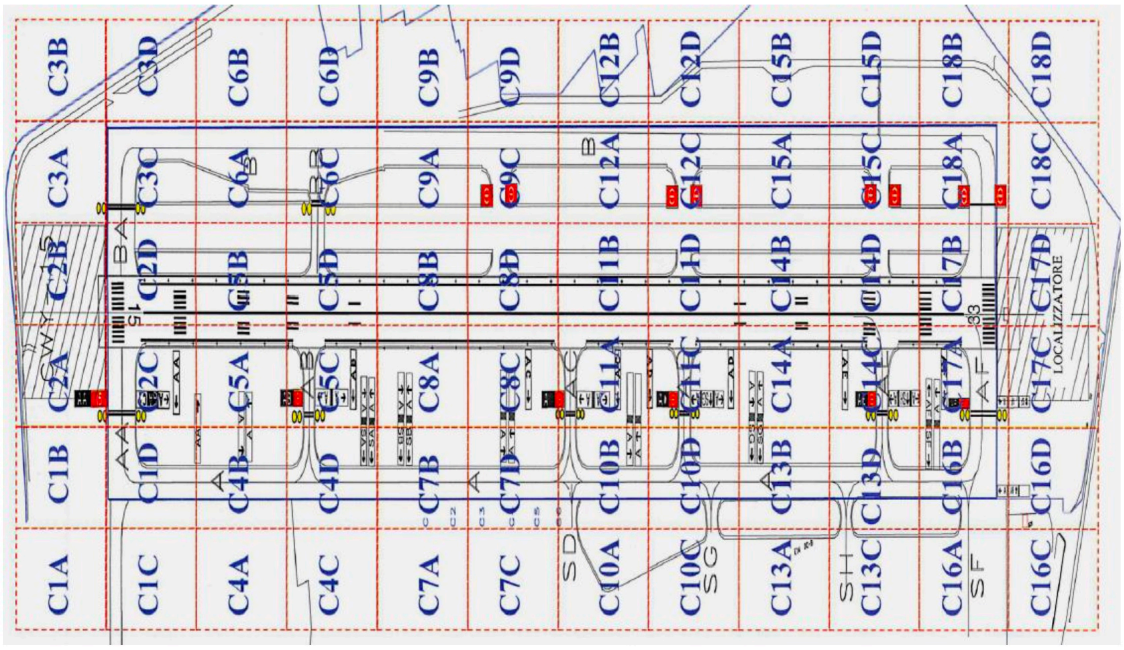

Picture 10 : birds inspection grid

The BCU removed the birds by 35 total pistol shots. In this circumstance were found no carcasses of birds.

On the morning of the accident, a scheduled inspection was carried out, beginning of the same at 06.20 'LT (05.20' UTC) and ended at 06.55 'LT (05.55' UTC).
These times have been detected by the inspection form and are consistent with the schedules associated with radio communications between BCU and TWR.
During the inspection, the presence of birds was not found.
As per communications between the TWR and the BCU at 05.21'15 "and reported previously, the latter had performed the above inspection on the maneuvering area without affecting the runway.

Birds removal procedures currently in use at Ciampino

At the date of preparation of this report, the procedures for removal of the birds are those contained in the current Airport Manual, section "MOV/11/Plan to reduce the risk of impact with birds and wild animals", an update of 26.6.2018.

The current plan is very different and much more extensive and in-depth compared to that in force at the date of the accident, containing now also measures aimed to ensure the constant surveillance of the flight areas to avoid the presence of birds and therefore the risk of bird strike. Among other things, it provide for the specific basic and recurring training for the personnel assigned to the removal of birds, actions to control the surrounding area with the involvement also of other institutional subjects of the local bodies of the Municipalities bordering, control and reclamation of the

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airport grounds from organic waste that can constitute an attractive source for wildlife, etc.

Also with regard to the inspections, there are some changes compared to the past. In particular, with regard to planned inspections, it is specified that "In the period of the presence of starlings, usually placed between September and mid-March, the inspection starts: 15 minutes before the ephemeris time (dawn) of the day with continuous presence until two hours later. The checks continue throughout the day on an hourly basis.

The last inspection begins two hours before the ephemeris (sunset) of the day with presence continue up to 15 minutes later. After the starling's concentration period has been completed, the inspection begins [omissis] ».
Lastly, the considerable increase in the technological equipment of the BCU will also be highlighted.

1.11.FLIGHT RECORDERS

This paragraph contains the most interesting information concerning the onboard recording equipment.

1.11.1.General

The aircraft had two flight recorders on board:

• the FDR P/N 980-4700-042 (SN 4415);
• the CVR P/N 980-622-001 (SN 120-10231).
Both recorders are solid-memory technology.

1.11.2.State of discovery

Both recorders were removed from the aircraft on the same day of the accident and transported to the ANSV laboratories, in apparent perfect state. The download of data and audio runways has been carried out without any inconvenience whatsoever by the same laboratories on the day of the accident.
For the purpose of decoding the data FDR downloaded, the applicable layout data frame was received from Boeing to the ANSV in .ffd format.

1.11.3.Data downloaded

The synchronization between the flight data and the audio tracks was performed by taking as reference the activation of discrete FDR parameters, to which an audio signal corresponds clearly identifiable in CVR records. Specifically, they have been used discrete signals that are activated at times other than the impact with the birds.

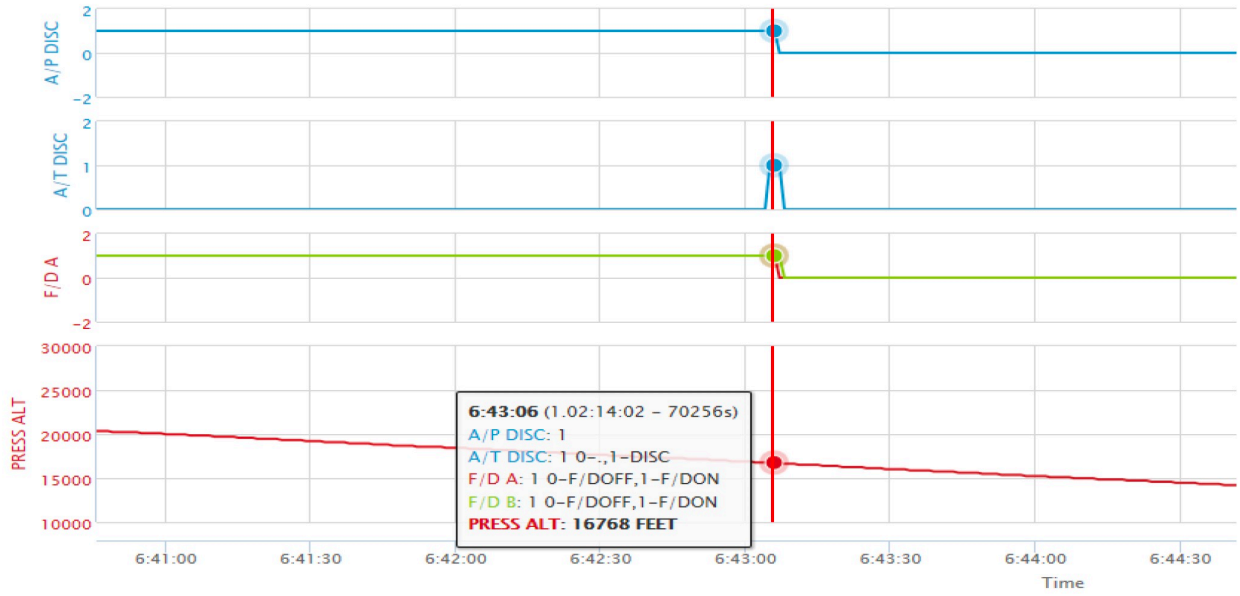
unofficial english translation by Aviation Accidents Database©

The data recorded by the FDR and referred to the pressure altitude have been recorded having as reference the value of 1013 hPa.
The value of QNH for Ciampino airport at the time of the accident was 1029 hPa, value selected by the crew on the onboard altimeter.
The difference of 16 hPa between the reference and real QNH results in a difference of about 432 feet.
The GPS data recorded by the FDR have been validated by reference to known points on the ground, specifically the point of initial contact on the ground and the stop of the aircraft threshold RWY 33.

Operations on land, take-off, cruise, descent until automation disarming

The aircraft started taxiing at 05.22 'and took off from the airport of Frankfurt Hahn for RWY 21 at 05.31'28 ". The take-off mass was 64,700 kg. The leveling at FL370 took place at 05.49'00 ".
The descent started at 06.20'50 ", leaving FL370 for FL330. The aircraft has reached FL330 at 06.24'54 ", maintaining this level until 06.28'12", when it started a continuous descent until the approach phase.
In the course of the descent and before the approach phase, two reductions of speed: the first to 250 knots passing FL200 at 06.40'52 "and the second to 220 knots at 06.48'06 "passing FL90. During the descent the crew, starting from 06.43'06 ", crossing the altitude of 16,800 feet, disengaged, in sequence, autothrottle, autopilot and flight director, and started, from 06.43'08 ", to manually fly the airplane as indicated by the switching of the autopilot, FD and autothrottle values.
These automatisms will remain disengaged until the end of the flight.

unofficial english translation by Aviation Accidents Database©

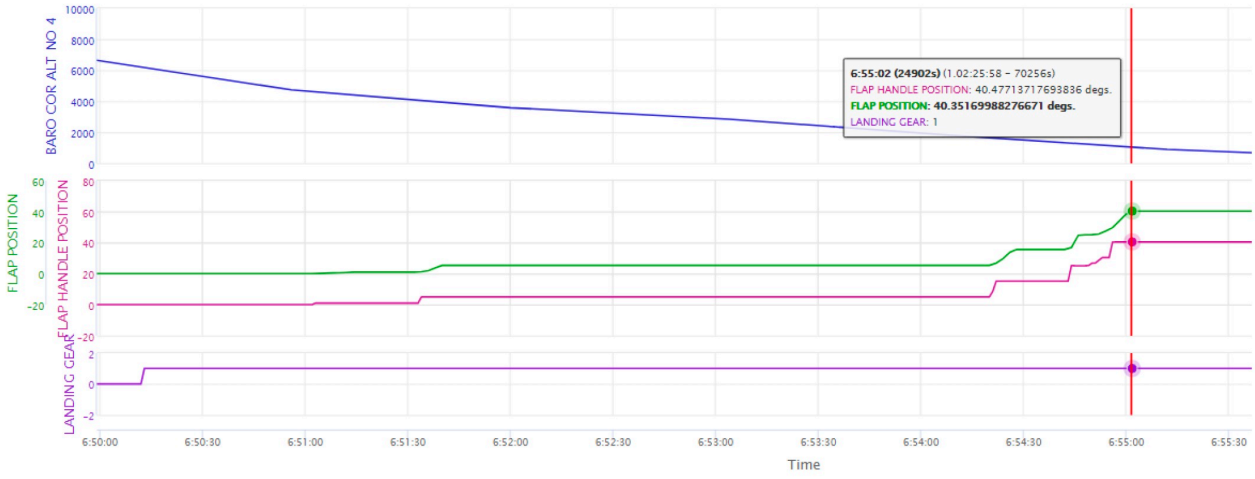


Picture 11 : autopilot disengagement, FD and autothrottle

From the disarming of the automations to the approach, up to the moment before of the visual acquisition of birds

During the approach phase, the following stages of the configuration of the aircraft are highlighted (time and altitudes referred to the achievement of the position):

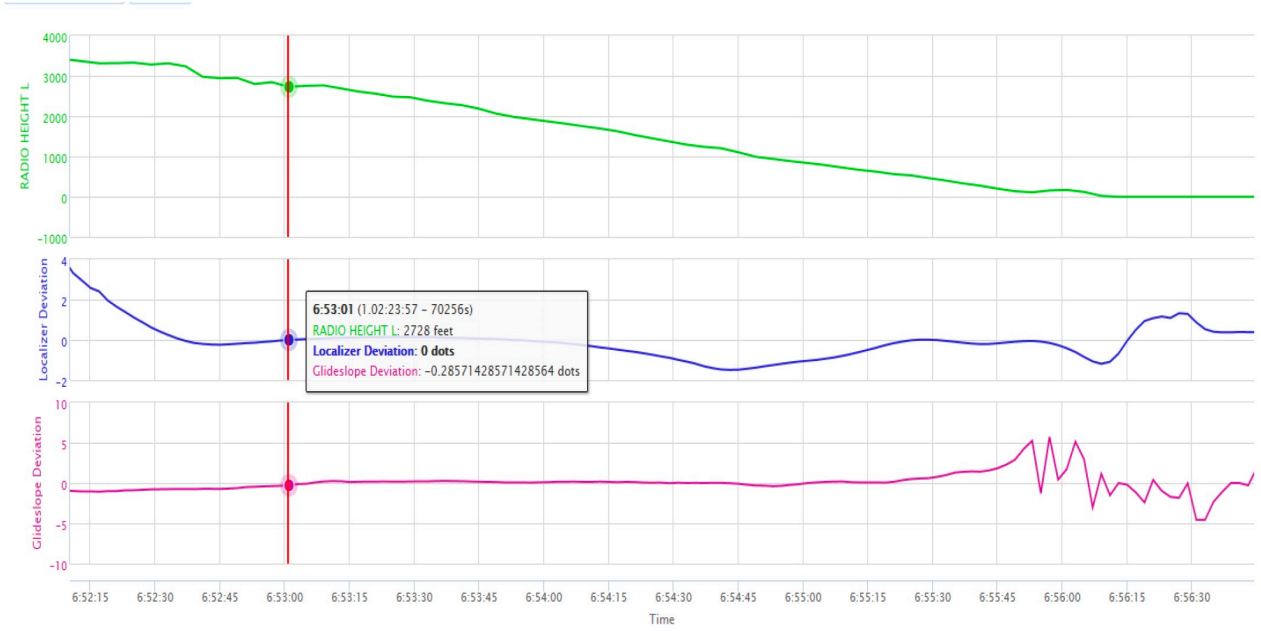
Event	UTC time	Pressure alt. (1013hPa)	Baro alt. (1029hPa)	Radio alt.
LG down	06.50'13 "	5760 ft	6192 ft	6070 ft
flap to 1	06.51'16 "	3840 ft	4272 ft	4295 ft
5 ° flap	06.51'40 "	3399 ft	3831 ft	3857 ft
15 ° flap	06.54'28 "	1024 ft	1456 ft	1405 ft
30 ° flap	06.54'56 "	640 ft	1072 ft	912 ft
40 ° flap	06.55'02 "	512 ft	944 ft	836 ft



Picture 12 : aircraft configuration sequence up to the selection of flaps 40°

unofficial english translation by Aviation Accidents Database©

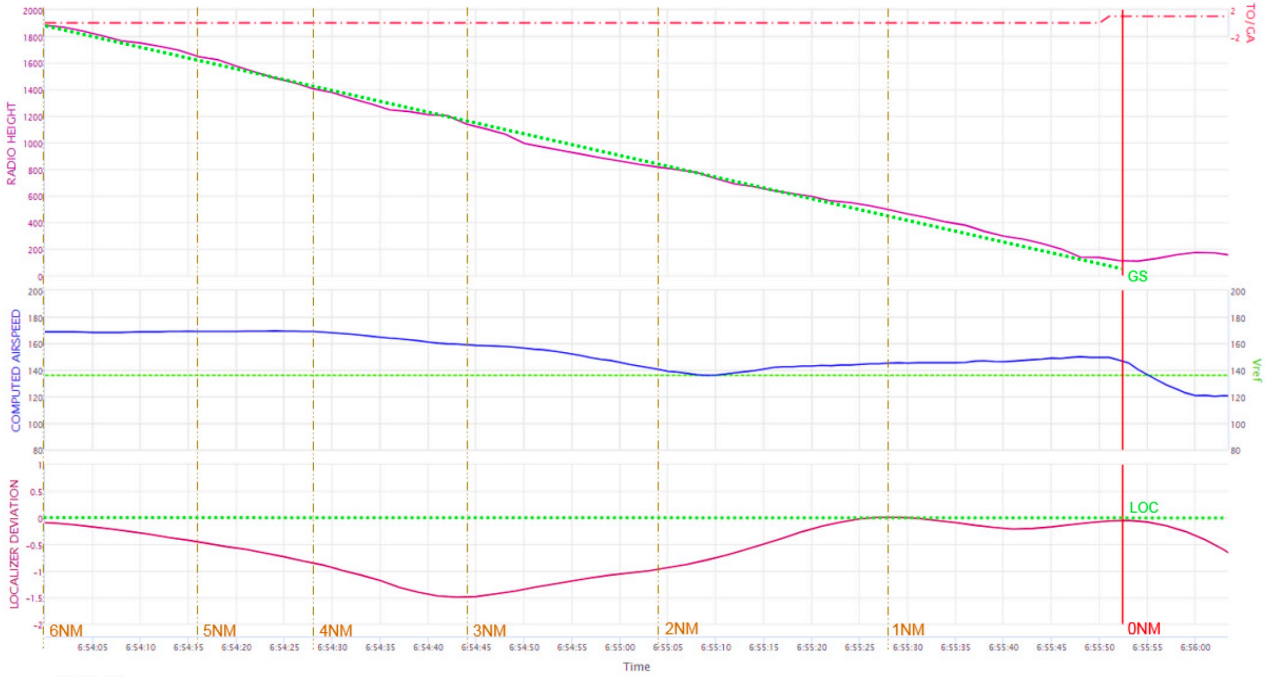
At 06.52'20 "the interception of the localizer began at around 11 NM from the airport, at an altitude of 3266 feet (pressure altitude of 2834 feet), performing a left turn and flying the intercepting heading 195° to stabilize on runway extended centerline at approximately 10 NM. The interception of the descent path took place at 06.53'05 ", with the aircraft stabilized on the localizer at a distance about 8.5 NM from the airport; the aircraft intercepted the localizer and the glide with configuration flaps 5° and landing gear extended.



Picture 13 : localizer interception

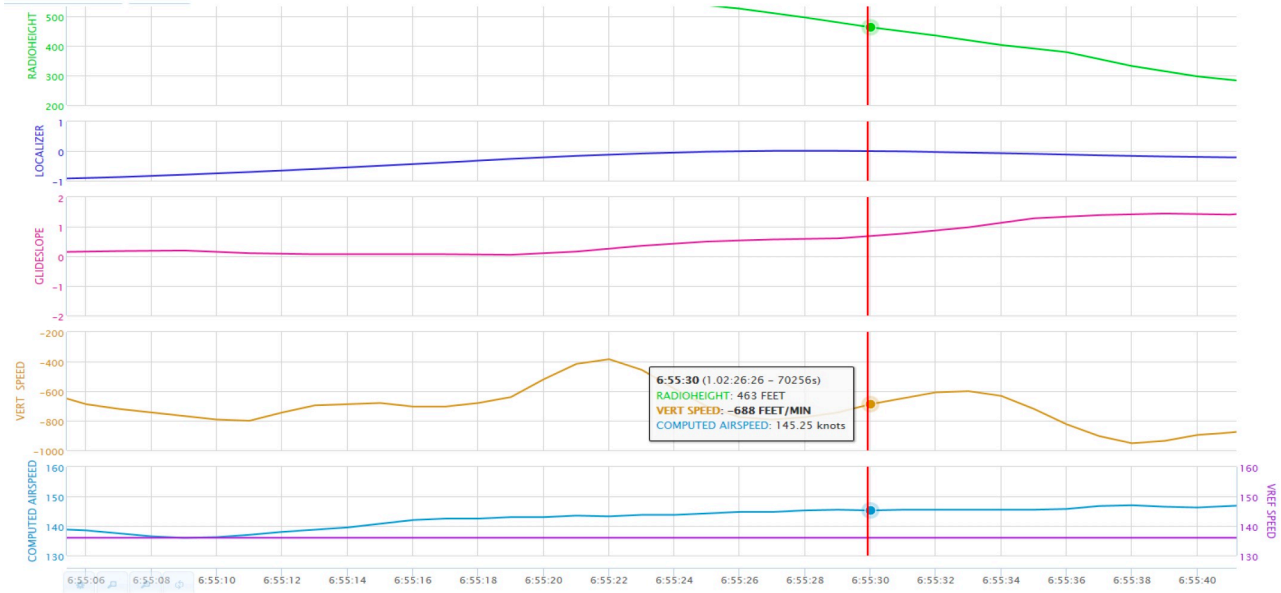
As highlighted in the following plot, tracking of the locator has highlighted an instability starting from 06.54'00 ", at a rad alt. height of 1882 feet.
At the distance of the aircraft of about 6 NM from the field, in fact began a progressive deviation to the right referred to the extension of the runway axis, up to the distance of about 3 NM, distance at which the correction that carried the aircraft was carried out on the localizer about 1 NM from the field.
The descent path has had a constant variometric trend, as highlighted by the rad alt. profile compared to the ideal glide path. CAS, in the final 40 seconds of approach, remained higher than the Vref of 136 knots of some knots (maximum value is about 13 knots at the time of application of the TO/GA).

unofficial english translation by Aviation Accidents Database©



Picture 14 : GS, LOC and Vref deviations

At the minimum, reached at 06.55'30 "(pressure altitude 256 feet, at a baro alt. coherent with the procedure minimums, equal to 720 feet), the aircraft was correctly configured for landing (extended landing gear, flaps 40°) and manually flown, with autopilot, flight director and autothrottle disconnected. It was also stable on the localizer, 0.7 DOT above the descent path, with a CAS of 145 knots, a VS of 688 feet/minute, N1 ENG1 at 65.75% RPM and N1 ENG2 at 66.5% RPM.



Picture 15 : reaching minima of ILS Z RWY15

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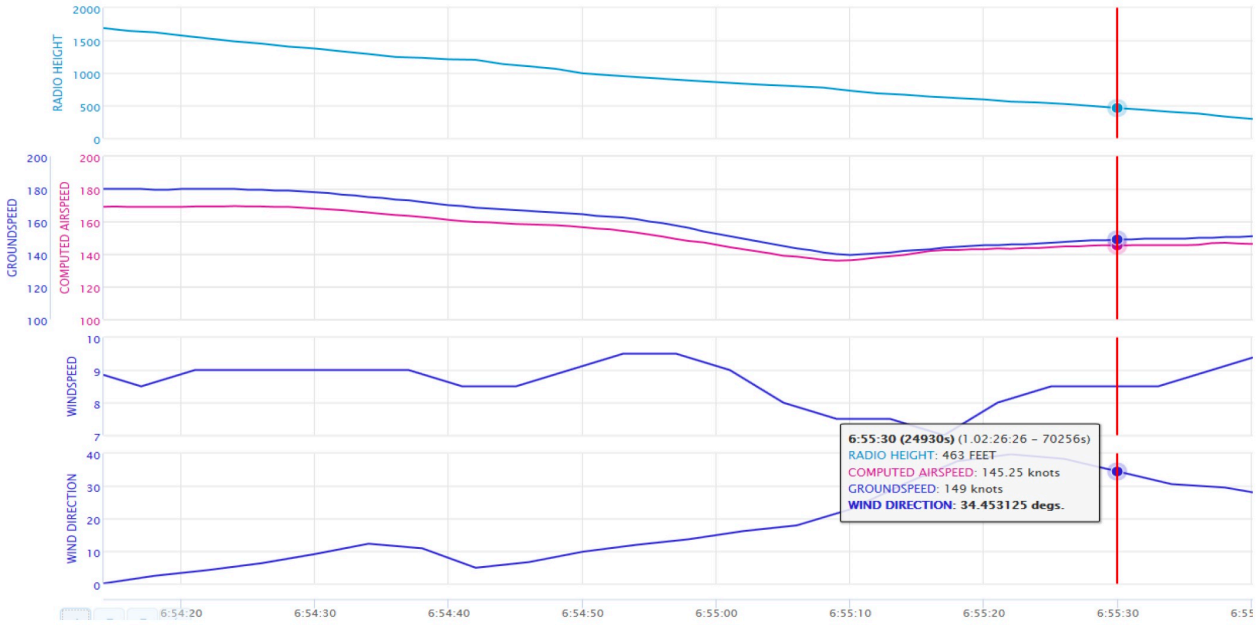
At the procedure minimums (06.55'30 "), as shown in the following figure, the wind came from 034 ° with a speed of 8.5 knots. The value of the groundspeed was 149 knots or 3.75 knots above the indicated speed value (145.25 knots). The maximum value of recorded wind during the ILS approach has been of 9.5 knots, coming from 012 ° to 06.54'54 "; the aircraft was about 1000 feet radalt, the indicated speed was 153.2 knots, while the GS was 161.5 knots.



Picture 16 : speed and direction of the wind at the MDA/DH

From the visual acquisition of the birds to the impact with the ground

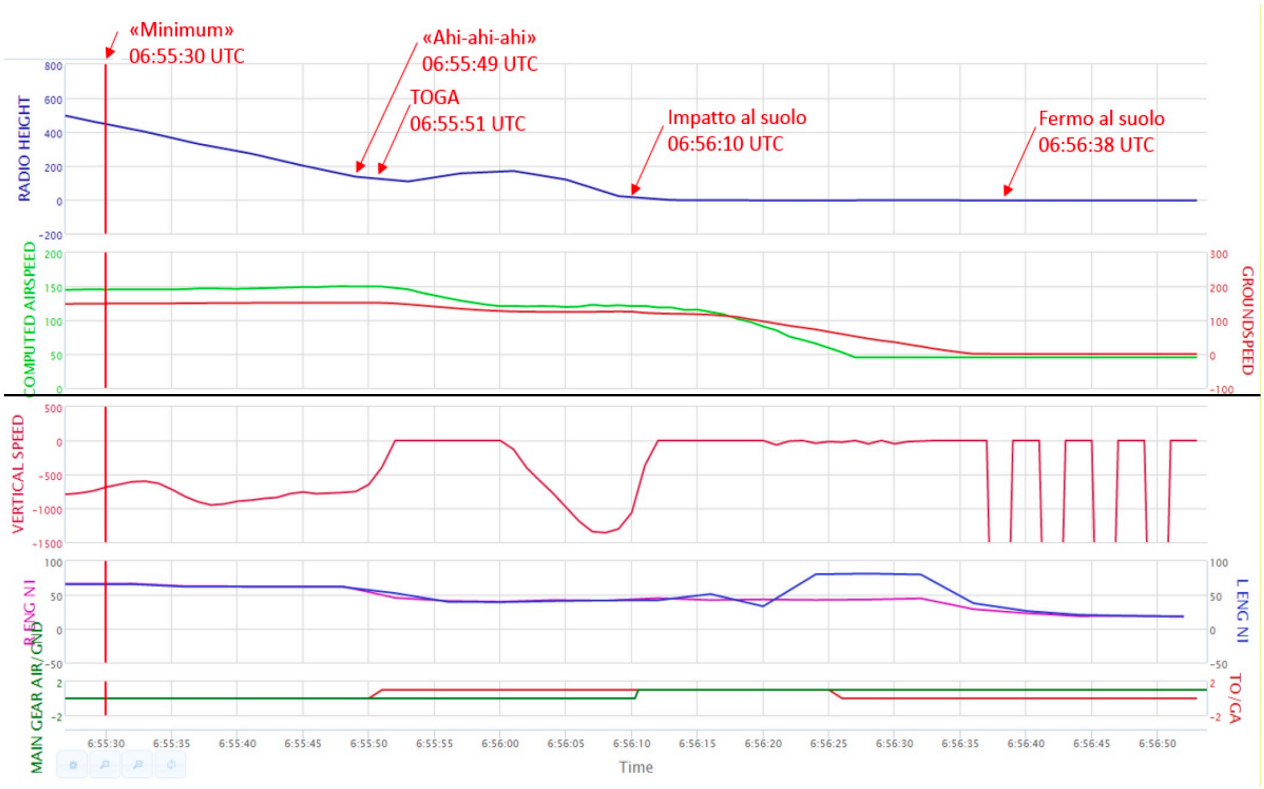
From 06.55'49 "there has been a reduction in the angle of descent and the vertical speed, which rose from -752 feet/minute to -391 feet/minute at 06.55'51 ", when TO/GA setting was recorded.

In detail, at 06.55'49 "(in correspondence of the second in which the CVR registered the exclamation of the commander "Ahi!" repeated about 10 times, as will be seen later at the sighting of the birds), the aircraft was aligned on the localizer, at one radalt height of 136 feet and a CAS of 149.5 knots, with engines N1 of 62%.

At 06.55'51 ", as mentioned, the activation of the go-around pushbutton was recorded using the first pressure of the TO / GA switch followed by the second pressure after 3 seconds, at 06.55'54 " to command the full go-around N1 limit.

unofficial english translation by Aviation Accidents Database©

When the TO / GA was applied, the vertical speed has been further and more rapid reduction and the descent trajectory of the aircraft had a slight increase in the radalt height (from 108 to 173 feet), up to 06.56'01 ".
After this time the aircraft resumed descent.



Picture 17 : N1 speed from MDA/DH to ground contact

At 06.55'56 "the flap selection was commanded, from 40 ° to 10 °, a position that was reached at 06.56'12 ", with the aircraft on the ground.
From the FDR data it is clear that the commander has acquired control of the aircraft at 06.55'58 ", or 7 seconds after the activation of the TO/GA.

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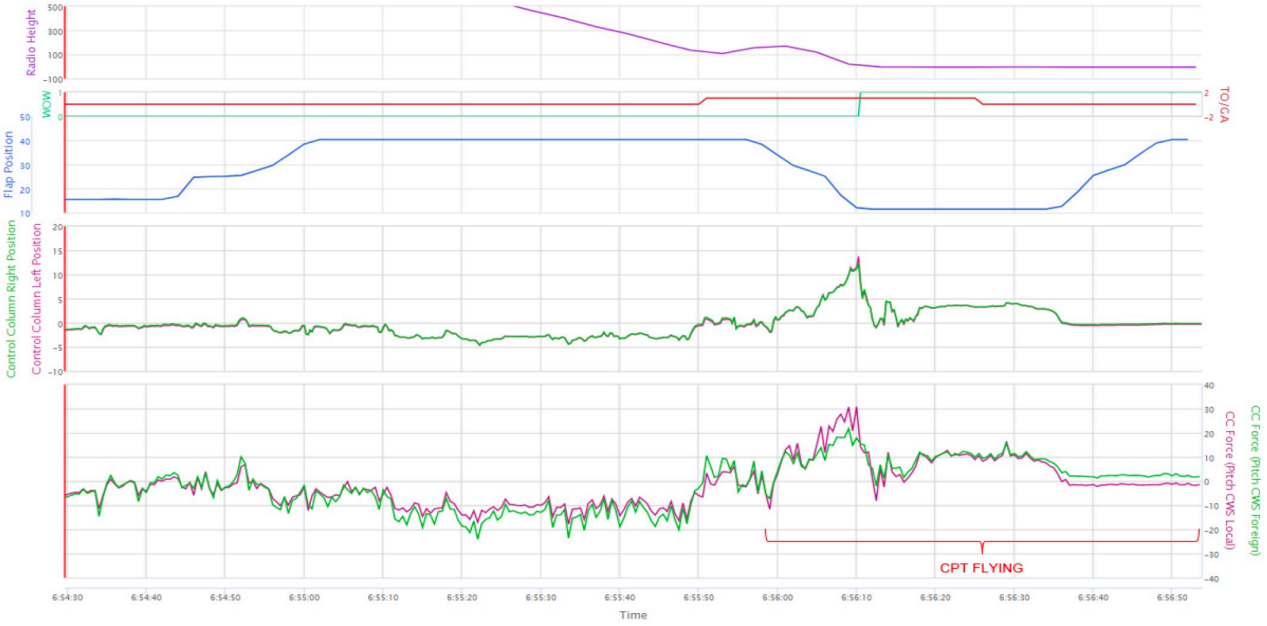


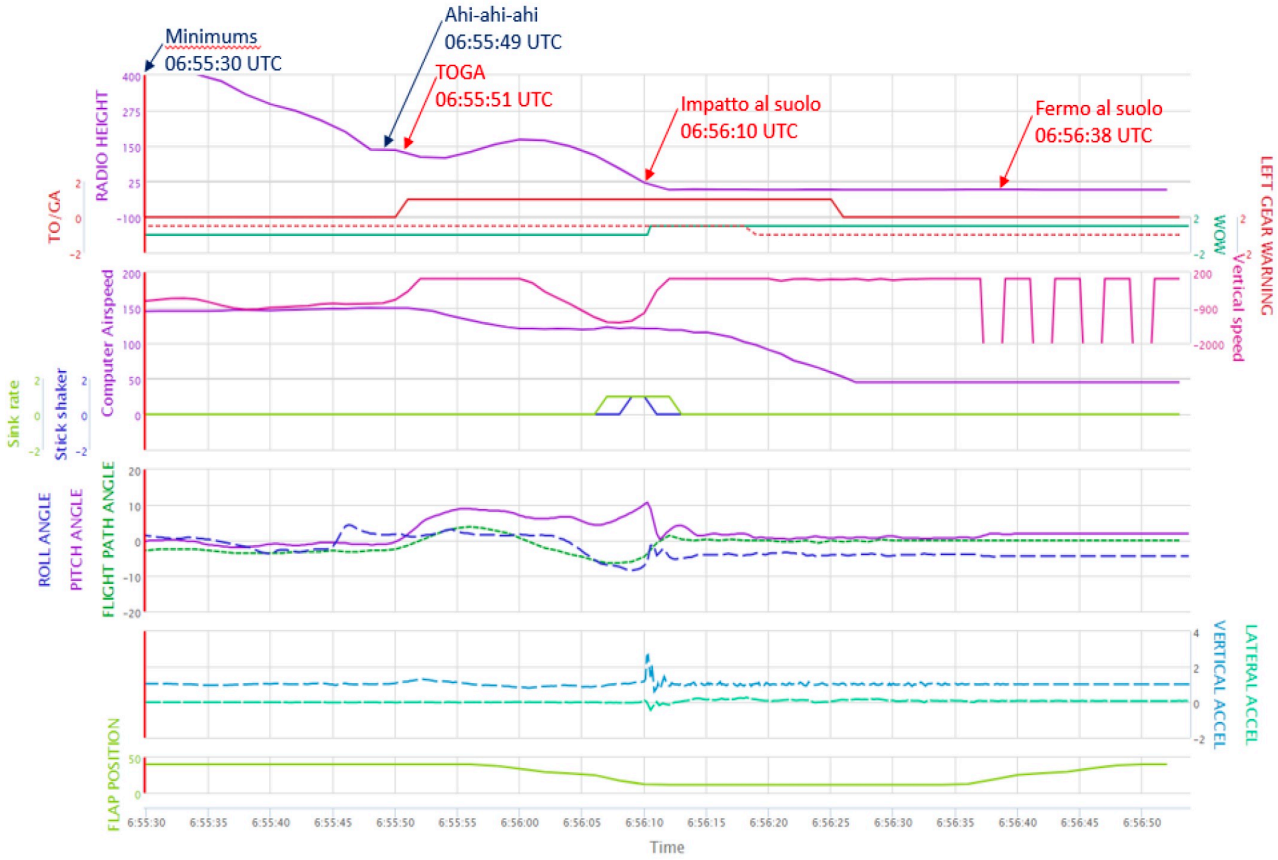
Picture 18 : Selection of Flaps and takeover of flight controls by PIC

From the moment the go-around was commanded, with consequent variation of attitude, the speed registered a progressive decrease.

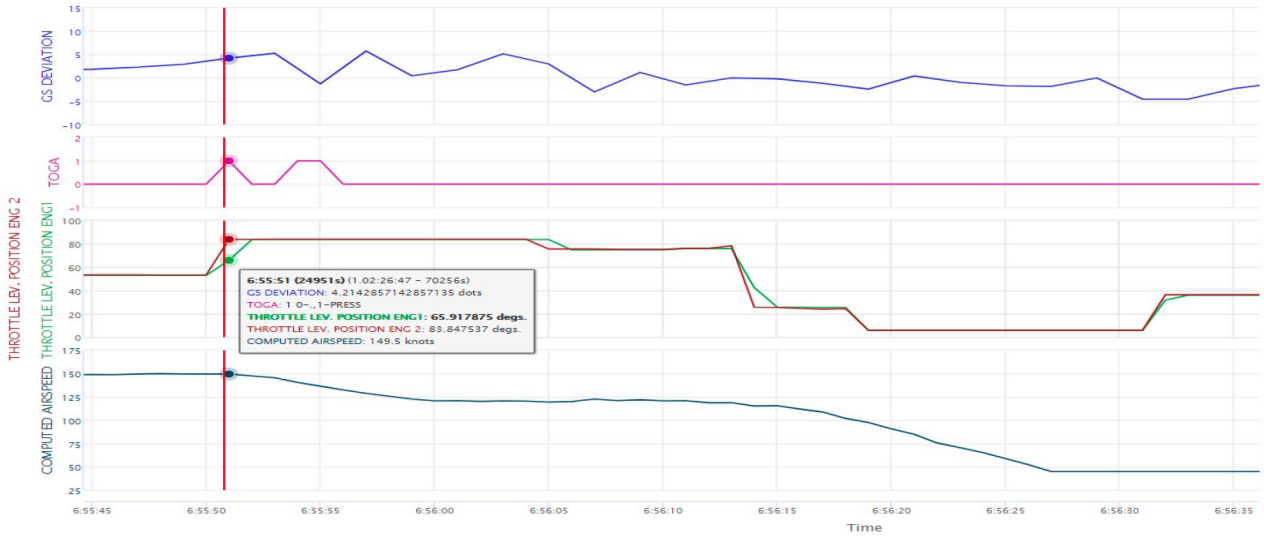
At 06.56'07", with a CAS of 122.75 knots, the activation of the sink rate was recorded and at 06.56'09" of the stick shaker, matching with the maximum vertical speed reached by aircraft, of -1360 feet/minute.

At 06.56'10", the aircraft touched the ground (switching of WOW) with a pitch of 10° and roll -6°, indicated a speed of 120.75 knots, vario metric airspeed of -1064 feet/ minute, vertical acceleration of 2.66 g and a side one of -0.45 g.

unofficial english translation by Aviation Accidents Database©



Picture 19 : sink rate, aerodynamic data, and acceleration on impact



Picture 20 : Glide and CAS trend at TO/GA selection

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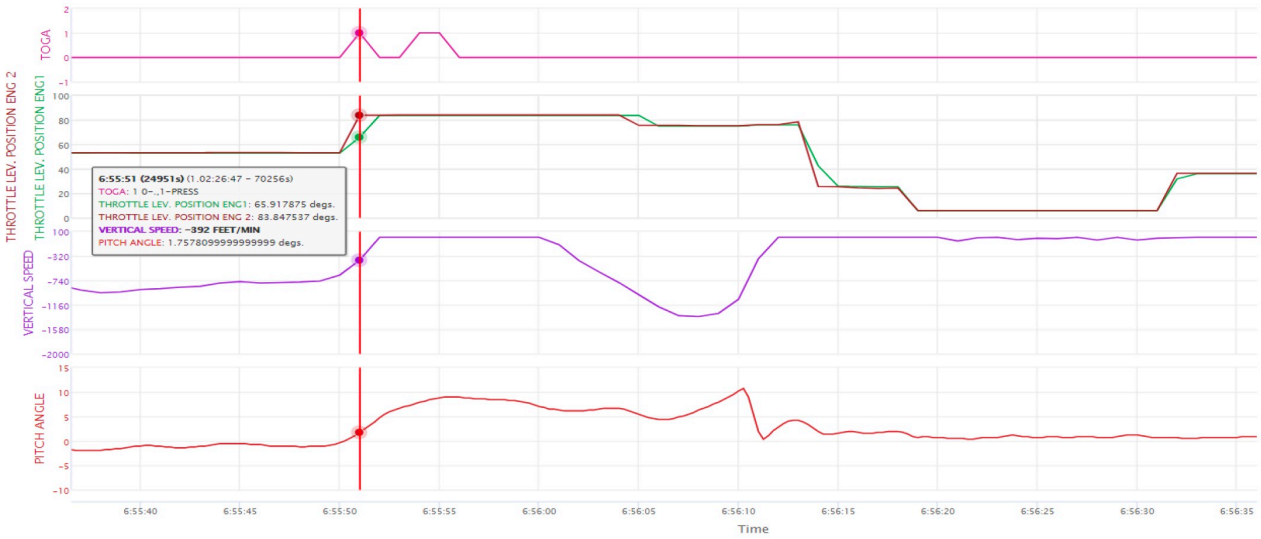
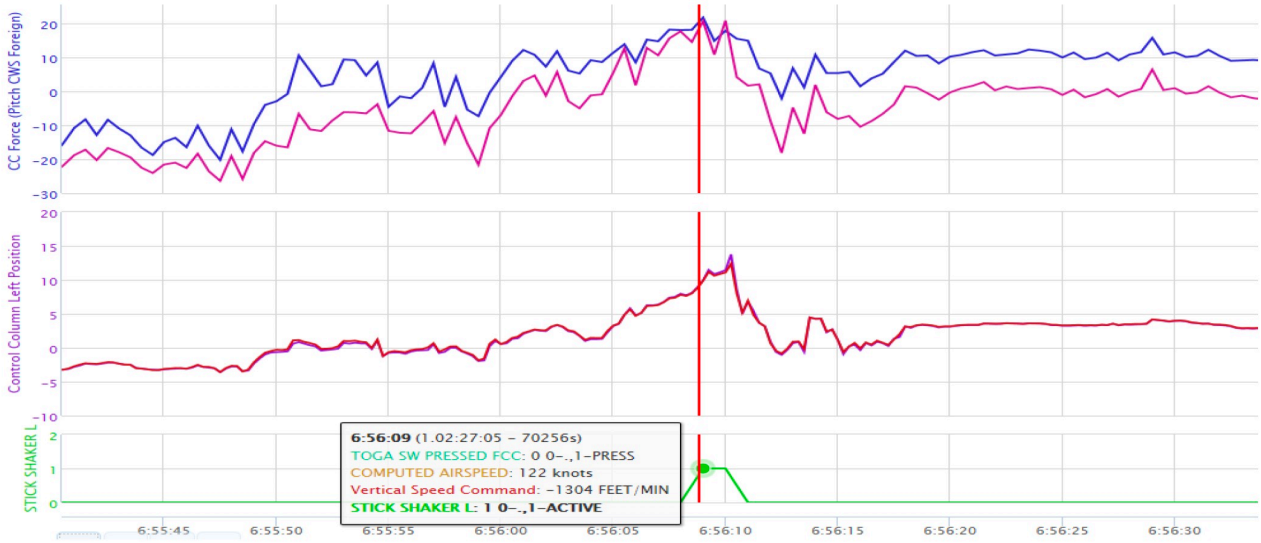


Picture 21 : V/S and pitch angle at TO/GA selection



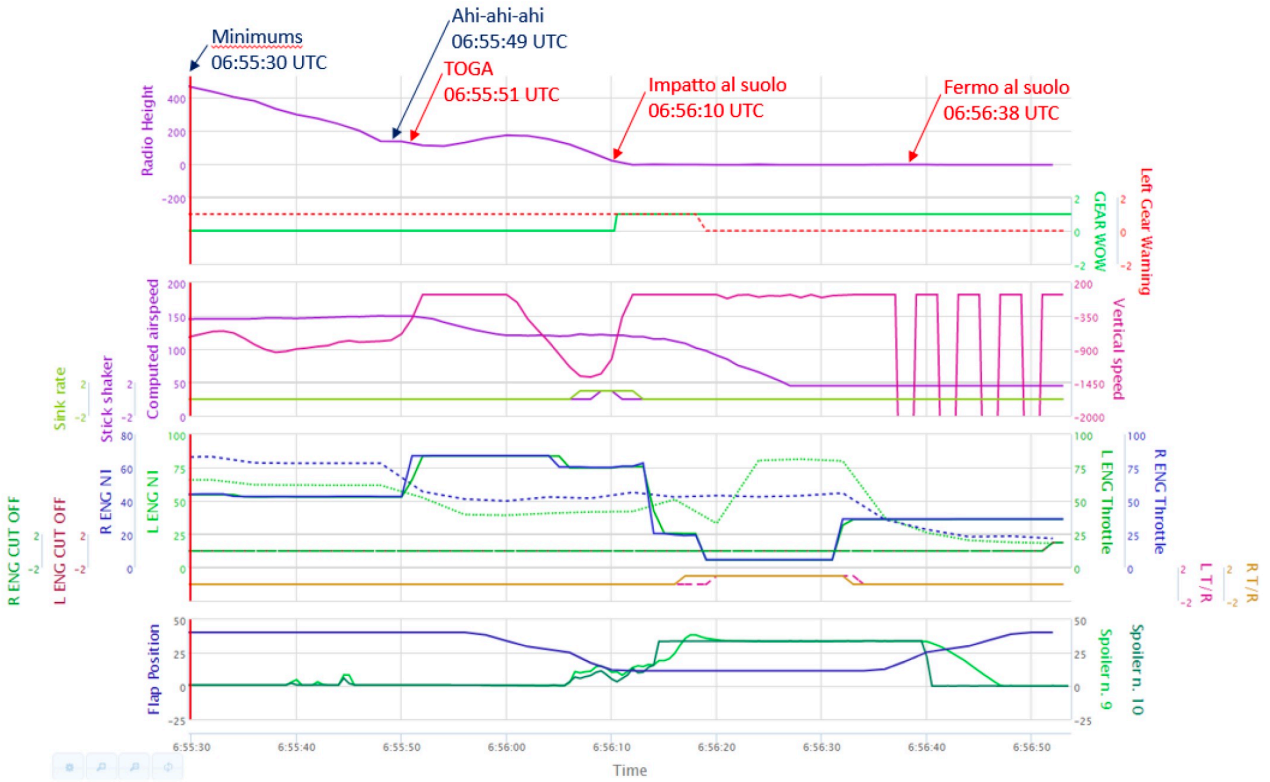
Picture 22 : action on flight controls at activation of stick shaker

Ground deceleration run

After the touchdown, at 06.56'10 "and up to 06.56'38", the plane has decelerated with the use of the brakes, the thrust reverse eng. 1 and spoilers. During the ground run, the activation of the warning related to the unsafe condition of the left landing gear is recorded.

With stopped aircraft, it was noticed the lowering of the flaps at 40 ° and the zeroing of the spoilers.

unofficial english translation by Aviation Accidents Database©



Picture 23 : flap movement, spoilers, and thrust reverser

Pitch and deceleration

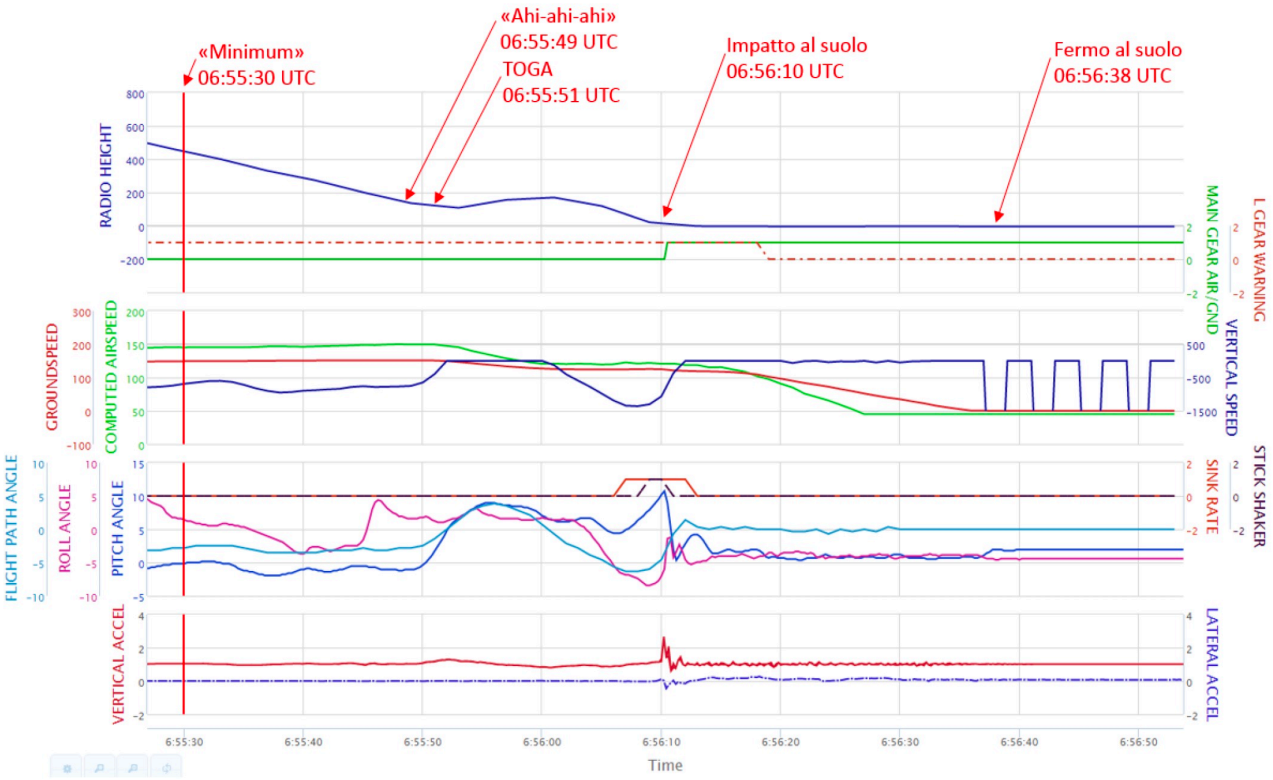
The next plot shows how the aircraft, from the moment of sighting flock of birds, has progressively varied the flight path angle, which before of the sighting was correctly around -3°, reaching, in a phase of go-around, up to about +4°, then lowered to minimum values (-7 °).

In these phases, the activation of the sink rate warning (at about -6 ° flight path angle) and the stick shaker were recorded. The activation of the latter occurred at an angle of attack of about 21°.

In the phase in which the flight path angle has changed from -3 ° to about +5 °, the pitch angle has changed from about -1 ° to +9 °, and then keep positive some degrees until the impact with the ground.

The magnetic heading of the aircraft was also characterized by excursions to the right and left with respect to the runway direction (150 °), accompanied by excursions on the roll axis. The aircraft impacted the runway with a roll angle of about 6 ° to the left and a pitch of about 10 °.

unofficial english translation by Aviation Accidents Database©



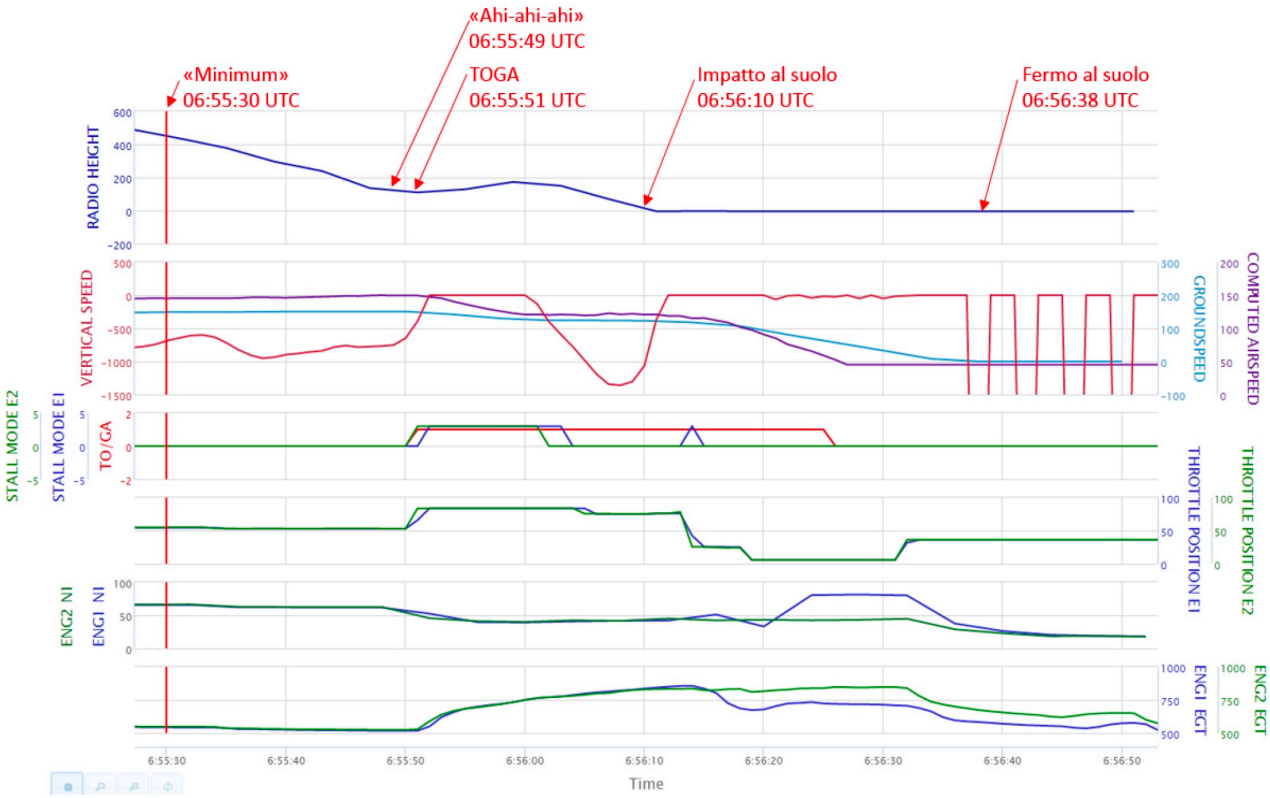
Picture 24 : pitch and deceleration data

Engines behavior

Regarding the behavior of the two engines, when TO / GA was selected, both entered a stall (state 3): the right engine at 06.55'51 ", the left a second later. The N1 of both fell from 66% up to a value around 40%, value to which they remained until the impact with the ground, after which the left engine has increased the N1 up to 81% because of the activation of the reverse thrust, while the right remained at values below 45%, until shutdown.

Together with the lowering of the N1, there was a sudden increase EGT of both engines.

unofficial english translation by Aviation Accidents Database©



Picture 25 : behavior of engines

1.11.4.Transcription of the CVR

The CVR recorded 2 hours and 54 seconds of the audio track. The first 29 minutes and 42 seconds are relating to the last flight of the previous day.

From the time CVR 00:29:42 the recording of the accident flight begins.

The audio track then recorded all the phases of the accident flight, since the aircraft was electrically powered before starting in Frankfurt Hahn until the power supply has been removed when the plane, stopped on the runway and the passenger disembarking started.

The communications show that the first official was the PF of the sector, while the commander was the PM.

Recording for logical purposes has been divided into the following phases:

1. operations on the ground, take-off, cruise, descent until automation disarming;
2. approach until the moment before the visual acquisition of the birds;
3. from the visual acquisition of the birds to the impact with the ground;
4. ground deceleration run and immediate actions after landing.

By listening to the communications inside the cockpit, recorded by the CVR, it was possible to get the following piece of evidence at the indicated registration times.

unofficial english translation by Aviation Accidents Database©

CVR: operations on the ground, take-off, cruise, descent until automation disarming

The pushback and start operations were completed at 05.26'59 ". The crew has carried out the checks as required by SOP and was authorized to taxi and take off for RWY 21.

Take-off took place at 05.31'24". After the take-off, the flight was initially authorized to FL240, with further authorization to FL370 final level with a direct route to Trasadingen.

The flight has contacted the German, Swiss and Italian air traffic control and it was instructed on the Trasadingen / Odina / Ruxol route and at the beginning of the descent to FL330.

At 06.25'27 "there was a detailed briefing carried out by the FO to the commander, in agreement with the provisions of the SOPs, on the approach to Ciampino with a comment of the ILS procedure for RWY 15, including the missed approach procedure and the validation of the data entered in the FMS and of which, below, there is an excerpt of the transcription.

«As for the briefing. BOLSENA three foxtrot. From BOLSENA to TIBER. BOLSENA 2-5-0, TIBER 2-3-0, then URBE 2-10. 2-5-0, 2-3-0, 2-1-0, BOLSENA, TIBER, URBE. We are going below ... minimum altitude here. We know this. Mountains are pretty much here, on this side. We are staying on this one. From URBE then is the ILS runway 1-5."

Then a radio call took place, which authorized to continue the descent to FL290; the commander and the FO have tuned the VOR and ILS apparatuses, after which the FO has resumed the briefing:

"Missed 3000 feet. Outer marker 16-25. Minimum 7-20. Elev 4-2-7. 4-50 up here. MSA based on ROM VOR is 8 thousand 1 hundred".

The captain confirmed: "Yes it is CAVOK."

The FO: "Yes, it is CAVOK so it should be visual. As for the go around, it will be: PRESS TO/GA, GO GOUNDUND, FLAPS 15, SET GO AROUND THRUST, POSITIVE RATE GEAR UP, RNAV, FLAPS 5. We are flying, since Pratica di Mare is U / S ... we are flying, as soon as possible, turn right, max 1-8-5. "

At this point, another call for air traffic control took place later of which the FO has continued with the confirmation of having already inserted the RATIR point instead of Pratica di Mare for a missed approach.

unofficial english translation by Aviation Accidents Database©

At 06.42'50 "the crew, considering the excellent weather conditions, decided to conduct the approach manually, ie without automation (autopilot, auto throttle and flight director).
At 06.43'02 "the autopilot and the autothrottle and the flight director were disengaged; the CM-2 from this moment conducted the aircraft manually.

CVR: approach until the moment before the visual acquisition of the birds
The following is a transcription of the communications of the approach phase until the moment before the visual acquisition of the birds.

UTC	STAT.	COMMUNICATION
06.49'40 "	ATC	RYR41CH descend 3000 feet clear ILS ZULU RWY 15 reports established
06.49'45 "	RYR	3000 feet clear, ILS Zulu, I'll call you established RYR41CH
06.49'50 "	CPT	I know my friend
06.49'51 "	FO	3 thousand sets
06.50'00 "	FO	We are ...
06.50'01 "	CPT	We are high ...
06.50'03 "	*AW*	INTERMITTENT HORN (2)
06.50'05 "	CPT	Wheels?
06.50'06 "	FO	Yeah ... get the gear
06.51'00 "	FO	Flaps one, match speed
06.51'11 "	CPT	You have the field in sight?
06.51'12 "	FO	Yeah, it's a little bit on the left
06.51'15 "	CPT	Yeah. Look, look
06.51'31 "	FO	Flap 5 and match speed
06.52'18 "	CPT	You can start turning
06.52'22 "	FO	LOC alive
06.52'23 "	CPT	Do you want the approach ... on this one or ...?
06.52'26 "	FO	Yeah ...
06.52'27 "	CPT	Yeah? Ok
06.52'29 "	ATC	RYR41CH confirm established?
06.52'31 "	CPT	affirmative
06.52'32 "	ATC	41CH position URBE, number one, TWR 120.5 buongiorno
06.52'37 "	CPT	120.5
06.52'39 "	FO	Runway in sight
06.52'42 "	CPT	3000 ... and then ...
06.52'44 "	FO	.... the glide ...
06.52'45 "	CPT	Yeah ...
06.52'47 "	CPT	Ciampino buongiorno, RYR41CH fully established, ILS 15 , distance 9 miles
06.52'53 "	TWR	RYR41CH Ciampino buongiorno to you, number one on the approach , on the field on ILS ZULU 15, CAVOK , Temperature 7, QNH 1029, the wind is calm now and you are clear to land runway 15
06.53'06 "	CPT	Clear to land 15 RYR41CH. Thank you
06.53'10 "	CPT	OK?
06.53'11 "	FO	So there we are
06.53'15 "	CPT	I seat the girls
06.53'16 "	FO	Yes, thank you
06.53'18 "	*AW*	CONTINUOUS HORN

unofficial english translation by Aviation Accidents Database©

06.53'22 "	FO	We have glide slope capture
06.53'23 "	CPT	Yeah ...
06.53'25 "	CPT	Missed Approach
06.53'26 "	SV	Twentyfive hundred
06.53'27 "	FO	Yeah missed approach 3000 feet
06.53'30 "	CPT	3000 is set
06.53'32 "	FO	Very good
06.53'33 "	CPT	Very good, very good
06.54'19 "	FO	Flaps 15, landing checks to flaps and match the speed please
06.54'24 "	CPT	Start switches
06.54'26 "	FO	Continuous
06.54'27 "	CPT	Recall
06.54'28 "	FO	Check
06.54'29 "	CPT	Speed barke
06.54'30 "	FO	Armed
06.54'31 "	CPT	Landing gear
06.54'32 "	FO	Down three green
06.54'32 "	CPT	Autobrake
06.54'33 "	CPT	Look at the localizer my friend
06.54'34 "	FO	Auch ...
06.54'35 "	CPT	Ooh, ooh ...
06.54'37 "	FO	My bad
06.54'38 "	CPT	Oh, yes please ... come back
06.54'43 "	CPT	Flaps 30
06.54'44 "	FO	Yeah, flaps 30
06.54'50 "	*SV*	ONE THOUSAND
06.54'51 "	FO	One thousand, check flaps ...
06.54'52 "	CPT	Continue a little bit to the left
06.54'54 "	CPT	I'll give you flaps 40
06.54'56 "	FO	40, thank you
06.54'57 "	CPT	A little bit to the left ... like that
06.55'02 "	CPT	141.
06.55'03 "	CPT	Flaps?
06.55'05 "	FO	40, and green lights
06.55'07 "	CPT	Ok
06.55'08 "	CPT	Do you have the runway in sight?
06.55'09 "	FO	Yes ...
06.55'10 "	CPT	Look at your speed
06.55'12 "	CPT	Ok, continue like that
06.55'17 "	CPT	Ok, a little bit to the right
06.55'20 "	*SV*	PLUS HUNDRED
06.55'23 "	CPT	Check
06.55'23 "	FO	Check
06.55'25 "	CPT	500 continue
06.55'30 "	*SV*	MINIMUMS
06.55'31 "	CPT	Continue
06.55'31 "	FO	Land
06.55'33 "	CPT	Reduce the speed to bit, you are high

unofficial english translation by Aviation Accidents Database©

CVR: from the visual acquisition of the birds to the impact with the ground
The following is a transcription of communications during this phase.

UTC	STAZ.	COMMUNICATION
06.55'49 "	FO	Nice
06.55'49 "	CPT	Ahi, Ahi, Ahi, Ahi, Ahi, Ahi, Ahi, Ahi, Ahi, Ahi, Ahi,!
06.55'51 "	*NOISE*	bang
06.55'52 "	CPT	Go around ... go around ... go around
06.55'53 "	FO	Go around, flaps 15
06.55'54 "	CPT	Go around ... go around
06.56'00 "	CPT	[omissis]
06.56'04 "	CPT	On est dedans
06.56'07 "	*SV*	SINK RATE
06.56'08 "	*SV*	SINK RATE
06.56'09 "	AW	STICK SHAKER
06.56'10 "	CPT	[omissis]
06.56'10 "	*NOISE*	TOUCH DOWN

To be underlined therefore as, at 06.55'49 ", while the FO commented« Nice », at the same time, the commander had begun to exclaim "Ahi!", repeated for about 10 times and for the next two seconds.

At 06.55'51 "there was a roar, with a change in the background noise of the engines, that become irregular.

At 06.55'52 "the commander ordered the" Go around ... go around ... go around ".
At 06.55'53 "the FO confirmed" Go around, flaps 15 ".
At 06.55'54 "the commander repeated" Go around ... go around ".

At 06.56'07 "and the following second, the synthetic voice warning "sink rate" was activated, repeated twice.

At 06.56'09 "the stick shaker was activated and after a second the commander's exclamation and the landing noise.

CVR: ground deceleration run and immediate actions after landing
The aircraft hit the ground at 06.56'10 "; at 06.56'18 ", with the aircraft on the runway and in deceleration, the commander confirmed "My control".

unofficial english translation by Aviation Accidents Database©

At 06.56'38 "the aircraft stopped on the runway and at the same time the commander ordered, via intercom, to remain seated, repeating the order twice.
From 06.56'44 "to 06.56'47" the commander, commanded to the FO, "We do ... open the outflow valve. », starting the procedure to secure the aircraft.
At the same time, the FO communicated to Ciampino TWR «Is maintaining ... on the runway, MAYDAY. " After that, when the engines were switched off, the Recording stopped.

1.12.INFORMATION ON THE WRECKAGE AND ON THE PLACE OF IMPACT

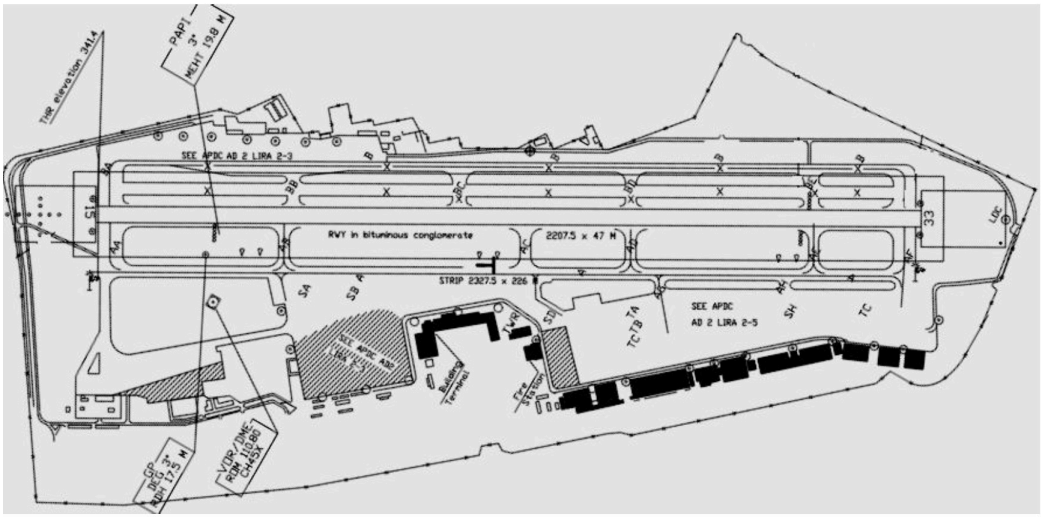
This paragraph shows the information acquired from the examination of the wreckage and the place of the event.

1.12.1.Place of the accident

The accident happened inside the airport perimeter of Ciampino airport.
As will be specified below, the aircraft has impacted the runway at the coordinate points 41° 47'55.59 "N 12° 35' 41.71" E, near the "AC" taxiway.

Photo 4 : Ciampino airport (on Google Earth)

unofficial english translation by Aviation Accidents Database©



Picture 26 : Airport diagram

1.12.2.Trails on the runway and distribution of scraps

The traces associated with the violent contact between the aircraft and the ground are in proximity to the intersection of the taxiway "AC" with the runway, intersection positioned at approx. half of the total length of the runway. The traces on the ground, detected and present in the following image are in chronological order:

- Impact trace of the lower part of the tail against the asphalt surface of the "AC" taxiway;
- Impact of the left landing gear against the asphalt surface of the runway;
- Impact of the right landing gear on the lawn adjacent to the right edge of the runway;
- A Continuous trail of the left engine and left landing gear from the first point of contact until the aircraft's final stop point.

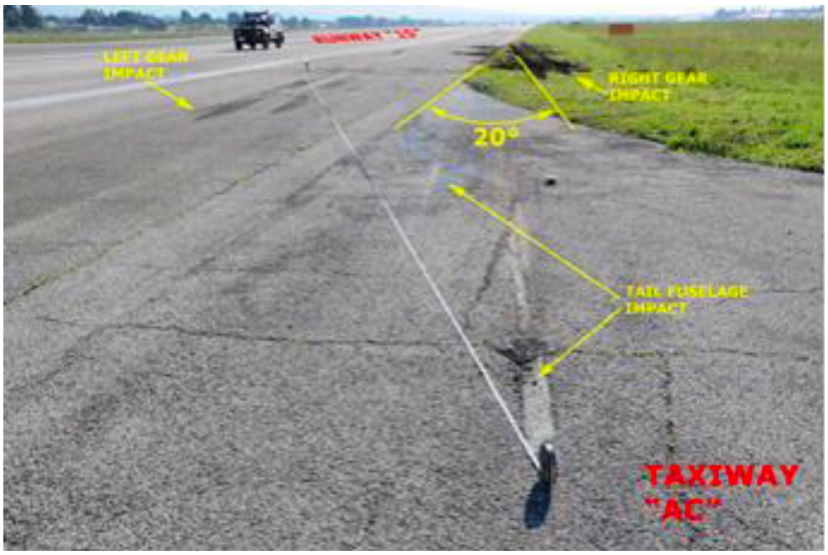


Photo 5 : runways on the ground of the landing gear and tail

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From all these traces emerges an angle of about 20° between the direction of the aircraft at contact with the runway and its axis.
In the next image, an overview of the traces.

Photo 6 : overall traces of landing gear and tail

Near the RWY15 beginning, about 100 m from the threshold, and more precisely in the part of lawn between the "Centerline bars n°2" and the "Centerline bars n°3" of the "CALVERT" approach system, a large number of dead bird remains were scattered.
Most of the organic remains were concentrated within an ellipsoidal zone, closer to the pylon "Centerline bars n°2", whose major axis was about 35 m, while the smaller one was about 10 m.

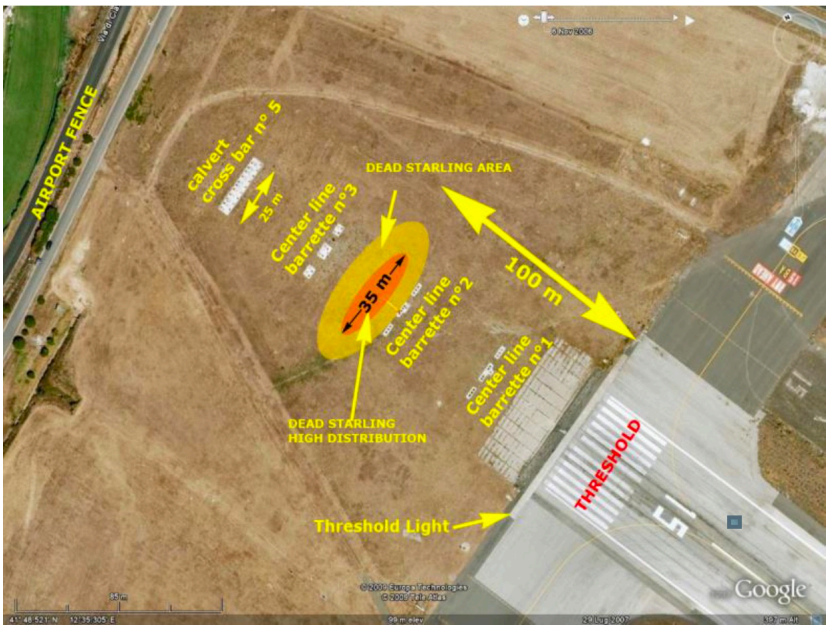

Photo 7 : distribution of bird remains

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During the reclamation of the area, carried out with the support of an ornithologist, they were identified and recovered about 120 carcasses of starlings or remains of them. Among the recovered material no organic remains belonging to other species of birds have been identified.

1.12.3.Wreckage examination

The aircraft stopped at the end of the runway, corresponding to the RWY 33 threshold, resting on the main right-hand landing gear, the nose gear, and the left-hand fan cowl.

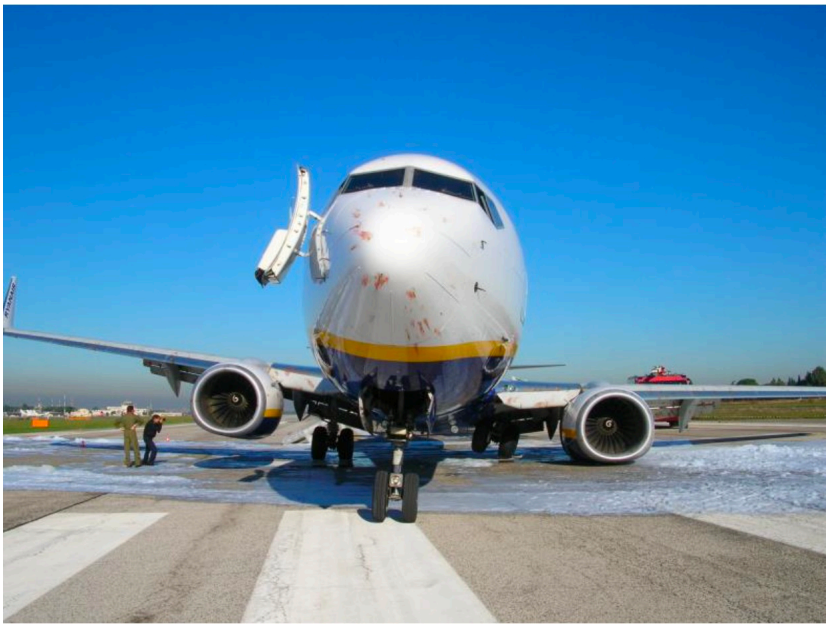

Photo 8 : airplane on the runway

The right rear slide was deployed during the disembarkation phases of the passengers and crew.

Photo 9 : the slide of the right door deployed

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Fuselage

The fuselage has multiple signs of impact with birds (not less than 86), visible in the subsequent images. Windshields have some impacts with birds in the upper part and the central one.

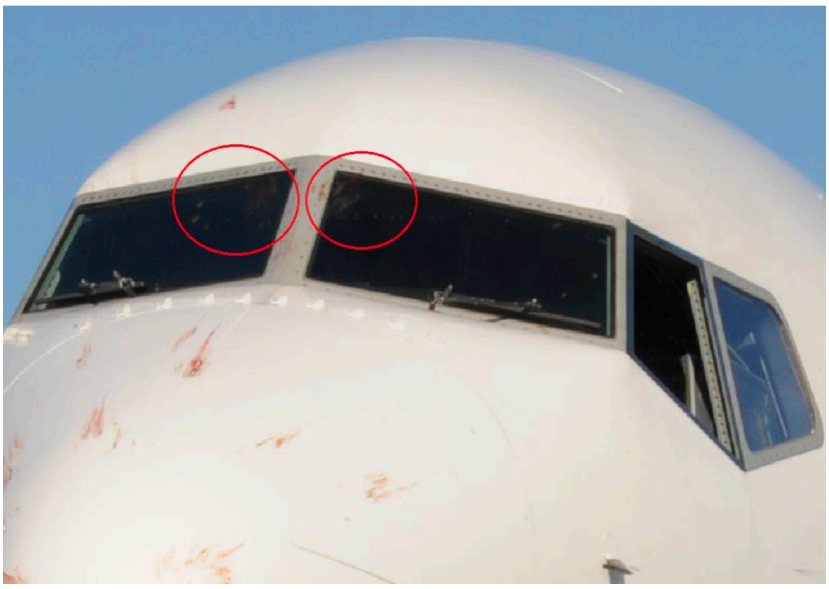

Photo 10 : bird impacts on the windshield

On the lower back of the fuselage, there are evident damages due impact and sliding against the asphalt of the runway.

The lower part of the passenger cabin floor structure presents extensive deformations.

Photo 11 and Photo 12 : damage to tail and cabin floor

Wings and related mobile surfaces

On the left wing, there are many points of damage and embossing, both on the upper, and on the lower part of the wing. The flaps have dents.

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Photo 13 and Photo 14 : impact of birds on wings

Landing gear

The left main landing gear is severely damaged, the shock absorber passed through the wing.

The landing gear doors of the left main landing gear are severely damaged.

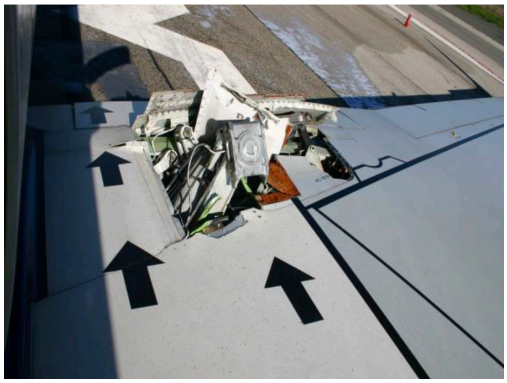

Photo 15 and Photo 16 : left side, damage to main landing gear and wing

Engines

The engines have many traces of impact with birds on their respective air intakes.

Photo 17 and Photo 18 : bird strikes on engine intakes

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On the fan cowl of the left engine, there are damages from swiping on the asphalt, thrust reverser doors are locked in a partially open position.

Photo 19 : thrust reverser locked in a partially opened position

1.12.4.Impact dynamics

For the reconstruction of the impact dynamics, reference was made to the traces on the ground, at evidence found on the aircraft, at the shooting of the surveillance cameras, at the synchronization of FDR and CVR data, and to witness statements.

The damages found on the aircraft have allowed confirming that there was a contact of the tail of the aircraft with the runway, contact that caused a plastic deformation of the structure. The traces on the ground have allowed us to precisely determine the point and the mode of initial contact of the aircraft with the ground. It was also possible, on the base of the traces detected on the ground, to reconstruct the trajectory of the aircraft from the first contact with the runway, up to the stop point.

Photo 20 : the ground roll of the airplane

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The traces on the ground show how the lower part of the tail has contacted the asphalt near the "AC" junction, the right main landing gear has contacted the adjacent lawn the runway and the main left-hand landing gear the right-hand side of the runway.

The point of contact is positioned at 1150 m from the runway, at 790 m from the aiming mark and at 1057 m from the end of the runway.

From the videos available from the airport cameras it was possible to acquire a series of useful frames to reconstruct the trajectory and final pitch of the aircraft up to impact with the runway.

Photo 21 : overlapping frames from the airport video camera

Immediately after the first contact with the runway, the left-hand landing gear has given way, causing contact with the left engine fan cowl runway.

The aircraft continued its run on the ground with the continuous left fan cowl in contact with the runway, following a curved trajectory, which led him to touch the left edge of the runway and then to return to the center of the latter.

The aircraft was definitively shut down near the threshold opposite to landing runway, on the designation number of the threshold RWY 33, after a path on the ground of about 998 m from the initial contact.

From the initial point of contact with the runway, along with the entire path on the ground and on the definitive stop point of the aircraft, no evidence or traces of fire were detected.

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Below is a summary of the final trajectory of the aircraft, section from the animation realized by the ANSV, obtained from FDR and CVR data, synchronized each other.

Picture 27 : ANSV reconstruction, the final trajectory of EI-DYG

The FDR data, as seen above, indicate that the aircraft was landing with flaps configuration with 10° and the landing gear in the "down" position.
At the time of contact with the runway, which took place at 06.56'10 ", the aircraft had the following parameters:

1. pitch: +10.72°;
2. roll: -5.97°;
3. magnetic heading: 142°;
4. speed: 120.75 knots;
5. AoA: between 21° to -3°;
6. VS: -1064 feet / minute;
7. flight path angle: -4.57 °.

Furthermore, the stick shaker and the "sink rate" warning were active.
The engine speed, according to the impact, was: left 41.75%; right 41,62%.
The aircraft, on impact, had a mass of 61.144 kg (134.800 lbs). Upon contact with the ground, a vertical acceleration of 2.66 g and a side of -0.45 g were recorded.

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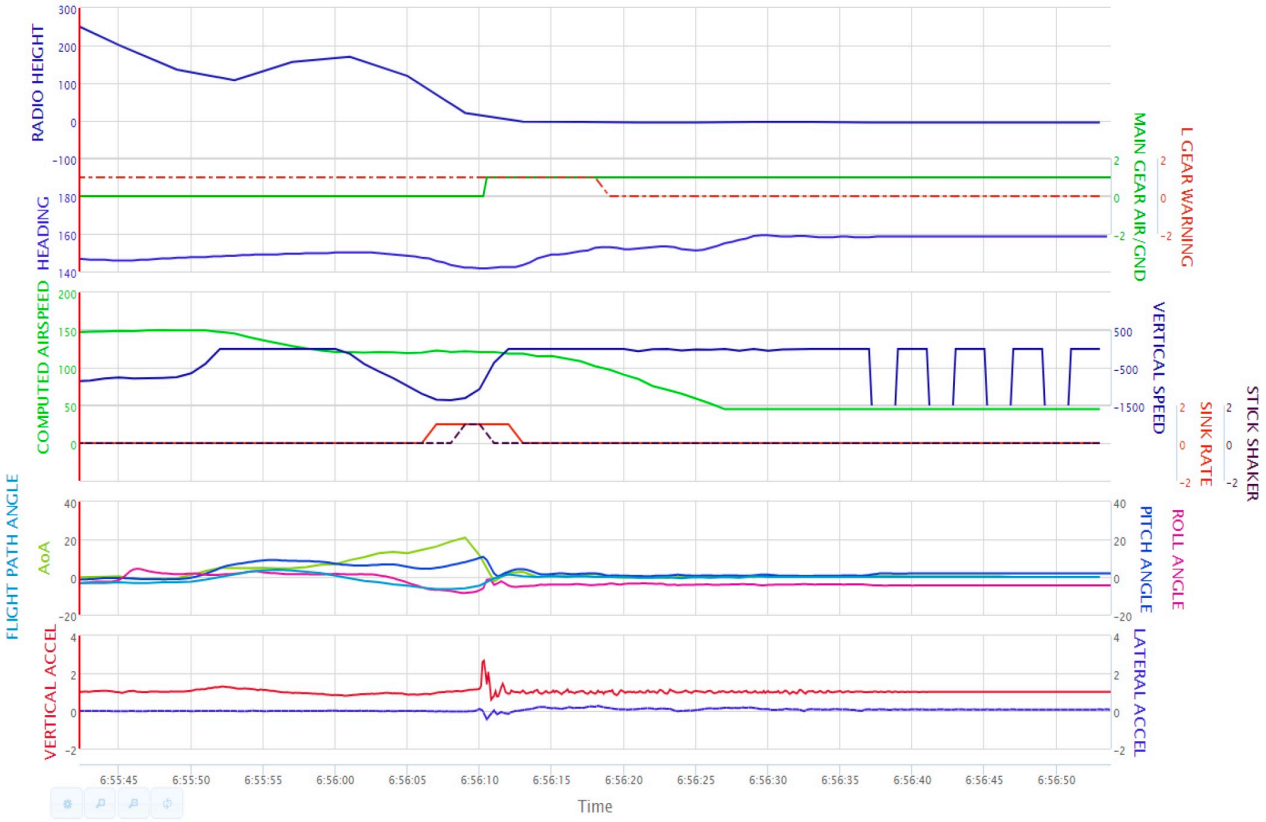

Picture 28 : aerodynamic parameters and accelerations at ground contact

After 9 seconds (06.56'19 ") from contact with the runway, the left landing gear indication is activated unsafe, which can be detected the "L GEAR WARNING" signal.

The aircraft continued the ground run by decelerating by means of brakes, spoilers and of the thrust reverser of the left engine only, from 06.56'20 "to 06.56'33", with a value maximum of 81% of N1. The aircraft stopped on the runway at 06.56'38 ", 50 m from the end of the runway.

Both engines were switched off at 06.56'52 "(ENG CUTOFF). In the landing run, following the collapse of the left landing gear, the left engine fan cowl is coming to contact with the runway.

The critical phase began at 06.55'51 ", when following the go-around command, stall of both engines occurred.

At this time the aircraft speed was 149 knots and the radalt height between 136 (at 06.55'50 ") and 112 feet (at 06.55'52").

The maximum vertical speed changed from a value of 752 feet per minute at the moment of the activation of the TO / GA at a minimum value of 0 feet/minute in two seconds (06.55'52 ").

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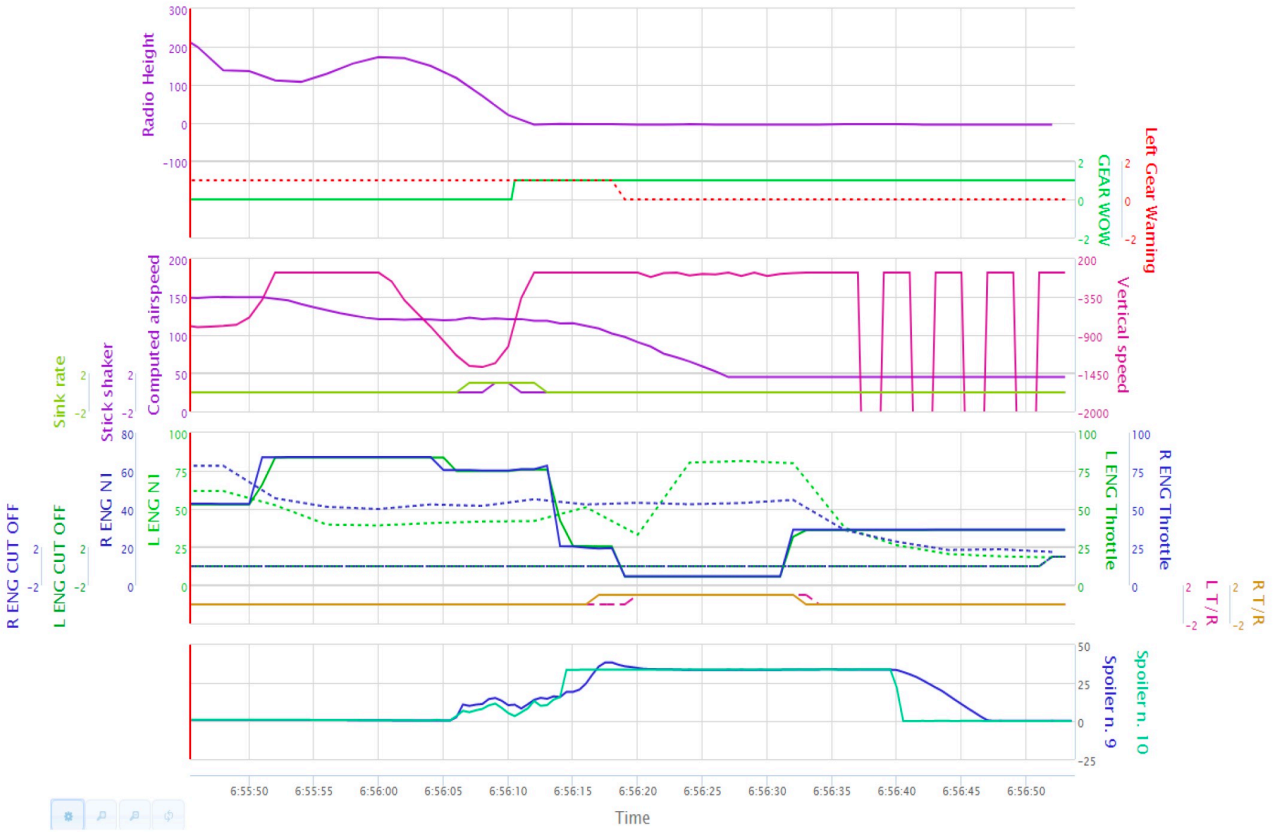
From this moment a progressive decrease of the speed and an increase in the angle of attack, which reached the values of 120.75 knots and 21 ° of AoA at 06.56'10 ", when the aircraft was at a radalt height of 21 feet.

19 seconds passed from TO/GA to ground contact.



Picture 29 : engine parameters and thrust reverser activation

1.12.5.Failures related to the event

Aircraft had no failures in the moments preceding the accident.

At 06.55'51 "the FDR recorded a stall on both engines, concurrent with the application of the TO / GA command and that continued until hours 06.56'03 ".

This failure is due to the impact with the birds and contact with the runway.

1.13.MEDICAL AND PATHOLOGICAL INFORMATION

No medical or pathological evidence emerged that could have influenced happening of the event.

1.14.FIRE

Not applicable.

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1.15.ASPECTS RELATED TO SURVIVAL

On board the aircraft there were 166 passengers and 6 crew members (2 pilots and 4 flight attendants). After the accident, 6 passengers and 2 flight attendants were subjected to health checks. It is not possible to know the extent of the injuries, nor the circumstance in which these occurred (landing or evacuation), except for the injury suffered from the flight attendant No. 3, who reported it happened during the landing and that even some other passengers received first aid before leaving the aircraft.
The position on board of passengers who have suffered injuries is not known, as at the time of the facts, the operator adopted the "free seating policy".

Immediately after the crash of the aircraft, at 06.56'38 ", the commander ordered, via PA, "Remain seated, remain seated".
At 06.56'44 ", he began to secure the aircraft, ordering the FO« We do ... open the outflow valve. "
At the same time, the FO carried out the radio communication at Ciampino TWR: «Is maintaining ... On the runway, MAYDAY. "; after which, when the engines are switched off, the CVR registration ends.

For the following phases, reference was made to testimonial statements (cockpit crew and flight attendants).
In particular, for what happened in the front of the passenger cabin, we refer to the declarations of flight attendants No. 1 and No. 4, and for the back of the airplane those of the assistant n°3.
The commander reported that he had put the parking brake on, that he had lowered the speed brake, to have positioned the flaps at 40°, declared mayday and depressurized the aircraft.
The commander then declared that he had turned off the engines and ordered, via PA, to stay seated and being out of the flight deck to assess the situation. Not having seen signs of smoke or fire, having noticed that the passengers were calm and silent, decided to disembark passengers normally by means of stairs. The decision not to use the slides was motivated by the fact that their use, deemed unnecessary, could have increased the chances that passengers could report injuries during evacuation through the slides themselves.

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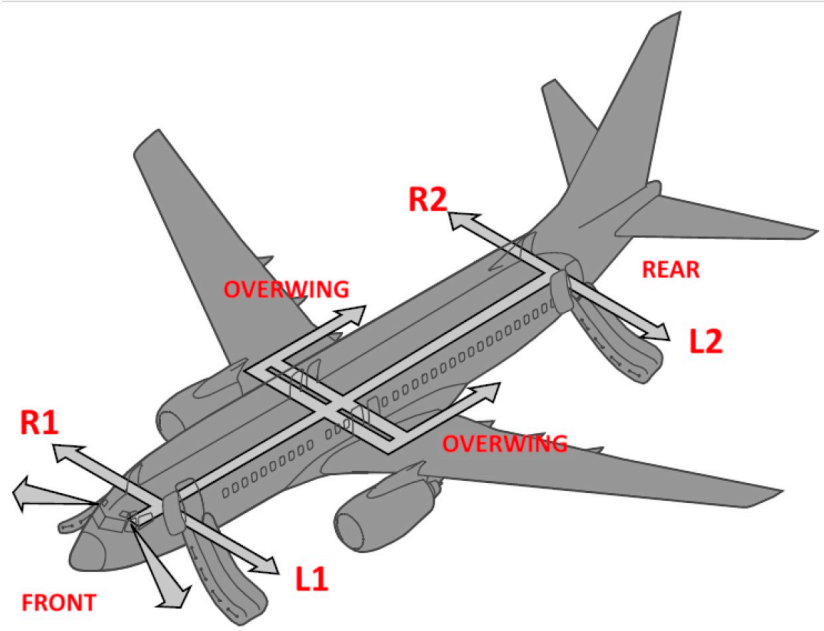
The flight attendant No. 1, which occupied the position of the purser in the front, has reported having experience, in the final stages of approach, an unusual noise, smell of "Burnt chicken" and, after a few seconds, the heavy contact of the aircraft on the ground.
He also stated that he waited until the airplane had completely stopped and to have heard the order of the commander, via PA, to remain seated.
After a short time, he noticed the commander leaving the cabin and ordered to remain seated.



Picture 30 : emergency exits diagram

The cabin attendant No. 1 communicated via intercom to the attendants seated in the rear of the cabin the commander's order.
He noted that the firefighters had positioned a stair lift at the door L2 (actually, the door was R1) and had ordered the attendant to inflate the R2 slide.
Attendant No. 1 said he had tried to communicate to the Fire Brigades the need to have stairs instead of the slides, but these did not speak English. The procedure was described as "very slow".
After verifying that there were no passengers incapacitated or passengers still on board, the crew came out of the aircraft from the L2 door (actually, the exit was the R1).

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The flight attendant No. 4, who sat on the jump seat at the front of the aircraft, confirmed what was already reported by the assistant n °1, except that the door reported from the attendant as L2 was actually the R1. He also stated that once the aircraft stopped, he unfastened and checked the internal and external conditions of the aircraft.

The commander was out of the cockpit, providing instructions, confirming that he had had a bird strike and lost both engines, not to deploy the slides for evacuation of the aircraft and to wait for the fire brigade.

The assistant No. 4 therefore stated that he had gone into the back of the aircraft to give instructions to assistants No. 2 and No. 3 and to give first aid to some passengers.

Upon the arrival of the Fire Brigade, the assistant No. 4 went back to the front, where he opened the door R1 to allow the docking of the platform, from which they disembarked the passengers.

Photo 22 : passenger disembarkation with a Fire Brigades vehicle

Eventually, after verifying that no passengers had remained on board, he left the aircraft, from the R1 door.

The flight attendant No. 3, who sat for the landing together with the assistant No. 2 on respective jump seat in the rear galley, reported that when the aircraft was close to the ground, a strange, burnt smell was felt in the back and since the landing did not follow he guessed a missed approach, though there had been no warning. Assistant No. 2 grabbed the intercom, awaiting instructions and at the same time, the aircraft hit the ground. The landing was reported as very heavy and followed by a rebound. In this phase the flight attendant No. 3 reported having felt severe pain in the back.

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Flight attendants No. 2 and No. 3 waited for the signal of evacuation and they heard the warning in PA to remain seated. The flight attendant No. 4, went into the rear galley to retrieve ice for passengers' first aid, informed the two assistants who were in that area that a bird strike had occurred and requested help from assistants No. 2 and No. 3 to provide first aid for passengers.
In this circumstance assistant No. 3 reported having noticed the oxygen masks leaks and 3 of the 4 wing emergency exits opened, most likely by the passengers. Assistants No. 2 and No. 3 were instructed to return to the rear galley for providing any assistance, in case the evacuation continued through the rear doors of the aircraft. Assistants No. 2 and No. 3 were instructed to disarm, via intercom, by order of the Commander, the slide of the exit R2 and to open the door.

Photo 23 : passengers evacuating through the right rear door slide

There was no order of evacuation. After the double warning «Remain seated», the commander exited the cabin. Attendants sitting the back jumpseats received the communication, from the attendants of the forward stations, that the commander ordered to disarm the slides and to disembark by stairs.
From what reports of the cabin crew it shows that there was no order of "brace for impact " before the event.
The rear right slide was operated at a later time after it was already been disarmed and by order of the fire brigade, who asked to close the door, arm the slide and open the door to activate the slide.

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It was not possible to determine the number of passengers disembarked through the slide. The assistant reported in the statement to have noticed, at the time of opening of the door, the copious presence of foaming around the plane. He reported having noticed the wing emergency exits (left one and two right) open. He then noted, in the course of evacuation, aircraft instability, with movements both on the roll axis both pitching. He reported that passengers delayed evacuation operations in an attempt to take hand baggage and to take photographs.

Below is an excerpt from the Boeing 737 NG FCTM relating to the methodology of evacuation:
«When is it necessary to evacuate passengers and crew, the captain has to choose between commanding an emergency evacuation using the emergency escape slides or less urgent means such as deplaning using stairs, jetways, or other means. All available sources of information should be used to determine the safest course of action including reports from the cabin crew, other airplanes, and air traffic control. The captain must then determine the best means of evacuation by carefully considering all factors. These include, but are not limited to:

- the urgency of the situation, including the possibility of significant injury or loss of life if a significant delay occurs;
- the type of threat to the airplane, including structural damage, fire, reported bomb on board, etc .;
- the possibility of the fire spreading rapidly from spilled fuel or other flammable materials;
- the extent of damage to the airplane;
- the possibility of passenger injury during an evacuation using the escape slides.

If in doubt, the crew should consider an emergency evacuation using the escape slides. "

1.16.TESTS AND RESEARCH MADE

Both engines CFM56-7B26 / 3, S / N 896379 (# 1) and S / N 896387 (# 2), have been removed from the aircraft on 14 January 2009 and sent to the GE plants in Cardiff (UK), where, starting from February 5, 2009, were performed the teardown of the modules and components of both of them.
The two engines both had 2419 hours and 1498 operating cycles since new.
Below are the main elements that emerged from the investigation conducted.

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The external visual inspection of the fans highlighted 55 points of impact with birds on the fan of the left engine and 30 points on the right engine fan; on both fans there were no apparent damage and deformation of the aerodynamic profile of the blades; has been found a slight deformation of the engine case fan # 1, due to contact and subsequent creep with the runway of its fan cowl[1].

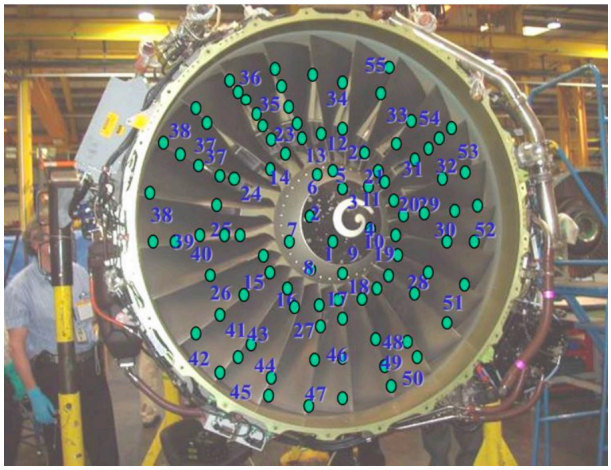

Photo 24 : bird impacts on engine fan #1

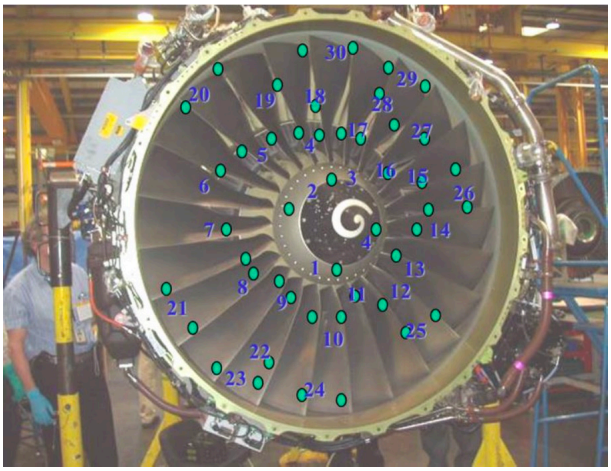

Photo 25 : bird impacts on engine fan #2

Inside the fan, the booster compressor, the high-pressure compressor and the combustion chambers of both engines there was a considerable amount of residuals of organic material, in greater quantity in engine # 2 than engine # 1, despite the few traces of impact on the relative fan.

The presence of organic residues has produced a severe alteration of the aerodynamic profiles of the compressor blades and the partial obstruction of the air passages to the various sensors and in the combustion chambers.

A limited presence of metal splatter has also been detected on the hot parts of both engines, however not such as to alter its functional characteristics.

The accessories of both engines have undergone specific inspections and functional tests, without experiencing malfunctions.

No defects that occurred prior to the ingestion of the engines were found on both engines.

1. To represent the mapping of the impacts of the birds on the fans of the two engines (photos 24 and 25 taken from the CFM report), the same basic picture was used for convenience.[1]

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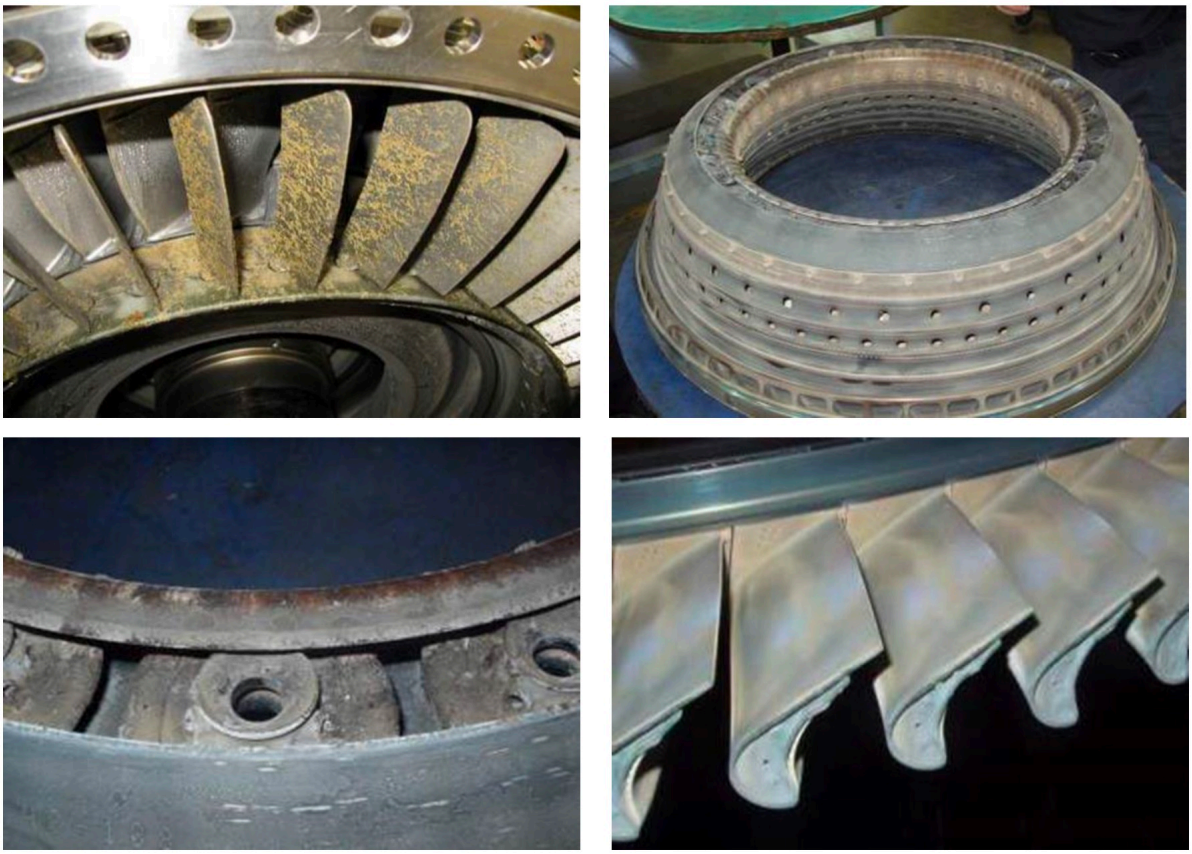
Photo 26, 27, 28 and 29: engine # 1, disassembly conditions in modules.



Photos 30, 31, 32 and 33: engine # 2, disassembly conditions in modules.

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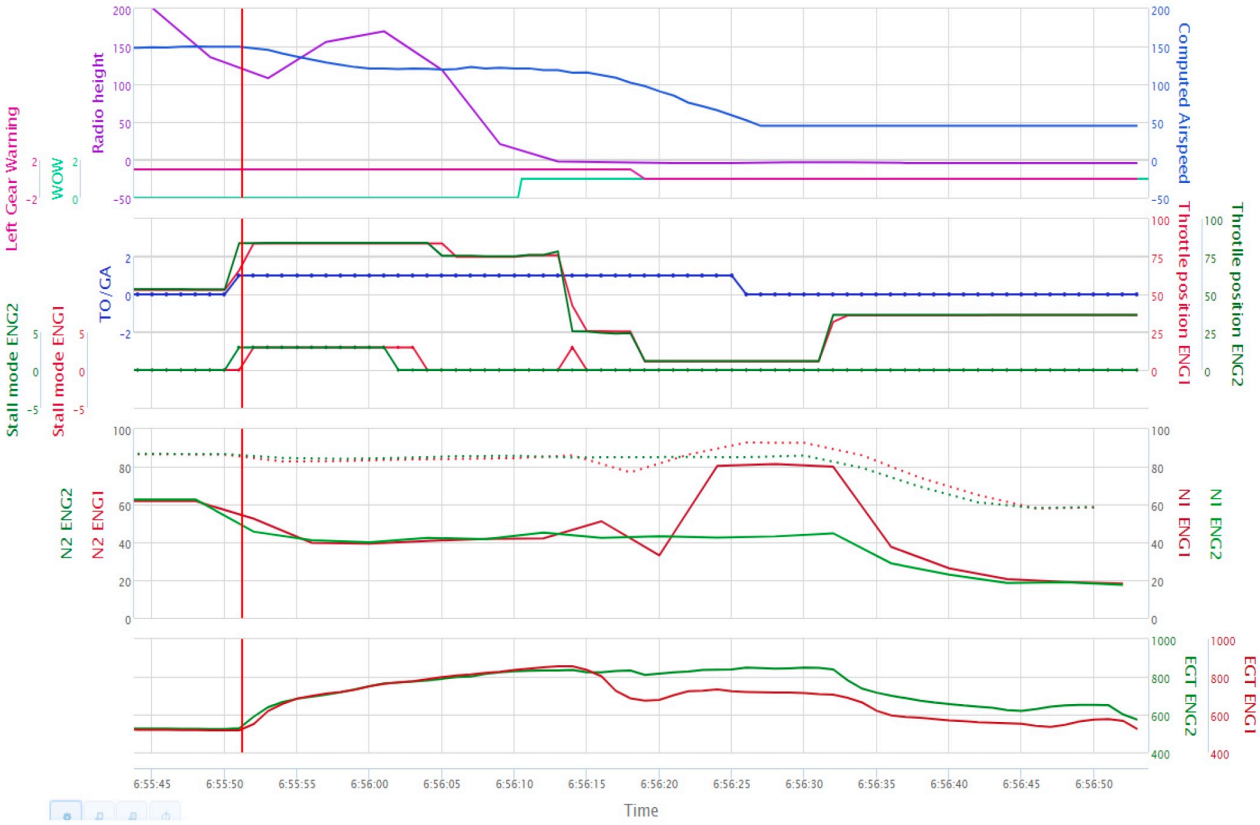
Based on the engine parameters registered by the FDR and following the analysis of the data collected from the EECs of both engines, the investigation conducted allowed to reconstruct the behavior of engines following massive ingestion of birds.
Immediately after the impact with the birds and the application of the TO / GA command (in correspondence of the vertical red line in the following plotting), both engines have experienced a fall in N1 revolutions from 62% to 52% and 46%, respectively for the engine left and right. The N2 remains substantially stable at about 83% (a fall of about 3%), while EGT temperatures had a sudden increase of about 300 ° C
in the next 24 seconds. The fall of N1 and the rise in EGT occurred together with a series of "surge[2]" tested by both the compressors and indicative of a severe aerodynamic disturbance of the flow of air inside the HPC.



Picture 31 : behavior of N1, N2, EGT, stall mode at TOGA throttle selection

These repeated surges caused a fluctuation of the transmitted pressure values from the High Pressure Compressor Discharge Pressure (CDP), with a corresponding fall of the N1 revolutions (from 62% to about 40%) and N2 (stabilized at 83%) and a sudden increase EGT values, due to a loss of air flow through the engine.

[2] The surge is distinguished from the stall because it consists in a total interruption of the normal flow of air inside an axial compressor, while the stall is represented by an interruption / disturbance of the air flow, confined to a part of the compressor. The surge causes an immediate increase of the internal pressure of the compressor and consequent violent inversion of the normal flow of air inside the same compressor, to which strong noises are associated intensity (bang).

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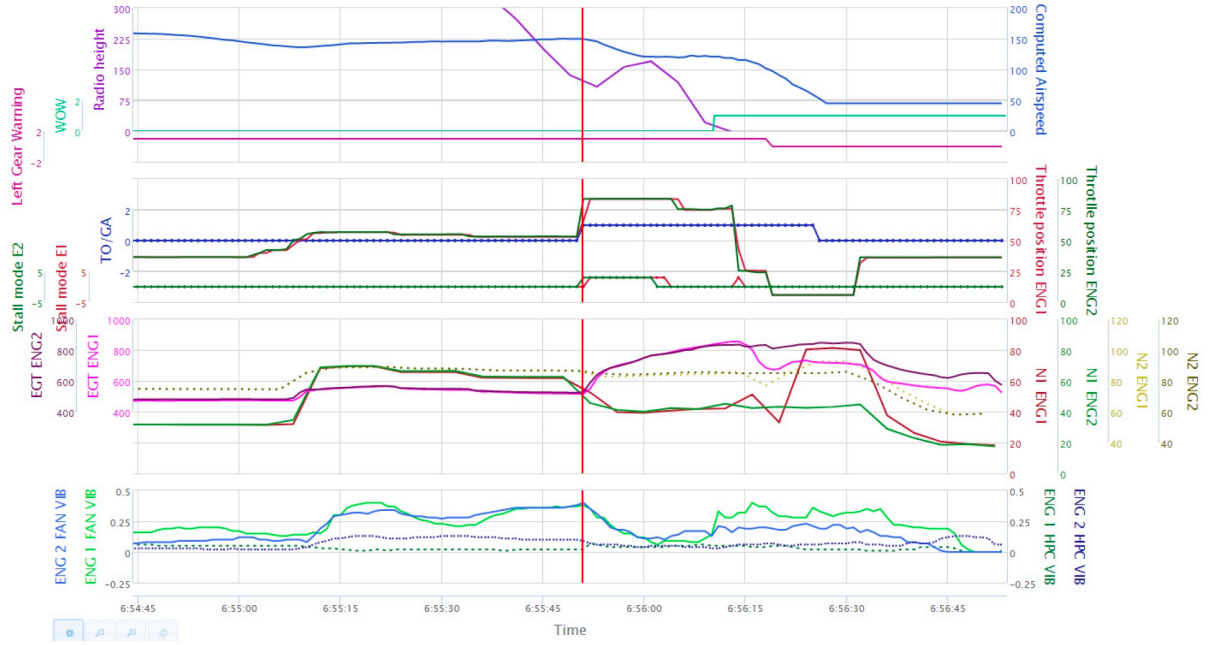
Considering that N1, N2, and CDP are parameters used by FADEC to regulate the fuel flow, the fall of the N1 and N2 laps caused an attempt by FADEC to restore laps increasing the fuel flow. The latter is however limited by the acceleration data of the engine, which are based on the parameters CDP, N2, and T25.

The low CDP values caused by the compressor surge resulted in fuel values flows too low to maintain the level of N1 required by the crew.

As can be seen from the subsequent graph, the engine throttle levers remain in position full forward until 06.56'05 ", that is 5 seconds before the impact on the ground, when they were brought slightly backward (MCL position); during the next deceleration run after the ground impact of the aircraft, both engine throttle levers were commanded backward from MCT to IDLE and then to the subsequent activation of the thrust reverser (T / R), followed by a different behavior of the two engines:

- on the left engine the N1 increase to about 80%, ensuring a correct inversion of the thrust of the relative thrust reverse;
- on the right engine, the N1 does not increase, remaining at values around 40% and thus not generating reverser thrust through the T/R; the same engine seems to restore its correct functionality only in the final stages of deceleration of the aircraft on the runway, with the idle throttle.



Picture 32 : engine vibrations before bird sighting and stall

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Vibration regimes recorded for fans and HPC of both engines, reported in the previous plot, do not indicate abnormal vibrations in the seconds before the application of the TO / GA command, vibrations possibly due to impacts with birds.
The evolution of the fan and HPC vibrations in the phases of approach and short final of the previously performed flights indicates a level of engine vibration similar to that observed in the flight of the accident.

1.17.ORGANIZATIONAL AND MANAGEMENT INFORMATION

The operator is a "low cost" airline based in Dublin and operating base at the London Stansted airport.
The operator uses exclusively Boeing 737-800 aircraft, whose fleet consists of over 300 airplanes.
The company has been operating for several years at Ciampino airport with daily flights to and from numerous national and international airports.

1.18.ADDITIONAL INFORMATION

1.18.1.Testimonials

Testimony of the commander

The commander was interviewed in three distinct phases: in the last audition he listened to the CVR and taken note of an animation related to the final phases of the flight, made by ANSV laboratories.
During the first hearing, released shortly after the event, he reported that the flight of the incident was the first of the day, which occurred on the second day of service.
He reported that the weather conditions were characterized by excellent visibility and absence of cloud cover.
The aircraft was number 1 on approach; after being authorized to the Urbe a 3000 feet for ILS Z for RWY 15 at Ciampino, the first officer, PF, carried out an ILS raw data approach (without the use of AP, AT, FD). On the indication of the ATC, the speed was reduced to 210 knots and the flaps extended. Extension of Landing Gear was anticipated in order to increase the rate of descent and to slow down.

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The stabilization on the ILS took place on time and the airport was acquired visually with considerable advance. Controls and calls were made in agreement to the company SOP; at 500 feet the aircraft was stabilized in relation to the parameters planned, so that approach was continued.
At about 200 feet the impact occurred with a large flock of birds.
He immediately ordered the go around, carried out according to the company SOP from the first officer. The lack of response of the engines was observed, with values of N1 al 40%; at this point, the commander took control of the aircraft for landing in an emergency. A hard landing took place with a stall at the time of the flare and consequent tail strike. The right main landing gear touched the grass so that large part of the energy was absorbed by the left main landing gear, which collapsed during the deceleration run.

The commander had specified that he had not received any communication on frequency about the presence of birds within the airport and that, despite having flown a lot in Italy, he had never seen before such a concentration of birds.

Subsequently, it was considered necessary to proceed with a further hearing of the commander, on some specific aspects of interest.
Bird visual acquisition.

- The commander explained that he visually acquired the flock of starlings during the ILS approach, when this had crossed the airplane's path from right to left, disappearing on the left side and down, respect his field of vision. A few seconds later, he saw the flock reappear coming from the left, as if it had made an inversion of the trajectory of flight (such as an "Immelmann" turn) and showed up in front of the aircraft. To this, he made the exclamation of surprise "Ahi, ahi, ahi, ...!".
- Recalled to memory of the initial impact of the aircraft with the most dense part of the flock, instant to which the commander has associated the "bang" recorded by the CVR, followed by a series of impacts with single birds, like "hail noise", and then from vibrations on the whole structure of the plane.
- He mentioned how the collisions of birds on the windshield were minimal (or even void) and that there has never been a loss of eye contact with the runway e the surrounding areas.

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- He said he was right to assume that the FO, engaged in the conduct aircraft and intent to correct the speed and altitude parameters for landing, has not been able to see the birds until now of the crossing of the flock. He believes that the "nice" comment of the FO was its indication of the positive tendency to recover the correct parameters.
- Reiterated that on the day of the event there were no current NOTAM related to the presence of birds on the airport or having been warned about it.

The Sequence of events.

- In the analysis of what happened in the two seconds in which he pronounced «Ahi, ahi, ahi, ...! » and up to the verbal command go around, the commander confirmed, in order, to have visually acquired the birds, to have felt the impact, to have ordered the go-around maneuver.
- The commander has confirmed that, while he ordered the maneuver with the call out “go-around ", contextually could have put the hand himself on the throttle levers for making it easier to advance to the TO / GA position.
- The commander has confirmed that the TO / GA switch may have been pressed at the time of the throttle advancement.
- He was not able to tell how the flap lever could form position a 40 ° overcome the detent of the position at 15 °, but recognized that the background noise recorded by the CVR may be the "click" of the passage of the position at 15 °, to continue to the 10 ° position.
- Reiterated that, considering the time available (less than 2 seconds) and the fact that the attention was focused to the threat of the birds in ahead, it was not possible to observe the N1 value of the motors in the phase between the sighting of the birds and the go around.

Approach.

- The commander has confirmed that, due to the excellent condition weather, he thought it appropriate to provide the possibility for the young FO to carry out a manual approach in raw data, considering the manual flight a skill very important for every pilot.
- Confirmed that the speed limitation at 210 knots imposed by the control of the traffic had contributed to being a bit high and therefore to have to anticipate the configuration of the aircraft.

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- He confirmed that, at the minimum, the aircraft had appeared slightly high and slightly faster than the target speed of 141 knots (defined by himself as equal to the Vref +5 nodes), but that the approach was stabilized according to criteria of the operator's SOPs.
- It has however judged the stabilization, before the sighting of the birds, such to allow the continuation in a safe way for the landing, judging that the FO was correcting parameters appropriately.
- The commander confirmed this aspect also commenting what registered by the CVR to the minimum: in fact, he declared «Continue» and the «Land» FO.
- He declared to have ordered the go-around and then to be intervened instinctively on the controls, without however communicating it verbally, keeping the control of the airplane until it stops on the runway.

Go-around.

- The captain confirmed the sighting of the birds and the subsequent impact he had destabilized the approach, calling it "de-tuned". About that term, he clarified how he no longer considered safe to continue consideration of the resulting between some pre-existing aspects, which he had already considered before approach, such as limited runway length compared to airports greater (characterized by longer runways), the weight of the aircraft and the component of wind in the queue, and of those that have occurred, such as destabilization and the hypothesis that the impact could have caused damage and therefore limitations (engine, braking system, etc.)
- The commander has reiterated that normally the pilot, in doubt, is trained and conditioned to reattach, as "the threat is from the ground and not the sky". He reiterated that the probability of having a problem with both engines in approach both remote and at the time of the facts not even considered, while the reattached with a single engine is not a serious problem and once in air can opt for diversion on an airport with more suitable characteristics (Fiumicino, Pratica di Mare).

Landing stage.

- The commander reiterated the extreme importance of manual conduct skills airplane, especially in exceptional events such as the event concerned, characterized by a landing without engines available.

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- He confirmed that, after making sure he had no thrust, he checked the area surrounding, looking for a flat area, commenting that it was still inside the airport area, preparing for the landing.
- He confirmed that he tried to regain alignment with the runway and to have touched the ground while still being correcting.
- The commander has defined meeting and the impacting the birds with terms such as to qualify the situation as highly unexpected and surprising.

Procedures.

- The commander reiterated that at the time of the facts there were no guidelines, procedures or training for this type of scenario.

Flight crew training.

- The commander reiterated that the FO, although recently hired and with relative few hours of flight, was already enabled for the scheduled activity, having completed the training expected.
- The commander held the instructor rating on the type of aircraft, though did not exercise this function within the operator.
- The commander had extensive familiarity with the Ciampino airport, having operated previously and with the same type of aircraft, also with another operator.

Testimony of the first officer

The testimony of the first officer, released to the investigators in the hours following the event, it is substantially in agreement with the commander, confirming the presence of a huge flock of birds, similar to a black cloud coming from below. He also confirmed that, after the impact with the birds, the commander took over control of the aircraft, which landed heavily after activation of the stick shaker.

Other Testimonials

a) Flight attendants.
The testimonies of the flight attendants on board the aircraft were reported in paragraph 1.15 "Aspects related to survival".

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Photo 34 : eyewitness position (from Google Earth)

b) Commander of a parked airplane.

A commander on board an aircraft parked at stand 113 (item 2, photo 34), hearing the noise of a jet engine at low operating speed and with a noise of background similar to crackling, it turned and visually acquired the 737-800, to an estimated height of about 200 feet from the runway.

The aircraft had flames in the back of the engines, but not from the fan cowls (flames similar to an engine tail-pipe fire or those of an afterburner).

The aircraft was in a slight pitch up and with extended landing gear. The flight path, initially level, then began a gradual descent to disappear behind the building of the terminal, next to where the witness was.

c) Captain of I-DEAC airplane's registration marks.

The aircraft C525 identification marks I-DEAC was, at the time of the event, stopped at the holding point on the "A" intersection at Ciampino airport (point 3, photo 34).

The commander of the I-DEAC declared to the ANSV that, during the taxi from the apron to the "A" intersection, he noticed the birds, laid on the ground, that were "Slightly" in flight to the right of the extended runway centerline, aligned with the taxiway on which he passed.

From the position in which it was located (holding point "A"), he saw the EI-DYG aircraft approaching and declaring that it was perfectly aligned with the runway axis and that it was an about 50 feet above the same threshold next to landing, perhaps in slightly lower than the normal descent path.

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While the aircraft was in this position, they took off from a point to the ground to about 50 m from the runway threshold, corresponding to the C2A and C2B areas of the grid shown in figure 10, about 300-400 small birds, which have hit in both the front of the aircraft, both the engines of the same.
The commander also claimed to have clearly heard the noise caused by the stall of the compressors, even though he was inside another aircraft. He added then that the Boeing 737 EI-DYG, instead of touching the ground because of the very low altitude, changed attitude, going up along the trajectory up to a maximum height estimated around 150 feet, reached near the half of the runway, in front of the airport TWR.
In this phase, the commander saw flames coming out of the right engine and remains of birds from the left engine, then saw the aircraft in a left-wing slip and impact violently the ground. The impact caused a big white smoke.
The commander (on specific request of the ANSV) stated that the flames were emitted only from the right engine, that the flames were almost continuous and that it did not start at the moment of impact with the birds, but started when the aircraft went it was about halfway up the slope, at a height that was the highest of its attempted go-around trajectory, with aircraft in left-wing slip. Finally, he added that the fire continued even after the aircraft had started the descent trajectory.

d) Testimony TWR controller of Ciampino.
The controller, at 06.45 ', after taking the shift from the dismantling TWR / APP controller from the night shift, he started the service on the 120.5 frequency station, contacted from the flight RYR41CH once issued by Roma ACC / ARR (position at point 1, photo 34).
The controller provided the weather information, the instructions provided, and the Ryanair flight permission to land, being the only approaching traffic.
He noticed that, while the aircraft was flying over the light path for RWY 15, a large one flock of birds rose from the trees near the path and precisely to Est of the same, which collided with the aircraft in a very short final.
The aircraft then assumed a positive pitch attitude, as if the pilot had decided to carry out a go-around in a very short final.
The controller added that "you could hear the noise of the engines that, after the first moment of apparent spool up, they began to give bumps in rapid succession and simultaneously from both engines there were evident flames. "

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He added, finally, that the aircraft gained slightly height, but that immediately afterward he kept an attitude first with right yaw, and then, after correcting the position kept going down towards the ground.

1.18.2.Characteristics of the area surrounding the Ciampino airport

The Ciampino airport is located in the territory of the homonymous Municipality, on the slopes of the Colli Albani hills, on which the Municipalities known as "Castelli Romani" is. The territories of the Municipalities belonging to the Regional Park of the Roman Castles are protected areas. In the area, there are natural areas of interest. The territory to the East (beyond the built-up area of Ciampino), to the South-East and to the South Ciampino airport is characterized by the presence of agricultural land, water basins, and woods.

1.18.3.The starling

The remains found both in the airport grounds and inside the engines and the landing gear compartment of EI-DYG aircraft have been identified as belonging to starlings.

The starling, whose scientific name is "sturnus vulgaris", is a medium-small bird dimension: generally, it does not exceed 23 cm in length and 40 cm in wingspan and has a weight that varies between 40 and 100 grams. The starling is widespread in areas with temperate and boreal climate and is one of the most adaptable species in different environments (countryside, urban areas, hills, but also frequents forests and wetlands).

In the past, it was usual to spend the night in the rushes and in the woods, but for some years it has demonstrated a marked preference for urban and suburban areas, where it takes refuge in the evening together with hundreds of comrades, in a sort of "collective dormitories". It feeds mainly on the ground and the diet is omnivorous and adapts to the season and availability of food.

One of the most evident characteristics is the gregarious behavior that manifests itself especially during feeding, displacement flights, and night dorms. The first starlings from abroad reach Italy in mid-August, but the very migration, which affects some tens of millions of individuals, occurs from the end of September to the first decade of November, with a peak between the second half of October and the beginning of November[3].

[3] Source of information: LIPU (Italian League for Bird Protection).

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1.18.4.Review of operating procedures

The go-around is a maneuver that is carried out for Safety reasons when the pilot decides or is instructed to interrupt the approach and to abort a landing.

In order to be able to carry out a more in-depth analysis of the actions undertaken from by the crew, it was considered necessary to examine, with reference to the maneuver mentioned, the following operational procedures:

- Boeing FCOM and QRH;
- Boeing FCTM;
- Ryanair Operations Manual.

The execution of the go-around procedure is illustrated on the FCOM, vol. 1 and provides that:

- the pilot flying press the TO / GA switch and make the call “go-around, flap 15";
- the pilot monitoring confirms that the thrust of the engines increases to the value foreseen for the go-around and call "flap 15", selecting the flaps at the 15 ° position and checking them effective retraction;
- the pilot flying rotates to the pitch for the go-around and announces "set go-around thrust";
- the pilot flying verifies the correctness of the "mode annunciation";
- the pilot flying, when there is a positive indication of the climb, commands the retraction of the landing gear ("gear up"), monitoring the acceleration;
- the pilot monitoring verifies that there is a positive indication of the VSI and of the altimeter and after that announcements "positive rate", bringing the landing gear lever to UP position.

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Go–Around Procedure Single Channel or Manual - Pilot Flying and Pilot Monitoring < RYR >

PILOT FLYING	PILOT MONITORING
Push TO/GA switch. Call "GO-AROUND - FLAPS 15." If full G/A thrust is required, push the TO/GA switch again after reduced G/A thrust is established.	Confirm thrust advances toward G/A. Call "FLAPS 15", position FLAP lever to 15 and monitor flap retraction.
Rotate to go–around attitude and call "SET GO-AROUND THRUST."	
Verify mode annunciation.	
When positive rate of climb is indicated, call "GEAR UP" and monitor acceleration.	Verify that both VSI and altimeter indicate a positive rate of climb and call "POSITIVE RATE" and move the gear lever to the UP position.
Check flight instrument indications (MCP speed window blanks.)	
Above 400 feet, call for appropriate roll mode and commence flap retraction.	Verify annunciation. Position FLAP lever as directed, monitor flaps and slats retraction and call "FLAPS UP, NO LIGHTS."

Picture 33 : from FCOM

The standards call-outs during the ILS approach phase for landing or possibly go around are reported in the FCOM and in the FCTM, of which the excerpt in the figure is shown. As you can see the criteria that determine the calls "CONTINUE", "LANDING", "GO AROUND" is based on the acquisition or not of visual references for landing.

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Standard Callouts - ILS Approach

CONDITION / LOCATION	CALLOUT (Pilot Monitoring, unless noted)
First positive inward motion of localizer pointer	"LOCALIZER ALIVE"
First positive motion of Glide Slope pointer	"GLIDE SLOPE ALIVE"
Final approach fix inbound	"OUTER MARKER/FIX, ____FT"
500 ft. AFE (Check autoland status annunciator, if applicable)	"500 FEET" (F/D or single autopilot approach) Autoland status "FLARE ARMED" (Autoland callout only) Autoland status "LAND 2 or LAND 3 or NO AUTOLAND"
100 ft. above DA(H) (fail passive airplanes)	"APPROACHING MINIMUMS"
Individual sequence flasher lights visible	"STROBE LIGHTS"
At AH (fail operational airplanes) - check autoland status annunciator	"ALERT HEIGHT"
At DA(H) with individual approach light bars visible	"MINIMUMS - APPROACH LIGHTS / RED BARS" (if installed)
At DA(H) - Suitable visual reference established, i.e., PM calls visual cues	PF: "CONTINUE"
At DA(H) - Suitable visual reference not established, i.e., PM does not call any visual cues or only strobe lights	PF: "GO AROUND"
At minimums callout - If no response from PF	"I HAVE CONTROL_____" (state intentions)
Below DA(H) - Suitable visual reference established	"THRESHOLD/RUNWAY TOUCHDOWN ZONE"
Below DA(H) - Suitable visual reference established	PF: "LANDING"
Below DA(H) - Suitable visual reference not established, i.e., PM does not call any visual cues	PF: "GO AROUND"

Picture 34 : standard callouts

The operating procedures in force at the operator involved in the accident are illustrated in the Ryanair Operations Manual (OM), Part A. In particular, Chapter 8 defines the "Operating Procedures", pointing out, in point 8.0.2, how the operating philosophy is illustrated in the FCOM, the QRH and the FCTM: «The operating philosophies are presented in the FCOM Vol 1, Normal procedures, QRH and FCTM (Flight Crew Training Manual) ».

The go-around procedure is explained in paragraph 8.3.0.3.3 of the Ryanair OM and also in this case the reference is to the profiles illustrated in the FCOM, QRH and FCTM: "The conduct of the Go-around and the areas of responsibilities for the crew member, the standard operating procedures, and the Go-Around profiles are presented in FCOM Vol 1, Normal Procedures, and QRH for non-normal Go-Around procedures. Additional guidance is provided in the Boeing Flight Crew Training Manual. ".

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When they perform a go-around is described in the following point 8.3.0.3.9. Here we specify how the maneuver should be performed if the visual references for the landing were not acquired upon reaching MDA or DA.
Furthermore, the maneuver must be started if:

1. the success of the approach becomes doubt, for example, the approach is not stabilized within 500 feet AAL (300 feet AAL after circling), if the landing threshold is not clearly identified, etc .;
2. in the case of engine failure on final, when in IMC and under 1000 feet AAL;
3. if any significant deviations from the normal take place below 1000 feet AAL approach path and corrective action does not have an immediate conclusive effect;
4. if, unless in VMC, the doubt arises that the aid used for the approach does not work properly;
5. upon indication of the ATC;
6. upon the decision of the Commander;
7. in the case of activation of the flap load relief after the applicable landing gate (1000 feet AAL IMC or 500 feet AAL VMC).

The stabilized approach criteria definition is listed in the FCOM vol. 1.
The stabilized approach condition, according to the Ryanair definition, is:

- be at the correct final approach speed or in correction phase if less than Vref;
- or to more than 10 Vapps;
- the vertical speed is proportional to the current ground speed;
- the VS does not exceed 1000 feet/minute continuously, unless required by the procedures in force and previously briefed;
- on the approach profile and in landing configuration;
- the value of engine N1 at the appropriate thrust setting.

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The Ryanair landing gates are then defined, ie the heights when the aircraft must be stabilized, with the landing checklist completed. Otherwise, it is indicated the obligation to go around.
For the ILS precision approach, the landing gate is 1000 feet AAL in IMC and 500 feet AAL feet in VMC.
Following is the description of the criteria for the call "500 continue" / "500 go around", according to which in order to call "500 continue", the PM must have ascertained that:

- the speed is the Vref or Vref 20 knots;
- the aircraft is vertically on the glide path (+/- 1 dot or 3 red/3 white of the PAPI);
- the aircraft is horizontally on the centerline (+/- 1 dot);
- the appropriate thrust setting is applied;
- the landing checklist is completed;
- the vertical speed is proportional to the current ground speed but not higher than 1000 feet/minute unless it has been commented in the briefing.

If one of these parameters cannot be confirmed, the call is "500 / go around".

The FCTM provides information and recommendations on maneuvers and flying techniques and has the purpose of providing supporting information to the procedures illustrated in the FCOM; It provides furthermore, clarifications on the techniques useful for the pilot to carry out the aforementioned procedures more safe and efficient.

In the "Non-Normal Operations" the piloting techniques associated with the "Non-Normal Checklists" listed in the QRH and additional guidelines are provided for situations beyond the scope of NNCs.

The Manual, in the general guidelines, specifies that if in the approach and landing phase occurs an uneven situation, a rushed approach could often complicate the situation. Unless the circumstances require an immediate landing, it is indicated to complete all corrective actions before starting the final approach («*Approach and Landing. When a non-normal situation occurs, a rushed approach can often complicate the situation. Unless circumstances require an immediate landing, complete with corrective actions before the final approach.* ").

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The same FCTM also makes some considerations about the go around in the case of malfunction of an engine during the final approach. If one engine malfunction occurs during final approach with flaps in the position of landing, the decision whether to continue the approach or perform a go-around should be taken immediately. If the approach is continued and available thrust available sufficient, continue the approach with the flaps in the landing configuration. If the approach is continued and the available thrust is not sufficient for the configuration with the flaps in the landing position, retract the flaps at 15 ° and adjust the thrust on the operative engine («*If an engine failure should occur on the flaps in the landing position, the decision to continue the approach or execute to go-around should be made immediately. If the approach is continued and sufficient thrust is available, continue the approach with landing flaps. If the approach is continued and sufficient thrust is not available for landing flaps, retract the flaps to 15 and adjust thrust on the operating engine.*
[omissis]. If a go-around is required, follow the Go-Around and Missed Approach procedures except use flaps 15 at if trailing edge flaps are at 30 or 40. Subsequent flap "retraction should be made at a safe altitude".

The QRH synthetically treats non-normal procedures.
In the introductory part ("Checklist Introduction - Non-Normal Checklist - CI.2.2") is specified how no procedures can be defined for each specific situation imaginable and that the checklists cannot replace common sense and discretion and the assessments of the commander ("*While every attempt is made to provide needed non-normal checklists, it is not possible to develop checklists for all conceivable situations, especially those involving multiple failures. In some unrelated multiple failure situations, the flight more than one checklist or exercise judgment to determine the safest course of action. The captain must assess the situation and use good judgment to determine the safest course of action. [omissis] Pilots must be aware that checklists cannot be created for all conceivable situations and are not meant to replace good judgment. In some conditions, deviation from checklists may, at the captain's discretion, be needed.* ").

In conclusion, no indications or guidelines were found in the operational manuals in force at the time of the incident that could be of support in building the decision-making process of the crew, helping to decide, in case a non-normal condition arose in the final phases of the approach, if to perform a missed approach or, if rather, to continue until landing.

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In this regard, in relation to what has been highlighted, it is interesting to have one comparison with another highly critical situation in which a crew can be found (the rejected take-off), for the management of which the aforementioned FCOM provides instead detailed guidelines in relation to the criteria to be taken to decide whether to stop the take-off or continue.
As highlighted also recently by specific studies[4], although the go-around maneuver falls within the normal procedures, the same, however, may present some critical issues.

1.18.5.Radar tracks

The approach control service for RYR41CH was provided through the mean of the radar.

The recording of the radar data of the RYR41CH flight, according to the normalized time base, showed the last radar plot at 06.56'22 ", but the last two radar plots showed one indication of navigated track[5] and therefore were discarded for the analysis of the radar plot.

The following figure shows the last 30 seconds of interception and processing of the radar track of the RYR41CH flight, graphically shown in green on the support of Google Earth between the indices from 1 to 7, each with an interval of about 5 seconds, beginning at 06.55'42 "and last at 06.56'12".
Due to the rounding of the entire minutes and seconds of the geographic coordinates in the of transposition program on Google Earth of the registration strings of the radar plot, the representation of the longitudinal axis of the aircraft path appears to be shifted approximately 80 m to the East and has been, artfully, re-proposed the possible real path, in projection to ground, through the yellow line with the last section in light blue, consistent with the path the aircraft reconstructed based on FDR data, including the obvious deviation to the right at index 3.

[4] FSF, Go-Around Decision-Making and Execution Project, March 2017, available at https://flightsafety.org/wp-content/uploads/2017/03/Go-around-study_final.pdf

[5] The process, called "runwaying process", differentiates the two phases through a specific graphic indication in presentation (radar presentation symbol surmounted by one or more horizontal lines) and in the recording of each single processing string (runway not navigated, or presentation symbol corresponding to radar response recorded, or navigated runway, or presentation symbol corresponding to lack of radar response recorded).

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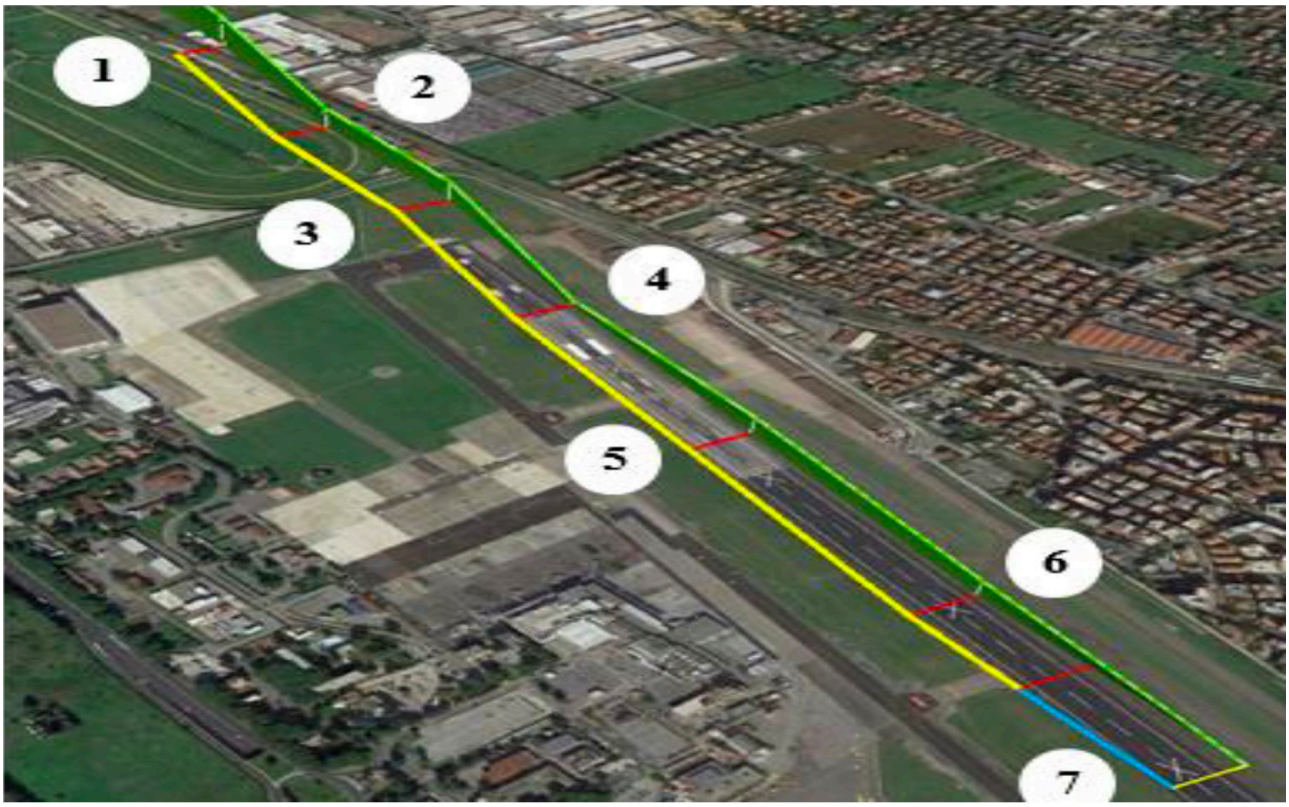

Picture 35 : reconstruction with radar data of final trajectory (with Google Earth)

1.19.USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

Not applicable.

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CHAPTER II - ANALYSIS

2. GENERAL

The objective elements acquired during the investigation are analyzed below, described in the previous chapter.

The objective of the analysis is to establish a logical link between the acquired evidence and the conclusions.

2.1. ENVIRONMENTAL FACTOR – AIRPORT

2.1.1.Bird scaring procedures

From the examination of the legislation referred to in paragraph 1.10. incomplete compliance would have emerged with the MOV / 11 section contained in the Airport Manual in force at the date of the event with the provisions of the circular ENAC APT-01A.

In particular, according to what is specified in the section MOV / 11, the prevention activity e removal of the birds would have substantially actualized at the date of the accident, in carrying out a series of inspections (verifications), which could be scheduled, on request or following an alleged impact report. There would not be any trace instead, in the same section MOV / 11, of any procedures, reasonably more incisive, through which the BCU should have exercised a continuous supervisory action on airport grounds and disturbance of the fauna ", so as to induce the birds to consider the airport unpleasant and unsafe place.

In line with the provisions of the current documentation, the personnel was acting accordingly with the BCU, the morning of the accident, it was limited to carrying out the first of the three scheduled inspections.

The same staff of the BCU was however aware of the presence of starlings on the airport already from the days before the accident (survey of about 1300 units, identified and removed the previous evening). In this context, it seems appropriate to represent that the commander has pointed out to the ANSV that there were no NOTAMS to inform about the presence of birds.

Said that considering the extreme mobility and unpredictable behavior of the starlings, more effective action of prevention and therefore of contrast of the presence of birds would seem achievable precisely through a work of constant vigilance and removal, rather than through periodic inspections.

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The procedures in force by the airport operator for the prevention of bird risk strike are, at the date of this report, very different from those in force at the date of the accident and are structured in such a way as to also ensure the constant surveillance of flight areas to avoid the presence of birds.

With regard to the surveillance activity by TWR staff, by the applicable law, it appears that the monitoring functions are closely linked to the supply of the ATS service, and not functional to a simple activity of surroundings environmental supervision. Therefore, in the absence of any impediment to landing, the conditions existed for the CTA TWR to give to RYR41CH, already at the time of first radio contact, the authorization to land.

2.1.2.Reconstruction of the point of impact with the birds

From testimonial statements acquired by ANSV (EI-DYG commander, commander of the C525 I-DEAC, TWR controller) could not be established in an unambiguous way, from where the flight of starlings originated.
However, the univocal and precise determination of the bird's takeoff point is not that relevant to analyze the effectiveness of the procedures, as the birds were in any case in or near the airport grounds, in areas highly sensitive to air traffic, and available means and planned inspections are proven to be ineffective in identifying, with timing and effectiveness, their presence.
The following analysis will focus, therefore, on the moment and on the impact position of the birds with the B737 and on the phases following the impact itself.

By the analysis of the CVR and FDR, by the location of bird’s remains, by the observations made on the aircraft and by the testimonial statements it was possible to establish the point of impact and quantify the number of birds that hit the fuselage and engines.
In particular, thanks to the synchronization of the CVR recording with FDR data, it is possible to locate the point where the commander repeatedly exclaims «Ahi!» (a period corresponding to the time 06.55'49 ", substantially overhead the Airport fence).

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Picture 36 : bird sighting point along aircraft trajectory.

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It was also possible to define the point where the application of the TO / GA occurred and the simultaneous "bang", corresponding to the stall of both engines and the impact with the starlings (a point corresponding to time 06.55'51 ", about 100 m from the beginning of the runway).

Picture 37 : engine stall and impact with birds

This last point is substantially on the vertical of the maximum concentration area of bird carcasses found on the ground.

2.2. AIRCRAFT

No evidence emerged about any technical issue the aircraft until the moment of impact with the birds.

The damages caused to the airframe and to the flight controls from the impact with the birds are irrelevant as regards operation and conduct following the impact of the aircraft; and of its systems; on the other hand, they are relevant for the functioning of the engines, to which they are a specific paragraph will be dedicated in the analyzes that follow.

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Airframe

The damages present on the cell are all consistent with the pitch and the speed with which the aircraft came into contact with the runway and the impact with the flock of birds.

Landing gear

The high vertical speed (1064 feet/minute) and an uneven pitch (about 10 ° of pitch up and 6 ° roll to the left), led the airplane to initially touch the "AC" runway/ intersection with left landing gear and tail, then with right-hand landing gear e-nose one.

The vertical acceleration recorded at the time of contact with the runway (2.66 g) does not result particularly high; the structural damage to the left landing gear is explained in the asymmetry, at the landing, previously described, where the energy of the impact was absorbed above all by the left landing gear: this has caused the structures to break down of the same and the breakthrough, by the shock absorber, of the left wing.

The failure of the left landing gear led to the contact of the lower part of the fan cowl of the left engine with the surface of the runway.

During the landing run, the braking action was exerted through the brakes, spoilers of both the wings and the thrust reverser on the left engine, whose reverser doors remained open due to the interference of the engine fan cowl with the runway surface.

Engines

The operation of both motors is regular until the command is activated TOGA.

In the moment in which the go-around was commanded, with the contextual application of the TO / GA command, there is a significant drop in the N1 revolutions of both motors (approx. 17% for the right engine, 10% for the left engine), a small reduction in N2 laps (about 3%), while the EGT temperatures of both engines experience a significant increase, equal to about 300 ° C in the next 24 seconds.

Within 1 second from the application of the TO / GA command, on both engines was recorded a condition of stall mode 3, indicative of a deep stall concerning both engines and consistent with the fall of N1 and the sudden increase in EGT.

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The sampling of the N1 turns, carried out every 4 seconds, does not allow to exclude that the fall of N1 may be initiated within the 3 seconds that constitute the time interval between the figure recorded at 06.55'48 "(N1 at about 62%) and the figure recorded at 06.55'52" (major fall of N1); in particular, it does not exclude that the drop in laps may be started in the two seconds preceding the activation of the TO / GA command, which occurred at 06.55'51 ".

Regarding this aspect, it is useful to analyze in detail the behavior of another of the parameters indicative of a stall condition, the EGT: in the time frame consisting of 2 seconds between the last value of N1 recorded (06.55'48 ") and the application of the TO / GA command (06.55'51 "), no significant variations in temperature were recorded, which instead increases its value significantly only after the activation of the command TO / GA (approx. 100 ° C, 2 seconds after TO / GA application).

The analysis conducted on the vibration parameters recorded for the fans and HPC of both engines indicates the absence of abnormal vibrations in the seconds preceding the application of the command TOGA.

The investigation conducted at GE Cardiff indicates, as a cause of the surge experienced by both engines, the presence of significant amounts of organic remains in the fan boosters and in the core of both engines, which significantly altered the aerodynamic internal flow, so as to generate the surge.

Available data indicate that the effects of this alteration of the aerodynamic flow (strong variations of N1 and EGT) were revealed at the same time as the general application power through the TO / GA command; this alteration of the aerodynamic flow does not have effects on engine parameters before TO / GA.

The above considerations allow us to formulate two hypotheses, concerning the moment in which the ingestion, of the birds by the engines may have occurred:

1. contextually to the application of the TO / GA, given the absence of significant changes both in terms of vibrations and engine parameters before that moment;
2. before applying the TO / GA command, but without causing variations of the main engine parameters.

The first hypothesis is certainly the most probable; it can therefore reasonably be assumed that the ingestion of the birds may have occurred simultaneously with the application of the command TO / GA, not having the FDR recorded significant changes in the operation of both the engines before this moment.

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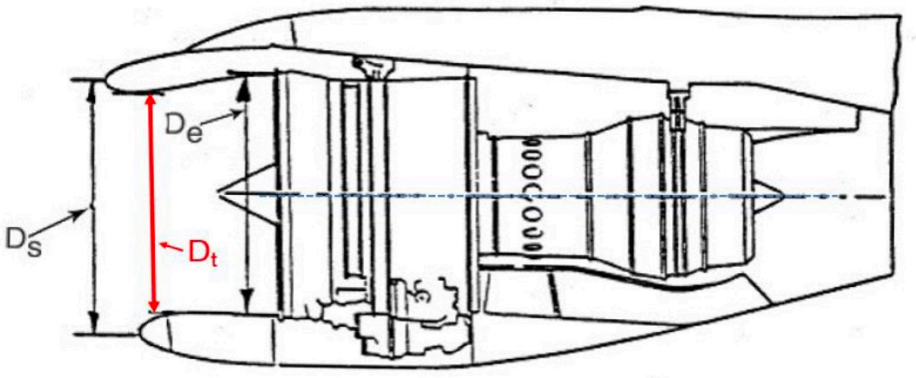
For an assessment of the compliance of the engines with the certification requirements compared to the resistance to bird ingestion it is necessary to evaluate the number and total weight of the birds ingested.
The number of impacts on the fan blades (55 and 30, respectively for left and right), though not being directly indicative of the number of birds that have actually been ingested from the individual engines – seen the fragmentation of the bird that can occur after the first impact and the subsequent multiple impacts that the same bird can cause – is anyway indicative of a significant amount of ingested birds. This consideration is confirmed by the considerable amount of organic deposits identified internally to both engines (higher in the right engine, in spite of the fewer impacts on the relative fan) and considered the cause of the surge experienced by the engines.
The above leads us to believe that the number and weight of the birds ingested by the engines have been certainly high, even if not precisely quantifiable.
The applicable certification standards (CS-E 800 and, with some differences from the previous one FAA 14 CFR 33.76) require, in case of impact with small birds, that ingestion by the engines of the same does not lead to any of the following conditions:

1. loss of more than 25% of power in TO / GA;
2. engine shutdown.

The requirements set in terms of the number of birds and total weight vary according to the value Engine Inlet Throat Area (the area related to the Dt diameter, shown in the image that follows).



Picture 38 : Engine inlet Throat diameter (Dt)

The Engine Inlet Throat Area for the CFM56-7B26 / 3 engine is 2570 in^2 (1.658m^2).
For this value of Engine Inlet Throat Area, the regulation shows a maximum value of 16 birds having a unit weight of 85 grams (corresponding, substantially, to the average weight of an adult starling).

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Said all above, it's impossible of accurately determining the number of birds actually ingested by both engines but is still possible to hypothesize that the number of birds ingested by them was very likely higher than required by the reference certification standards.

The above considerations therefore, lead us to believe that there were no shortcomings of design/certification of engines, having ingested a number and a total weight of birds higher than the quantities required by the certification requirements.

2.3. FLIGHT CONDUCT

From the analysis of the CVR recordings, from the FDR data, from the testimonial statements, from the video and photographic evidence collected at the accident site it was possible to reconstruct the following.

2.3.1. Ground operations, take-off, cruise and descent until disconnecting automation

The B737 marks EI-DYG, operating the flight FR4102, ATC radio callsign RYR41CH, before sector of day for the crew, it has been conducted since its initial stages with the FO (CM-2) in the role of PF and the commander (CM-1) in the role of PM; the aircraft had taken off from RWY21 in Frankfurt Hahn at 05.31'24" to Rome Ciampino, with 172 people on board.

The procedures for engine start, taxiing, take-off, and climb were carried out without any unexpected or significant event.

After the takeoff and initial clearance to GROSTENQUIN and FL240, the flight was authorized to climb to the final cruising level of FL370 and to a TRASADINGEN-ODINA-RUXOL.

The flight was therefore in perfect time and the weather conditions at the airport destination were optimal.

Immediately after starting the descent, leveled off at FL330 and waiting for further authorization to descent, the FO PF carried out an in-depth briefing on the approach, including the description of the ILS "Z" approach procedure for RWY 15 at Ciampino and checking the procedure of missed approach.

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The briefing was carried out according to the company procedures (B737 FCOM and FCTM, OM) and has covered every aspect, both referring to the instrumental procedure and to the validation of data entered in the onboard navigation system.
The FO-PF briefing covered the standard arrival procedures Bolsena 3F, the limitations of speed: in particular, the STAR altitudes, the frequencies and the radio aids, the profile and the development of the ILS procedure, the MSA, the 720 feet DA and the airport elevation.
The meteorological conditions have been commented and it has been enunciated by the CM-2, with self-confidence and without hesitation, like a phase 1 procedure or a memory item (like it happens, for example, when the rejected takeoff procedure is told aloud during the pre-takeoff briefing) the go-around procedure, as foreseen by the FCOM.
Eventually, the route of the missed approach was commented, inserted and validated.
No mention was made in this circumstance (as a possible indicator of a possible awareness of the presence of birdlife on the airport), the possible presence of birds on the airport or precautionary procedures in case of potential encounter/impact with birds.
Because of the observation that the meteorological conditions at the airport of destination were optimal, the commander, during the descent, offered the chance for the first officer to make the approach in manual mode for training and conducting the aircraft without the use of automation, practice at the time of the facts allowed by the operator and considered important by the commander to develop and maintain manual piloting skills.
At 06.43'05 ", crossing the 16.800 feet in descent, the autopilot was disengaged, the autothrottle and the flight director, thus flying in the defined raw data mode.
The aircraft, from that moment until the landing, was conducted manually.

2.3.2. From the disarming of the automation to the approach until the moment before of the visual acquisition of birds

Roma Radar cleared the flight for the ILS "Z" approach procedure for RWY 15 at Ciampino airport; after the aircraft had leveled at FL90, it was given to the latter the 160° vector for the interception of the localizer ; followed by further authorization to descend to 6000 feet and proceed to direct NDB URBE. In this phase, the commander confirmed that he had the runway in sight.

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The approach was carried out in a stabilized manner and in accordance with the procedures approved by the operator, although the extension of the landing gear has been anticipated than expected, to facilitate speed control and to cope with excess of height more rapidly, also in consideration of speed limitation imposed by air traffic control to sequence the approaching traffic.
In fact, the landing gear was extended at 06.50'13 ", at a QNH altitude of 6192 feet. At 06.51'40 ", at a height of 3831 feet, the 5° flaps were selected.
With the 5° flaps the interception of the localizer occurred (the commander communicated, at 06.52'18 "," You can start turning ", the FO, at 06.52'22" "LOC alive").
At the first radio contact with Ciampino TWR, the commander confirmed that he was stable on the localizer and 9 NM from the airport. The TWR provided the clearance to land and the last meteorological situation on the airport, characterized by wind calm and CAVOK.
At 06.53'22" there was communication, inside the cockpit," We have glide slope capture" by the FO.
The approach, flew in manual mode, was characterized by some deviations from the localizer, corrected by the CM-2 with verbal inputs from the commander.
In this regard, during the approach, some verbal interventions were recorded by the commander related to the ILS conduct, in particular, referred to the alignment on the localizer, as shown below.
Starting from about 6 NM, a deviation from the localizer begun.
After the flap selection 15, while carrying out of the pre-landing checks, the commander draw the attention of the FO to correct alignment as soon as possible ("Look at the localizer my friend" and "Oh, yes please ... come back".
This situation, started around 6 NM, was corrected starting from about 3.5 NM, when the aircraft stabilized again on the localizer about 1 NM from the runway.
The commander subsequently continued to provide indications for keeping the parameters. After the synthetic voice calls "ONE THOUSAND", "Continue a little bit to the left", «A little bit to the left ... like that», «Look at your speed. Ok, continue like that "," Ok, a little bit to the right »; after the synthetic voice calls "MINIMUMS", "Reduce the speed a bit, you are high ».

The final configuration for landing, with the selection of the 40 ° flaps, took place at 06.54'52 "at a radalt altitude of 996 feet and at a distance from the field of about 2.5 NM.
Then followed the completion of the pre-landing checks as required by the checklist.

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After the synthetic voice call "ONE THOUSAND" and before the "MINIMUMS" notice, the commander, after having said «A little bit to the left ... like that», he asked the FO «Do you have the runway in sight? " The FO responded in the affirmative.
At the moment of the "MINIMUMS" sound warning, recorded by the CVR at 06.55'30 ", the aircraft was about 1 NM from the runway threshold, configured for landing and aligned with the center line, with a CAS of 145 knots, then 9 knots higher than the Vref (136 knots) and 4 knots compared to the computed speed target (Vref +5 knots), and a vertical speed of 688 feet/minute.
At the "MINIMUMS" call, almost simultaneous both pilots made their calls, the Commander («Continue») and FO («Land»).
Therefore it is possible to say that, according to the criteria shown on the operational documentation, at 500 feet AGL the aircraft was within the parameters defined by the "stabilized" approach criteria, so it could continue for landing.
According to the commander in the interview, until the moment of sighting and impact with the birds, he believed to be able to continue the maneuver of approach and landing safely, considering the parameters, as well supported by the "Continue" call.
In this phase, the PF (FO) considered that all the necessary conditions to proceed upon landing they were satisfied; moreover, from the declaration "Land", it is believed that he was mentally prepared to carry out the landing maneuver.
The commander continued to provide verbal indications to correct the parameters: al 06.55'33 ", in fact, when the aircraft was about 1 NM from THR, to a CAS of 145 knots, ordered with a calm and controlled tone: "Reduce the speed a bit, you are high".
The commander himself stated that he felt confident that the deviation of the parameters of altitude and speed with respect to those envisaged were of such a size as to be easily corrected in the remaining approach phase, so as to make a safe landing.

2.3.3. From the visual acquisition phase of the birds to the impact with the ground

At 06.55'49 ", while the FO was busy observing the altitude and speed instruments for regaining the correct parameters, commenting «Nice», confirming the positive correction in progress, the commander exclaimed "Ahi!" (repeated for about 10 times in the next 2 seconds), having realized that a flock of birds was coming back on the approach path.

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At 06.55'51 ", at a radalt altitude between 136 and 112 feet and at a distance of approx. 100 m from the runway threshold, almost simultaneously came the order of the commander «Go around» (repeated three times) and activation of the TO / GA pushbutton.
From the testimonial declarations, it cannot be excluded that the commander acted instinctively on throttle levers, anticipating, in fact, the action verbally commanded to the FO.

The throttles were all positioned forward and the flaps controlled from 40 ° to 10 °, exceeding the "Detent" positioned in the 15 ° position, just to avoid a retraction beyond the position expected for the go around. From the testimonial declaration of the commander, the selection was not voluntary, nor was there any awareness of the error in the selection. This action is indicative of a reaction to an unexpected situation, typical of what is defined as "startle effect"[6].

When the TO / GA is activated, when the throttles have been positioned "full forward", the environmental channel of the CVR recorded a strong "bang", noise confirmed by the commander during the interview and assigned by the same to the impact with the flock.

The CVR evidence, the parameters of the engine and the position of the maximum concentration of the carcasses of the birds on the ground indicate that the impact with the birds (or rather the crossing of the flock that caused multiple impacts) occurred simultaneously with the activation, through the push button, of the go around, in conjunction with the stall of the engines and the verbal communication of the commander «Go around ... go around ... go around», when the aircraft was about 1 second from reaching the RWY 15 threshold and about 7-8 seconds from the point of normal contact with the runway, with the aircraft between 136 and 112 feet radalt, 149.5 knots and N1 62%.

Upon activation of the TO/GA (06.55'51 "), the Symbols of the Flight Director appeared indicating the pitch needed for the go-around; the FO has set this pitch, asking for the flap 15°: both engines, instead of increasing the rotation speed and providing the thrust needed for the go-around, they suffered a fall of N1 from about 62% to values around 40%, while the vertical speed has recorded a sudden reduction, while it was recorded a slight increase in the radalt height (from 112 to 173 feet), up to 06.56'01".

[6] On this subject, see: Various Authors, Startle and Surprise on the Flight Deck: Similarities, Differences, and Prevalence, in Proceedings of the Human Factors and Ergonomics Society 58th Annual Meeting - 2014, available in https://pdfs.semanticscholar.org/61c0/73be673efa2f45cef0687f8f843eaefdf6a3.pdf.

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The above resulted in a substantial absence of positive climb rate, which led the crew not to undertake the subsequent actions required by the checklist related to the go around, including the retraction of the landing gear.
At 06.55'56" the retraction of the flaps from 40° to 10° was commanded, a position that was reached at 06.56'12 ", with the aircraft on the ground.
From the FDR data it is clear that the commander has acquired control of the aircraft at 06.55'58", or 7 seconds after the activation of the TO/GA.
There were no communications between the pilots concerning the take over of controls of the aircraft until it has started the ground deceleration run.
The commander reported that, in this circumstance, he promptly intervened on the controls, but realizing that he did not have the thrust to continue the go-around and focusing all his attention to "looking out". He therefore realized that he was within the airport perimeter (exclamation of the commander «*On est dedans*») and to be able to bring the aircraft on the runway, while it had lost the alignment on the right probably due to an asymmetrical thrust of the engines during the go-around.
The change in attitude and the lack of thrust of the engines led, among other things, to a rapid decrement of the speed and an increase in the angle of attack.

From 06.56'01" the aircraft started to lose altitude, despite the pitch up command still applied by the crew; at 06.56'07", with a CAS of 122.75 knots, it is recorded the activation of the "SINK RATE" and at 06.56'09" of the stick shaker, in correspondence of the maximum vertical speed reached by the aircraft equal to
-1360 feet / minute (value indicative of an aerodynamic stall condition), of a progressive decrease in speed and an increase of the angle of attack, which reached respectively the values of 120.75 knots and 21° of AoA, one second before contact with the runway, when the aircraft was at a 21 feet radio altitude.

At 06.56'10 ", the aircraft touched the ground (switching of the WOW) with a pitch of 10° and roll -6°, indicated a speed of 120.75 knots, a variometric speed of -1064 feet, vertical acceleration of 2.66 g lateral -0.45 g.

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Picture 39 : point of impact with the ground

So the aircraft lost altitude due to the aerodynamic stall, with the throttle levers of the engines in the position of maximum power request, without however any consequent response from the engines, and impacted the ground near the taxiway "AC", at about half the total length of the runway, with a vertical acceleration of 2.66 g.

It was deepened the genesis of the decision of the commander to go-around.
The testimonial declaration of the latter has provided, in this regard, some food for thought ("*we are heavy, we have a bit of tailwind, we know that Ciampino has a bit short runway, it is CAVOK condition, we know we have Fiumicino close-by. "; «We know at that point that we hit something important. So maybe we have damaged the gear. We do not know. I have doubt. As we were taught at that time, in case of doubt: go around. We were trained for that! And I believe it is still applicable. In case of doubt, go around.* ").
The commander also confirmed that the length of the RWY of Ciampino (2207 m), defined as *a bit short* compared to other airports, such as those of departure (Hahn) or of the alternate (Fiumicino), was considered by him a criticality, if associated to the possible problem of an instability on the parameters, such as to affect the length of the landing roll, as a consequence of a inaccurate touchdown point or for the reduction of the braking performance of the aircraft in case of failure.
Regard this, the actual distance needed to stop the aircraft has been calculated, extrapolated from the QRH Advisory Information, in order to evaluate how much this perception of criticality was actually true under the specific conditions of the circumstance under analysis.

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Considering the mass of the aircraft landing at 61,100 kg, a component of 5 knots tailwind, a Vref of +10 kts, a temperature of about 10° C below ISA, dry runway, max manual braking, use of T/Rs and a height over the threshold of 100 feet (50 feet above the expected glide path), the ALD[7] is equal to around 1341 m, therefore well below the length of the runway available.
However, although this value may not be critical, it is necessary to point out that the one is given by the QRH, it can only be used in an emergency or re-tactical planning. In fact, the value that is considered in the planning phase, as required by the applicable regulations, it is the RLD[8], which is computed multiplying the required landing distance data ALD times a factor of 1.67.

It is also a common perception, supported by the performance tables and also confirmed by other pilots operating on Ciampino airport with B737 aircraft, that, with aircraft landing mass exceeding 60,000 kg, the presence of a component of tailwind above 5 knots need to pay particular attention to keep parameters and accuracy at the point of contact.

It is also clear that a precise recalculation of the ALD in the variety of cases and in the light of any possible failures, cannot be carried out continuing the approach, but only once the this has been discontinued, with the aircraft under control and away from obstacles.

Therefore, it is assumed that although not having the precise data obtained during the planning phase at the time of the facts, that the order of magnitude known to the commander as RLD was such to make the commander himself perceive as critical the length of the available runway with the contingent penalties (destabilization of the aircraft in the final, tailwind component).

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[7] «Actual landing distance to the dry runway after crossing the runway threshold at 50 feet; [omissis] Actual landing distances are determined during certification flight tests without the use of thrust reversers »(FSF, FSF ALAR Briefing Notes 8.3 - Landing Distances, available at https://flightsafety.org/files/alar_bn8-3-distances.pdf).

[8] «Required landing distance is the distance derived from the actual landing distance. [omissis]
Required landing distances are used for dispatch purposes (ie, for selecting the destination airport and alternate airports) » (FSF, FSF ALAR Briefing Note 8.3 – Landing Distances, available at https://flightsafety.org/files/alar_bn8-3-distances.pdf)

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2.3.4.Deceleration on the ground

The traces on the ground indicate how the impact occurred before with the lower part of the fuselage tail and with the left landing gear against the asphalt surface of the taxiway "AC", then with the main right gear on the lawn adjacent to the right edge of the runway, following the collapse of the left-hand gear, with the left engine's fan cowl. The aircraft continued the ground run by decelerating by means of the brakes, spoilers and of the thrust reverser of the left engine only, which reached during the deceleration run a maximum value of N1 of 81%.

During the ground run, the commander confirmed that he was in control by saying "My control. "

After 9 seconds (06.56'19 ") from the contact with the runway, the unsafe gear indication was activated for the left one, indicated by the "L GEAR WARNING" signal switching.

The aircraft stopped on the runway at 06.56'38", about 50 m from the end of the runway.

Picture 40 : stopping point on the runway

Both engines were switched off at 06.56'52" (ENG CUTOFF).

The windshield, after landing, showed some traces of collision with birds, such as not to compromise the outward vision of the flight crew, such as confirmed during the interview by the commander.

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2.4. HUMAN FACTOR

2.4.1.Bird strike: a survey on existing guidelines/instructions

Regarding the go-around maneuver, it seemed appropriate to carry out one overview of existing guidelines/instructions regarding the actions to be taken in the case in some birds are encountered in short final.

a) Boeing

On the AERO magazine, Boeing, number 3 of 2011 (on a date after the event) the topic has been addressed within an article entitled "Strategies for Prevention of Bird-Strike Events"[9].

In the paragraph of that article, entitled "Practical bird strikes information for flight crews", the following prevention strategies are provided.

To prevent or reduce the consequences of a bird strike, the crew should:

- discuss the bird strike during the take-off or approach briefing in case of operations on airports with known or probable birds;
- be extremely cautious if birds are reported on the path of final approach; in this case, plan with a larger landing distance, to take into account the possible unavailability of thrust reverser in the event of an impact with the bird.

An additional prevention strategy is indicated in case the landing is assured:

- it is preferable to land among birds, rather than carry out a go-around procedure aimed at avoiding them; this reduces the energy of the impact, the potential for greater damage due to the high rotational speed of engines and the potential for multiple ingestions of birds by engines, in conditions of low kinetic and potential energy of the aircraft.

In the case of impact with birds during approach and landing it is suggested as follows:

[9] Roger Nicholson (PhD Associate Technical Fellow, Aviation System Safety), William S. Reed (Safety Pilot, Boeing Flight Technical and Safety), Strategies for Prevention of Bird-Strike Events, in Aero, QTR 3/2011, 17 ss., Available at http://www.boeing.com/commercial/aeromagazine/articles/2011_q3/pdfs/AERO_2011_Q3 .pdf .

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- if the landing is assured, continue the landing maneuver is the preferable option. If you come across a flock with numerous birds is advisable to penetrate the flock and to land, maintaining an operating regime of the engines as low as possible and if ingestion is suspected in the engines, limiting the use of the thrust reverse on landing to the minimum necessary to stop the aircraft on the runway, since the use of the reverse thrust can increase the damage to the engine, especially when there are indications such as vibrations or temperature rising.

b) Airbus

Airbus, as part of its publications, has published in Airbus Flight Operations Briefing Notes, an article on "Birdstrike Threat Awareness"[10], which seems useful to recall in the context of the survey on the procedures and indications applicable to a generic bird strike in the final.

Airbus starts by stating that the documentation in question (Flight Operations Briefing Notes - FOBN) is published with the intention of providing general information on the subject of "applicable standards, flying techniques, and best practices, operational and human factors, suggested company prevention strategies and personal lines of defense-related to major threats hazards to flight operations safety ».

The prevention strategies indicated in this matter suggest, if in presence of birds in the short final, not to go-around, but to penetrate/fly through the flock and land, trying to keep a low setting of the engines.

In this case, the use of the reverse thrusts on landing after an impact with the bird should be avoided, as it could increase the level of damage to the engine, especially in the presence of indications such as vibrations or high engine temperatures.

c) UK CAA

An interesting note from the UK CAA, entitled "Air Carrier Flight Crew Guide – Bird Strike Mitigation "[11], concerning the issue represented by the birds in the phase of landing, underlines how, with the setting of the engines during approach, any bird ingested by the engine can transit through the fan (bypass) avoiding affecting the engine core, thus reducing the probability of causing serious damage.

[10] Airbus, Birdstrike Threat Awareness, in Flight Operations Briefing Notes, available at https://www.skybrary.aero/bookshelf/books/181.pdf.

[11] UK CAA, Capt. Paul Eschenfelder and Capt. Richard Sowden, Air Carrier Flight Crew Guide - Bird Strike Mitigation, available at https://www.skybrary.aero/bookshelf/books/2405.pdf .

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If you enter a flock of birds on final, with a typical engine approach setting and under conditions where the landing can be carried out with that setting, it is preferable to continue through the flock and land. Indeed, the high engine rpm with which the penetration into the flock would take place later an attempt to perform a missed approach could result in serious damage to the engine and loss of thrust.
It is also suggested to prepare to fly momentary instrumental conditions in case the remains of birds obscure the windshield.

d) SKYbrary

The Skybrary[12] website contains several contributions on the theme of bird strikes. In this case, it seemed interesting to recall here an article entitled "Bird Strike on Final Approach: Guidance for Flight Crews "[13].
In the article in question, two possible scenarios are presented.
The first scenario considers an approaching aircraft, which, next to landing, impacts a bird. The question to ask is whether it is preferable for the pilot to land or start a go-around procedure.
In this situation, the first question to ask is related to the extent of the damage suffered and to the consequences, in terms of safety, on the conduct of the aircraft. The real entity of the damage and in particular of damage related to the engine, the steering surfaces or the landing gear it may not be manifest until the moment when we proceed to apply power, configure or maneuver the aircraft. The situation could then arise where, afterward having started the missed approach maneuver, the pilot is in a situation where the runway is passed by the aircraft, but the latter is not in a condition to fly safely a missed approach. Therefore, in such a scenario, it is preferable to continue approaching and landing.

[12] «SKYbrary is an electronic repository of safety knowledge related to flight operations, air traffic management (ATM) and aviation safety in general. It is also a portal, a common entry point, that allows users to access the safety data made available on the websites of various aviation organizations - regulators, service providers, industry. "(as specified in https://www.skybrary.aero/index.php/About_SKYbrary).

[13] SKYbrary, Bird Strike on Final Approach: Guidance for Flight Crews, available at https://www.skybrary.aero/index.php/Bird_Strike_on_Final_Approach:_Guidance_for_Flight_Crews

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The second scenario considers the case in which a pilot sees a flock of birds in front of him during the final approach. One wonders whether it is preferable for the pilot to land or start a procedure of missed approach.
Even in this situation, the first question to ask is related to the real possibility of avoiding the flock, performing a missed approach. It is necessary to keep two factors in mind: in the first place, the behavior of the birds, with reference to the flight trajectories, which it varies from species to species and remains completely unpredictable. Secondly, the difference in the extent of the damage, if the possible ingestion of the birds takes place with the engines at a low level operating regime, as in the case of the approach, or at a high regime, as in the case of a missed approach.
Again, therefore, unless the go-around occurs with such an advance to be expected, with a reasonable degree of certainty, that the maneuver will have a positive outcome, it is considered less risky to proceed for landing.

e) Boeing FCTM

Below, with reference to the bird strikes, there is an extract of the modification introduced in the FCTM Boeing B737, after the event in the analysis.
«Bird Strikes Experience shows in the aviation. Most bird strikes come at very low altitudes, below 500 feet AGL. This section deals with bird strikes that affect the engines.
Recent studies of engine bird strikes reveal that about 50% of engine bird strikes damage the engine (s). The risk of engine damage increases proportionally with the size of the bird and with increased engine thrust settings. When an engine bird strike damages the engine, the most common indications are significant vibrations due to fan blade damage and an EGT increase.

Preventative Strategies

Airports are responsible for bird control and should provide adequate wildlife control measures. The large birds or flocks of birds are reported or observed near the runway, the crew should consider:

- delaying the takeoff or landing when fuel permits. Advise the tower and wait for airport action before continuing
- takeoff or land on another runway that is free of bird activity, if available.

To prevent or reduce the consequences of a bird strike, the crew should:

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- discuss bird strikes during takeoff and approach briefings when operating at airports with known or suspected bird activity
- be extremely vigilant if birds are reported on the final approach
- if birds are expected on the final approach, plan additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

Notes: The use of weather radar to scare the birds have not been proven effective.

Crew Actions for a Bird Strike During Takeoff

If a bird strike occurs during takeoff, the decision to continue or reject the takeoff is made using the criteria in the Rejected Takeoff maneuver of the QRH. If a bird strike occurs above 80 knots and prior to V1, and there is no immediate evidence of engine failure (eg failure, fire, power loss, or surge/stall), the preferred option is to continue with the takeoff followed by an immediate return, if required.

Crew Actions for a Bird Strike During Approach or Landing

If the landing is assured, continuing the approach to landing is the preferred option. If more birds are encountered, fly through the bird's flock and land. Maintain as low a thrust setting as possible.

If engine ingestion is suspected, limit reverse thrust on landing to the amount needed to stop on the runway. Reverse thrust may increase engine damage, especially when engine vibration or high EGT is indicated. "

f) Training at the operator after the incident (Recurrent Simulator Training)

Below is an excerpt of the contents of the recurrent training carried out at simulator prepared by the operator from 2009.

«Survival training was introduced in 2009 in response to the RYR CIA incident, BA777 at LHR and the US Airways ditching in the Hudson River.

Crews were given minimal pre-briefing of the events to allow maximum startle effect to be achieved in the simulator.

Crews were also informed that their performance during the Survival Training would not be formally graded to encourage crews to develop skills that are beyond the scope of prescribed emergency procedures. "

The scenarios proposed in the session include:

- Birdstrike at 700 ft on final approach leading to double engine failure;

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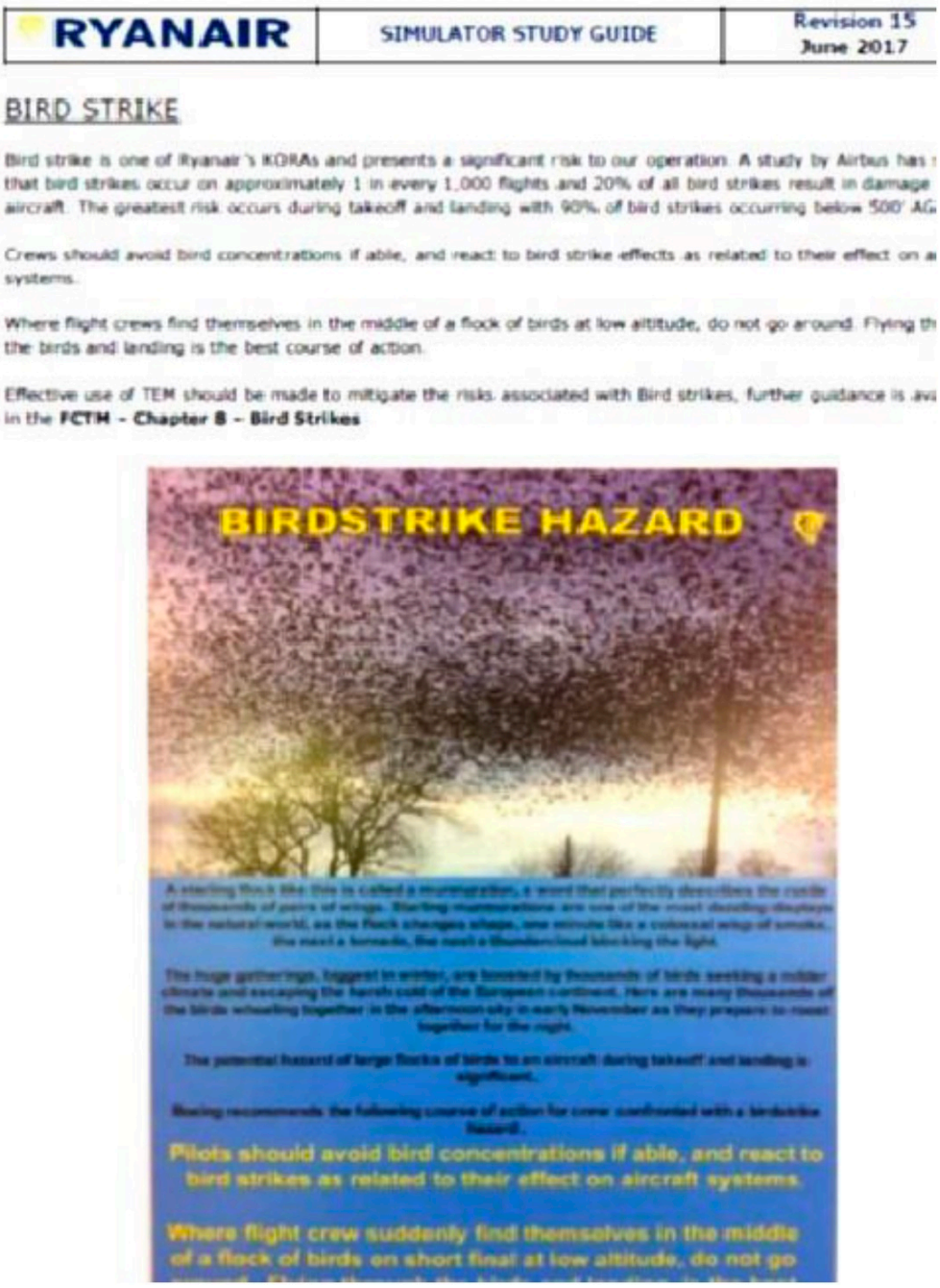
- Birdstrike on departure passing 6000 feet allowing a turn back to the airport for a glide approach;
- Birdstrike passing 3000 feet on departure necessitating a ditching in the Irish Sea.

«In 2015, an engine surge at low altitude caused by a birdstrike that led to an engine failure was added following feedback from the RYR SMS. ".



RYANAIR | SIMULATOR STUDY GUIDE | Revision 15 June 2017

BIRD STRIKE

Bird strike is one of Ryanair's KORAs and presents a significant risk to our operation. A study by Airbus has
that bird strikes occur on approximately 1 in every 1,000 flights and 20% of all bird strikes result in damage
aircraft. The greatest risk occurs during takeoff and landing with 90% of bird strikes occurring below 500' AG

Crews should avoid bird concentrations if able, and react to bird strike effects as related to their effect on a
systems.

Where flight crews find themselves in the middle of a flock of birds at low altitude, do not go around. Flying th
the birds and landing is the best course of action.

Effective use of TEM should be made to mitigate the risks associated with Bird strikes, further guidance is avu
in the **FCTM - Chapter 8 – Bird Strikes**

Picture 41 : Ryanair, Simulator Study Guide, birdstrike hazard

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g) EASA

ANSV, always within the aforementioned survey conducted on the theme of the bird strike, considered useful to formulate some questions to EASA. The latter confirmed that there are no specific bird-strike provisions under the Air Ops legislation except the obligation to report events.

The EASA has also specified that mitigation actions in this area must be reported in the SOPs, in the field of crew training and documented in the OMs operator.

2.4.2.Final considerations

The go around is a maneuver that is carried out for safety reasons, as, for example, in these cases:

- lack or loss of visual landing cues by the crew;
- A sudden change in wind speed, which could compromise the safety of the continuation of the approach;
- evidence of a runway incursion;
- in the case of non-stabilized approach.

The non-execution of the go around or it's not timely performance had, in several occasions, made serious events and runway excursions.

However, it should be noted that this maneuver and the management of the immediately subsequent phase of the flight are not risk-free[14].

The go-around ordered by the commander in the accident under examination does not have contraindications in the training and operational documentation examined and in force at the time of the facts.

The set of regulations, in fact, emphasized the opportunity to proceed with a go around in case of the occurrence of unexpected events in the final stages of landing; consequently and consistently with this approach, it was not implemented any guideline resulting from a prior evaluation regarding the opportunity to go-around or to complete the landing maneuver in circumstances such as those that occurred in the accident in question.

[14] «One of the largest contributing factors to fatal accidents to successfully execute a go-around or a failure to make a timely decision to go-around. However the go-around manoeuvre itself, and subsequent flight management, will introduce new risks »: SKYbrary, Go-Around Execution, available at https://www.skybrary.aero/index.php/Go-around_Execution .

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The above was confirmed by the commander in his statements when he affirmed: «*As we were taught at that time, in case of doubt: go around. We were trained for that! And I believe it is still applicable. In case of doubt, go around.* "

The commander's decision to go-around in the very short final, following the impact with a flock of birds, put the aircraft in a situation of serious criticality, much higher to what – with the benefit of a "retrospective" evaluation – the crew would be found to face if he had made an immediate landing.
Consider, for example, the case in which the aircraft had begun to lose altitude out of the airport area; or if, as a result of a variometric indication initially positive, the crew had retracted the landing gear.

In a scenario like the one under consideration, the risk associated with the decision to go-around with hypothetical lack of response of both engines, while the aircraft could be found consequently to an altitude and position no longer able to guarantee an emergency landing in the airport – is considered higher to that one of landing.
The theoretical preparation for the execution of the maneuver and the practical training for the go-around cannot ignore the identification of specific scenarios, where the risk associated with the execution of this maneuver changes significantly.

Among these scenarios, it seems appropriate to predict and characterize the collision with birds in the phased approach.
The evaluation of the analyzed literature leads one to believe that, in circumstances such as that encountered in the case in question, it would be less risky to land, rather than carry out a go around.
This assessment is based on the assumption that, from an energy point of view, the aircraft (7-8 seconds from the touchdown) was already "safe on the runway".

It was therefore considered that the process, which determined the decision to go-around in the specific event, took place over a period of several seconds (probably 2) and in a phase in which the crew, at least the FO PF, was by now predisposed to the imminent landing.
This decision-making process took place without any precursor or pre-warning, as can be seen from the relaxed atmosphere inside the cockpit during the final approach phases, as well as the absence of exclamations / indicative comments of Attention/ alarm situation.

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The sudden and impromptu exclamation of surprise by the commander is indicative of lower situational awareness, typical of the "surprise effect"[15].

We also questioned the plausibility of the hypothesis that, in similar cases, can take over mental conditioning of the pilots. This conditioning leads to being "go around minded" and then to proceed to uncritically go-around, perhaps to avoid marginal damage, after landing, which is then pointed to the decision of the pilot of not having a go-around. This can lead, as a consequence, that the pilot, with doubts and very little time available to decide, go-around without an adequate risk assessment.

In the analysis of the specific case it was therefore considered that the decision of the go-around can be sought in one or more of the following reasons:

1. attempt to avoid the flock of birds;
2. loss of visual contact with the runway;
3. ascertainment or hypothesis of a failure which is intended to be resolved and assessed before landing;
4. loss of stabilization from the path following an avoidance maneuver.

The interview with the commander allowed to eliminate the first two hypotheses, motivating the decision of the go-around rather as a combination of the last two.
They certainly influenced the decision:

- the awareness of landing on an airport with characteristics of a length of the limited runway (2207 m), with aircraft fully loaded with passengers and with a tailwind component, a situation in which every significant deviation from approach parameters or destabilization requires a go-around;
- have an alternate airport such as Fiumicino in the close vicinity with a 3 km long runway, with optimal weather conditions and without problems of fuel ;
- the fear that, as a result of the numerous impacts of the birds, they could have occurred damage or limitations to the braking system;

[15] «Surprise is defined as a cognitive-emotional response to something unexpected, which results from a mismatch between one's mental expectations and perceptions of one's environment »(refer to: Startle and Surprise on the Flight Deck, cited in 6).

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- the possible conditioned reflex caused by the training received so that in case of doubt, it is better to go-around and the awareness that accidents often happen because it is decided to continue a non-stabilized approach, rather than to proceed with a go-around.

It is considered highly unlikely that, in situations such as the one in which the crew is found, there is the concrete possibility of carrying out an adequate risk assessment, due to the lack of time available to decide which course to follow.
This risk assessment should rather be carried out before the approach.
In the absence of relevant regulations (as confirmed to ANSV by EASA), it is therefore considered essential that specific guidelines on the topic examined be provided to pilots from by the operators or under the theoretical training or the simulator, taking into account the different possible scenarios.
In fact, unlike what happens for the critical phase of take-off, for which multiple considerations exist in the FCOM and FCTM of the various aircraft in order to decide if to abort or not to take off at the occurrence of certain circumstances, for the landing were not found, at least in the FCTM of the B737 in force at the time of the accident, indications of the behavior to behave when certain situations occur. These indications were introduced in the Manual in question only after the incident.
The same operator involved in the EI-DYG incident also considered it appropriate to introduce training aimed at managing scenarios such as the one that occurred, however only after the accident.

In conclusion and in light of the above considerations, it is considered essential that guidelines similar to those introduced by Boeing in the FCTM in relation to bird encounter and to bird strikes in critical phases of flight (such as take-off, approach and landing) are extended by manufacturers to all commercial aviation line aircraft, being simultaneously taken into consideration by the operators during the training theoretical / practical of cockpit crew.

The event is essentially characterized by absence (at least for the cockpit crew of the B737 EI-DYG) of warning signals, at a time when the crew was mentally predisposed to landing, next to transit from the approach phase to the one of landing. This mental predisposition has probably generated a surprise effect, " as it would seem to be confirmed by the commander exclamation (" Ahi ! " repeated several times), rather than a less instinctive verbal communication (e.g. «birds ahead»).

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To this can also be added the "startle effect", which justifies the instinctive reaction that led to move (for reasons not explained by the pilot himself) the flap selector to the position 10° instead of 15°, as foreseen by the go-around procedure, overcoming the same detent that physically inhibits exceeding of 15°.

The "surprise effect" and the "startle effect" negatively affect situational awareness, which, with little time available, generate inability to correctly perform the information processing, decision making and problem-solving: the cognitive sciences teach that reactions and decisions made instinctively are not necessarily the most correct.

This negative impact needs to be eliminated or reduced through specific training.
In particular, these negative effects should be avoided during the most critical phases of the flight.

In these phases, unexpected but plausible scenarios should be identified, with respect to which identify ways and procedures suitable to contain these effects.
So the training above should produce conditioning of the crew such as to guarantee the correct answer to unexpected events.
Among these constraints, clear and positive communication techniques should be developed to indicate a "threat".
In the event, the "bird encountering on final" event should generate, by the pilot who first acquires the "threat", a communication like: "birds 12 o'clock ", rather than an instinctive and too general expression like" Ahi, ouch ...! ".
A correct phraseology, from a CRM point of view, would consequently bring both crew members at the same level of awareness, which next would benefit from decision-making process (eg "I land" or "Go around").
It is therefore considered that training should be aimed to cope with the "surprise" and "startle" effects (assuming non-routine situations) and to train crews to implement the most appropriate procedures.

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The BEA, following subsequent events[16], also highlighted that initial and recurrent training, as it is given now, does not promote or verify the abilities to respond to unexpected situations in an appropriate manner. In fact, the exercises are known to the crews and do not allow verification of skills in the area of resource management outside the known context. For this reason, the BEA had, time ago, issued two safety recommendations having the EASA as a target:

- «EASA review the requirements for initial, recurrent and type rating training for pilots in order to develop and maintain a capacity to manage crew resourses when faced with the surprise generated by unexpected situations; [Recommendation FRAN - 2012 - 042] »;
- «EASA ensure that operators reinforce CRM training to enable the acquisition and maintenance of adequate behavioral responses in unexpected and unusual situations with a highly charged emotional factor. " [Recommendation FRAN - 2012 - 043]. "

The principle contained in the aforementioned recommendations (need of training for unexpected events) is acceptable, even if the BEA refers to a situation different than the one in question, as the AF447 event occurred at high levels share and during the cruise.
It is believed that in-flight phases such as take-off or landing, certainly more "time critical" compared to the cruise, this training for unexpected events is indispensable.

[16] In this regard, see the final report on the accident on the BEA website, on 1 June 2009, to the Airbus A330-203 brands F-GZCP, operating the flight AF447, from Rio de Janeiro to Paris.

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CHAPTER III - CONCLUSIONS

3. GENERAL

This chapter contains the facts established during the investigation and the causes of the event.

3.1. FINDINGS

- The flight crew members were holding of the necessary aeronautical licenses and qualified to carry out the flight.
- The flight represented the first sector of the day for the crew.
- The FO (CM-2) performed the tasks of PF and the commander (CM-1) of PM.
- Start-up, taxiing, take-off and ascent procedures were carried out without any unexpected or significant event.
- Meteorological conditions at the destination airport were optimal.
- The PF carried out a detailed briefing on the approach, including the missed approach procedure.
- The AIP of Ciampino airport, in the "additional information" section, reported only the presence of gray crows on all airport grounds and during all year round.
- The NOTAMs in force did not contain any warning regarding the presence of birds on Ciampino airport.
- The crew had not been informed in any way about the problem of the birds; He has not, as a consequence, dealt with this aspect in the briefing.
- Bird removal procedures were contained in the Airport Manual e they referred to the provisions of the circular ENAC APT-01A.
- The circular ENAC APT-01A provided that the service performed by the BCU would not have had to intervene only when the birds were removed, but it would also have due to the continuous monitoring of the environment and disturbance of the fauna, with ways to make it consider the airport an unpleasant and unsafe place.
- The Airport Manual (section MOV / 11) provided scheduled execution of inspections (sunrise, 1.00 pm, and sunset), on request (with limited BCU intervention at the time necessary to perform inspection and removal of the bird) or for verification the following reporting of presumed impact.

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- The first of the three scheduled checks envisaged by the Airport Manual in force at the time of the accident and related to the scheme of birds removal had been regularly carried out between 05.20 'and 05.55' on the day of the accident, without founding the presence of any birds.
- As from communications between TWR and the BCU, the latter had performed the above inspection on the maneuvering area without affecting the runway.
- 16 take-offs and landings movements for RWY15 were recorded at the airport prior to the incident of Ciampino (of which 8 after the inspection of the BCU, completed at 05:55 '); the last of these flights landed about 4 'before the event.
- It is reasonably possible that the flock has positioned itself at the point of subsequent flight in the time interval between the landing of a Saab 340 aircraft and the moments immediately preceding the impact with the EI-DYG.
- None of the crews belonging to the 8 flights after the end of the BCU inspection reported an anomaly in the operational activity connected with the possible presence of the bird.
- The approach to Ciampino was carried out with an ILS “Z” procedure for RWY15, with manual flying (no autopilot, no autothrust, no FD) for CM-2 training.
- The approach was flown in a stabilized way, according to the procedural requirements of the operator.
- The manual approach has been characterized by some deviations from the localizer, corrected by the CM-2 following verbal input by the commander.
- The final configuration for landing, with the selection of 40° flaps, has been achieved at 06.54'52", at a height of 996 feet and at a distance of about 2.5 NM.
- At the "MINIMUMS" auto-callout, the almost simultaneous call out of the commander («Continue») and of the FO («Land») took place.
- At the radalt height of 136 feet and at a distance of about 300 m from the runway threshold, the commander, having visually acquired the birds on the flight path, began to exclaim, repeatedly. in rapid sequence «Ahi, ahi, ...!».
- At a radalt altitude between 136 feet and 112 feet and at a distance of about 100 meters from the runway threshold the activation of the TO / GA pushbutton took place.
- The FO has given the acknowledge: «*Go around, flap 15*», setting the go-around.

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- Simultaneously with the activation of the TO/GA the stall of both engines took place and the CVR recorded strong bang.
- The impact with the flock of starlings corresponds to the bang, which occurred with the aircraft at approx. 100 m from the RWY15 threshold position, in flight, to which point corresponds, on the ground, where the maximum concentration of poultry carcasses has been found.
- At the go around the flap, the lever was positioned at 10° instead of the 15° required and foreseen by the go-around procedure with two engines.
- At the TO/GA, both engines, instead of increasing the rotary speed, have dropped by approx. 62% of N1 to about 41%.
- When the TO / GA was applied, the vertical speed has undergone a rapid reduction; it was recorded a slight increase in the radalt height (from 112 to 173 feet), up to 06.56'01"; subsequently the aircraft continued to lose altitude, despite the command to climb.
- There has been a progressive decrease in speed and an increase in the angle of attack until the stick shaker was activated at a height of 21 feet.
- The aircraft has impacted the ground in aerodynamic stall conditions, near the taxiway "AC", about half of the total length of the runway, with a landing mass of 61,100 kg and 3800 kg of fuel, with flaps in transit from 40° to 10° (position actually reached 12.1°) and a vertical acceleration of 2.66 g.
- 9 seconds after contact with the ground, an unsafe left landing gear indication was triggered.
- The aircraft continued the ground run by decelerating through brakes, spoilers and thrust reverse of the left engine only.
- The aircraft stopped on the runway at 06.56'38 ", about 50 m from THR 33.
- Passengers have been disembarked by the use of a stair lift and, on the order of the Fire Brigades, from one of the rear slides, differently than previously arranged by the commander.
- Until the time of the accident, neither the manufacturer nor the operator had foreseen, within the applicable manuals (FCOM, FCTM and OM), guidelines or procedures referring to the actions to be taken in case of encounter or impact with birds in the approach/landing stages.

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- The aeronautical literature, in the years following the event, underlined, through articles, the criticality related to a go-around following a bird strike, for reasons e considerations below:
  - – the real extent of damage to the aircraft (in particular engines) may not be manifest until it is decided to apply power;
  - – following a missed approach, the pilot could be in a situation in which the runway disappears under the nose of the aircraft, and at the same time, the same aircraft is not in a condition to fly;
  - – to the revolutions of the engines characteristic of the approach phase, the damage can probably be within to the fan stage and do not affect the engine core;
  - – the high engine rpm with which would take place following an attempt to go around after passing into the flock could result in damage greater to the engine and consequent loss of thrust.
- The literature examined suggests landing, as a result of impacts with birds during the approach/landing, and not to make a go around.
- Boeing, following the event, introduced in the FCTM of the B737 one "Recommended technique" referred to the case of the bird strike, which provides both strategies of prevention, both guidelines relating to actions to be implemented by the crew in case of impact in the take-off or landing phases, agree with the concepts expressed in the referred aeronautics literature.
- There is no evidence that other aircraft manufacturers have entered, in their own manuals, guidelines in case of bird strikes similar to those introduced by Boeing.
- After the event, the operator involved developed specific training regarding encounter of birds taking off and landing.
- There appear to be no indications, at a regulatory level (EASA), aimed at making sure that all the operators follow the aforementioned training practice.
- At the time of the facts, it does not appear that there were types of training aimed at managing and mitigate the effects of "surprise" and "startle" on the flight conduct, effects they have influenced the actions carried out by the flight crew.

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3.2. CAUSES

The accident was caused by an unexpected loss of thrust on both engines consequent to a massive impact with birds, during the go-around maneuver.

The loss of thrust prevented the crew from successfully carrying out the go-around and led the aircraft to a non-stabilized contact with the runway.

The following factors contributed to the event:

- the inadequate effectiveness of the control and scaring measures of the avifauna placed on the date of the accident, by the airport manager;
- the decision of the captain to carry out a go around when the aircraft was about 7 seconds from the touchdown with the runway. This last decision was however significantly influenced:
  1. by the lack of indications to the flight crew regarding the procedures more suitable to be adopted in the case of single or multiple impacts with birds in the landing stage;
  2. from the lack of specific crew training about "surprise" and "startle" effects in critical flight phases.

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CHAPTER IV - SAFETY RECOMMENDATIONS

4. RECOMMENDATIONS

In light of the evidence gathered and the analyzes carried out, ANSV considers it necessary issue the following safety recommendations.

4.1. RECOMMENDATION ANSV-12 / 1525-08 / 1 / A / 18

Recommendation type: SRUR / SRGC.

Motivation: during the investigation it was found that training and operational instructions for crews of conduct may not always provide sufficient evidence for allow them to take decisions in a short time, on the basis of an estimate theoretical analysis of possible scenarios, taking into consideration risks and conditions psychological problems associated with them.

The investigated event can be framed as a flight through a flock of birds in approach / very short final phase, with the aircraft completely configured for landing and stabilized on the descent path. During this phase of the flight, the engines are operated at a relatively low thrust level, to which the birds possibly ingested could, generally, not affect the core of both engines (what not occurred in the event in question where the stall has, in any case, occurred to a regime of relatively low rotation), thus reducing the possibility of causing damage significant to them and allowing the aircraft to make a safe landing with the push selected for approach. Under such conditions, the decision to make one

The go-around maneuver, in which maximum thrust is applied to the engines, could increase the possibility of causing damages and malfunctions to the motors themselves, with consequent loss thrust available and impossible to complete, safely, the go-around maneuver.

The lack of clear indications directed to the conduct personnel in order the possibility of carrying out the go-around maneuver in this type of scenario or not, can bring the crew to apply "uncritically" (and without the necessary awareness potential consequences) the go-around maneuver, which, in this kind of scenario, can present higher risks than those of leading the aircraft to landing.

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The considerations above are consistent with what has already been expressed and recommended, ad example, from Boeing, Airbus, UK CAA, compared to the scenario in question.
Following the event, Boeing introduced one in the FCTM of the B737 "Recommended technique" referred to the case of the bird strike, which provides both strategies of prevention, both guidelines relating to actions to be implemented by the crew in case of impact in the take-off or landing phases.
Addressees: EASA and FAA.
Text: ANSV recommends providing flight crews, guidelines or procedures, operational and training, based on a careful assessment of the risks associated with the conduct approaching aircraft, when the latter is interested or close to being affected, by impacts, even multiple, with birds. These guidelines/procedures should provide the following points:

- discuss the bird strike during the take-off and approach briefing, in case of operations on airports with the presence of birds, known or probable;
- in case of impact with birds, even multiple, if the landing is assured, it is preferable to land while maintaining the lowest possible engine power setting instead to carry out a go-around procedure (in case of ingestion, especially massive, of birds, engine damage could be greater in the presence of high engine speeds engine operation, typical of the go-around);
- take into account that, in the case of a go-around, damage to the engines could prevent it completely safe execution, of the go-around maneuver, with the consequent impossibility to land in the airport.

4.2. RECOMMENDATION ANSV-13 / 1525-08 / 2 / A / 18

Recommendation type: SRUR / SRGC.
Motivation: initial and recurrent training, as currently provided, seem not to be optimized to promote or develop the ability to handle situations unexpected, which generate the "surprise" and "startle" effects.
After the event, the operator involved in the accident put in place a specific training; however, it does not appear to the ANSV that there are indications on a normative level aimed to generalize this type of training.
At the training level they should, therefore, be identified, with particular reference to the critical phases of flight, unexpected events, but plausible, able to generate such effects of "Surprise" and "startle".

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Crews should be trained to deal with these events, through visualization and conditioning exercises.

The training to cope with the negative consequences of these two effects would have one significant importance in helping to minimize the possibility of taking inadequate decisions, such as, for example, in the case of a bird strike/bird encounter in the approach and landing phases.

Addressees: EASA and FAA.

Text: ANSV recommends providing guidance on the adoption of specifics training programs for flight crews, aimed to cope with the effects "Surprise" and "startle", especially in critical phases of flight, such as approaching and landing.

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APPENDIX

According to what is allowed by the international and EU law on investigations of safety (Annex 13 to the Convention on International Civil Aviation, Regulation EU n. 996/2010) the following authorities have sent comments to the draft (in English) of the final report of inquiry prepared by the ANSV:

- AAIU (Ireland);
- BEA (France).

Some of the comments submitted are only relevant to the English language version of the present report.

The comments that ANSV agreed with have been integrated into the text of the report, **while those not agreed are shown below**.

COMMENTS TRANSMITTED BY THE AAIU

Ref.	Reason proposed change	Proposed amendment
Pag 104 of this report	The report discusses the startle effect using a verbal communication of “birds ahead” instead of “ahi” repeated 10 times. The expression “ahi” is an expression of surprise. If the crew were able to verbalize “birds a 12 o’clock or similar then they would not be surprised.	The recommendation contradicts the findings.

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