ANSV AGENZIA NAZIONALE PER LA SICUREZZA DEL VOLO

FINAL REPORT

accident occurred
to the aircraft B737-8AS registration marks EI-DYG,
Ciampino Airport,
10th November 2008

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OBJECTIVE OF THE SAFETY INVESTIGATION

The Agenzia nazionale per la sicurezza del volo (ANSV), instituted with legislative decree No 66 of 25 February 1999, is the Italian Civil Aviation Safety Investigation Authority (art. 4 of EU Regulation No 996/2010 of the European Parliament and of the Council of 20 October 2010). **It conducts, in an independent manner, safety investigations.**

Every accident or serious incident involving a civil aviation aircraft shall be subject of a safety investigation, by the combined limits foreseen by EU Regulation No 996/2010, paragraph 1 and paragraph 4 of art. 5.

The safety investigation is a process conducted by a safety investigation authority for the purpose of accident and incident prevention, which includes the gathering and analysis of information, the drawing of conclusions, including the determination of cause(s) and/or contributing factors and, when appropriate, the making of safety recommendations.
The only objective of a safety investigation is the prevention of future accidents and incidents, without apportioning blame or liability (art. 1, paragraph 1, EU Regulation No 996/2010). Consequently, it is conducted in a separate and independent manner from investigations (such as those of Judicial Authority) finalized to apportion blame or liability.
Safety investigations are conducted in conformity with Annex 13 of the Convention on International Civil Aviation, also known as Chicago Convention (signed on 7 December 1944, approved and made executive in Italy with legislative decree No 616 of 6 March 1948, ratified with law No 561 of 17 April 1956) and with EU Regulation No 996/2010.

Every safety investigation is concluded by a report written in a form appropriate to the type and seriousness of the accident or serious incident. The report shall contain, where appropriate, safety recommendations, which consist in a proposal made with the intention of preventing accident and incidents.
A safety recommendation shall in no case create a presumption of blame or liability for an accident, serious incident or incident (art. 17, paragraph 3, EU Regulation No 996/2010).
The report shall protect the anonymity of any individual involved in the accident or serious incident (art. 16, paragraph 2, EU Regulation No 996/2010).

N.B. The accident covered by this final report occurred before EU Regulation no. 996/2010 came into force. Consequently, the regulations in force before the above-mentioned EU Regulation no. 996/2010 were applied to its investigation.

GLOSSARY

(A): Aeroplane.
AAIU (Ireland): Air Accident Investigation Unit.
AAL: Above Aerodrome Level.
ACC: Area Control Centre or Area Control.
ADIRS: Air Data Inertial Reference System.
ADIRU: Air Data Inertial Reference Unit.
AFDS: Autopilot Flight Director System.
AGL: Above Ground Level.
AIP: Aeronautical Information Publication.
ALD: Actual Landing Distance.
ALS: Approach Lighting System.
AM: Italian Air Force.
AMSL: Above Mean Sea Level.
ANSV: Agenzia nazionale per la sicurezza del volo (Italian Civil Aviation Safety Investigation Authority).
AOA: Angle of Attack.
AOC: Air Operator Certificate.
A/P: AutoPilot.
APP: Approach control office or Approach control or Approach control service.
ARP: Airport Reference Point.
ASDA: Accelerate-Stop Distance Available.
A/T: Autothrottle.
ATC: Air Traffic Control.
ATPL: Airline Transport Pilot Licence.
ATS: Air Traffic Services.
AW: Acoustic Warning.
BCU: Bird Contol Unit.
BEA: Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation civile (French Civil Aviation Safety Investigation Authority).
BIRDTAM: Bird To Air Man.
CAS: Computed Air Speed.
CAT I, **CAT II**, **CAT III**: Instrumental Approach Category.
CAVOK: Ceiling and Visibility OK.
CDP: High Pressure Compressor Discharge Pressure.
CDS: Common Display System.
CPL: Commercial Pilot Licence.
CPT: Captain.
CRM: Crew Resource Management.
CTA: Air Traffic Controller.
CVR: Cockpit Voice Recorder.
DCA: Direzione circoscrizione aeroportuale (Airport Aviation Authority).
DH: Decision Height.
DME: Distance Measuring Equipment.
DOC: document.
DU: Display Unit.
EASA: European Aviation Safety Agency.
EEC: Electronic Engine Control.

EFIS: Electronic Flight Instrument System.
EGT: Exhaust Gas Temperature.
ENAC: Ente nazionale per l'aviazione civile (Italian Civil Aviation Authority).
ENAV SPA: Società nazionale per l'assistenza al volo (Italian air navigation service provider).
FAA: Federal Aviation Administration.
FADEC: Full Authority Digital Engine Control.
F/C: Flight Cycle.
FCOM: Flight Crew Operating Manual.
FCTM: Flight Crew Training Manual.
FD: Flight Director.
FDMAS: Flight Data Management Automated System.
FDR: Flight Data Recorder.
F/H: Flight Hours.
FI: Flight Instructor.
FL: Flight Level.
FMA: Flight Mode Annunciator.
FMC: Flight Management Computer.
FMS: Flight Management System.
FO: First Officer.
FPL: Flight Plan.
FT: Foot, 1 ft = 0,3048 m.
GND: Ground.
GPWS: Ground Proximity Warning System.
G/S: Glide Slope (or **GP**, Glide Path).
GS: Ground Speed.
HPA: Hectopascal.
HPC: High Pressure Compressor.
IAS: Indicated Air Speed.
IATA: International Air Transport Association.
ICAO/OACI: International Civil Aviation Organization.
IFR: Instrument Flight Rules.
IIC: Investigator-In-Charge.
ILS: Instrument Landing System.
IR: Instrument Rating.
ISA: International Standard Atmosphere.
JAA: Joint Aviation Authorities.
KT: Knot.
LDA: Landing Distance Available.
LE: Leading Edge.
LOC: Localizer.
MCT: Max Continuous Thrust.
MDA: Minimum Descent Altitude.
MEP: Multi Engine Piston.
METAR: Aviation routine weather report.
MHZ: Megahertz.
MSA: Minimum Sector Altitude.
MTOM: Maximum Take Off Mass.
ND: Navigation Dislay.
NDB: Non-Directional radio Beacon.
NM: Nautical Miles (1 nm = 1852 m).

NNC: Non Normal Checklist.
NOTAM: Notice To Air Men.
NTSB: National Transportation Safety Board.
OCA: Obstacle Clearance Altitude.
OCH: Obstacle Clearance Height.
OM: Operations (or Operating) Manual.
OM: Outer Marker.
PA: Public Address.
PAPI: Precision Approach Path Indicator.
PF: Pilot Flying.
PFD: Primary Flight Display.
PM: Pilot Monitoring (or PNF).
P/N: Part Number.
PNF: Pilot Not Flying.
QNH: Altimeter setting to read on the ground the airport altitude.
RA: Radio Altimeter (or Radar Altimeter).
RLD: Required Landing Distance.
RPM: Round per minutes.
RWY: Runway.
SEP: Single Engine Piston.
SMS: Safety Management System.
SMYD: Stall Management Yaw Damper.
S/N: Serial Number.
SOC: Sicurezza operativa e controllo voli.
SOP: Standard Operating Procedures.
SRGC: Safety Recommendation of Global Concern.
SRUR: Safety Recommendation of Union-wide Relevance.
STAR: Standard Instrument Arrival.
SV: Syntetic Voice.
T/B/T: Air/Ground radio communications.
TE: Trailing Edge.
THR: Threshold.
TODA: Take-Off Distance Available.
TO/GA or **TOGA**: Take Off/Go Around.
TORA: Take-Off Run Available.
T/R: Thrust Reverse.
TRI: Type Rating Instructor.
TWR: Aerodrome Control Tower.
TWY: Taxiway.
UOC: Ufficio operazioni correnti (Current Ops Office).
UTC: Universal Time Coordinated.
VFR: Visual Flight Rules.
VHF: Very High Frequency (from 30 to 300 MHz).
VMC: Visual Meteorological Conditions.
VNL: Correction for defective Near Vision.
VOR: VHF Omnidirectional radio Range.
VREF: Velocity of Reference.
VS: Vertical Speed.
VVF: Vigili del fuoco, fire fighters.
WOW: Weight on Wheel.

INTRODUCTION

The accident occurred on 10th November 2008 at 06.56 (07.56 local time), at Ciampino Airport and involved a B-737-8AS type aircraft, registration marks EI-DYG.
The Boeing 737-8AS aircraft, registered EI-DYG, took off from Frankfurt Hahn (EDFH) airport at 05.30 on 10th November 2008 bound for Rome Ciampino (LIRA) with 166 passengers and 6 crew members on board.
As it was approaching the destination airport, it collided with a thick flock of starlings on the very short final approach.
At birds visual acquisition, the crew interrupted the landing procedure, set a go-around manoeuvre but both engines did not provide the necessary thrust for the manoeuvre, the aircraft rapidly lost speed and height and impacted heavily on the runway. The main left landing gear detached from its anchoring on its route on the ground and the lower part of the left engine nacelle came into contact with the runway.
The aircraft continued its run on the ground until reaching a complete halt at RWY threshold 33.
The 6 crew members and 166 passengers evacuated the aircraft without further inconveniences.

ANSV was informed of the accident immediately after the event by ENAV SpA and carried out an operational inspection with its own team of investigators at the accident site on the same day of the event.
ANSV sent notifications of the event, in compliance with the international regulations (Annex 13 to the Convention on international civil aviation), to the following bodies: ICAO, NTSB, BEA, AAIU.
NTSB, BEA and AAIU accredited their own representatives in the investigation conducted by ANSV.
The significant delay in publishing this report is due, on the one hand, to the retirement of some investigators, who, over time, have been appointed as IIC (investigator-in-charge), on the other hand, to the known shortage of personnel affecting the ANSV investigation area.

All the times shown in this final report, unless otherwise specified, are expressed **in UTC**, which, on the date of the event, corresponded to the local time minus 1h.

This report has been translated and published by the ANSV for the English-speaking concerned public. The intent was not to produce a factual translation and, as accurate as the translation may be, <u>the original text in Italian is the work of reference</u>.

CHAPTER I

FACTUAL INFORMATION

1. GENERAL

The objective elements collected during the safety investigation are shown below.

1.1. HISTORY OF THE FLIGHT

The Boeing 737-8AS aircraft, registration marks EI-DYG and radio call sign RYR41CH, took off from Frankfurt Hahn (EDFH) airport at 05.30 on 10th November 2008 inbound Rome Ciampino (LIRA) with 166 passengers and 6 crew members on board.

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

The aircraft established the first radio contact with Ciampino TWR communicating that it was 9 NM from the runway and stabilised on the ILS for RWY 15.

The aircraft, authorized and configured for the approach, was proceeding for landing, when, in very short final, it collided with a thick flock of birds (later identified as starlings).

The crew interrupted the landing procedure, initiating a go-around manoeuvre.

With both engines not delivering the necessary thrust and a flight attitude set for climbing, the aircraft rapidly lost speed and height, hitting the runway heavily in proximity of the taxiway "AC".

Then, on first contact with the runway, which occurred with the main landing gear properly extended and with the lower part of the fuselage tail section, the main left landing gear detached from its anchoring during the landing run and the lower part of the left engine nacelle came into contact with the runway.

The aircraft stopped near RWY threshold 33.

The Fire Brigade vehicles immediately arrived at the aircraft and sprayed extinguishing foam around it, particularly in the area where the engine nacelle had come into contact with the runway.

The Captain then arranged for the disembarkation of the passengers and crew using a ladder truck from the right front door, with the addition of the right rear slide, later activated and used.

1.2. INJURIES TO PERSONS

Injuries	Crew	Passengers	Total persons on board	Others
Fatal				
Serious				
Minor	2	6	8	
Nihil	4	160	164	
Total	6	166	172	

1.3. AIRCRAFT DAMAGES

The main left landing gear was torn from its anchoring, with its support leg sticking out from the upper surface of the left hand wing.

The lower part of the left hand engine nacelle came into contact with the runway, the thrust reverse panels (doors) in the open position.

The lower part of the fuselage, in the tail section, presented obvious signs of sliding and deformation of the structure caused by contact with the runway.

There was also buckling of the passenger cabin floor frame.

Not less than 86 bird impact points were identified on the radome and the front part of the fuselage, wing leading edges, flaps undersides, engine nacelles and landing gear.

There were numerous and solid organic residues and bird feathers on stator and rotor blades of the engine fans.

1.4. OTHER DAMAGES

Six passengers and two crew members complained about back pains after disembarkation from the aircraft and, after being examined at the "Pronto Soccorso Aeroporti di Roma [First Aid, Rome Airports]" in Ciampino airport, they were transferred by ambulance to hospital facilities for further checks.

1.5. PERSONNEL INFORMATION

1.5.1. Flight crew

Captain

General: male, 44 years old, Belgian citizen.

Licence: 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.
Periodical checks:	B 737 300-900 carried out on 10/07/2008.
Medical examination:	First class medical check, valid at the time of the accident, VNL limitation.

Captain's flying experience: the pilot had been employed, as Captain, with the aircraft operator involved in the accident for about 3 years.

He had been previously employed by another operator on the same type of B737 aircraft, also acquiring familiarity with Rome Ciampino airport. The Captain held a Type Rating Instructor qualification on B737 300-900 type aircraft, although did not have any training assignments with the operator involved in the accident.

At the time of the accident he had flown 9883 f/hs, of which 6045 f/hs on B737 type aircraft. The accident flight was the first flight of the day for the Captain. The Captain was in his second day of duty: he had gone into service the day before, following a rest period of 5 days.

First Officer

General:	male, 23 years old, Dutch citizen.
Licence:	CPL (A), valid.
Ratings:	B737 300-900, SEP (*land*), MEP (*land*), ME IR (SPA), ME IR (MPA).
Other qualifications:	Radiotelephony in English.
Periodical checks:	B737 300-900 carried out on 26/10/2008.
Medical examination:	First class medical check, valid at the time of the accident.

First Officer's flying experience: the pilot had been employed, as a first officer, with the aircraft operator involved in the accident for about 6 months (since May 2008). The pilot had obtained the commercial pilot licence on 3^{rd} April 2008 and taken the theoretical examination for the airline pilot licence with a JAA member State. The pilot had subsequently obtained the B737 300-900 type rating on 24^{th} April 2008, i.e. about 7 months before the accident. At the time of the accident, he had flown 600 f/hs, of which 400 on B737 type aircraft.

During the investigation, it emerged that the flight in which the accident occurred was the first flight of the day for the first officer.

The first officer was in his third day of service after a rest period.

1.6. AIRCRAFT INFORMATION

1.6.1. General information

The B737-800AS aircraft (AS identifies the operator) is built by Boeing Company and is an aircraft used for the commercial transport, with low wings fitted with winglets, a mainly metal frame, retractable tricycle landing gear, and is equipped with two CFM56-7B26/3 turbofan engines.

Its dimensions are shown in the two images below; the MTOM is 74.990 kg.

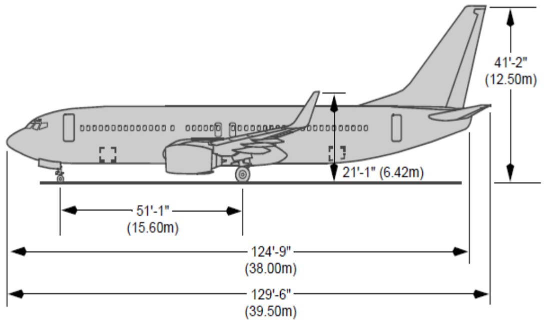


Figure 1: longitudinal dimensions.

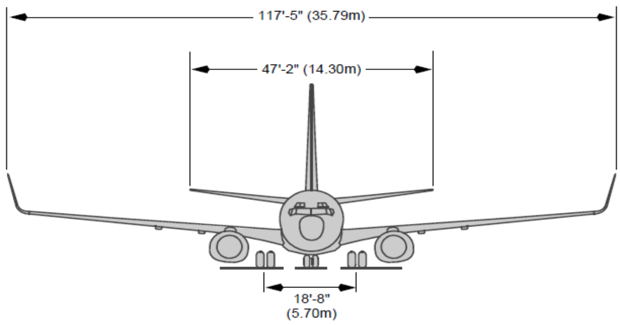


Figure 2: B737-800, front and vertical dimensions.

1.6.2. Specific information

Aircraft

Manufacturer:	Boeing Company, Seattle (US).
Model:	737-8AS.
Manufacture number:	33639.
Year of manufacture	2008.
Country and registration codes:	EI-DYG.
Certificate of registration:	Irish Aviation Authority no. 4959 of 25th March 2008.
Operator:	Ryanair Limited.
Airworthiness certificate:	Irish Aviation Authority no. 2328 of 25th March 2008.
Airworthiness review certificate:	Irish Aviation Authority, ARC no. 2328 Exp. Date 24th March 2009.

Total cell hours: 2419 F/H.

Total cycles: 1498 F/C.

Hours since last inspection: 152 F/H 100 F/C (check C, 27th October 2008).

Technical documentation compliant with current regulations/directives: YES.

Engines

Manufacturer: CFM.

Model: CFM56-7B26/3.

Engine position	S/N	Year of manufacture	Date of installation	Total hours (TSN)	Hours since last overhaul (TSO)	Hours since last scheduled maintenance	Hours since last unscheduled maintenance
1	896379		March 2008	2419h	2419h		
2	896387		March 2008	2419h	2419h		

1.6.3. Additional information

On-board systems

The B737-8AS is an aircraft fitted with EFIS instrumentation. The CDS provides the crew with information by means of six DU consisting of flat screen liquid crystal panels. The 4 units in front of the pilots present the PFD and the ND. The two inboard units present to the pilots primary engines indications (upper unit), engines and on-board systems (lower unit).

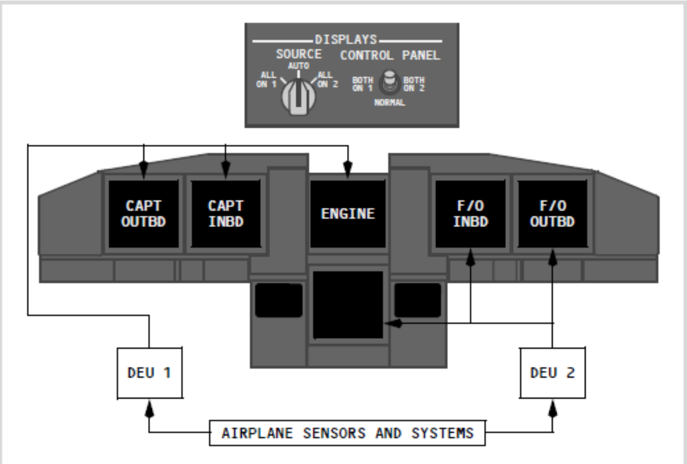


Figure 3: flight and navigation displays.

The navigation system includes the FMS, the GPS (two receivers), ADIRS (two independent platforms), the radio navigation system (one ADF, two DME, two ILS, marker beacons, two VOR), the transponder and the weather radar.

The integrated FMS permits centralized control of the aircraft's flight path and performance parameters. The FMC is the heart of the system and carries out the computation for the navigation and performance of the aircraft, providing control and guide commands. The navigation commands are sent to auto throttle, autopilot and flight director.
The aircraft is certified for ILS operations in CAT II-III and automatic landing (autoland).

Go Around mode

The AFDS provides indications for the execution of the go around in "GO AROUND mode".
This mode (GA) is activated by pressing one of the two TO/GA switches positioned on the throttle (see figure 4).
If both A/Ps are not engaged, a manual F/D only go–around is available under the following conditions:

- inflight below 2000 feet RA;
- inflight above 2000 feet RA with flaps not up or G/S captured;
- not in take-off mode.

With the first push of either TO/GA switch:

- A/T (if armed) engages in GA and advances thrust toward the reduced go–around N1 to produce 1000 to 2000 fpm rate of climb;
- the A/T Engaged Mode annunciation on the FMA indicates GA;
- autopilot (if engaged) disengages;
- pitch mode engages in TO/GA and the Pitch Engaged Mode annunciation on the FMA indicates TO/GA;
- F/D pitch commands 15 degrees nose up until reaching programmed rate of climb. F/D pitch then commands target airspeed for each flap setting based on maximum take-off weight calculations;
- F/D roll commands approach ground track at time of engagement;
- the command airspeed cursor automatically moves to a target airspeed for the existing flap position based.

With the second push of either TO/GA switch (if A/T engaged and after A/T reaches reduced go–around thrust):

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

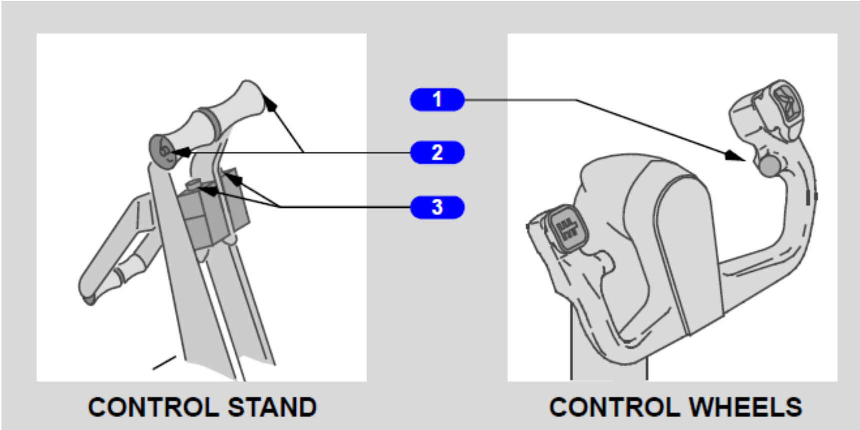


Figure 4: go-around button.

Flaps System

A brief description of the flaps system extracted from the Boeing FCOM Vol. 2 is shown below.

«**Flaps and Slats.** The flaps and slats are high lift devices that increase wing lift and decrease stall speed during take-off, low speed manoeuvring and landing.

LE devices consist of four 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 consist 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 flap 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 position, the TE flaps extend to the commanded position and the LE:

• flaps extend to the full extended position and

• slats extend to the extend position.

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

• flaps remain at the full extended position and

• slats extend to the full 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 flaps 15 for normal go–around».

Photo 1: flap command lever.

Stall Warning System

A brief description of the Stall Warning System extracted from the Boeing 737-8AS FCOM Vol. 2 is shown below.

«Natural stall warning (buffet) usually occurs at a speed prior to stall. In some configurations the margin between stall and natural stall warning is less than desired. Therefore, an artificial stall warning device, a stick shaker, is used to provide the required warning.

The stall 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 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.

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

DH/MDA automatic call out system

An extract from the Boeing 737-8AS FCOM Vol. 2 for DH/MDA callouts is shown below.

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

Callouts are based on radio altitude when the MINS selector 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 B737 QRH, in the *Performance In flight* section, shows a table which is an aid ("Advisory Information") in determining the Landing Distance in different conditions (Tab. 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 speed-brakes.
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 the landing distance.

Considering the mass of the aircraft on landing as 61,100 kg, a tailwind component of 5 kt, an airspeed of Vref+10 kt, a temperature of about 10° below ISA, dry runway, max manual braking, use of T/R and height of 100 ft on the threshold (50 ft above the glide path) the Landing Distance is about 1341 m.

1.7. METEOROLOGICAL INFORMATION

The weather conditions at the time of the accident did not reveal any particular anomalies or critical issues They were, in fact, characterised by clear sky and visibility over 10 km (CAVOK), wind calm, a temperature of 7°C and a QNH of 1029 hPa. (See the following METAR):

```
*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=
```

The local time corresponded to UTC + 1 hour and the event took place in daytime conditions. The sun rose at 5.53:14.

1.8. NAVIGATION AIDS

This section shows the information of interest regarding the aids for air navigation and their state of efficiency.

1.8.1. Navigation aids

Ciampino airport has the following radio aids:

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

Ciampino airport has ALS CAT 1 type approach lights for RWY 15; it has PAPI located on the right hand side of the runway with a descent angle of 3°.

The instrumental runway (ILS) is RWY 15. The procedure carried out by the accident flight was ILS-Z RWY 15 (CAT I). The procedure minimums for category “C” are 720 ft OCA equal to 379 ft OCH. The THR is located at 341 ft AMSL.

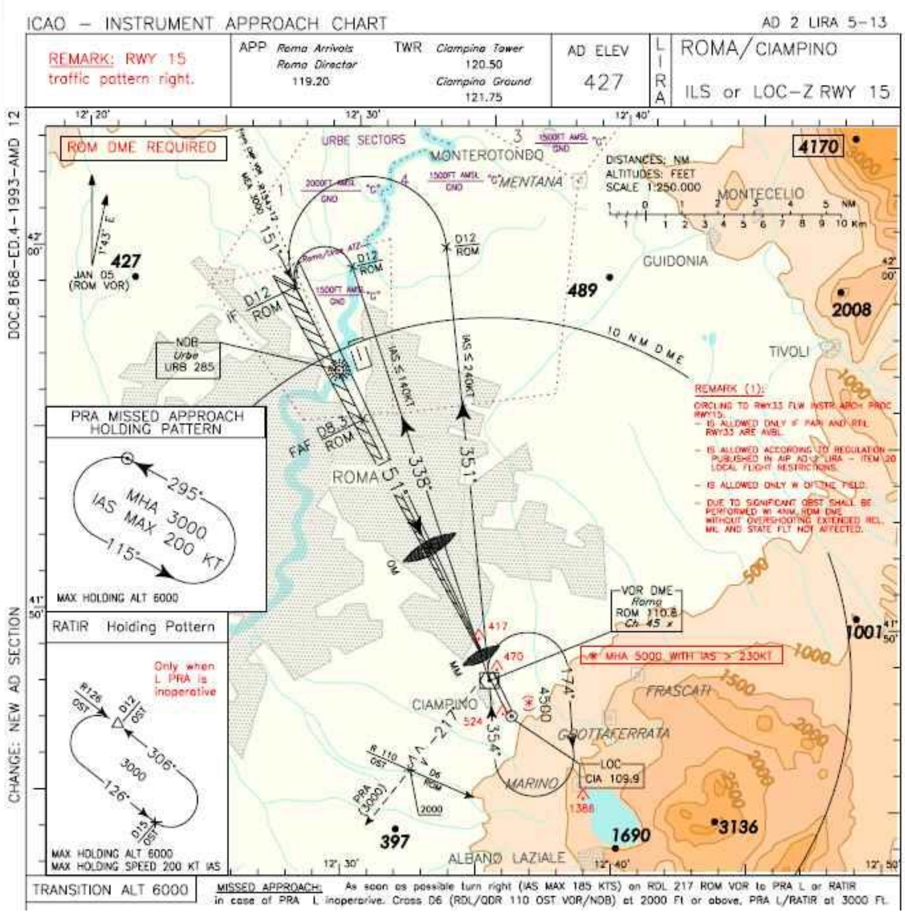


Figure 5: LIRA ILS Z RWY15.

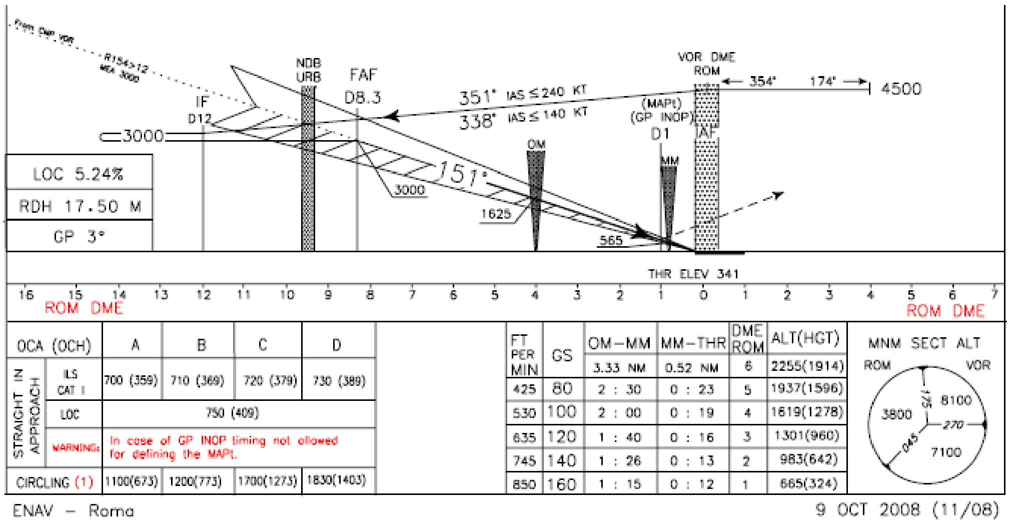


Figure 6: LIRA ILS Z RWY 15 glideslope.

1.9. COMMUNICATIONS

Information concerning the means and availability of communication system is reported below.

The RYR41CH flight maintained regular radio communications with the different ATS units during the flight.

At the date of the event, the approach control was provided, as today, by Rome ACC Arrivals sector (set of several control units that can be configured according to the traffic situation) of ENAV SpA and, in the circumstance, the particular control unit that had the responsibility of last ATS body for managing the flight before its transit into the competence of Ciampino TWR (managed by the AM), was the unit called TN EAST, freq. 127,950 MHz.

The radio and telephone communication systems managed by ENAV SpA are synchronised with the radar data recording system and the common time base updated automatically to UTC.

The radio and telephone communication systems managed by AM and serving the TWR had manual update to UTC thus determining a temporal misalignment of about 17 seconds in advance of the base times in the ENAV SpA systems.

The two time bases were therefore synchronised through the comparison of the different times to which the common telephone communications between the TWR and the APP refer, extrapolated and transcribed with reference to the timetables of two different communication systems.

The time base used for this report comes from the processing of the data downloaded from the aircraft's FDR, which is misaligned in excess of a minimum value of 3 seconds with the communication and radar system time base of ENAV SpA.

Therefore, the timetables for the transcriptions of the radio and telephone systems shown below have the reference timetables of the FDR.

1.9.1. Mobile service

Flight RYR41CH approached to Ciampino airport with authorisation to proceed to ILS Z RWY 15 issued by the Arrivals (TN EAST unit) sector; the last communication that the air traffic control had with the aircraft crew was between 06.52.28 and 06.52.36 with the request to confirm the stabilisation of the aircraft on ILS RWY 15, after which, there followed information on the position and the instruction to transfer radio contact with the next ATS unit, i.e. the TWR of Ciampino (freq. 120,500 MHz).

ACC: «Ryanair 41CH confirm established?».

RYR41CH: «Affirmative.».

ACC: «41CH position URBE, number one, TOWER 1205, buon giorno.».

RYR41CH: «1205.».

Flight RYR41CH contacted Ciampino TWR at 06.52.47, confirming that it was fully established on the ILS RWY 15 and its distance according to the VOR DME Rome (ROM) and, in response, received authorisation to land from the control tower.
RYR41CH: «Ciampino buon giorno, Ryanair 41CH fully established ILS 15, distance nine miles.».
TWR: «Ryanair 41CH Ciampino buon giorno 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.».

About an hour and a half before this happened, two radio communications between the TWR and the airport operator's personnel in charge of bird control (BCU - Bird Control Unit) on UHF frequency 417,750 MHz take on particular significance for the purpose of the event being discussed.
The first radio communication at 05.21.15 (all the communication BCU/TWR were in Italian.).
BCU: «Ciampino Torre da bird control.» (Ciampino Tower from bird control).
TWR: «Avanti.» (Go ahead).
BCU: «Buon giorno Torre, inizio l'ispezione come da programma, interessando l'area di manovra esclusa la pista.» (Good morning Tower, start of inspection as per programme, interesting the manoeuvring area excluding the runway).
TWR: «Buon giorno, riporta liberato.» (Good morning, report area free).
BCU: «Ricevuto.» (Roger).
With the inspection completed, the second radio communication at 05.55.26.
BCU: «Ciampino Torre da bird control.» (Ciampino Tower from bird control).
TWR: «Avanti.» (Go ahead).
BCU: «Terminata l'ispezione, riporto l'area libera.» (Inspection completed, I report area free).
TWR: «Ricevuto, grazie.» (Roger, thank-you).

The aircraft's first contact with the ground occurred at 06.56.10, in proximity of the TWY "AC" until the complete halt of the aircraft, near RWY THR 33, about 25 seconds later.

When the aircraft stopped on the runway, the TWR made a general call to all vehicles potentially listening on UHF frequency 417,750 MHz: «Per tutti i mezzi, per tutti i mezzi, incidente Boeing 738 fine pista.» (For all vehicles, for all vehicles, Boeing 738 accident end of runway). Prior to that TWR had already alerted the emergency vehicles by telephone immediately after acquiring evidence of the effects of impact with the flock of birds and observing the aircraft's first contact with the ground.

With the aircraft stopped, the last radio communication between the aircraft crew and the TWR took place at 06.56.48 to communicate they had a problem and needed in any case to maintain the runway:

RYR41CH: «RYR41CH is… Is maintaining… On runway, MAYDAY.», to which the TWR responded twice assuring the crew that rescue had been alerted and vehicles were arriving.

1.9.2. Landline service

Shown below is the original format of the FPL message, as extrapolated by FDMAS of ENAV SpA, compiled for the flight RYR41CH. The estimated time of departure from Frankfurt Hahn (EDFH) was 05.30 and estimated time of arrival at Rome Ciampino airport (LIRA) after an expected flight of one hour and thirty minutes, with the indication of speed, flight level and requested 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
```

As mentioned in the previous paragraph, with the aircraft still decelerating on the runway, the TWR activated the emergency acoustic signal and initiated the emergency procedure with notice to all the appropriate operators, first of all the airport operator's emergency health services, the military authority and the Fire Brigade, with whom the first telephone contacts were made at 06.56.16, 06.56.25 and 06.56.26 respectively.

1.9.3. Transcription of the communications

The transcription of the radio and telephone communications is shown in the two previous sub-sections.

1.9.4 Arrivals and departures recorded at Ciampino airport and ATC service

On 10th November 2008, before the aircraft operating the RYR41CH flight's accident, 16 arrival and departure movements were already recorded at Ciampino airport, of which 8 before and during the BCU inspection and 8 after the BCU inspection had been completed; no anomaly in the operations activity connected with the presence of birds was recorded for any of them.

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

At about 06.45, the rotation between the two air traffic controllers (CTA) at the TWR position took place: the end of the night shift and start of the morning shift.

No exceptional situation outside routine operations was recorded and regular management also allowed ordinary functionality checks of the alarm systems to be recorded which the outgoing TWR CTA made use of via 4 warning telephone calls with the organisations in charge between 06.46.37 and 06.47.32.

The last movement recorded before the accident, referred to a SAAB-340 (twin-engine turboprop), which landed on RWY 15 shortly before reporting at 06.52.06 on the GND frequency whilst it was vacating the runway via TWY AD, i.e. 41 seconds before RYR41CH made its first call on the Ciampino TWR frequency.

The international regulations (ICAO DOC 4444 "Air Traffic Management", from which the ATS Operating Manuals in force derive), which oversee the specific airport control tower functions, provide that:

«7.1.1.1 Aerodrome control towers shall issue information and clearances to aircraft under their control to achieve a safe, orderly and expeditious flow of air traffic on and in the vicinity of an aerodrome with the object of preventing collision(s) between:

a) aircraft flying within the designated area of responsibility 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 surveillance watch on all flight operations on and in close proximity of the vicinity of an aerodrome (aerodrome runways) as well as vehicles and personnel on the manoeuvring area.

Surveillance Watch shall be maintained by visual observation, augmented in low visibility conditions by an ATS surveillance system when available. [*omissis*].»

And with reference to the above-mentioned international rules:

«7.4.1.4.1 In the event the aerodrome controller, after a take-off clearance or a landing clearance has been issued, becomes aware of a runway incursion or the imminent occurrence thereof, or the existence of any obstruction on or in close proximity to the runway likely to impair the safety of an aircraft taking off or landing, appropriate action shall be taken as follows:

a) cancel the take-off clearance for a departing aircraft;
b) instruct a 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.

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

1.10. AERODROME INFORMATION

Rome Ciampino Airport (IATA CIA, ICAO LIRA) is located SE of Rome, just outside the perimeter of the “Grande Raccordo Anulare”, and falls partly in the area of the Municipality of Ciampino and partly in the Municipality of Rome.

On the North side, it borders the Capannelle racetrack, on the East, the inhabited area of Ciampino and on the South and West, the Appia Antica Park.

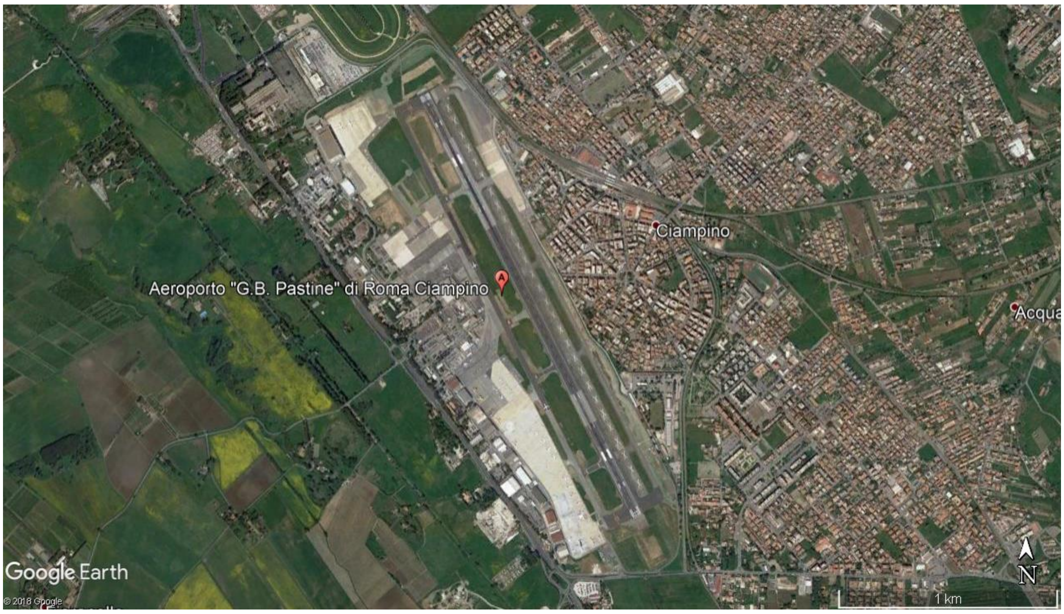


Photo 2: Ciampino Airport (on Google Earth).

At the date of the accident, Rome Ciampino Airport had the status of "Military airport open to civilian traffic". At the time of the accident, the current AIP Italia showed the following characteristics:

- ARP coordinates: 41°47'58"N 012°35'50"E;
- direction and distance from the city: SSE , 6.5 NM;
- permitted traffic: IFR and VFR;
- Annex 14 ICAO reference code for flight infrastructure: 4E;
- airport fire-fighting service category: CAT 8 ICAO provided by the Fire Brigade (the military fire-fighting service will intervene in case of emergency according to availability at the time, the training of personnel and operational plans being signed at local level).

Runway, bituminous conglomerate, with the following characteristics:

- dimensions in metres: 2207.5 x 47;
- TORA/TODA/ASDA/LDA RWT 15: 2207.5 m;
- numerical designation: 15-33;
- magnetic orientation: 151° to 331°;
- THR RWY 15 elevation: 341.4 ft;
- THR RWY 33 elevation: 427.2 ft;
- longitudinal slope: +1.17%;
- strip dimensions in metres: 2327.5 x 226;

The preferred RWY for take-off and landing is 15.

The Ciampino Airport AIP Italia, in the "additional information" part, showed only the presence of hooded crows in the airport grounds, all year round.
The NOTAM in force did not report any warning regarding the presence of birds at Ciampino Airport.

Procedure for bird strikes prevention at Ciampino Airport

The regulations in force at the time of the accident on bird strike prevention procedures were: ENAC APT-01A circular of 30/5/2007 bearing the "Direttiva sulle procedure da adottare per la prevenzione dei rischi di impatto con volatili negli aeroporti" (Directive on the procedures to adopt to prevent the risk of impact with birds at airports); the Airport Manual issued 2/5/2007 and in particular the "MOV/11/Piano per la riduzione del rischio di impatto con volatili" (MOV/11/Birdstrike risk reduction plan).
It is also recalled, for methodological completeness, the Ordinance no 6/2003 of the 24/6/2003 of ENAC-Rome Ciampino Airport Direction, as integrated on 5th August 2003, containing, in the annex, the "Procedura per l'allontanamento dei volatili dalle aree di manovra dell'aeroporto di Roma-Ciampino" (Procedure for the dispersal of Birds from the manouvering areas of Rome-Ciampino airport), even if it is legitimate to doubt the validity of the same, at least of those parts governed by the subsequent legislation on the subject.

The circular ENAC APT-01A (later replaced by the circular ENAC APT-01B of 23 December 2011) preliminarily highlighted that, in conjunction with the national legislation, there was an obligation, for the airport manager, to put in place appropriate containment actions to prevent the risks of aircraft impact with birds on the airports of competence and to limit their seriousness, on the basis of a risk assessment.
The circular above set forth that the operator of a commercial airport:

- reported every bird strike event to ENAC;
- drawn up the statistics for bird strike events and sends them to ENAC every year;
- in specific cases, commissioned natural environment type research.

The following events had to be reported:

- impact (or suspected impact) verified by the flying crew;
- reports of impact (or suspected impact) reaching the ATS service operators;
- damage to the aircraft reported by maintenance personnel as damage due to birdstrike;

- discovery of bird carcasses or remains on the runway or the area within 60 metres of the centre line;
- effects on flight operation (go-around, interruption of take-off as escape manoeuvre) due to birds.

The mentioned events, for which the naturalist environmental research needed to be commissioned, concerned the fact that only one of the following events had occurred, in the previous 12 months:

a) 5 or more bird strikes with aircraft per 10,000 movements (below the altitude limit of 300 ft);
b) multiple birdstrikes or birds ingestion in the engine (below the altitude limit of 300 ft);
c) bird strike that caused damage to the aircraft (below the altitude limit of 300 ft);
d) repeated observations of birds which by number or concentration are capable of causing the events as of points b) and c).

If the research had highlighted the existence of a “dangerous” bird strike risk level for air traffic (the circular does not provide a precise definition of “dangerous”), the airport operator would be obliged to define a specific prevention and control plan, taking into account the guidelines attached to circular APT-01A. This research would be sent to ENAC, which would then send any comments to the airport operator. If ENAC agreed with the existence of the bird strike risk level shown in the research, the management company would have to prepare and implement a specific prevention and control plan. This plan would also be sent to ENAC for evaluation and approved by it in the context of airport certification process.

After 12 months from the implementation of the measures in the plan, the airport operator would have to prepare a risk assessment based on the impacts of the period considered, compared with those of the same period in the two previous years, proposing, if there was not a reduction in the number and/or the seriousness of the impacts, an adjustment of the measures implemented.

To implement the prevention and control plan, the circular provided that a Bird Control Unit (BCU) must be established, the activities of which should be defined in the prevention and control plan because it should not only intervene at the time of dispersal but also exercise continuous monitoring over the airport grounds and disturb the fauna so as to make the airport an unpleasant and unsafe place for birds.

The organisation of the BCU in terms of human and material resources should have been tailored according to the characteristics of the airport.
Point 7 of the circular provided that ENAC should carry out, over the course of its inspection activities, checks that the bird strike prevention and control procedures have been implemented locally by the airport operator because the dispersal system and the procedures themselves are a requirement both for the certification of the airport and for maintaining such certification.

With regard to the risk assessment activities conducted by the airport operator in the years immediately before the accident, the events and more significant bird-strike data are shown below.

In 2003, a B737-400 experienced an impact with a flock of starlings a few metres before the contact with the RWY when landing at Ciampino. The occurrence was considered in the analyses of birdlife conducted by the airport operator.
The naturalist environmental research and the observation activity conducted by the operator in the following years, as described in the 2008 annual report, highlighted that between 2004 and 2008 (until the EI-DYG accident) the number of bird strikes reported against the number of movements varied between 3.16 and 1.36 per 10,000 movements.

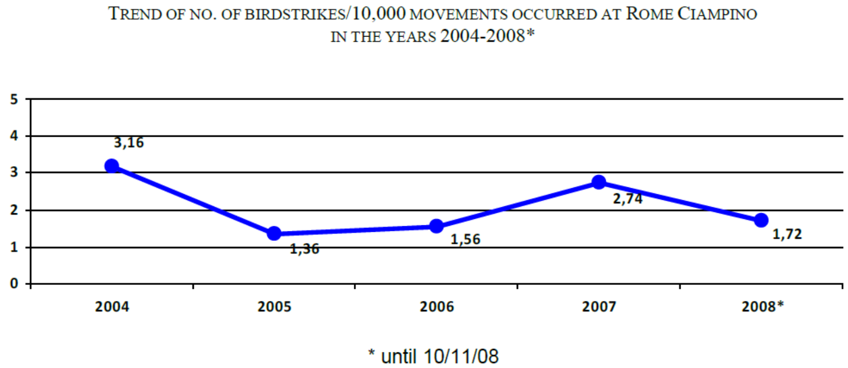


Figure 7: trend of bird-strikes between 2004 and 2008. (AdR, *Report on Birdstrike Situation at Ciampino "G.B. Pastine" Airport*, 19.11.2008).

On the basis of the data for this activity in 2005, the operator had selectively cut down 11 stone pine trees which were near the airport terminals and parking areas.

Photo 3: pines cuts (red areas).

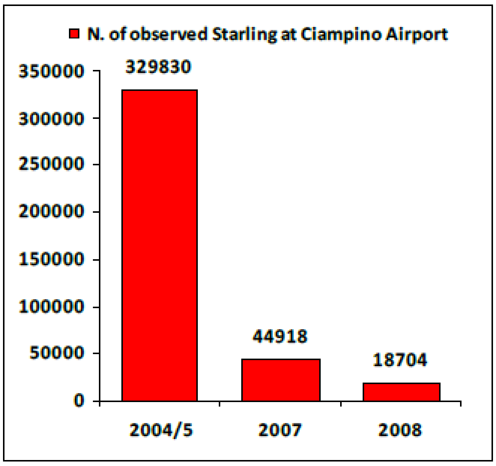


Figure 8: presence of starlings 2004/2008.

It can be seen from the study published by the airport operator after the accident (precisely on 19/11/2008) that the operator, when defining the risk for planning an adequate bird dispersal system, took into consideration not just the above, but also the data from a comparison of the same period of the year between 2007 and 2008, and in particular starlings at Ciampino Airport, which showed a reduction of about 56%.

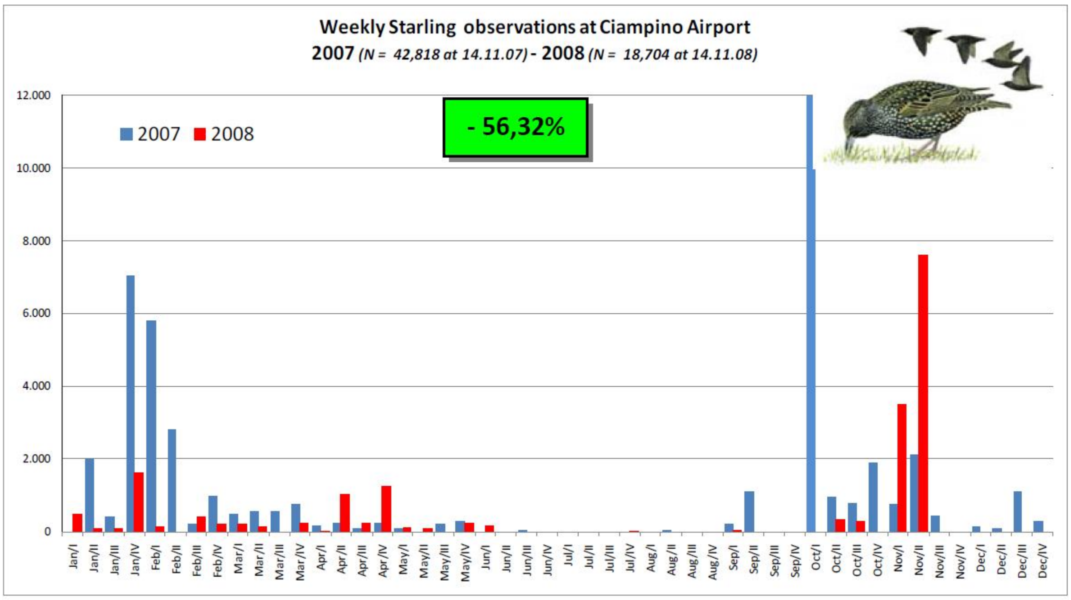


Figure 9: weekly comparison of starlings, 2007-2008.

Based on these studies, observations and conclusions, the operator drew up a bird dispersal plan that was then included in the Airport Manual.

The Airport Manual, 2nd ed. May 2007, in force at the date of the accident, specifies, in the preamble, that its main purpose is to define how the airport operator must fulfil its tasks in order to guarantee the conditions of correct management of the airport and safety of operations.

In particular, in the context of the manual, part MOV/11 contained the plan for the reduction of the impact risk with birds, of which the following relevant points are reported.

The plan defined the information flow as well as the responsibilities and operating methods for monitoring birdlife in order to guarantee constant surveillance of the flight areas and prevent the presence of birds, avoiding impact risks.

The subjects involved in the plan's activities were as follows: SOC Operational Safety (BC); SOC Flight Control; ENAC; AM TWR; SMS; Ciampino Airport Service Manager.

The inspections had to be carried out by the operational safety personnel, who, through the BCU, carried out the bird control and dispersal, as prescribed in the circular ENAC APT-01 (in the other part of the same plan the reference, however, it is at the APT-01A), with H24 service hours.

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

Three types of inspections were foreseen:

1. scheduled checks (which, during the winter period, affected the following periods: sunrise, 13.00 o'clock, sunset);
2. checks on request;
3. checks following a report of a suspected birdstrike**.**

The dispersal systems in use were the following: scare gun, scarecrow megaphone, acoustic signals installed on a motor vehicle.

The operating procedure provided that the inspections had to be carried out by checking for the presence of birds on the runway, taxiway and the immediate vicinities, reporting the birds presence/absence data by means of a dedicated “Ciampino Bird Inspection Form”. If the presence of birds was found, the devices mentioned above would be used, depending on their location and the type of bird.

The BCU staff member would continue checking the area affected, carrying on until the area was fully restored/removed of birds, then reporting the significant data (position, number, type of birds, means of dispersal used) on the “Ciampino Bird Inspection Form” and sending the form to the Airport Direction.

If the birds remained in the affected area, the BCU staff member would request the support of another vehicle and communicate the situation to the Operational Safety Supervisor, and, once the situation was detected, activate the most appropriate dispersal devices. At the end of the operation, he would communicate to the TWR that the birds had been removed from the flight infrastructure.

At the end of the last daily inspection, the Operations Safety Supervisor would have entered the data for all the inspections into the “Ciampino Bird Presence Monitoring/Bird strikes” sheet. If the presence of the birds was such as to compromise the safety of operations and it was not possible to guarantee that they had been removed, the Operational Safety Supervisor would inform the TWR and the SOC Manager and/or Operational Safety Technician. The latter would contact the ENAC on duty person to assess the infrastructure status downgrading and coordinate the possible issue of a BIRDTAM.

Once the information regarding the downgraded status had been received, they would have been communicated to the TWR.

In the absence of the SOC Manager and/or the Operational Safety Technician, the BCU staff member should have contacted the Ciampino Airport Service Manager who would be activated in accordance with the above.

For the inspections required by TWR/Flight Control, both generic or following suspected bird strikes, the BCU staff member would have proceeded according to the scheduled activities, providing the TWR with all the necessary information.

In the case of a strike where the remains of a bird were found, compilation of both the “Ciampino Bird Inspection Form” and the ENAC “Bird Strike Reporting Form” was requested, as well as checking the conditions of the aircraft affected taking, if needed, photographs and recovering the remains of the bird to identify the species.

If the remains of the bird(s) were not found, compilation of the “Ciampino Bird Inspection Form” was requested, specifying a negative result.

Concerning the Ordinance No. 6/2003 of the 24.6.2003 ENAC-Rome Ciampino Airport Direction, on whose full validity at the date of the accident, however, it is legitimate to be doubtful (even if it is reported among the normative references recalled by the “MOV/11/Plan for birdstrike risk reduction”), it can be seen that the same comprised many subjects required to report to TWR the ”visual acquisition” of birds, among them, for example, also pilots, Police, Carabinieri, etc.

Scheduled inspections on the day before the accident and on the day of the accident

The first two scheduled inspections (sunrise and 13.00 hours) on the day before the accident did not detect any presence of birds.

A scheduled inspection (sunset) took place on the evening of the day before the accident, starting at 16.25 and ending at 17.00, which had shown the presence of about 1000 starlings, resting on the grass, affecting sectors C2B and C3A and 300 starlings resting on the grass in sectors C1B and C1A.

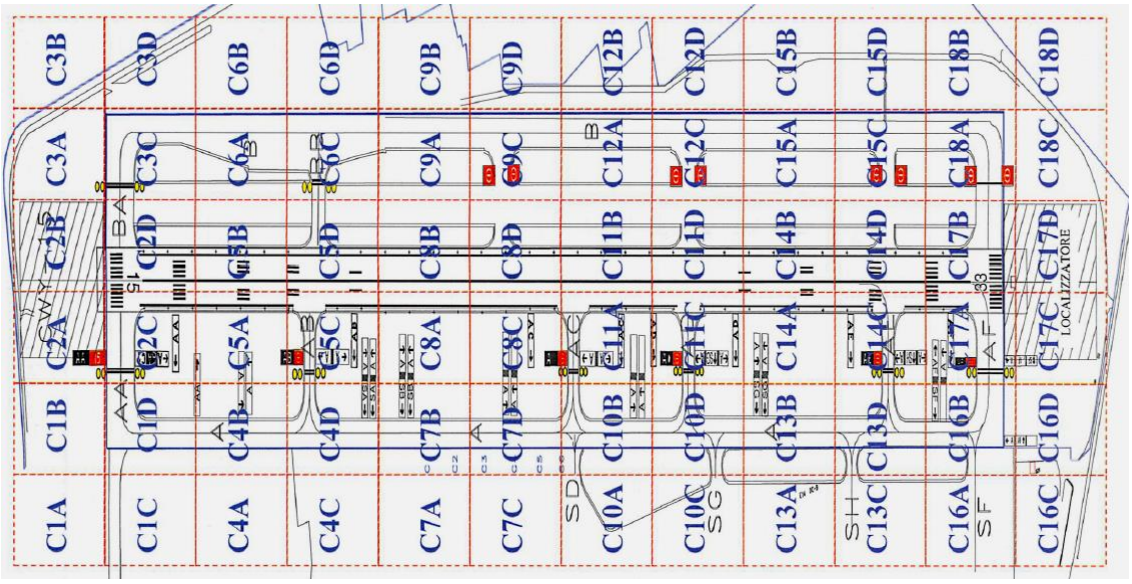


Figure 10: birdlife inspection grid**.**

The BCU dispersed the birds using a total of 35 gun salvoes. No bird carcasses were found in that circumstance.

On the morning of the accident, the scheduled inspection was carried out starting at 06.20 hours LT (05.20 UTC) and ending at 06.55 hours LT (05.55 UTC).

These times have been taken from the inspection form and are consistent with the times associated with radio communications between the BCU and the TWR.

During the inspection no presence of birds was reported.

As from communications between TWR and BCU at 05.21.15 hours and reported above, the latter had carried out the above inspection on the manoeuvre area not interesting the runway.

Bird dispersal procedures currently in use at Ciampino

At the time of this report, the bird dispersal procedures are those contained in the current Airport Manual, “MOV/11/Piano per la riduzione del rischio di impatto con volatili ed animali selvatici" (MOV/11/Plan for bird and wildlife strike risk reduction), updated on 26-6-2018.

The current plan is very different and far more extensive and in-depth than the one in force at the date of the accident, now also containing measures to ensure the constant surveillance of the flight areas to avoid the presence of birds and therefore the risk of bird strike.

It also provides basic and recurrent training for the personnel responsible for the birds dispersal, surveillance of the surrounding territory with the involvement also of other institutional entities of the local municipalities authorities, control and removal inside the airport of organic waste which may constitute an attractive source for wildlife, etc.

Also with regard to inspections there are new developments compared to the past.

In particular, with regard to the planned inspections, it is stated that during the period of the presence of starlings, usually in the period between September and mid-March, the inspection begins: 15 minutes before the sunrise with continuous presence until two hours after the sunrise. The inspections continue throughout the day on hourly basis. The last inspection begins two hours before the sunset with continuous presence until 15 minutes after the sunset. Once the period of concentration of starlings ends, the inspection begins.

Moreover, a significant increase in BCU technological equipment has been noted.

1.11. FLIGHT RECORDERS

The following paragraph reports the information concerning the on board data recording system.

1.11.1. General

The aircraft had two flight recorders on board:

- FDR P/N 980-4700-042 (SN 14415);
- CVR P/N 980-622-001 (SN 120-10231).

Both recorders have solid memory technology.

1.11.2. Conditions at recovery

Both recorders were removed from the aircraft on the day of the accident and carried to the ANSV laboratories in perfect conditions.

The data and audio tracks were downloaded without any kind of problem at the laboratories on the day of the accident. In order to proceed with the decoding of the downloaded FDR data, Boeing was requested to provide the applicable *data frame layout*, which arrived at ANSV in .ffd format.

1.11.3. Data downloaded

The synchronisation between the flight data and the audio tracks was carried out by taking as reference the activation of the FDR discrete parameters with a clear identifiable audio signal in the CVR. More specifically, were used discrete signals activated in times different from the bird strike event.

The data recorded by the FDR referring to pressure altitude, were recorded with the reference value of 1013 hPa.

The QNH value for Ciampino Airport at the time of the accident was 1029 hPa, the value selected by the crew on the on board altimeter.

The difference of 16 hPa between reference QNH and real entails a difference of about 432ft.

The GPS data recorded by the FDR were validated by taking known points of reference on the ground, more specifically the initial point of contact with the ground and the aircraft's stop point on RWY THR 33.

On-ground operations, take-off, cruising, descent until disengagement of the automatic systems

The aircraft started taxiing at 05.22 and took off from Frankfurt Hahn RWY 21 at 5.31.28. The mass at take-off was 64,700 kg. It levelled out at FL370 at 05.49.00.

The descent started at 06.20.50, leaving FL370 for FL330. The aircraft reached FL330 at 06.24.54 maintaining that level until 06.28.12 when it started a continuous descent until the approach phase.

Two speed reductions were recorded during the descent and before the approach phase, the first to 250 kt passing FL200 at 06.40.52 and the second to 220 kt at 06.48.06 passing FL90.

During the descent, starting from 06.43.06, the crew, on crossing an altitude of 16,800 ft, disengaged, in order, auto throttle, automatic pilot and flight director and started to manually fly the aircraft from 06.43.08, as indicated by the switching of the autopilot, FD and auto throttle values. These automatic systems would remain disengaged until the end of the flight.

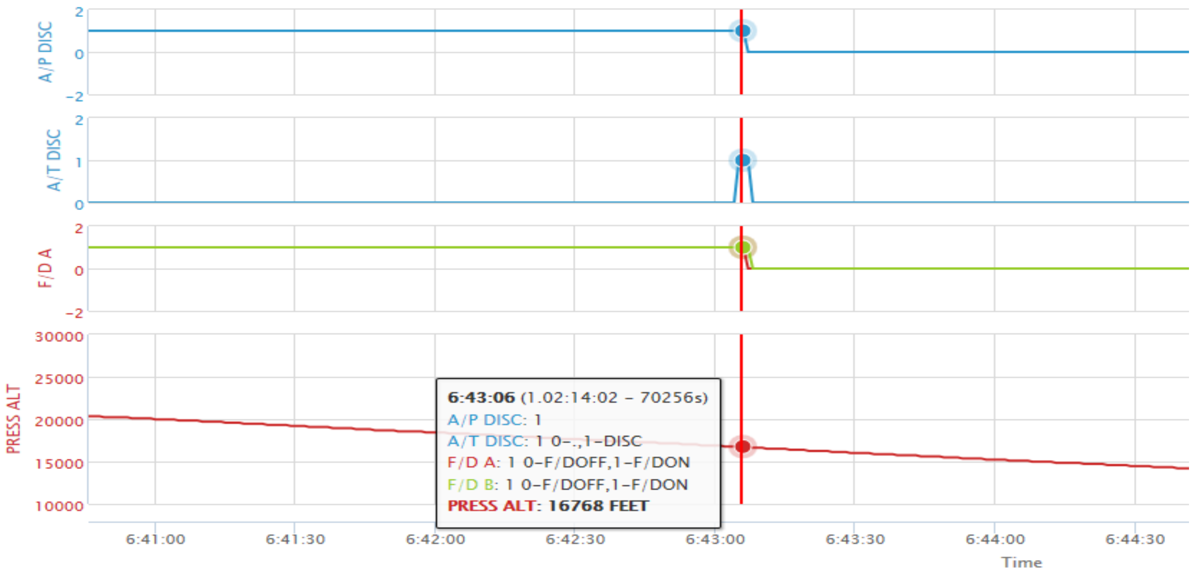


Figure 11: autopilot, FD and autothrottle disengagement.

From disengagement of the automatic systems to approach until birds visual acquisition

The following aircraft configuration positions are highlighted in the approach phase (time and altitude are referred to the moment in which the position has been reached):

Event	UTC hours	Pressure alt. (1013 hPa)	Baroalt (1029 hPa)	Radioalt
LG down	06.50.13	5760 ft	6192 ft	6070 ft
flaps at 1	06.51.16	3840 ft	4272 ft	4295 ft
flaps at 5°	06.51.40	3399 ft	3831 ft	3857 ft
flaps at 15°	06.54.28	1024 ft	1456 ft	1405 ft
flaps at 30°	06.54.56	640 ft	1072 ft	912 ft
flaps at 40°	06.55.02	512 ft	944 ft	836 ft

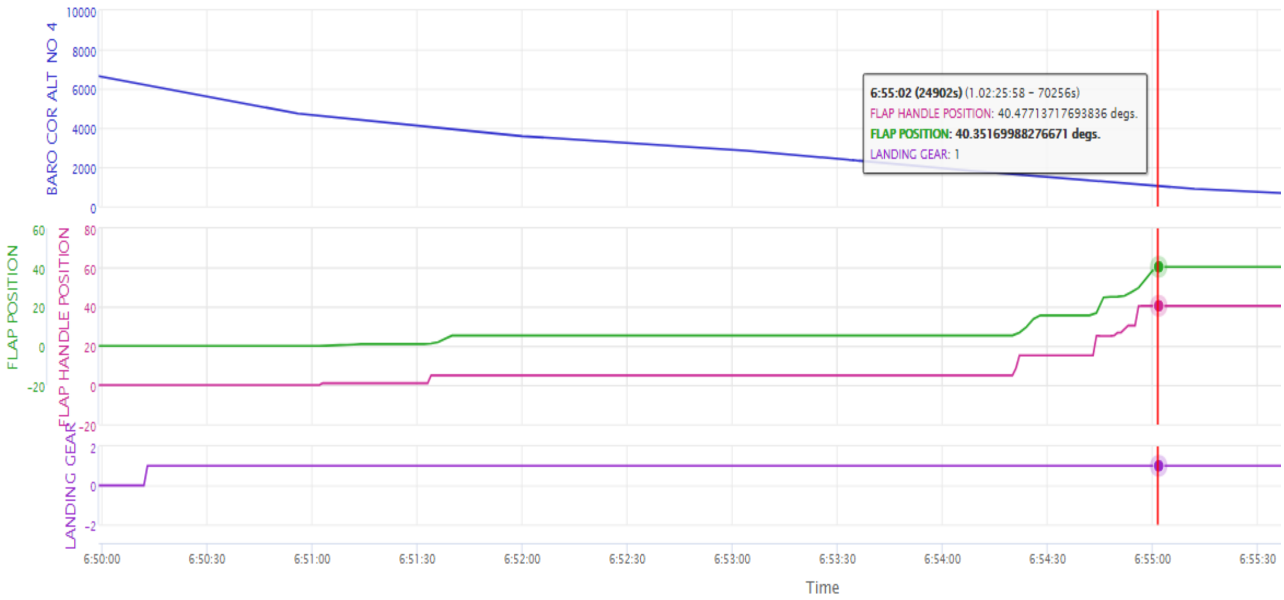


Figure 12: aircraft configuration sequence until flaps selection at 40°**.**

The localizer interception started at 06.52.20 at about 11 NM from the airport and an altitude of 3266 ft (pressure altitude 2834 ft) setting a left hand turn and leaving the 195° interception bearing to stabilise on the runway extension at about 10 NM. The glide path intercept took place at 06.53.05 with the aircraft stabilised on the localizer and at a distance of about 8.5 NM from the airport; the aircraft intercepted the localizer and glideslope with a flap configuration of 5° and landing gear extended.

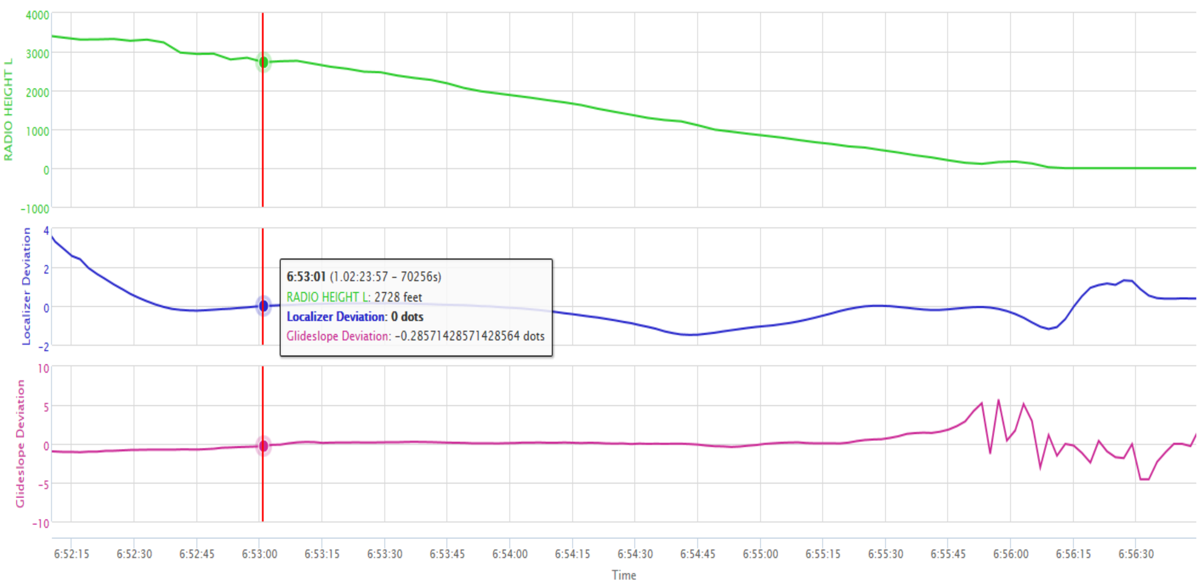


Figure 13: localizer intercept**.**

As shown in the data plots that follow, the localizer deviation data highlighted a flight path lateral instability, starting from 06.54.00 at 1882 ft radalt.

With the aircraft at about 6 NM from the field, a progressive right hand deviation from the runway axis extension took place until about 3 NM, when a correction was made and brought the aircraft onto the localizer at about 1 NM from the field.

The descent path had a constant variometric trend, as highlighted by the radalt profile compared to the ideal glide path. The Computed Airspeed, in the final 40 seconds of the approach, was a few knots above the *Vref* value of 136 kt (maximum difference of about 13 kt at the time the TOGA was applied).

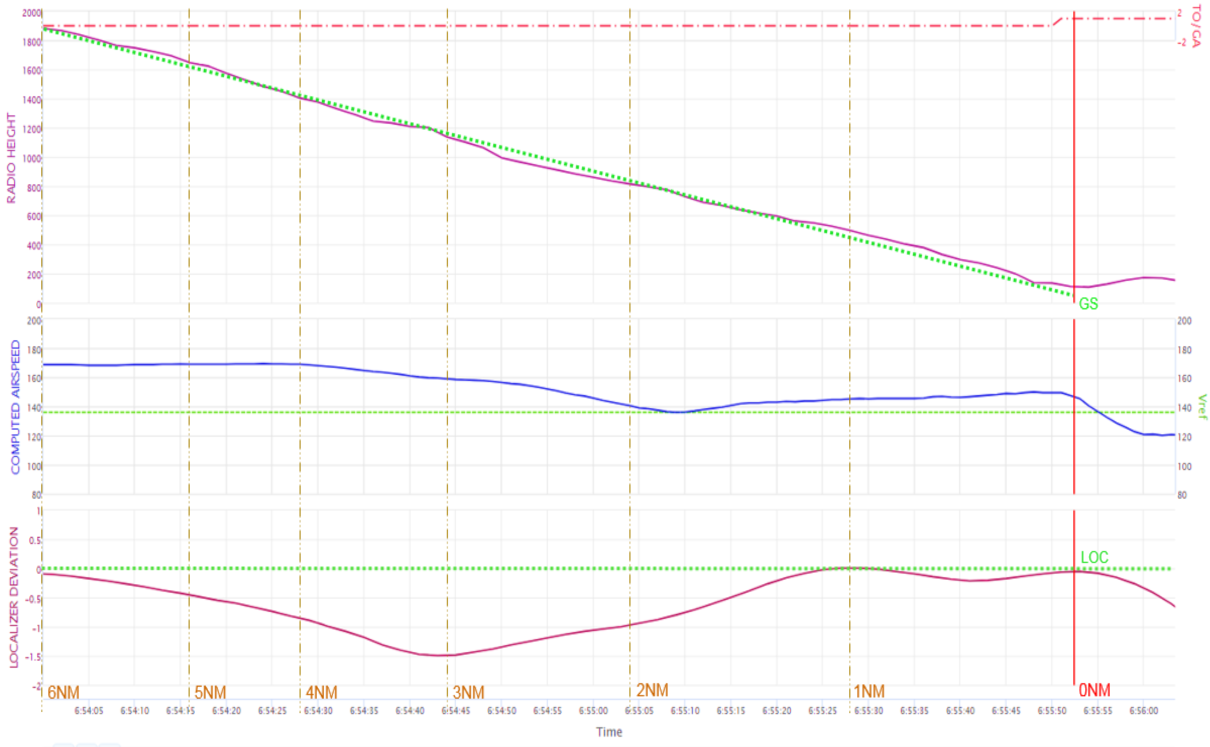


Figure 14: GS, LOC and Vref deviations**.**

At ILS minimums, reached at 06.55.30 (pressure altitude 256 ft, with a baroalt of 720 ft, consistent with the procedure minimums), the aircraft was correctly configured for landing (landing gears down and locked, flaps at 40°) and flown manually with autopilot, flight director and autothrottle disengaged. It was also stable on the localizer, 0.7 DOT above the glide slope, with a CAS of 145 kts, a VS of 688 ft/min, N1 ENG1 at 65.75% RPM and N1 ENG2 at 66.5% RPM.

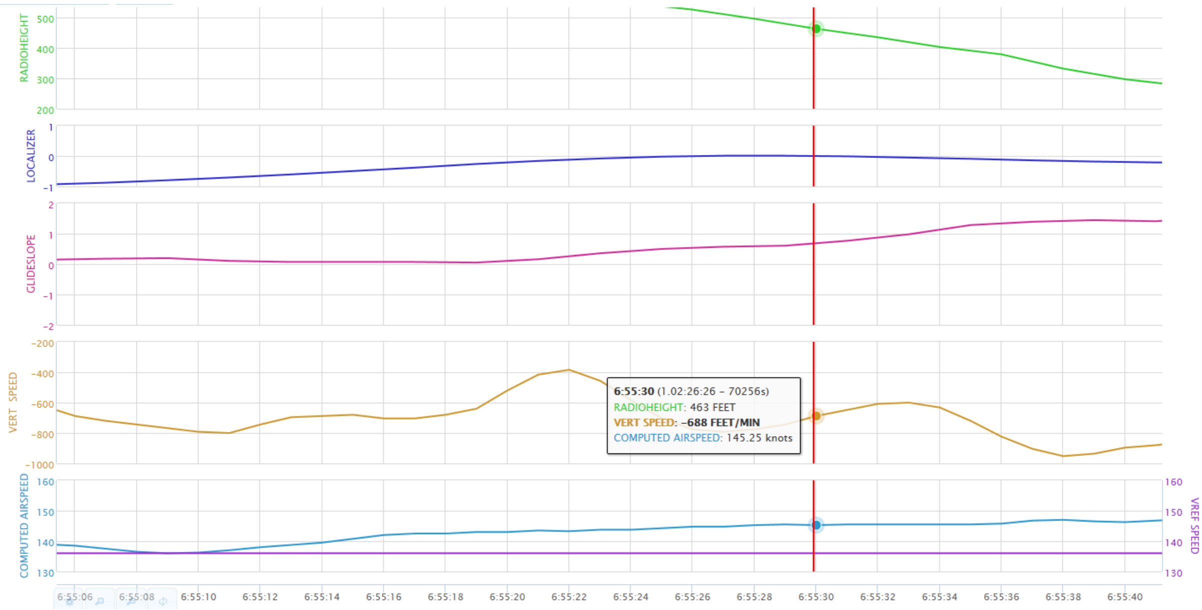


Figure 15: minimums reached ILS Z RWY15.

At procedure minimums (06.55.30), as illustrated in the following image, the wind was 8.5 kt from 034°. The groundspeed value was 149 kt, i.e. 3.75 kt above the indicated speed value (145.25 kt). The maximum wind speed value recorded during the ILS approach was 9.5 kt from 012° at 06.54.54; the aircraft was at a 1000 ft radalt, the indicated speed was 153.2 kt whilst the GS was 161.5 kt.

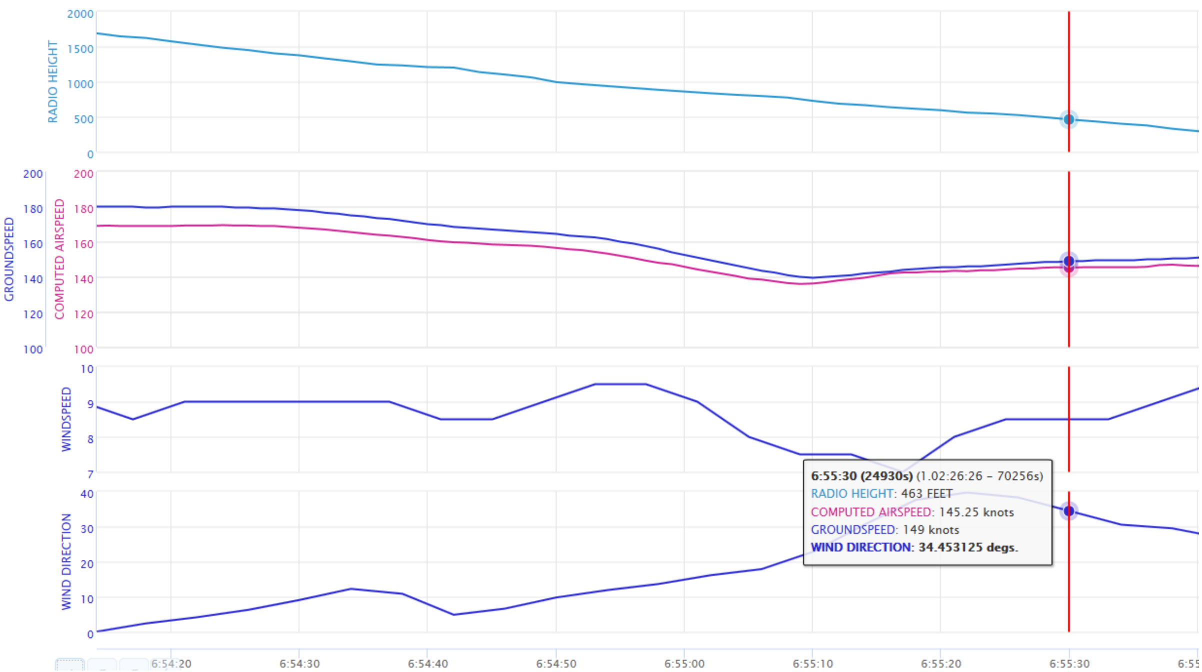


Figure 16: wind intensity and direction at the procedure minimums.

From birds visual acquisition to impact with the ground

From 06.55.49 it has been recorded a reduction of the angle of descent and of the VS, which went from -752 ft/min to -391 ft/min at 06.55.51, the time when the TOGA command was recorded.

In detail, at 06.55.49 (corresponding to the second when the CVR recorded the Captain's exclamation of «Ahi!» repeated about 10 times, as it will be shown later, following the sighting of the birds), the aircraft was aligned with the localizer, at a radio height of 136 ft and a CAS of 149.5 kt with engines at 62% N1.

At 06.55.51, as mentioned, the go-around pushbutton switch was recorded as being activated with the first push on the TOGA switch followed by a second push after 3 seconds at 06.55.54 to command the full go-around N1 limit.

When the TOGA was applied, the vertical speed underwent to a further sudden reduction, and in the aircraft's descent trajectory a slight increase in the radio altimeter height has been recorded (from 108 to 173ft) up to 06.56.01.

After that time, the aircraft returned to descend.

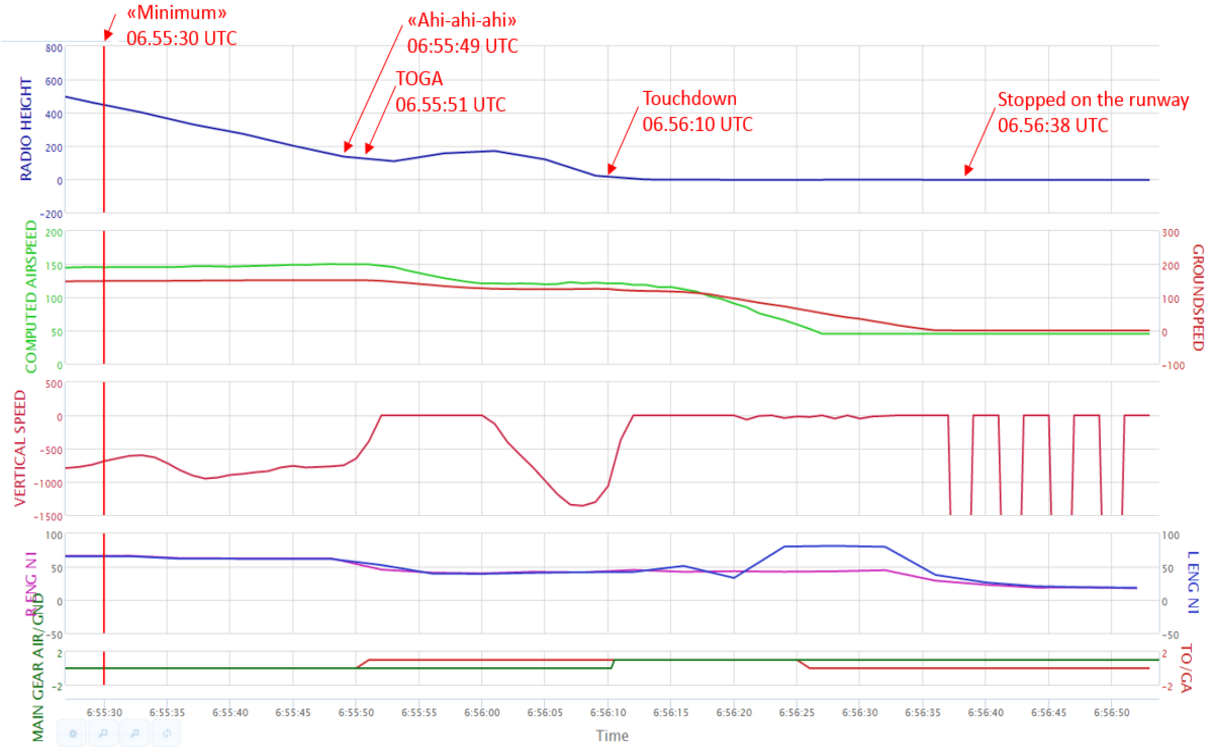


Figure 17: speed and engine N1 from the minimums to contact with the ground.

At 06.55.56, the selection of flaps from 40° to 10° position was commanded. This was reached at 06.56.12, with the aircraft on the ground.

The FDR data show that the Captain took aircraft control at 06.55.58, i.e. 7 seconds after activation of the TO/GA.

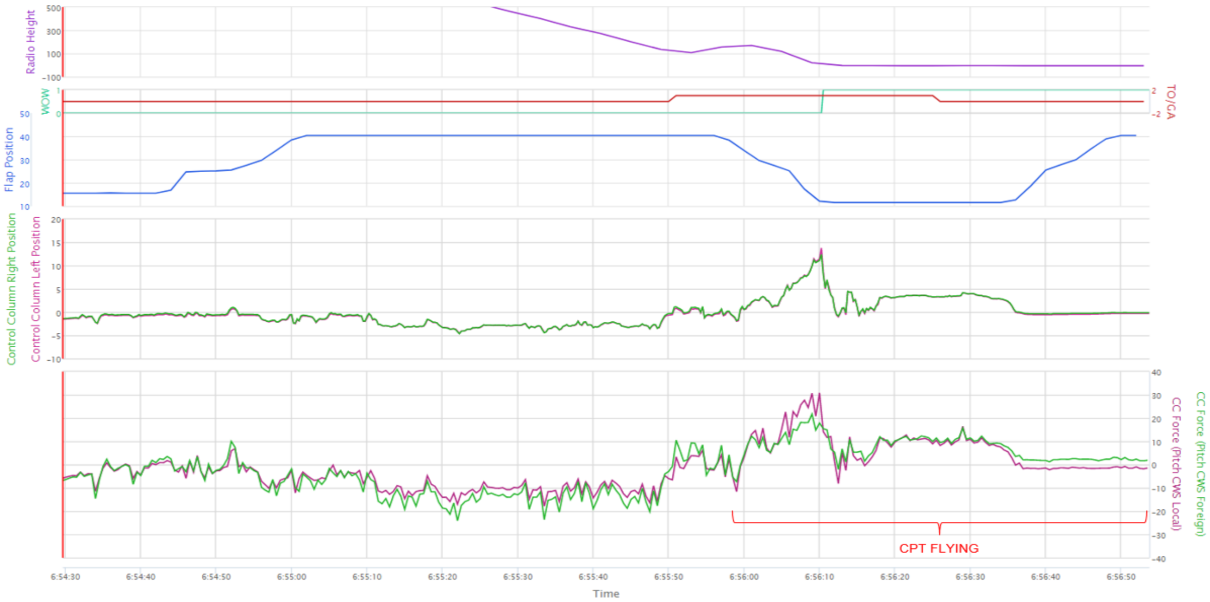


Figure 18: flap selection and acquisition of flight command control by the Captain.

From the time that go around was commanded, with the consequent change of attitude, the speed recorded a progressive decrease.

At 06.56.07, with a CAS of 122.75 kt, the sink rate warning activated, followed at 06.56.09 by the stick shaker, time corresponding to the maximum vertical speed of -1360 feet/min reached by the aircraft.

At 06.56.10, the aircraft touched the ground (WOW switch) with an attitude of about 10° pitch and -6° roll, indicated speed of 120.75 knots, VS -1064 ft/min, vertical acceleration of 2.66 g and and lateral acceleration -0.45g.

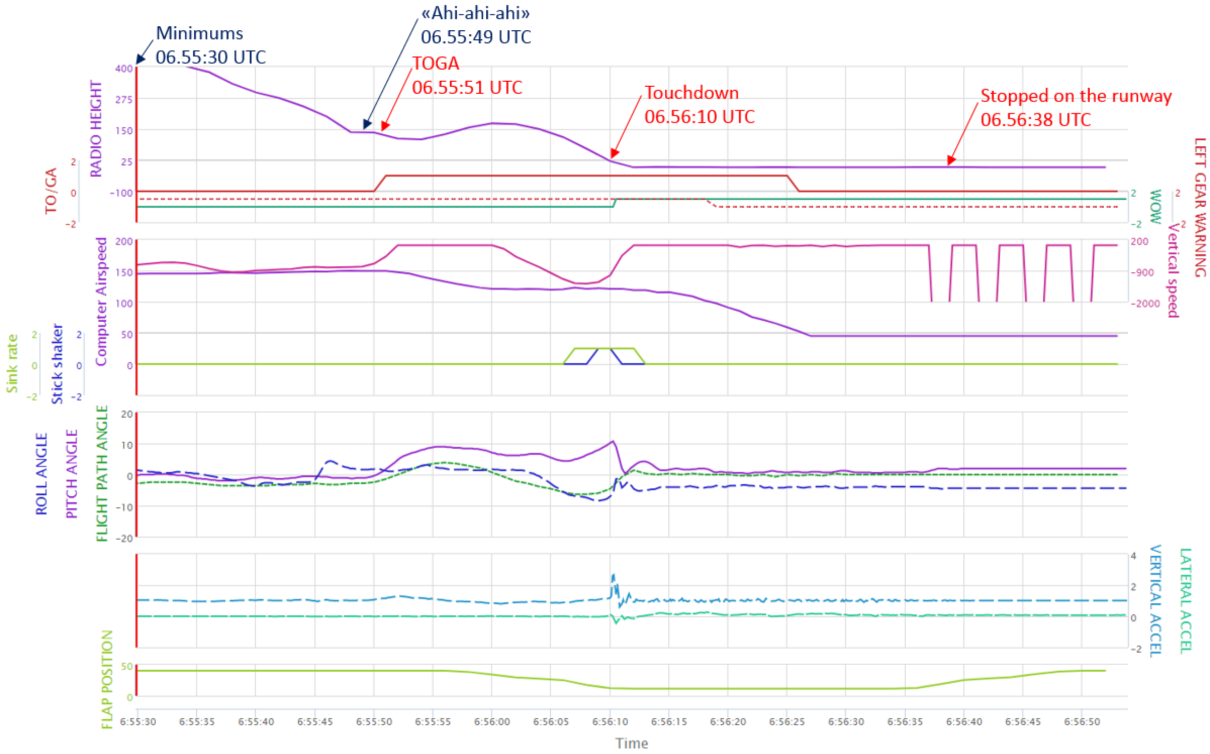


Figure 19: sink rate, aerodynamic data and accelerations at impact.

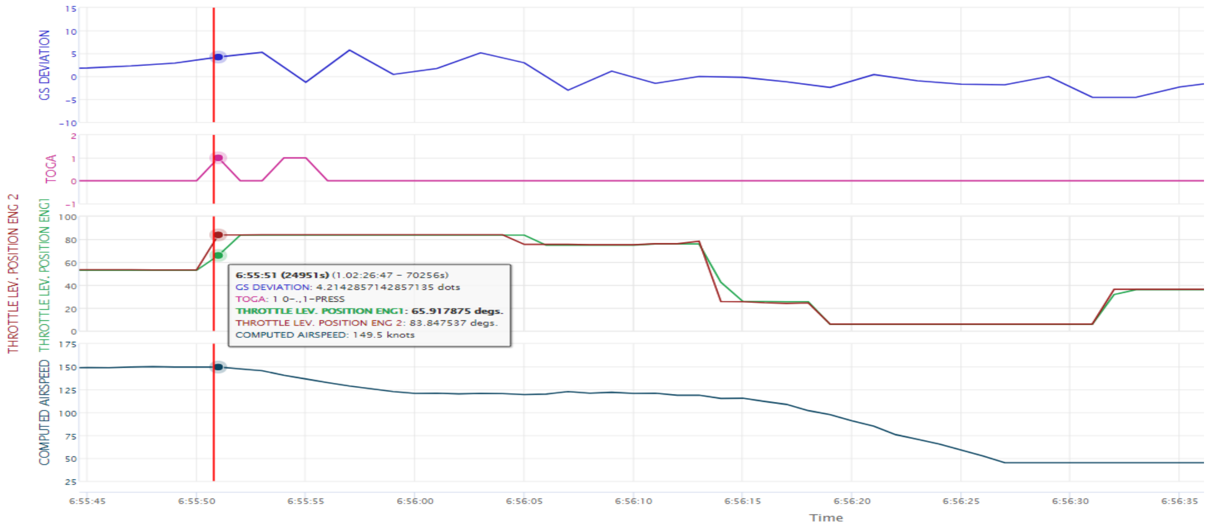


Figure 20: glide and computed airspeed trend at TO/GA selection.

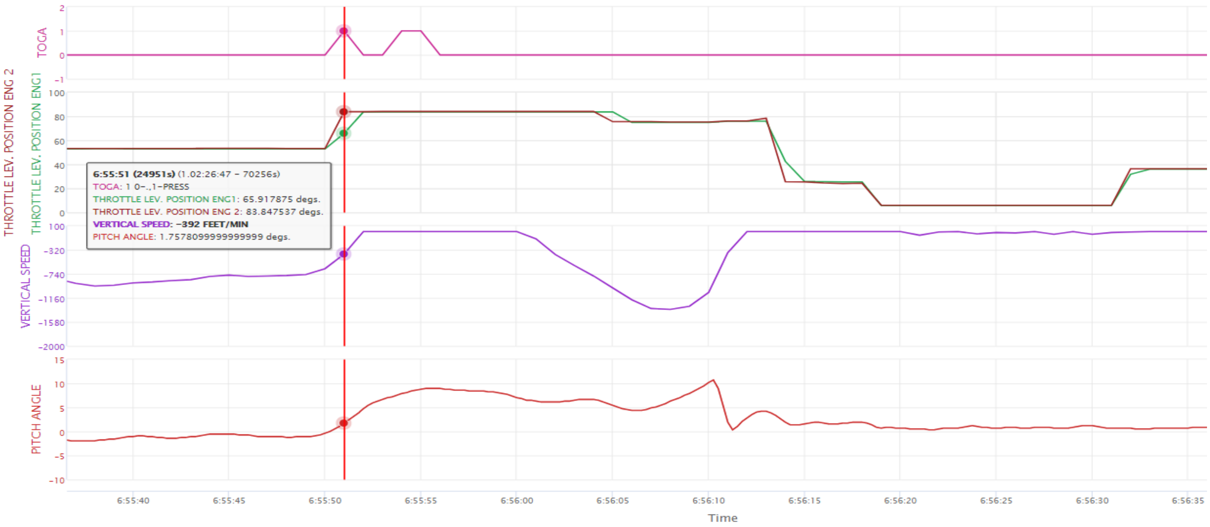


Figure 21: VS and pitch angle at TO/GA selection.

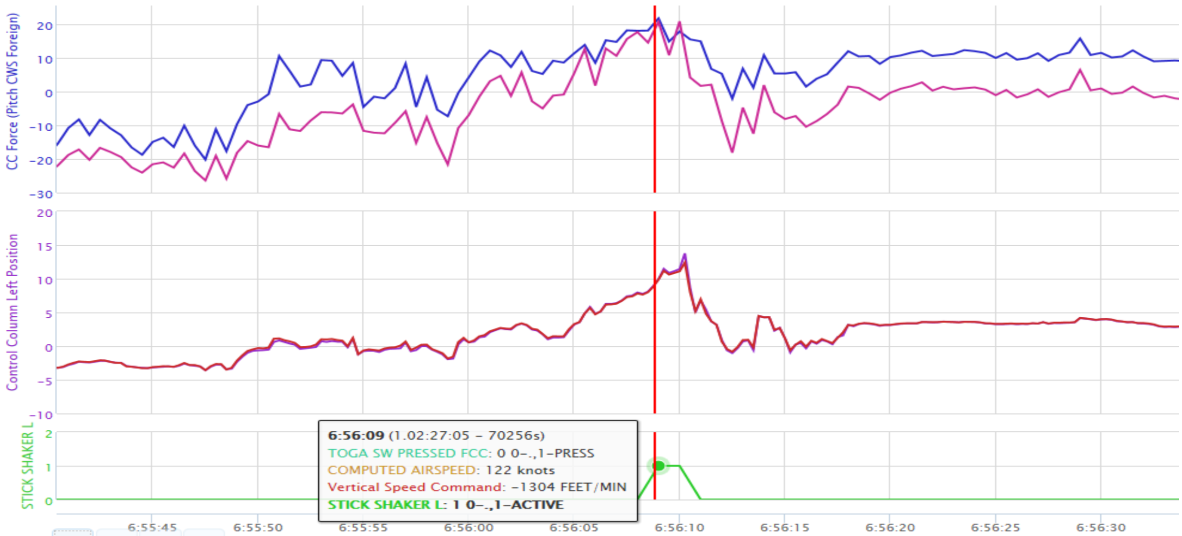


Figure 22: intervention on flight controls at activation of the stick shaker.

Landing roll

After the touchdown, the aircraft decelerated at 06.56.10 until 06.56.38, using the brakes, engine no. 1 thrust reverse and the spoilers. The warning of unsafe condition of left hand landing gear activated during the ground run.

With the aircraft stationary on the runway, the flaps were lowered to 40° and the spoilers set to zero.

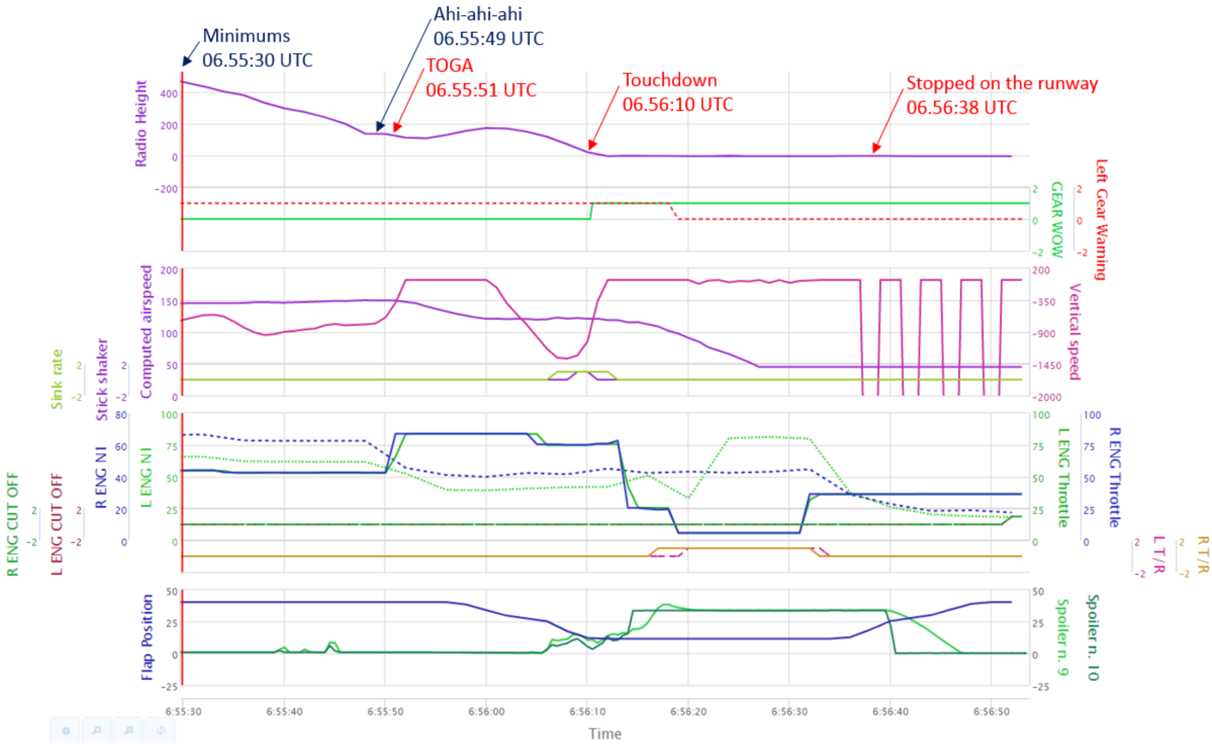


Figure 23: flap, spoilers and reverse thrust trend.

Attitude and decelerations

The following data plot highlights how the aircraft, from the visual acquisition of the flock of birds, progressively changed the flight path angle, which was correctly set at around -3° before the birds visual acquisition, reaching up to about 4° at the go around phase then going down to the minimum values (-7°).

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

In the phase when the flight path angle went from -3° to about 5°, the pitch angle changed from about -1° to 9° and then remained a few degrees positive until the impact with the ground.

The aircraft's magnetic heading was also characterised by left and right deviations for the runway direction (150°), together with deviations on the roll axis. The aircraft impacted the runway with a roll angle of about 6° to the left and a pitch angle of about 10°.

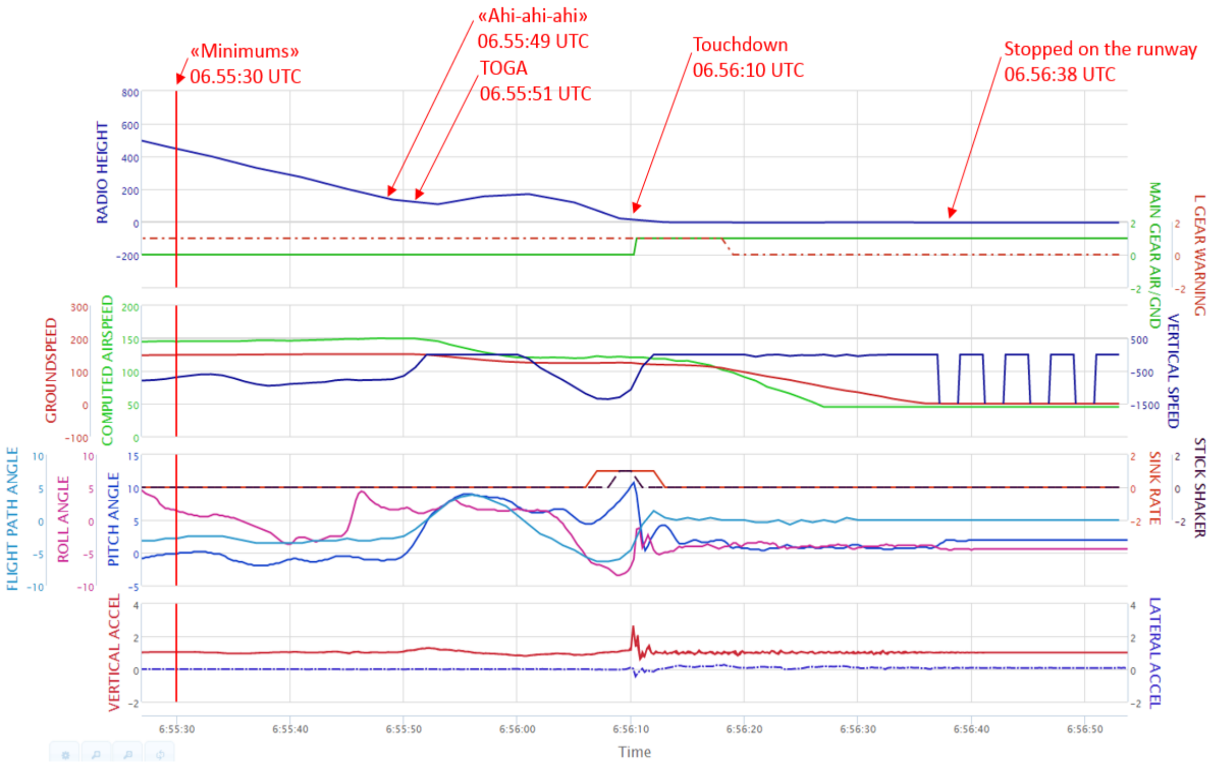


Figure 24: attitude and acceleration data.

Engines behaviour

With regards to the behaviour of the two engines, both experienced a stall condition (state 3) when TO/GA was selected, the right hand engine at 06.55.51, the left 1 second later; the N1 RPM of both engines dropped from 66% to a value around 40%, where they remained until impact with the ground, after which the left engine increased RPM up to 81% through activation of the thrust reverse, whilst the right remained at values below 45%, until being shut down.

A sudden rise of the EGT of both engines was recorded coinciding with the reduction of the N1 rpm.

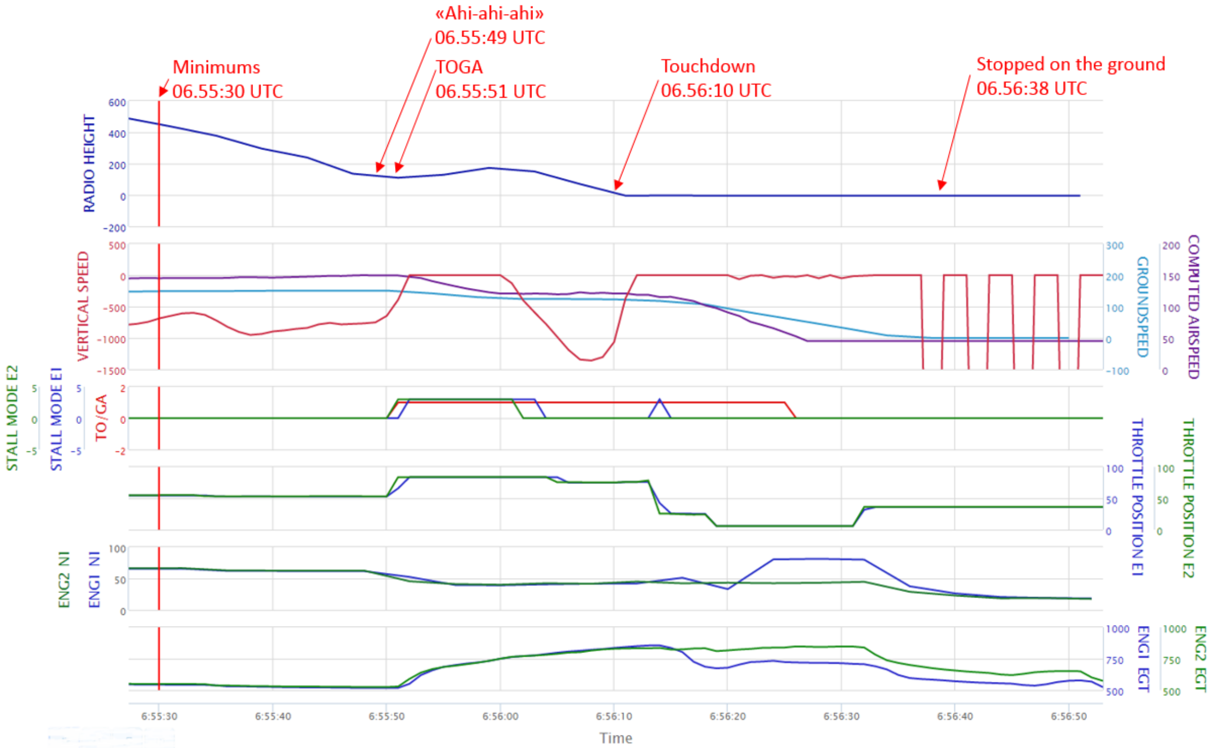


Figure 25: engines behaviour.

1.11.4. CVR transcription

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

The CVR recorded the flight involved in the accident from 00:29:42.

The audio track therefore recorded all the phases of the flight involved in the accident, from when the aircraft was electrically powered before moving in Frankfurt Hahn until the electricity was powered off, when the passenger disembarking procedure was initiated, after coming to a halt on the runway.

The communications show that the first officer was the PF on the leg whilst the Captain was the PM.

For logical purposes, the recording was divided into the following stages:

1. on-ground operations, take-off, cruising, descent until disengagement of the automatic systems;
2. approach until moment before the visual acquisition of the birds;
3. from visual acquisition of the birds to impact with the ground;
4. deceleration run on the ground and immediate action after landing.

From CVR reading it was possible to get the following evidence at the recording times indicated.

CVR: ground operations, take-off, cruising, descent until disengagement of the automatic systems.

The push and start operations were completed at 05.26.59. The crew carried out the checks by SOP and was cleared to taxi and take-off for RWY 21.

The rotation took place at 05.31.24. After take-off, the flight was initially cleared to FL240 with further clearance to final level FL370 and direct route to Trasadingen.

The flight contacted the German, Swiss and Italian air traffic control centres and was instructed to the Trasadingen /Odina/Ruxol route and the start of the descent to FL330.

At 06.25.27, a thorough briefing, carried out by the FO to the Captain, in compliance with the SOP, took place about the approach to Ciampino, with ILS procedure for RWY 15 briefing, inclusive of the missed approach procedure and validation of the data entered in the FMS. An excerpt of the transcription is shown here below.

«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. Mountain are pretty much here, on this side. We are staying clear of mountains if we stay on this one. From URBE then is the ILS runway 1-5.».

There then followed a radio call that cleared to continue the descent to FL290; the Captain and FO tuned the VOR and ILS equipment after which the FO resumed the briefing:

«Missed 3000 feet. Outer marker 16-25. Minima 7-20. Elev 4-2-7. 4-50 up here. MSA based on ROM V-O-R 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 GOAROUND, 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 that point there was a further air traffic control call, after which the FO proceeded to confirm that the RATIR point had already been entered in place of Pratica di Mare for missed approach.

At 06.42.50, the crew, considering the excellent meteorological conditions, decided to conduct the approach manually, i.e. without automatic systems (autopilot, auto throttle and flight director).

At 06.43.02, the autopilot, auto throttle and flight director were disengaged; from that moment, the CM-2 flew the aircraft manually.

CVR: approach until the moment preceding the visual bird acquisition

The transcription of the communications held in this phase is shown below.

UTC	**STAT.**	**COMMUNICATION**
06.49’40”	ATC	RYR41CH descend 3000 feet clear ILS ZULU RWY 15 report established
06.49’45”	RYR	3000 feet clear, ILS Zulu, I’ll call you established RYR41CH
06.49’50”	CPT	So my friend
06.49’51”	FO	3 thousand set
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 buon giorno
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 buon giorno, RYR41CH fully established, ILS 15, distance 9 miles
06.52’53”	TWR	RYR41CH Ciampino buon giorno to you, number one on the approach on field on ILS Zulu 15, CAVOK, temperature 7, QNH 1029, the wind is calm 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*
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 a bit, you are high

CVR: From visual bird acquisition to impact with the ground

The transcription of the communications held in this phase is shown below.

UTC	**STAT.**	**COMMUNICATION**
06.55’49”	FO	Nice
06.55’49”	CPT	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*

It should be noted that, at 06.55.49, whilst the FO was commenting «Nice», the Captain had begun to exclaim «Ahi!» repeated about 10 times in the following two seconds.

At 06.55.51, a loud bang was heard, with a change of in the engines noise, which had become irregular.

At 06.55.52, the Captain ordered «Go around… go around… go around».
At 06.55.53, the FO confirmed «Go around, flaps 15».
At 06.55.54, the Captain repeated «Go around… go around».

At 06.56.07 and in the next second, the synthetic “sink rate” warning was played, and repeated twice. At 06.56.09, the activation of the stick shaker was heard and after a second the exclamation of the Captain and the noise due to the hard landing.

CVR: deceleration run on the ground and immediate action after landing

The aircraft hit the ground at 06.56.10; at 06.56.18, with the aircraft on the runway and decelerating, the Captain confirmed «My control».
At 06.56.38, the aircraft came to a halt on the runway and simultaneously the Captain, via interphone, ordered «Remain seated» and repeating the order twice.
From 06.56.44 to 06.56.47, the Captain turning to the FO ordered «We do… open the outflow valve.», starting the procedure to make the aircraft safe.

Simultaneously, the FO communicated to Ciampino Tower by radio «Is maintaining on the runway, MAYDAY.». After which the recording ended when both engines were switched off.

1.12. WRECKAGE AND IMPACT INFORMATION

This section reports the information acquired from the examination of the wreckage and the place of the event.

1.12.1. Place of the accident

The accident took place inside the Ciampino Airport grounds.

As will be specified below, the aircraft hit the runway in coordinate points 41° 47’ 55.59” N 12° 35’ 41.71” E, near taxiway “AC”.

Photo 4: Ciampino Airport (on Google Earth).

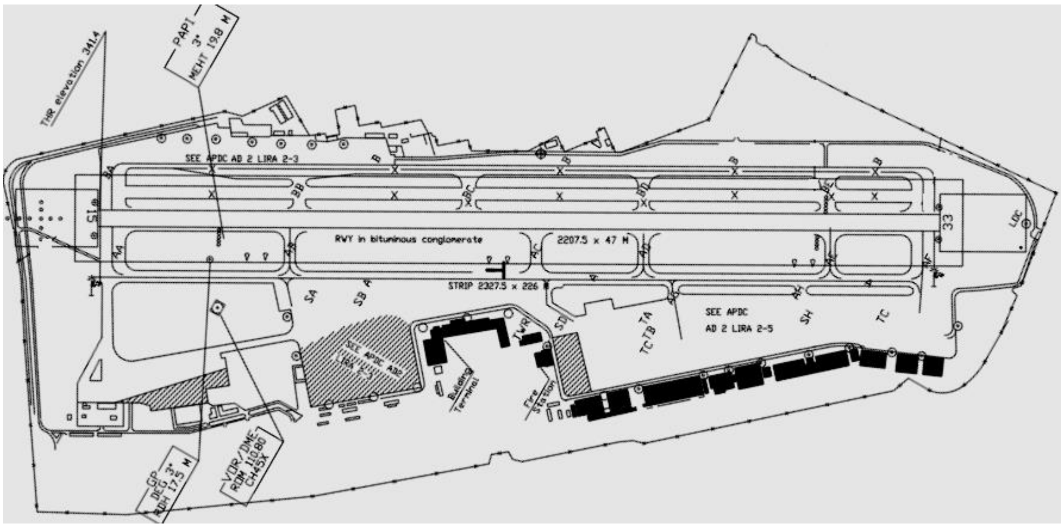


Figure 26: airport diagram.

1.12.2. Ground evidence and wreckage distribution

Ground evidence that can be associated with the hard contact between the aircraft and the ground are near the taxiway "AC" intersection with the runway, intersection positioned about half way along its total length. They are shown in the following image, in order of progress:

- marks of impact of the lower part of the tail fuselage with the asphalt surface of taxiway "AC";
- marks of impact of left hand landing gear on the runway asphalt surface;
- marks of impact of the right hand landing gear on the grass adjacent to the right edge of the runway;
- continuous marks of left hand engine and left hand landing gear scraping from the first point of contact to the final resting point of the aircraft.

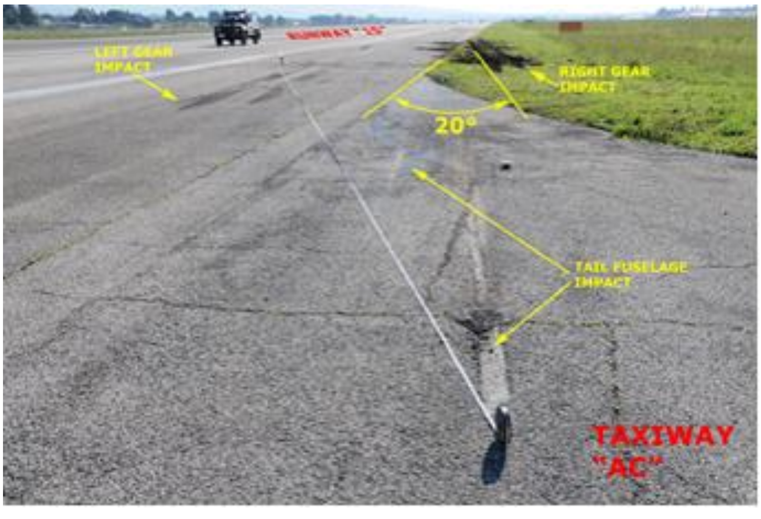


Photo 5: tracks of the landing gear and tail fuselage on the ground.

An angle of about 20° between the direction of the aircraft on contact with the runway and the axis of the runway emerges from the set of these marks.
In the next image, an overall view of the marks is reported.

Photo 6: overall view of the landing gear and tail fuselage marks on the ground.

A large number of remains of dead birds were spread in the area at about 100 metres before the runway 15 threshold and more precisely in the grass section between "*Center line barrette no. 2*" and "*Center line barrette no. 3*" of the "CALVERT" approach system.
The majority of the organic remains were concentrated inside an ellipsoidal area, closer to the "*Center line barrette no. 2*" pole, the larger axis of which was about 35 metres and the shorter one about 10 metres.

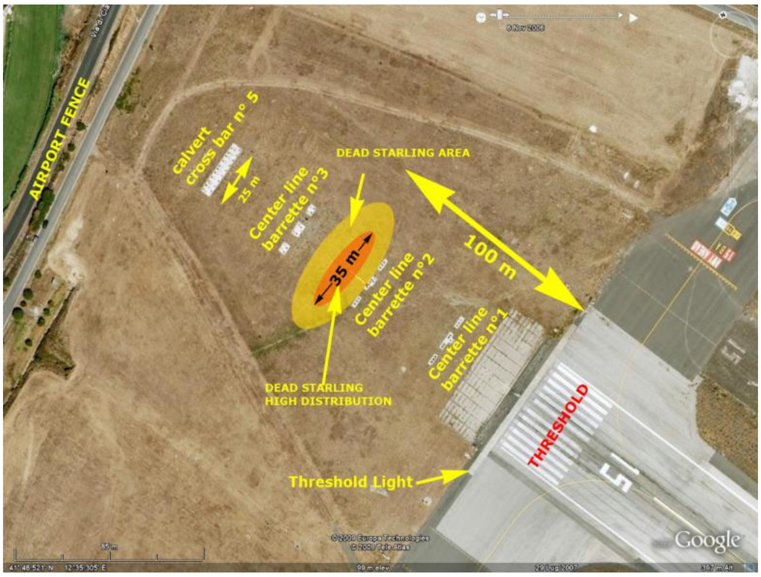


Photo 7: distribution of birds' corpses.

About 120 starling carcasses or remains of them were identified and recovered during the clearing of the area, which were carried out with the support of an ornithologist. No organic remains belonging to other species of birds were identified in the recovered material.

1.12.3. Wreckage examination

The aircraft came to a stop close to RWY 33 threshold, resting on the main right landing gear, front landing gear and left engine nacelle.

Photo 8: aircraft at rest on the runway.

The right hand side slide had been deployed during the disembarkation of the passengers and crew from the aircraft.

Photo 9: slide from the rear right hand door activated.

Fuselage

The fuselage shows multiple bird strikes (no less than 86), visible in the next images. The windshield panels show some bird strikes in their top central part.

Photo 10: bird strikes on the windshield panels.

There are clear signs of damage caused by the impact and scraping along the asphalt runway on the lower tail part of the fuselage.

The lower part of the passenger cabin floor structure shows extended deformation.

Photos 11 and 12: damage to the tail and passenger floor structure.

Wings and relative surfaces

There are multiple damage points on the left hand wing and buckling on both the top surface and underside of the wing. The flaps showed some dents.

Photos 13 and 14: bird strikes on wings.

Landing gear

The main left hand landing gear is seriously damaged, its shock absorber has gone back into the wing. The main left hand landing gear doors are heavily damaged.


Photos 15 and 16: damage to the main left hand landing gear and wing.

Engines

Both engines show many bird strike points on their respective air intakes


Photos 17 and 18: bird strikes on the engine air intakes.

The left hand engine nacelle shows damage from scraping along the asphalt; the thrust reverse doors are locked in a partially open position.

Photo 19: thrust reverse locked in partially open position.

1.12.4. Impact dynamics

Reference was made to the tracks on the ground, the evidence found on the aircraft, the surveillance camera footages, the synchronisation of the FDR and CVR data and witnesses statements for the reconstruction of the impact dynamics.

The damage found on the aircraft confirmed that the tail of the aircraft came into contact with the runway, causing permanent deformation of the structure.

The marks on the ground permitted to determine the initial point of contact and, to some extent, the aircraft's attitude at the time of initial contact. Thanks to the marks found on the runway surface, it was also possible to reconstruct the aircraft trajectory taken from the first contact with the runway to the point when it came to a halt.

Photo 20: ground roll of the aircraft.

The marks on the ground show how the lower part of the tail contacted the asphalt near the "AC" taxiway; the main right hand landing gear contacted the grass alongside the runway and the main left hand landing gear on the right centre-line of the runway.

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

A set of frames from the footage taken by the airport cameras were acquired and were used to reconstruct the trajectory and the final attitude in the aircraft up to impact with the runway.

Photo 21: airport camera frames merge: final phase.

The left hand landing gear collapsed almost immediately after the first contact, causing the left hand engine nacelle to contact the runway.

The aircraft continued its run on the ground and with the left hand nacelle in constant contact with the runway, followed a curved trajectory that brought it to skim the left hand side of the runway and then return to the centre of it.

The aircraft finally came to a stop near the opposite threshold, on the RWY 33 head designation number, after a run on the ground of about 998 metres from the initial contact.

No evidence or traces of fire were found from the initial contact point with the runway, along its run on the ground, and the aircraft's final resting point.

Below is shown an image summarising the final trajectory of the aircraft, taken from the animation realized by ANSV obtained from the synchronised FDR and CVR data.

Figure 27: ANSV reconstruction of the final trajectory of EI-DYG.

The FDR data, as previously seen, indicate that the aircraft was configured with the flaps at 10° and the landing gear in “down” position at the time of landing.

The aircraft had the following attitude and parameters at the time of contact with the runway, which occurred at 06.56.10:

1. pitch angle: +10.72°;
2. roll angle: -5.97°;
3. magnetic heading: 142°;
4. speed: 120.75 kts;
5. AoA: from +21° to -3°;
6. Vertical speed: -1064 ft/min;
7. flight path angle: -4.57°.

The stick shaker and the “sink rate” warning were also active.

The engine N1 RPMs at the impact were respectively: left 41.75% and right 41.62%.

The aircraft had a mass of 61,144 kg (134.800 lbs).

On contact with the ground, a vertical acceleration of 2.66 g and a lateral acceleration of -0.45 g were recorded.

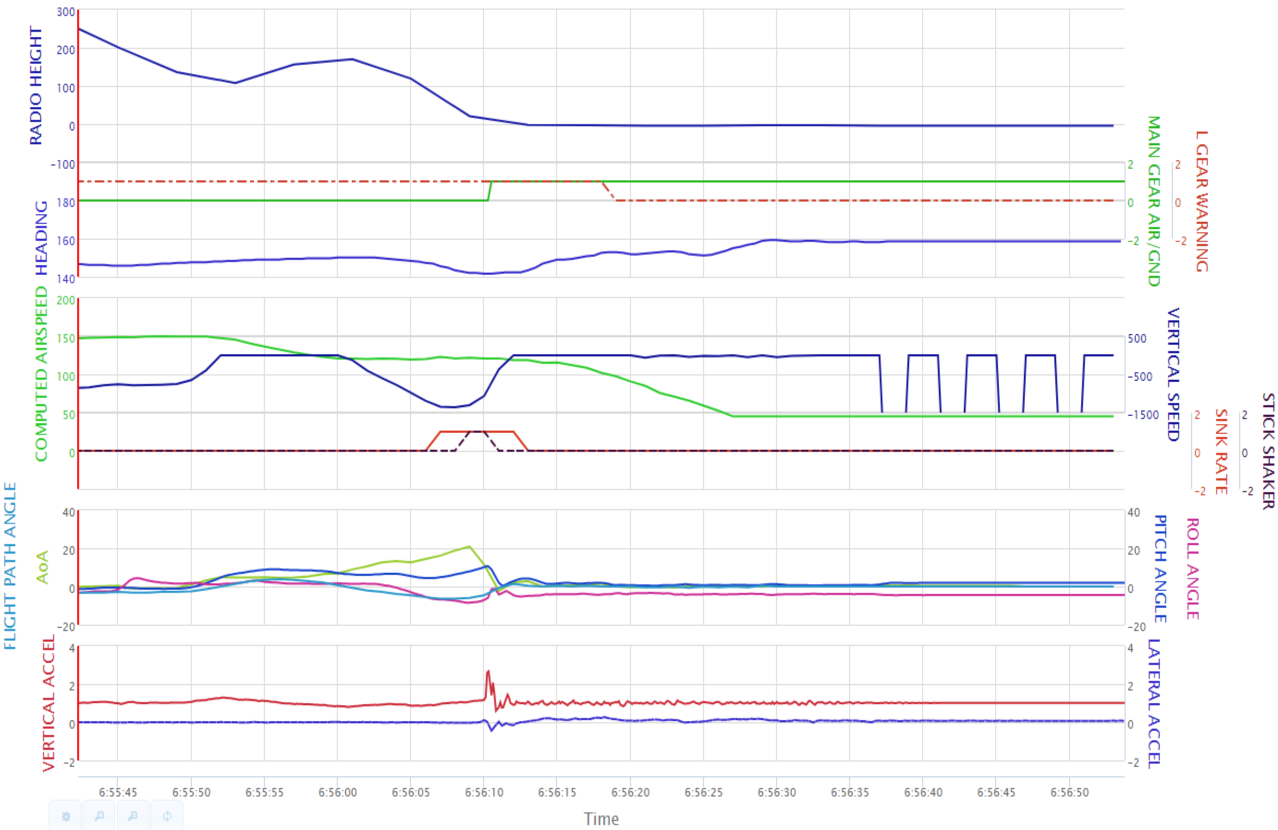


Figure 28: aerodynamic parameters and accelerations on impact with the ground.

9 seconds after contact with the runway (06.56.19), the warning of unsafe left hand landing gear activated which can be verified from the “L GEAR WARNING” signal switching.

The aircraft continued its run on the ground decelerating trough brakes, spoilers and thrust reverse only of the left hand engine, from 06.56.20 to 06.56.33 with a maximum N1 value of 81%. The aircraft came to a stop on the runway at 06.56.38, 50 metres from the end of the runway.

Both engines were cut off at 06.56.52 (ENG CUTOFF). During the landing run, the left hand engine nacelle came into contact with the runway following the collapse of the left hand landing gear.

The emergency phase started at 06.55.51, when both engines stalled when the go around was activated.

At that point the aircraft’s speed was 149.5 knots and the RA height between 136 (at 06.55.50) and 112 ft (at 06.55.52).

The maximum vertical speed went from a value of 752 ft/min at the time the TO/GA was activated to a minimum value of 0 ft/min in two seconds (06.55.52). From that time, there was a progressive reduction of speed and increase in angle of attack, which reached values of 120.75 kts and 21° of AoA at 06.56.10, when the aircraft was at a radalt height of 21 ft. 19 seconds elapsed from TOGA command to touch down.

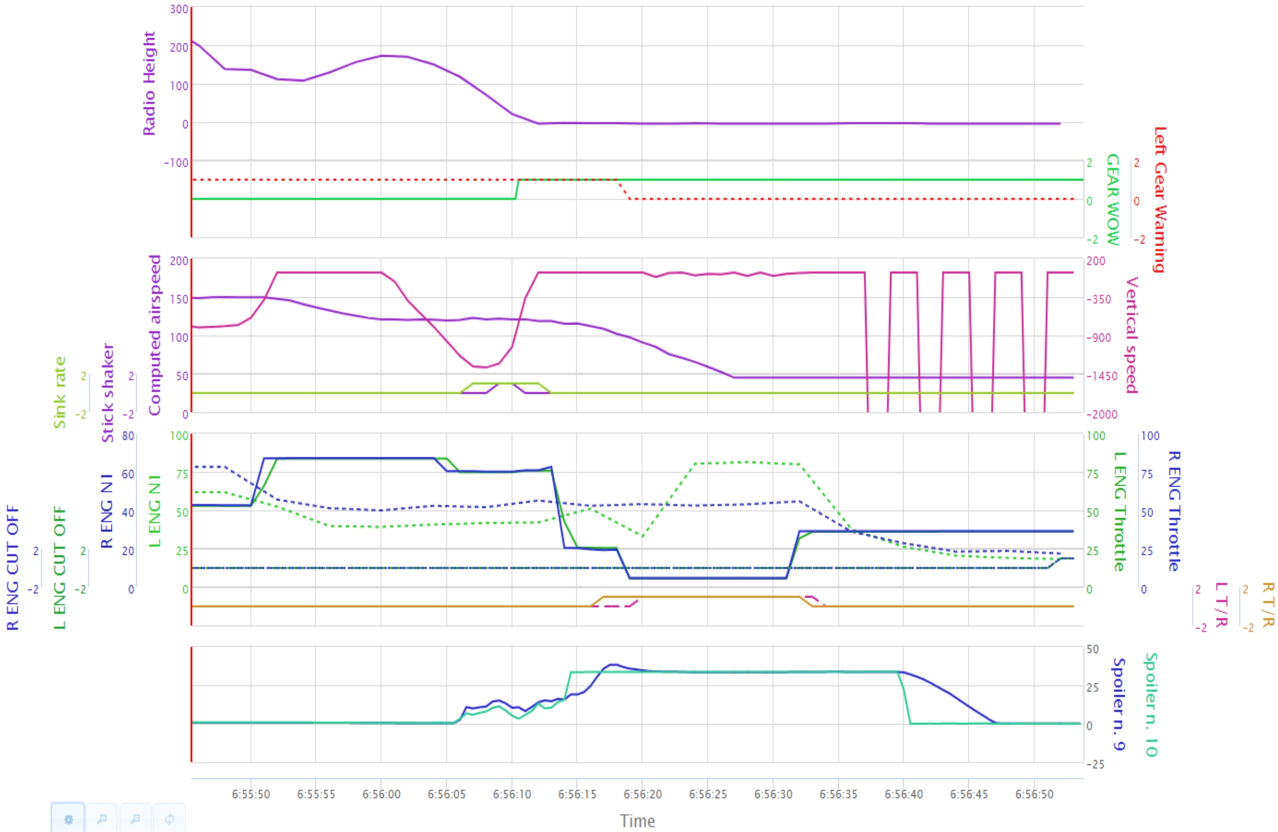


Figure 29: engine response and thrust reversers activation.

1.12.5. Failures connected with the event

The aircraft had no malfunctions prior to the accident.

At 06.55.51, the FDR recorded a stall condition for both engines, at the same time that the TO/GA command was applied; the stall condition continued until 06.56.03.

The damage found is due to impact with the birds and contact with the runway.

1.13. MEDICAL AND PATHOLOGICAL INFORMATION

No medical and pathological evidences that could have contributed to the genesis of the occurrence emerged.

1.14. FIRE

Not applicable

1.15. SURVIVAL ASPECTS

There were 166 passengers and 6 crew members (2 pilots and 4 flight attendants) on board the aircraft. Following the event, 6 passengers and 2 flight attendants had medical check-ups. It is not possible to ascertain the entity of the injuries or the circumstance in which they occurred (landing or evacuation, apart from flight attendant no. 3 who in his/her statement refers that he/she was injured during the landing and that some other passengers also received first aid before abandoning the aircraft).

The position on board of the passengers who reported injuries is not known, as the operator was implementing a "free seating policy" at the time of the events.

As soon as the aircraft came to a stop at 06.56.38, the Captain ordered «Remain seated, remain seated» via PA.

At 06.56.44, he started the aircraft safety procedure, ordering the FO «We do… open the outflow valve.».

Simultaneously, the FO communicated to Ciampino TWR by radio: "Is maintaining on the runway, MAYDAY.»; after which, the CVR recording ends when the engines are cut off.

For the subsequent phases, reference is made to the witnesses' statements (flight crew and flight attendants).

In particular, with regard to what happened in the front of the passenger cabin, reference was made to the statements of flight attendants no. 1 and no. 4, and, for the rear part, those of attendant no. 3.

The Captain reported that he had engaged the parking brake, lowered the speed brakes, positioned the flaps at 40°, declared mayday and depressurised the aircraft.

The Captain then stated that he had cut off the engines and ordered to remain seated through the PA system and that he had left the cockpit to assess the situation. Seeing no signs of smoke or fire and noting that the passengers were calm and quiet, he decided to disembark the passengers normally by means of the stairs. The decision not to use the slides was justified by the fact that using them, which was deemed not necessary, would have increased the possibility for passengers to be injured during an evacuation through the same slides.

The flight attendant at station no. 1, who occupied the purser position in the front area, reported that she had heard, in the final approach phases, an unusual noise, smelt "burnt chicken" and, after a few seconds, felt a very heavy contact of the aircraft with the ground.
She also stated she had waited until the aircraft had come to a complete halt and had heard the Captain's order to remain seated via the PA system.
After short time she noted the Captain exit the cockpit and give the «Remain seated» order.

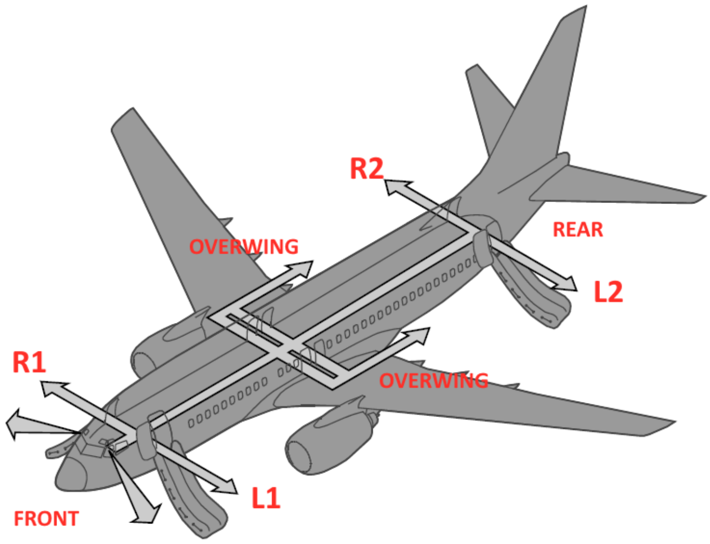


Figure 30: emergency exit diagram.

Attendant no. 1 proceeded to communicate the Captain's order to the attendant located in the rear part by interphone.
She noted that Fire Brigade had positioned a mobile ladder by exit L2 (the exit was actually R1) and had ordered the attendants to inflate slide R2.
Attendant no. 1 stated that she had tried to communicate the need to have stairs instead of slides to the Fire Brigade, but they did not speak English. The procedure was commented on as "very slow".
After checking that there were no incapacitated passengers or passengers left on board, the crew left the aircraft from door L2 (the exit was actually R1).
The flight attendant at station no. 4, who was sitting on the jump seat in the front area of the aircraft, confirmed what attendant no. 1 had reported, except that the door referred to by the attendant no. 1 as L2 was actually R1.
Once the aircraft had come to a stop on the ground, he stated that he had unbuckled himself and checked the conditions inside and outside the aircraft.

The captain was outside the cockpit giving instructions, confirming that they had had a bird strike and they had lost both engines, ordering not to inflate the slides for aircraft evacuation and to wait for the Fire Brigade.
Attendant no. 4 then stated that he went to the rear part of the aircraft to give instructions to attendants no. 2 and no. 3 and he gave first aid to some passengers.
On arrival of the Fire Brigade, attendant no. 4 went back to the front part where he opened door R1 to allow the platform from which the passengers disembarked to be docked.

Photo 22: disembarkation of passenger using mobile stairs.

Lastly, after checking that there was nobody left on board, the crew left the aircraft, by door R1.
Flight attendant at station no. 3, who was sitting together with attendant at station no. 2 in the rear galley during the landing, reported that, when the aircraft was very near the ground, there was a strange smell of burning in the rear part of the passenger cabin and that, as the landing did not follow immediately, she assumed it was a failed approach, although no warning had been given. Attendant no. 2 had the interphone in his hand awaiting instructions and the aircraft hit the ground at the same time. The landing was referred to as very heavy one and it was followed by a bounce. Flight attendant no. 3 reported that she felt strong back pain in this phase. Flight attendants no. 2 and no. 3 waited for the evacuation signal and heard the notice to remain seated over the Public Address (PA). Flight attendant no. 4, who had gone to the rear galley to get some ice for first aid to the passengers, informed the two attendants who were in that area that there had been a bird strike and asked attendants 2 and 3 for help in giving first aid to the passengers.

It was in this circumstance that attendant no. 3 reported noting the oxygen masks were deployed and that 3 out of 4 overwing emergency exits had been opened, most probably by the passengers. Attendants no. 2 and 3 were then instructed to return to the rear galley to provide assistance if the evacuation continued through the aircraft's rear door. Attendants 2 and 3 were instructed, on the Captain's order by interphone, to disable the slide on exit R2 and to open the door.

Photo 23: passengers evacuation through the rear right door slide.

No instructions where provided how to leave the aircraft. After the «Remain seated» call, the Captain came out of the cockpit. The attendants sitting in the rear stations received communication from the attendants in the front stations that the Captain was ordering the slides to be disarmed so that disembarkation could be by stairs.

From the crew's statements, it emerges that there was no "brace for impact" order before the event.

The right rear slide had been activated at a later time, after it had been disabled and on the order of Fire Brigade, which had asked for the door to be closed again, the slide to be enabled and the door to be opened to activate the slide.

It is not possible to determine how many passengers disembarked using the slide. The attendant reported in the statement that she had noted the abundant presence of foaming agent around the aircraft on opening the door. She reported that she had noted the overwing emergency exits were open (one left hand and two right hand). She then noted the instability of the aircraft during the evacuation, with both rolling and pitching movements. She reported that the passengers had delayed the evacuation operation in trying to recover baggage and taking photographs.

An extract from the FCTM on an evacuation by slides or stairs is shown below.

«When there is a need 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 fire spreading rapidly from spilled fuel or other flammable materials;
- the extent of damage to the airplane;
- the possibility of passenger injury during an emergency evacuation using the escape slides.

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

1.16. TESTS AND RESEARCH

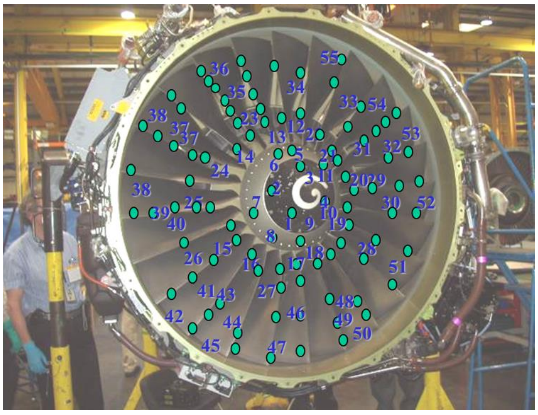
Both engines CFM56-7B26/3, S/N 896379 (#1) and S/N 896387 (#2) were removed from the aircraft on 14th January 2009 and sent to the GE facilities in Cardiff (UK) where, starting from 5th February 2009, the tear down operations were carried out on the modules and components of both engines.

Both engines had 2419 hours and 1498 operating cycles since new.

The significant elements emerging from the investigation carried out are shown below.

The external visual inspection of the fans showed 55 impact points with birds on the left hand engine fan, 30 points on the right hand engine fan, both fans without apparent damage and deformation of the blades' aerodynamic profile, slight deformation of the *fan case* engine #1, due to the contact with and subsequent scraping of its nacelle along the runway[1].

[1] Same engine image has been used to represent impact distribution



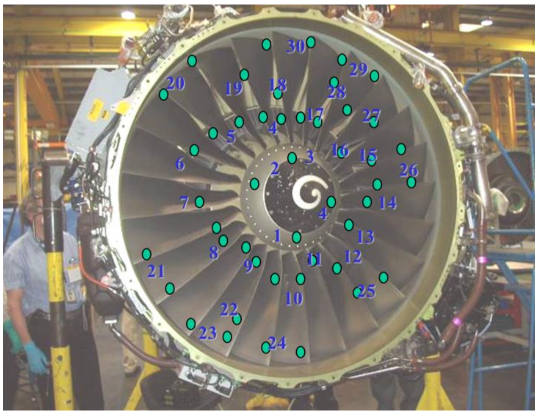


Photo 24: distribution of bird strike on fan, engine #1   Photo 25: distribution of bird strike on fan, engine #2.

There was a considerable amount of organic material inside the fan, the compressor booster, the high pressure compressor and the combustion chambers of both engines, a greater quantity in #2 compared to engine #1, despite lesser traces of impact in its FAN. The organic residues found produced a severe alteration of the compressor blades' aerodynamic profiles and partial airflow disruption, affecting the various sensors, and inside the combustion chambers.

A limited presence of metal splatter was also identified on the hot parts of both engines, not such as to change the functional characteristics of the parts concerned. The accessories of both engines underwent specific inspections and functional tests, without any anomalies being found. No faults were found on both engines prior to the ingestion of the birds.

Photos 26, 27, 28 and 29: engine #1, modules conditions.

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

Based on the engine parameters recorded by the FDR and following the analysis of the data taken from the ECC of both engines, the investigation carried out allowed to understand the engines behaviour following the massive ingestion of birds.

Immediately after the bird strike and application of the TO/GA command (corresponding to the vertical red line in the following plotting), both engines experienced a drop in N1 RPMs, from 62% to 52% and 46% for the left hand and right hand engine respectively. The N2 remained substantially stable at about 83% (a drop of about 3%), whilst the EGT temperature underwent a sudden increase of about 300°C in the next 24 seconds. The N1 drop and rise in the EGT took place at the same time as a series of "*surges*[2]" experienced by both compressors and indicative of a severe aerodynamic disturbance of the air flow inside the HPC.

[2] Surge is different from stalling because it consists of a total interruption of the normal air flow inside an axial compressor, whilst stalling is represented by an interruption/disturbance of the air flow, confined to a part of the compressor. A surge causes an immediate increase in the internal pressure of the compressor and consequent violent inversion of the normal air flow inside the compressor associated with very loud noises (bangs).

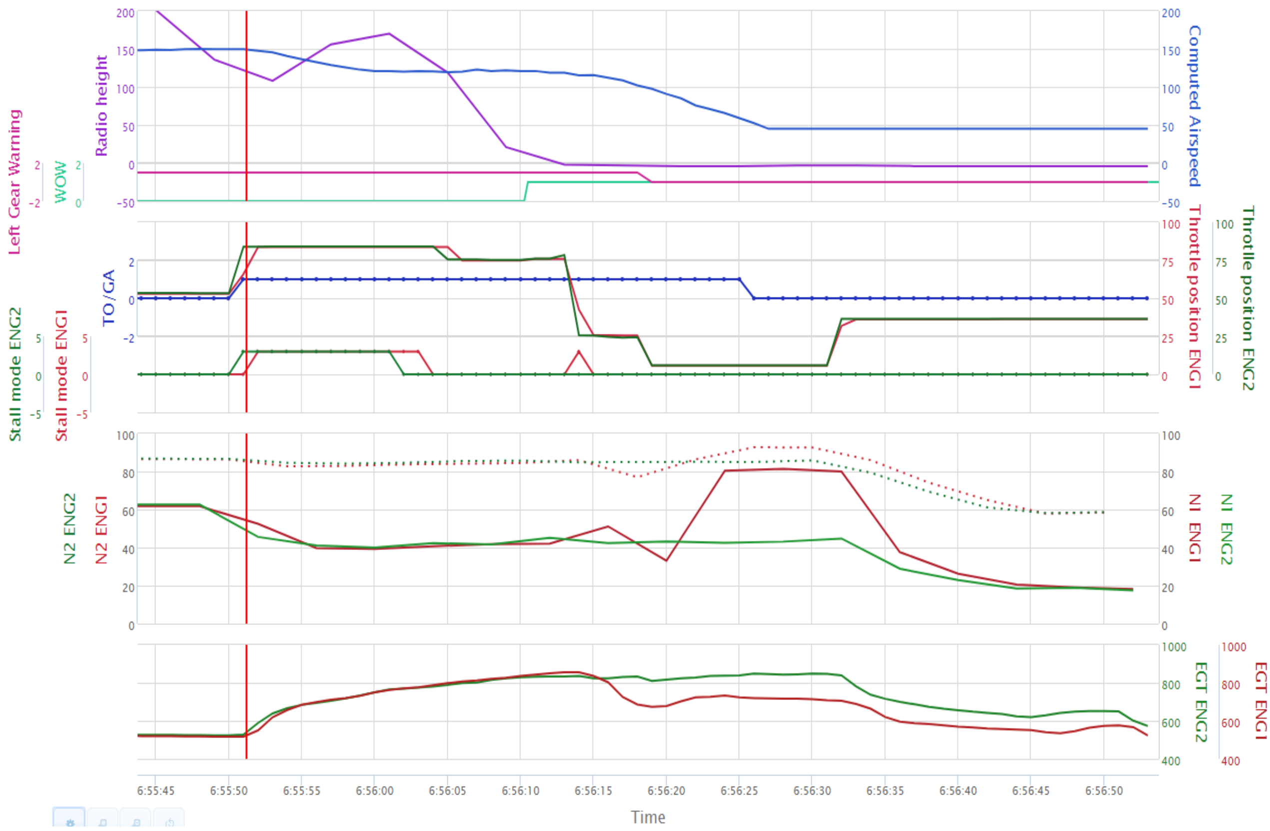


Figure 31: N1, N2, EGT behaviour, stall mode on throttles positions after TO/GA.

These repeated surges caused a fluctuation of the pressure values transmitted from the High Pressure Compressor Discharge Pressure (CDP), with a corresponding drop in the N1 (from 62% to about 40%) and N2 (stabilised on 83%) rpm and a sudden increase in the EGT values, due to a loss of air flow crossing the engine.

Considering that N1, N2 and CDP are parameters used by the FADEC to control the fuel flow; the drop in N1 and N2 rpm caused the FADEC to try to restore the rpm by increasing the fuel flow. However, the latter is limited by the engine's acceleration data, which are a function of the CDP, N2 and T25 parameters.

The low CDP values caused by the compressor surges led to fuel flow values that were too low to maintain the N1 level required by the crew.

As can be seen from the next plotting, the engine levers remain in full forward position until 06.56.05, i.e. 5 seconds before impact on the ground, to then be pulled back slightly (MCL position); during the deceleration run after impact with the ground, both the engine levers were commanded from MCL to IDLE and the thrust reversers (T/R) were activated, after which, as follows, different behaviour for the engines were observed:

- the N1 on the left hand engine increased to about 80%, ensuring the proper functionality of relative thrust reverser,

- the N1 rpm on the right hand engine did not increase, staying at values of 40% and thus not generating thrust inversion through the T/R. The same engine only seemed to restore its proper functionality in the final phases of the aircraft's deceleration on the runway, with the engine lever at idle.

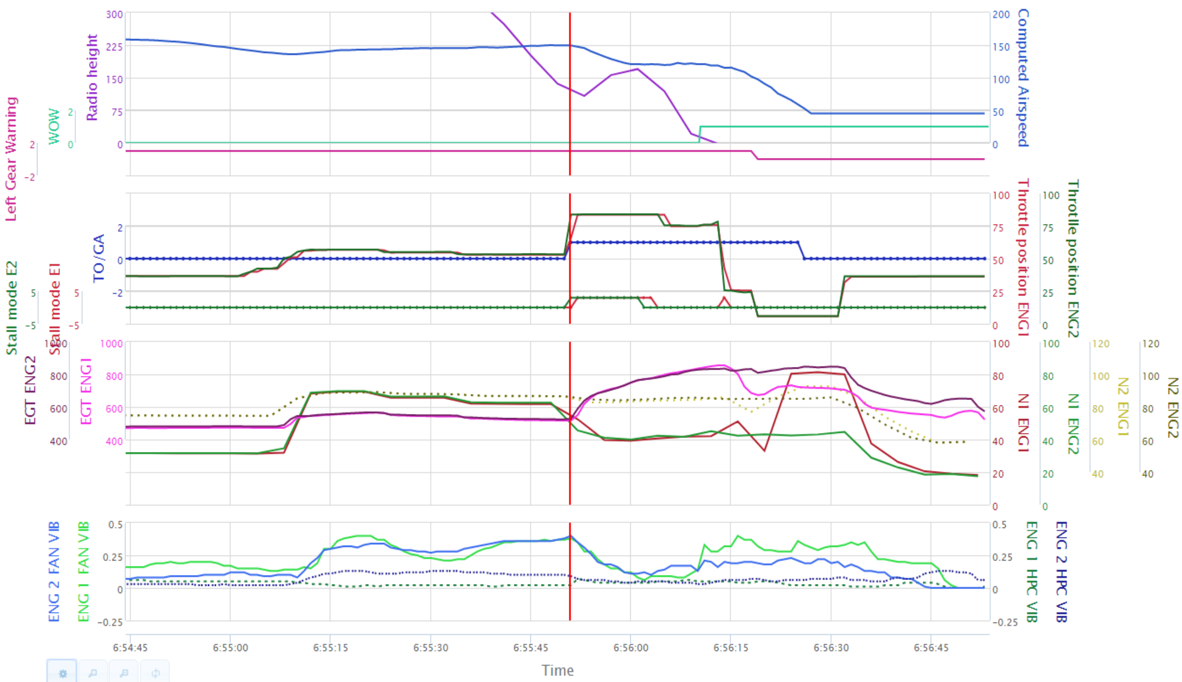


Figure 32: engine vibration level before birds acquisition and engines stall.

The vibration levels recorded for the FANS and HPC of both engines shown in the previous plotting do not indicate anomalous vibrations in the seconds prior to the TOGA command being activated, vibrations that may possibly be an indication of bird strikes.

The FAN and HPC vibrations trend in the approach and short final in the previous flights indicates engines vibrations levels similar to the ones indicated in the accident flight.

1.17. ORGANISATIONAL AND MANAGEMENT INFORMATION

The operator is a "low cost" airline with registered office in Dublin and operations base at London Stansted Airport.

The operator exclusively uses Boeing 737-800 aircraft and its fleet consists of over 300 aircraft.

The company has regularly used Ciampino Airport for many years with flights to and from numerous domestic and international airports.

1.18. ADDITIONAL INFORMATION

1.18.1. Statements

Captain statements

The Captain was interviewed in three distinct stages: on the last interview the Captain heard the CVR recordings and watched an animation of the final phases of the flight made by the ANSV laboratories.

During the first interview, shortly after the accident, he had referred that the flight of the accident was the first of the day and occurred on the second day of service.

He reported that the meteorological conditions were characterised by excellent visibility and absence of cloud cover (CAVOK conditions).

The aircraft was number one in the approach; after being cleared to Urbe at 3000 ft for the ILS Z for RWY 15 in Ciampino; the first officer, PF, carried out a raw data ILS approach (without the use of AP, AT and FD). On instruction of the ATC, the speed was reduced to 210 kts and the flaps lowered. The landing gear was lowered early to increase the rate of descent and reduce speed. The stabilisation on the ILS took place in the set times and the airport was acquired visually considerably in advance. The checks and the radio calls were carried out in accordance with the company SOP; at 500 ft, the aircraft was stabilised on the set parameters and the approach therefore continued.

The impact with a large flock of birds took place at about 200 ft.

He immediately ordered the go around, which was carried out by the first officer in accordance with the company's SOPs. The failure of the engines to respond was observed, with N1 values at 40%; at this point the Captain took control of the aircraft for the emergency landing.

A landing took place with the right-hand landing gear first that probably came in contact with the grass, leaving all the energy to be absorbed by the left-hand landing gear, which collapsed during the deceleration run.

The Captain stated that he had not received any radio communication about the presence of birds in the airport and that, though he had flown a lot in Italy, he had never seen such a concentration of birds.

It was deemed as necessary to have a further interview with the Captain with the following evidence related to some specific aspects of interest.

Birds visual acquisition.

- The Captain explained that he had visually acquired the flock of birds when, during the ILS approach, it had crossed the approach path from right to left in flight, disappearing below on the left from his field of vision. A few seconds later, he had seen the flock re-appear from the left, as if they had made a flight trajectory inversion (as an "Immelmann" turn), and arrived in front of the aircraft; at this point he exclaimed his surprise «Ahi, ahi, ahi, …!».
- He reported that he remembered the aircraft's initial impact with the thickest part of the flock, time that the Captain associated with the bang recorded on the CVR, followed by a series of single bird impacts like "hailstones" and then vibrations on the aircraft's structure.
- He mentioned how the bird strikes on the windscreen had been minimal (or even nil) and that never lost visual contact with the runway and the surroundings.
- He believes that the FO, occupied with flying the aircraft and intent on regaining the speed and altitude parameters for the landing, could have had no way of seeing the birds until the flock crossed by. He considers that the FO's comment "nice" was an indication that the parameters were being regained.
- He reiterated that there were no NOTAM in force for the presence of birds at the airport on the day of the event and that he had not been warned in this regard by any means.

Sequence of the events

- In the analysis of what happened in the two seconds in which he pronounced «Ahi, ahi, ahi, …!» and until the verbal command "go around", the Captain confirmed, that he had, in this sequence, sighted the birds, noticed the impact and ordered the go around manoeuvre.
- The Captain confirmed that when ordering the manoeuvre with the "go around" call out he might at the same time have put his hand on the throttle to ease its progress into the TO/GA position.
- The Captain confirmed that it is possible that the TOGA switch was pressed at the time the throttles were pushed forward.
- He could not explain how the flap lever, from a position of 40°, overcame the detent of the position at 15°, but recognised as an option the click of the passage of the position at 15° to move on to the position at 10° in the CVR background noise.

- He reiterated that, considering the time available (less than 2 seconds) and the fact that attention was diverted to the threat represented by the birds in front, it was not possible to observe the N1 value of the engines in the phase between the visual acquisition of birds and the go around.

Approach phase

- The Captain confirmed that, considering the excellent meteorological conditions, he had considered to offer the young FO the opportunity to do a raw data manual approach, deeming manual flight a very important skill for every pilot.
- He confirmed that the speed limit of 210 knots set by the traffic control had contributed to being a bit high and therefore having to anticipate the aircraft's configuration.
- He confirmed that the aircraft reached the minimums slightly high and slightly fast compared to the target speed of 141 kts (defined by the Captain as VREF + 5 knots) but the approach path was stabilised as per the operator's SOPs.
- In any case, he considered that the stabilisation before the sighting of the birds was such as to permit to safely continue the approach, considering that the FO was correcting the parameters properly.
- The Captain confirmed this aspect also commenting as recorded by the CVR at the minimums: in fact, he stated «Continue» and the FO «Land».
- He also confirmed that he had ordered the go-around and had then intervened instinctively on the control wheel, without however communicating this verbally, maintaining control of the aircraft until it came to a stop on the runway.

Go around

- The Captain confirmed how the sighting of the birds and subsequent impact had destabilised the approach, defining it as «de-tuned». With regard to this term, he clarified how he no longer considered it safe to continue considering the combination of some pre-existing aspects that he had already considered before the approach, such as the limited length of the runway compared to bigger airports (longer runways), the weight of the aircraft and the tailwind component, and the added ones, such as the destabilisation and the possibility that the impact could have caused damage and hence limitations (engine, braking system, etc).
- The Captain affirmed that normally a pilot in doubt is trained and conditioned to go around, because «the threat is from the ground and not the sky».

He affirmed the probability of having problems with both engines on approach is remote and was not even considered at the time of the events. Whilst a go around with only one engine is not a serious problem and once in the air, a crew can opt for diversion to an airport with more suitable characteristics (Fiumicino, Pratica di Mare).

Landing phase

- The Captain highlighted the extreme importance of the skills to fly the aircraft manually, and these skills could become very important especially in exceptional events like the accident investigated which was characterised by a landing without sufficient engine thrust.
- He confirmed that, after realising he had no thrust, he checked the surroundings to look after a flat area, commenting that as he was still above the airport grounds, he prepared for landing.
- He confirmed that he had tried to regain alignment with the runway and had touched the ground whilst still in the correction phase.
- The Captain defined meeting and striking the birds in such terms as to qualify the situation as highly unexpected and surprising.

Procedures

- The Captain reaffirmed that there were no guidelines, procedures or training for this type of scenario in place at the time of the events.

Flight crew training

- The Captain confirmed that the FO, although only recently recruited and with few flying hours, had already completed the training needed to be employed as FO by airline.
- The Captain held an instructor qualification on the type of aircraft, although he did not practiced that function with the operator.
- The Captain was very familiar with Ciampino Airport, having previously operated there with the same aircraft type for different operators.

First Officer statements

The statement of the first officer, given to the investigators in the hours after the event, is substantially in agreement with the Captain’s, confirming the presence of an enormous flock of birds similar to a black cloud that came from below. He also confirmed that, after the bird strike, the Captain took control of the aircraft which landed heavily after activation of the stick shaker.

Other statements

a) *Flight Attendants*

The statements of the flight attendants on board have been reported in section 1.15 “survival aspects”.

Photo 34: position of eye witnesses (on Google Earth).

b) *Captain aboard a parked aircraft*

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

The aircraft was showing flames at the rear part of the engines but not from the nacelles, (flames like an engine tail pipe fire or afterburner).

The aircraft had a slight nose-up attitude and landing gear lowered. The flight path, initially leveled, started a gradual descent to disappear behind the terminal building, next to which the witness was parked.

c) *Captain of the aircraft I-DEAC*

The C525 aircraft, registration I-DEAC, was stopped at the holding point on “A” of Ciampino Airport at the time of the event (point 3, photo 34).

The I-DEAC Captain stated to ANSV that, during his taxi from the parking apron to holding position “A”, he spotted birds on the ground which were just gone airborne from the area on right of the extension of the runway axis, aligned with the taxiway on which he has been taxing.

From the position he was in (holding position "A") he saw the aircraft approaching and stated that it was perfectly aligned with the runway axis and was about 50 ft above its threshold near touch down, possibly slightly lower than the normal descent path.
Whilst the aircraft was in this position, about 300-400 small birds rose into flight from a point on the ground about 50 m from the runway threshold, corresponding to areas C2A and C2B in the grid shown in Figure 10, and hit both the front part of the aircraft and its engines.
The Captain also stated that he clearly heard the noise caused by the compressors stalling despite being inside another aircraft. He then added that the Boeing 737 EI-DYG, instead of touching down considering the very low height, changed attitude rising above the trajectory to a maximum estimated height of about 150 feet, which was reached near the half-way of the runway in front of the airport's control tower.
At this stage, the Captain saw flames coming out of the right hand engine and bird remains from the left hand engine, he then saw the aircraft wing swinging to the left and hit the ground violently. The impact caused a large cloud of white smoke.
The Captain stated (in reply to a specific ANSV question) that the flames were emitted from the right hand engine only, that the bursts of flames were almost continuous and had not started at the time of the bird strike but when the aircraft was about half-way along the runway at the top of the go around trajectory actually flown, with the aircraft swinging to the left. Finally, he added that the bursts of flames also continued after the aircraft started its descent.

d) *Statement of the Ciampino TWR controller*

At 06.45, the controller, after the hand-over with the colleague at the end of the night shift, took service at TWR station (120.5), the frequency contacted by the flight RYR41CH once released from Rome ACC/ARR (position at point 1, photo 34).
The controller provided the Ryanair flight with meteorological information, the necessary instructions and clearance for landing, as it was the only traffic approaching.
He noted that, whilst the aircraft was overflying the ALS for RWY 15, a thick flock of birds took flight from the trees close to the path, and specifically to the EAST of it, and collided with the aircraft as it was in its very short final approach.
The aircraft then took on a nose-up attitude as if the pilot had decided to do a go around in the very short final approach.
The controller added «si udiva il rumore dei motori che, dopo un primo momento di apparente ripresa, cominciavano a dare colpi sordi in rapida successione e, simultaneamente

da entrambi i motori, fuoriuscivano evidenti fiammate.» (you could hear the noise of the engines, which, after first apparently picking up, began to give dull knocks in quick succession and evident bursts of flames from both engines at the same time).

Finally, he added that aircraft gained height slightly but immediately afterwards pitched down with a yaw to the right and then continued to descend to the ground.

1.18.2. Ciampino Airport geographic environment

Ciampino airport is located in the area of the same municipality, on the slopes of the Colli Albani, on which are based all municipalities known as “Castelli Romani".

Such areas belong to the Regional Park of the Castelli Romani and are protected.

In the surroundings there are some natural areas.

The East (beyond the city area of Ciampino), South-East and South area of the Ciampino airport, are characterized by the presence of agricultural land, water basins and woods.

1.18.3. The starling

The carcasses found both in the airport grounds and inside the engines and landing gear bays of the aircraft EI-DYG were identified as starlings.

The starling, which the scientific name is “sturnus vulgaris”, is a small-medium size bird which generally does not exceed 23 cm in length and 40 cm in wing span and whose weight varies from between 40 and 100 gm. The starling is widespread in the mild temperature northern areas and is one of the species that adapts best to different environments (countryside, urban areas and hills, but also frequents wooded places and wet areas). In the past, it used to pass the nights in reed thickets and woods, but for some years now it has shown a marked preference for urban and suburban areas, where it takes refuge at night, together with hundreds of companions, in a sort of “collective dormitory”. It mainly feeds on the ground, is an omnivore and adapts to the season and the contingent availability of food.

One of the most obvious characteristics is the gregarious behaviour which is mainly shown during feeding, migration flights and night-time dormitories. The first starlings from abroad reach Italy in mid-August, but the true migration, involving millions of individuals, takes place from the end of September to the first ten days of November, peaking between the second half of October and the start of November[3].

[3] Source: LIPU (Lega Italiana Protezione Uccelli, Italian League for Bird Protection).

1.18.4. Operating procedures

The go around is a manoeuvre that is performed for safety reasons when the pilot decides or is instructed to interrupt the approach and abort the landing.

In order to be able to analyse the action taken by the crew in greater depth, it was considered necessary to examine, with reference to the above-mentioned manoeuvre, the following operating procedures:

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

The execution of the go around procedure is illustrated in the FCOM Vol. 1 and provides that:

- the pilot flying presses the TO/GA switch and makes the “go around, flap 15” call out;
- the pilot monitoring confirms that the engine thrust increases to the required value for the go-around and calls “flap 15” selecting the flaps at the 15° position and checking that they have actually retracted;
- the pilot flying rotates to the required attitude for the go-around and announces “set go-around thrust”;
- the pilot flying then checks that the required flying modes are correctly displayed;
- when a positive rate of climb is indicated, the pilot flying calls “gear up” and monitors acceleration;
- the pilot monitoring verifies that the VSI and altimeter indicate a positive rate of climb and calls “positive rate” and moves the gear lever to the UP position.

BOEING

737 Flight Crew Operations Manual

Normal Procedures - Amplified Procedures

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."

Figure 33: From FCOM.

The standard call outs during an ILS approach for landing or Go Around are shown in the FCOM and FCTM, an extract of which is shown as in the figure. As can be seen, the criteria determining the "CONTINUE", "LANDING" and "GO AROUND" call outs are based on the acquisition or not of the visual references for landing.

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"

Figure 34: standard call outs.

The operating procedures in force with the Airline Operator are illustrated in the document "Ryanair Operations Manual" Part A. In particular, chapter 8 defines the Operating Procedures, remarking at 8.0.2 Standard Operating Procedures how the operating philosophy is illustrated in the FCOM, QRH and 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 illustrated in chapter 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 responsibility for each crew member, the standard operating procedure, 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.».

Paragraph 8.3.0.3.9 describes when to carry out a Go Around. A go around shall be initiated if the required visual reference for landing has not been established on reaching the MDA or DA.
A go around shall also be made:

1. if the success of the approach becomes doubtful, e.g. approach not stabilized by 500 ft AAL (300 ft AAL after circling), required elements of the landing threshold not clearly identified, etc.;
2. in case of engine failure on final approach when IMC and below 1,000 ft AAL;
3. if below 1,000 ft AAL, any significant departure from the normal approach path occurs and corrective action is not immediately effective;
4. if the approach aid in use or the respective aircraft installation is suspected to be malfunctioning, unless VMC;
5. upon instruction of ATC;
6. at the discretion of the Captain;
7. flap load relief activation after the applicable landing gate (1,000 ft AAL IMC, 500 ft AAL VMC).

The criteria for defining a stabilised approach are listed in the FCOM volume 1:
A stabilised approach, by Ryanair definition:

- be at the correct final approach speed or correcting if less than Vref;
- or greater than Vapp speed + 10 knots;
- the vertical speed is proportional to the current ground speed;
- V/S is not more than 1000fpm continuously unless required by the published procedure and previously briefed;
- on approach profile and in the landing configuration;
- engine N1 at appropriate thrust settings.

The Ryanair landing gates are thus defined, i.e. the heights at which the aircraft must be stabilised with the landing check list completed. Otherwise, the obligation to go around is indicated.
For a precision approach, the landing gate is 1000 ft AAL in IMC and 500 ft in VMC.

Follows the description of the criteria for the "500 continue"/"500 go around" call, in accordance with such criteria, in order to call "500 continue", the PM must have verified that:

- the speed is at Vref or Vref + 20 kts;
- the aircraft is vertically on the glide path (+ o – 1 dot or 3 red or 3 white of the PAPI);
- the aircraft is horizontally on the centerline (+ o – 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 above 1000fpm unless briefed prior.

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

The FCTM provides information and recommendations on manoeuvres and flying techniques and its purpose is to support the procedures illustrated in the Flight Crew Operations Manual, as well as the techniques designed to aid the pilot in carrying out these procedures in the safest and most effective manner.
The **"**Non-Normal Operations" describes the pilot techniques associated with the "Non Normal Check Lists" listed in the QRH and provides further guidelines for situations beyond the scope of the NNC.
The above manual specifies how, during the Approach and Landing phases, «When a non-normal situation occurs, a rushed approach can often complicate the situation. Unless circumstances require an immediate landing, complete all corrective actions before beginning the final approach.».
The FCTM provides some instructions regarding the considerations on the go around if an engine malfunctions during the final approach: «If an engine failure should occur on final approach with the flaps in the landing position, the decision to continue the approach or

execute a 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 initially if trailing edge flaps are at 30 or 40. Subsequent flap retraction should be made at a safe altitude and in level flight or a shallow climb.».

The QRH deals synthetically with non-normal procedures.
The introduction ("*Checklist Introduction – Non-Normal Checklist – CI.2.2*") specifies how procedures cannot be defined for every specific conceivable situation and that the checklists cannot replace the good sense, discretion and judgement of the Captain.
«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 crew may combine elements of 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 intended to replace good judgment. In some conditions, deviation from checklists may, at the captain's discretion, be needed.».

In conclusion, no considerations or guidelines were found in the operations manuals in force at the time of the events which could have supported the decision making process that determines the execution of a missed approach rather than a landing when a non-normal condition arises in the terminal phases of an approach.
Whilst, for example, with regard to the procedure to abort on take-off, a highly critical situation both for the time available to make the decision and for the aircraft's performances, there are detailed guidelines in the FCOM regarding the criteria to adopt for the decision to interrupt or proceed, this does not occur for the landing phase and missed approach.
As also highlighted recently by specific studies[4], the go around manoeuvre can present critical issues, even though it falls under normal procedures.

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

1.18.5. Radar plots

The approach control service for RYR41CH was provided with the aid of radar.

Radar data recording of RYR41CH flight, under a standardised time basis, showed the last radar plot at 06.56.22, but the last two radar plots showed an indication of navigated track[5] and were therefore discarded for analysis of the radar tracking.

The figure represents the last 30 seconds of interception and processing of the radar tracking for flight RYR41CH shown graphically in green on Google Earth support between points 1 and 7, each with an interval of about 5 seconds, starting at 06.55.42 and ending at 06.56.12.

Because of the effect of the geographical coordinates approximation of the radar plot recordings in order to enter such data in Google Earth, the representation of the longitudinal axis of the aircraft's route seems to be translated by about 80 m east and its possible real route has been artfully re-proposed, projected on the ground, through the yellow line with the last section in blue, consistent with the aircraft's route reconstructed from the FDR data, including the clear deviation to right, corresponding with point 3.

Figure 35: reconstruction using of final trajectory using the radar data (on Google Earth).

1.19. USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

Not applicable.

[5] The tracking process differentiates two phases through a specific graphical indication in presentation (radar presentation symbol overlapped by one or more horizontal lines) and in the recording of every single processing string (track not navigated, i.e. presentation symbol corresponding to recorded radar response, or navigated track, i.e. presentation symbol corresponding to lack of recorded radar response).

CHAPTER II
ANALYSIS

2. GENERAL

The objective elements collected over the safety investigation, which were described in the previous chapter, are analysed below.

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

2.1. AIRPORT ENVIRONMENT

2.1.1. Bird control and dispersal procedures

According to the directives mentioned in para 1.10., the MOV/11 section of the Airport Manual, seems to be not fully compliant with the provisions of the circular ENAC APT-01A.

In particular, based on what specified in section MOV/11, the prevention and dispersal of birds would have essentially been carried out by means of a series of inspections, which could be scheduled, on request or following an alleged bird impact reported.

The same MOV/11 section does not include procedures, reasonably more incisive, through which the BCU would have had to exert a continuous surveillance and disturbance of wild fauna on airport areas, so to force fauna to perceive the airport as an unpleasant and unsafe place.

In line with the provisions of the Airport Manual, the BCU personnel, on the morning of the accident, simply performed the first of the three scheduled inspections.

The same BCU staff, however was already aware of the presence of starlings on the airport, from the days prior the accident (massive detection of about 1300 specimens, identified and dispersed in the evening of the day before).

In such context, it is appropriate to represent that the Captain pointed out to the ANSV that there were no NOTAMs informing about the presence of birds.

Given the extreme mobility and unpredictable behaviour of starlings, a more effective preventive action and, hence, to avoid the presence of birds, seems to be achievable through constant surveillance and dispersal, rather than through periodic inspections.

At the date of this report, the procedures adopted and put in place by the airport operator for bird strike prevention are very different from those in force at the time of the accident and are structured in a way to ensure constant monitoring, aimed to avoid the presence of birds.

With regard to the surveillance activity of TWR personnel, the applicable regulations show that the above surveillance functions are strictly connected with the provision of the ATS service, and not intended as a mere activity of surveillance of the surrounding environment. Therefore, in the absence of any condition preventing landing, there were the conditions at the time of first radio contact, to give the RYR41CH the landing clearance.

2.1.2. Reconstruction of the point of impact with the birds

Based on witness statements, (EI-DYG captain, C525 I-DEAC Captain, TWR controller) it is not possible to establish unambiguously from where the flight of the starlings took off.

Determining the precise unambiguous point from where the flock took off is not so significant for the purpose of analysing the effectiveness of the procedures because the flock/flocks were in any case near or inside the airport grounds, in highly sensitive areas for air traffic, and the means available and scheduled inspections have shown no effectiveness in promptly identify their presence.

The analysis that follows will therefore concentrate on the time and position in which the aircraft struck the starlings and the phases after that strike.

It has been possible to establish the point of impact and quantify the number of birds that affected the fuselage and engines from analysis of the CVR and FDR, from the finding of the remains of the birds and the investigations carried out on the aircraft.

More particularly, thanks to the synchronisation of the CVR recording with the FDR, it is possible to locate the point when the Captain exclaimed «Ahi, …!» (point corresponding to the time 06.55.49, substantially over the airport fencing).

Figure 36: point of birds visual acquisition.

It is also possible to identify the point at which the TO/GA is applied and the "bang" is recorded, the latter corresponding to the engines stalls and to the aircraft impact with the flock of starlings (at 06.55.51, about 100 m from the runway threshold).

Figure 37: engine stalling point and bird strike.

This point of impact is corresponding to the area of maximum concentration of bird carcasses found on the ground.

2.2. AIRCRAFT

Based on the witness statements, data and evidence available, the aircraft did not show any technical malfunctions until the bird strike.

The damage caused to the fuselage and flight controls by the bird strike did not affect the ability to control the aircraft; however the same bird strike severely affected the engines operations. A specific section dealing with engines behaviour follows.

Fuselage

The damage on the fuselage is fully consistent with the attitude and 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 ft/min) and the aircraft attitude, not levelled (about 10° pitch up and 6° roll to the left), has caused the aircraft to initially touch the runway/taxiway AC with the left landing gear and tail and then with the right and nose landing gear.

The vertical acceleration recorded at the time of contact with the runway (2.66 g) is not particularly high; the structural damage to the left hand landing gear can be explained by the asymmetry of the previously described landing, where the energy of the impact was absorbed by the left hand landing gear, causing its strengthening structures to collapse and the shock absorber to penetrate the left hand wing structures.

The collapse of the left hand landing gear caused the lower part of the left hand engine nacelle to come into contact with the runway surface.

During the landing run, the braking action was exercised through the brakes, the spoilers on both wings and thrust reverse on the left hand engine, which doors remained open because of the interference of the engine nacelle with the runway surface.

Engines

The operations of both engines were regular until the TO/GA command was activated.

When the go around was ordered with the simultaneous application of the TO/GA command, there was a significant drop in N1 rpm in both engines (about 17% for the right hand engine and 10% for the left hand engine) and a slight reduction of N2 rpm (about 3%), whilst the EGT temperature of both engines experienced a significant rise, about 300°C in the next 24 seconds.

A stall mode 3 condition was recorded on both engines within 1 second of the TO/GA command being applied, this is indicative of a deep stall on both engines and consistent with the drop in N1 and the sudden increase in the EGT.

The N1 rpm sampling, carried out every 4 seconds, does not allow to exclude that the drop in N1 could have started in the 3 seconds that constitute the time interval between the datum recorded at 06.55.48 (N1 at about 62%) and the datum recorded at 06.55.52 (significant drop

in N1); in particular, it does not exclude that the drop in rpm could have started in the two seconds preceding the activation of the TO/GA command, which occurred at 06.55.51.
With regard to this aspect, it is useful to analyse the behaviour of one of the other parameters indicative of a stall condition, the EGT; in the time frame consisting of the 2 seconds between the last recorded N1 value (06.55.48) and the application of the TO/GA command (06.55.51), no significant changes in temperature were recorded, but its value increases significantly only after the TO/GA command is activated (by about 100°C, 2 seconds after application of TO/GA).
The analysis carried out on the vibration speeds recorded for the FAN and HPC of both engines indicates the absence of anomalous vibrations in the seconds preceding the application of the TO/GA command.
The investigation carried out at GE Cardiff indicates the presence of considerable quantities of organic remains in the FAN boosters and cores of both engines as the cause of the surges experienced by both engines, which significantly changed the aerodynamic flow inside them, so much so as to generate the surges as of above.
The available data indicate that the effects of this change in aerodynamic flow (large changes in N1 and EGT) are clearly simultaneous to the application of maximum power via the TO/GA command; this change of the aerodynamic flow did not produce effects on the engine parameters before TO/GA application.

The considerations above allow two hypotheses to be drawn regarding the time when the ingestion of the birds by the engines could have occurred:

1. at the same time as the application of the TOGA, given the absence of significant changes both in terms of vibrations and engine parameters before that time;
2. before the application of the TOGA command, without this causing changes in the main engine parameters.

The first hypothesis is without any doubt the more probable one; it can be reasonably assumed that the birds were ingested at the same time the TO/GA command was applied, since the FDR had not recorded significant changes in the operation of both engines before that moment.

The number and total weight of the birds ingested must be evaluated for an assessment of the engines’ compliance with the certification requirement.

The number of impacts on the fans (55 and 30 for left hand and right hand respectively), though not being directly indicative of the number of birds that were actually ingested by the individual engines, given the fragmentation of the bird that can occur after the first impact and the subsequent multiple impacts that the same bird can cause, is however indicative of a considerable quantity of ingested birds.

This consideration is confirmed by the significant quantity of organic remains found inside both engines (greater in the right hand engine, despite the smaller number of impacts on its fan) and considered the cause of the surges experienced by both engines.

The above leads to assume that the number and weight of the birds ingested by the engines was certainly high, even if they cannot be quantified precisely.

The applicable certification standards (CS-E 800 and, with some differences to the previous, FAA 14 CFR 33.76) require, in the event of impact with small size birds that their ingestion by the engines does not lead to any of the following conditions:

1. loss of more than 25% of power under TOGA thrust;
2. the engine being shut down.

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

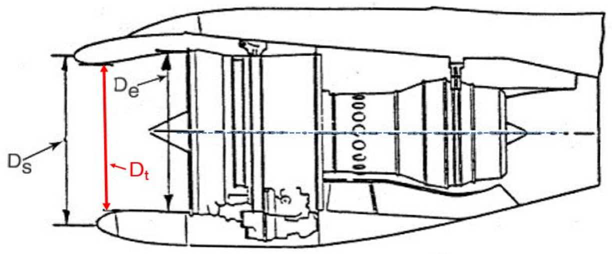


Figure 38: Engine inlet throat diameter (Dt).

The Engine Inlet Throat Area for the CFM56-7B26/3 engine is 2570 in^2 (1.658 m^2).

For this Engine Inlet Throat Area value, the standard shows a maximum of 16 birds with a unit weight of 85 g (corresponding to the average weight of an adult starling).

In light of the discussion concerning the inability to precisely determine the number of birds actually ingested by both engines, it is nevertheless possible to assume that the quantity of birds ingested by engines was very likely greater than the max amounts required by certification standards for which the CFM56-7B26/3 engines were certified.

According to the above, there were no design/certification deficiencies regarding the engines, since they had ingested a number and a weight of birds that were greater than the max amounts indicated by the certification requirements.

2.3. FLIGHT EXECUTION

It is possible to reconstruct the following from the analysis of the CVR recordings, the FDR data, witness statements, the video and photographic evidence and the evidence gathered at the place of the accident.

2.3.1. Ground procedures, take-off, cruising and descent until automatic systems disengagement

The B737 registration EI-DYG, operating the flight FR4102, radio call sign RYR41CH, first leg of the day for the crew, was flown from its initial phases with the FO (CM-2) as PF and the Captain (CM-1) as PM; it took off from RWY 21 in Frankfurt Hahn at 05.31.24 inbound to Rome Ciampino with 172 persons on board.

The start-up, taxiing, take-off and climb were carried out without any unexpected or significant events.

After take-off and initial clearance to GROSTENQUIN and at FL240, the flight was cleared to climb to final cruising level FL370 on a TRASADINGEN – ODINA – RUXOL route.

The flight was thus perfectly on schedule and the meteorological conditions at the destination airport were optimal.

Immediately after commencing the descent, levelled at FL330 and awaiting further clearance to descend, the FO (PF) carried out a thorough approach briefing, including the description of the ILS "Z" approach procedure for RWY 15 in Ciampino and the missed approach procedure.

The briefing was carried out in accordance with the company procedures (B737 FCOM and FCTM, OM) and covered every aspect referring to both the instrument procedure and the validation of the data entered in the onboard navigation system.

The briefing of the FO PF covered the standard arrival procedure Bolsena 3F, the speed limitations, in particular, and the STAR altitudes, frequencies and radio assistance, the profile and development of the ILS procedure, the MSA, the DA of 720 ft and the airport elevation.

The meteorological conditions were commented on and the CM-2 stated, assuredly and without hesitation the go-around procedure, as provided by the FCOM, using the same standards as a phase 1 or memory item procedure (as happens, for instance, when you say the abort take-off procedure aloud during the before take-off briefing).

Finally, the route for a missed approach was commented upon, entered and validated.

No mention was made in this circumstance of the possible presence of birds on the airport or precautionary procedures in case of bird encounter/bird strike (as a possible indicator of any awareness of the crew about the presence of birdlife on the specific airport).

Following verification that the meteorological conditions at the destination airport were optimal, the Captain offered, during the descent, the first officer the chance to make the approach in manual mode for training and to fly the aircraft without the use of automatic systems, a practice permitted at the time by the operator and deemed important by the Captain for development and maintenance of manual flying skills.

At 06.43.05, crossing 16,800 ft in descent, the autopilot, autothrottle and flight director were disengaged, thus flying in raw data mode.

The aircraft was flown manually from that moment until landing.

2.3.2. From the automatic system disengagement until moment before birds visual acquisition

Rome Radar cleared the flight for the ILS “Z” approach procedure for RWY 15 at Ciampino Airport and once levelled at FL90 provided the vector 160° for the localizer intercept; it then authorised further descent to 6000 ft and to proceed directly to URBE NDB. The Captain confirmed that the runway was in sight at this phase.

The approach was flown as a stabilised approach consistent with the requirement of the operator’s approved procedures although with an anticipated landing gear extraction, aimed to facilitate speed control and to descend more quickly, also taking into account the speed limitation set by the ATC to sequence the traffic on approach.

In fact, the landing gear was extracted at 06.50.13 at a QNH altitude of 6192 ft. At 06.51.40 and an altitude of 3831 ft, the flaps were selected at 5°.

The localizer intercept took place with the flaps at 5° (the Captain communicated «You can start turning» at 06.52.18, the FO «LOC alive» at 06.52.22).

On first radio contact with Ciampino TWR, the Captain confirmed that they were established on the localizer at 9 NM from the field. The Tower gave clearance for landing and the latest meteorological situation at the field, which was characterised by wind calm and CAVOK.

At 06.53.22, the inter cockpit communication «We have glide slope capture» from the FO was recorded.

The approach, flown in manual mode, was characterised by some deviations from the localizer, corrected by the CM-2 following verbal input from the Captain.

In this regard, some of the Captain's verbal interventions referring to the conduct of the ILS approach, particularly with reference to alignment on the localizer, were recorded, and more specifically:

The deviation from the localizer started at about 6 NM from the field.

After selecting flaps 15, when carrying out the pre-landing checks, the Captain drew the FO's attention to regain alignment as soon as possible «Look at the localizer my friend» and «Oh, yes please… come back.».

This deviation started around 6NM and the correction initiated around 3.5 NM from the airfield; the aircraft was again stabilised on the localizer at about 1 NM from the runway.

The Captain continued to provide instructions for maintaining the parameters.

After the synthetic warning "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 warning "MINIMUMS", «Reduce the speed a bit, you are high».

The landing configuration with flap selection at 40° was set at 06.54.52, at an altitude of 996 ft radalt and a distance of about 2.5 NM from the field.

The completion of the pre-landing checks then followed, as provided for by the check-list.

After the "ONE THOUSAND" synthetic call out and before the "MINIMUMS" alert, the Captain, after saying «A little bit to the left… like that» asked the FO «Do you have the runway in sight?». The FO replied affirmatively.

At the time of the "MINIMUMS" synthetic call out, recorded by the CVR at 06.55.30, the aircraft was about 1 NM from the runway threshold, configured for landing and lined up with the centre line, at a CAS of 145 kt, thus 9 kt above the Vref (136 kt) and 4 kt above the computed target speed (Vref + 5 kt) and at a vertical speed of 688 ft/min.

On the "MINIMUMS" synthetic call out, there were the almost simultaneous call outs of the Captain («Continue») and the FO («Land»).

It is therefore possible to affirm that, according to the criteria shown in the operating documentation, the aircraft, at 500 ft AGL, was within the parameters that define the "stabilised" approach and could thus proceed to land.

Based on the Captain's statement at the time of the interview, until the birds sighting and the bird strike, he believed that having considered the flight parameters, he could continue the approach and landing manoeuvre safely, the latter confirmed by the call «Continue».

In this phase, the PF (FO) considered that all the necessary conditions to be able to proceed with landing had been met; moreover, his statement «Land» confirms he was mentally prepared for carrying out the landing manoeuvre.

The Captain continued to provide verbal instructions to correct the parameters at 06.55.33; in fact, when the aircraft was about 1 NM from the THR, at 145 kts CAS, he ordered in a quiet and controlled tone: «Reduce the speed a bit, you are high».

The same Captain stated that he felt confident that the actual altitude and speed deviations, compared to the requested parameters could easily be corrected in the remaining approach phase, so that a safe landing could be made.

2.3.3. From birds visual acquisition to ground contact

At 06.55.49, whilst the FO was busy observing the altitude and speed instruments to regain the correct parameters and commented «Nice» to confirm the positive correction in progress, the Captain exclaimed «Ahi!» (repeated about 10 times in the next 2 seconds), realising that the flock of birds was seen again on the approach path.

At 06.55.51, at an altitude between 136 and 112ft radalt and a distance of 100 m from the runway threshold, almost simultaneously the Captain's ordered «Go around», repeated three times and the TO/GA pushbutton was activated.

Based on the witness statements, it cannot be excluded that the Captain intervened instinctively on the throttles, anticipating, *de facto*, the action ordered verbally to the FO.

The throttles were positioned fully forward and the flaps commanded from 40° to 10°, overcoming the "*detent*" positioned in the 15° position to prevent retraction beyond the position requested for the go around manoeuvre.

From the statement made by the Captain, the selection was not voluntary nor was there any awareness of the flaps selection error.

This action is indicative of a reaction to an unexpected situation, typical of a phenomenon defined as "startle effect"[6].

[6] On the matter you can see: *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 on https://pdfs.semanticscholar.org/61c0/73be673efa2f45cef0687f8f843eaefdf6a3.pdf.

On activation of the TOGA, when the throttles were full forward, the CVR CAM channel recorded a loud “bang”, a noise confirmed by the Captain during the interview and attributed to the impact with the flock.

The CVR evidence, the engine parameters and the position of the maximum concentration of the bird carcasses on the ground all indicate that the impact with the birds (or better the crossing of the flock which caused multiple impacts) occurred simultaneously with the activation, via the pushbutton, of the go around.

The go around activation coincided with the stall of both engines and the Captain’s verbal communication «Go around… go around…go around», when the aircraft was about 1 second from reaching the RWY 15 threshold and about 7 to 8 seconds from the normal point of contact with the runway, with the aircraft between 136 ft and 112 ft radalt, 149.5 kts and N1 62%.

On activation of the TOGA (06.55.51), the Flight Director symbols appeared indicating the necessary attitude for the go around, the FO set that attitude, requesting the flaps at 15°: both engines, instead of increasing rpm and providing the necessary thrust for the go around, experienced an N1 drop from about 62% to values around 40%; the vertical speed had a sudden reduction, causing a slight increase in the radalt (from 112 to 173 ft), until 06.56.01.

The above represented a substantial absence of positive rate of climb, which therefore did not induce the crew to take the subsequent actions provided by the checklist for go around, among these the landing gear retraction.

At 06.55.56, the flaps selection from 40° to 10° was commanded. This position was reached at 06.56.12, with the aircraft on the ground.

The FDR data show that the Captain took the aircraft control at 06.55.58, i.e. 7 seconds after activation of the TO/GA.

There were no communications between pilots regarding the handover of aircraft control until it started its deceleration run on the ground.

The Captain reported that in that circumstance he promptly intervened on the controls and noted that he did not have the thrust to continue the go around, then turned all his attention to “look outside”. He then realised he was inside the airport perimeter (Captain’s exclamation «On est dedans») and capable of bringing the aircraft, which had lost its alignment on the right likely due to asymmetric engines thrust at go around, to land on the runway.

The change of attitude and lack of engines thrust led also to a rapid airspeed drop and angle of attack increase.

From 06.56.01, the aircraft began to lose height, despite the nose up command still applied by the aircrew; the sink rate activation was recorded at 06.56.07, with a CAS of 122.75 knots, the stick shaker activation, at 06.56.09, corresponding to the max vertical speed of –1360 feet/min reached by the aircraft (indicative of an aerodynamic stall condition) and a progressive speed reduction and angle of attack increase, which reached values of 120.75 kts and 21° of AoA respectively, 1 second before the runway contact, when the aircraft was at a radalt height of 21 ft.

At 06.56.10, the aircraft touched ground (WOW commutation) with an attitude of about 10° pitch and -6° roll, an indicated speed of 120.75 knots, variometer of -1064 ft, vertical and lateral acceleration of 2.66 g and -0.45g respectively.

Figure 39: point of ground impact.

The aircraft had therefore lost height because of the aerodynamic stall, with the engine levers at maximum power position but without response from the engines and impacted the ground near taxiway “AC”, about half way along the total length of the runway, with a vertical acceleration of 2.66g.

The possible reasons behind the Captain’s decision to go around were investigated.

The following statements from the captain provided some elements: «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 damages at the gear. We don’t 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 Captain also confirmed that the Ciampino RWY length (2207 m), defined as "a bit short" compared to other airports such as the one he came from (Hahn) or the alternate one (Fiumicino), was considered a critical issue by him if associated with any problem or an instability on the parameters, such as to influence the length of the landing run, either as a consequence of an imprecise point of contact or through the reduction of the aircraft's braking performance due to a failure.

In this regard, the landing distance necessary to bring the aircraft to a stop was calculated; it was extrapolated from the QRH *Advisory Information* in order to assess whether this perception of the critical issue was actually justified in the specific conditions of the event under analysis.

Considering the mass of the aircraft as 61,100 kg on landing, a tailwind component of 5 kt, a velocity of Vref+10 kt, a temperature of about 10° below ISA, dry runway, max manual braking, use of T/R and height of 100 ft on the threshold (50 ft above the predicted glide path), the ALD [7] is about 1341 m., therefore quite less than the available runway length.

Nevertheless, although this value may not be critical, it is necessary to point out that this datum, taken from the QRH, is only applied in emergency conditions or during the tactical re-planning phase. In fact, the value that is considered during planning, as provided by the applicable regulations, is the RLD[8], which is calculated multiplying the ALD by a factor of 1.67.

It is also a common perception, supported by performance tables and confirmed by other pilots operating at Ciampino Airport with the B737, that with an aircraft landing mass above 60.000 kg, the presence of a tailwind component of more than 5 knots makes necessary to pay particular attention to maintain the parameters and be precise with the runway point of contact.

[7] «Actual landing distance is the distance used in landing and braking to a complete stop (on a 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 Note 8.3 — Landing Distances*, available on https://flightsafety.org/files/alar_bn8-3-distances.pdf).

[8] «Required landing distance is the distance derived by applying a factor to the actual landing distance. [*omissis*] Required landing distances are used for dispatch purposes (i.e., for selecting the destination airport and alternate airports)» (FSF, *FSF ALAR Briefing Note 8.3 — Landing Distances*, available on https://flightsafety.org/files/alar_bn8-3-distances.pdf).

Moreover, it is obvious that a recalculation of the ALD in the variety of contingent cases and in light of any additional failure cannot be carried out when approaching, but only once the latter has been interrupted, with the aircraft under control and separated from obstacles.
Though the data considered during the approach planning are not available, it is therefore possible to assume that the Required Landing Distance known by the Captain was such that the Captain felt the runway length available as critical, in presence of contingent penalties (destabilisation of the aircraft in the final phase, tailwind component).

2.3.4. Landing roll

The ground marks indicate that the impact first occurred with the lower part of the fuselage tail and the main left landing gear against the asphalt surface of taxiway “AC”, then with the main right landing gear on the grass adjacent to the right edge of the runway, followed by the collapse of the left hand landing gear and runway contact with the left engine nacelle.
The aircraft continued its ground run decelerating through the brakes, spoilers and left engine thrust reverse only, which reached a maximum N1 value of 81% during the deceleration run.
During the ground run, the Captain confirmed he had aircraft control, uttering «My control».
9 seconds after runway contact (06.56.19), the left landing gear unsafe warning activated via the “L GEAR WARNING” caption.
The aircraft came to a stop on the runway at 06.56.38, about 50 m from the end of the runway.

Figure 40: stop point on the runway.

Both engines were cut off at 06.56.52 (ENG CUTOFF).

After landing, the wind screen showed some traces of bird strike, but not so as to compromise the flight crew's outside field view, as confirmed by the Captain during the interview.

2.4. HUMAN FACTOR

2.4.1. Bird strike: survey of existing guidelines/instructions

Regarding the go around manoeuvre, it seemed advisable to carry out a survey of the existing guidelines/instructions related to actions to be taken in the event that birds are encountered during the short final of the approach phase.

a) ***Boeing***

The AERO periodical edited by Boeing, number 3 of 2011 (thus issued after the event), deals with the issue in the context of an article titled "Strategies for Prevention of Bird Strike Events[9]".

In the paragraph "Practical birds trikes information for aircrews", the following prevention strategies are defined.

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

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

If the landing is assured, further prevention strategy is indicated: «When landing is assured, consider landing through birds versus a missed approach to avoid birds. This reduces the energy of the collision, the potential for increased damage associated with engines at a high power level, and the potential for multiple engine ingestions at low airplane energy states and low altitude.».

In case of bird strikes during approach or landing, the following suggestion is given: «If the landing is assured continuing the approach to landing is the preferred option. If more birds are encountered fly through the bird flock and land. Maintain as low a thrust setting as

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[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 on *http://www.boeing.com/commercial/aeromagazine/articles/2011_q3/pdfs/AERO_2011_Q3.pdf* .

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 exhaust gas temperature is indicated.».

b) Airbus

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

Airbus makes clear that such documentation (Flight Operations Briefing Notes - FOBN) has been published with the aim to provide general information on «applicable standards, flying techniques and best practices, operational and human factors, suggested company prevention strategies and personal lines-of-defense related to major threats and hazards to flight operation safety».

The prevention strategies indicated in this regard suggest, in case of birds presence in short final, not to go around, but to penetrate/fly through the flock and continue for landing, trying to maintain a low engines setting. In such case, the use of thrust reverses on landing, after a bird impact, should be avoided, as it could increase engine damages, especially in presence of indications such as vibrations or high engines temperature.

c) UK CAA

An interesting note from the British Civil Aviation Authority (UK CAA) entitled "Air Carrier Flight Crew Guide – Bird Strike Mitigation[11]", deals with the issue represented by birds in landing phase. It underlines how, with the engine settings used during approach, any bird ingested by the engine may bypass the engine core via fans, thus reducing the likelihood of causing serious damages.

«At approach thrust settings ingested birds may bypass the engine core via the fan reducing the likelihood of serious damage. If birds are encountered at approach thrust settings and landing can be made with that thrust setting, continue through the flock and complete the landing. A go around attempt (high engine rpm) which enters the flock is more likely to

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

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

results in serious engine damage and loss of thrust. Be ready to transition to instrument flight if windshields become obscured.».

d) SKYbrary

On the Skybrary internet site[12] there are several contributions on bird strikes. In this case, it seemed interesting to mention here an article entitled "Bird Strike on the Final Approach: Guidance for Flight Crews"[13].

It presents two possible scenarios in this regard.

The first scenario considers an aircraft that while approaching, impacts a bird close to land.

«An aircraft is hit by birds while on final approach to land - should the pilot continue the approach or initiate a go around/missed approach?

Having encountered birds, the question to be answered is "what is the damage to the aircraft and what effect will this have on the safe conduct of the flight?"

The full extent of any damage, to the engines and/or the control surfaces and landing gear, may not be apparent until applying power, configuring, or manoeuvring the aircraft. It might therefore be the case that, if a go-around is initiated, the pilot rapidly finds themselves in a situation where the runway is disappearing beneath him but the aircraft cannot safely fly a missed approach.

Therefore, in the above scenario, it is advisable to continue the approach and land.».

The second scenario considers the case in which a pilot sees a flock of birds ahead of him on the final approach.

«A pilot sees a flock of birds ahead of him on final approach - should he continue the approach or initiate a go-around/missed approach?

Having seen the birds, the question to be answered is "if a go-around is initiated, how likely is it that the aircraft will avoid a bird strike?"

There are two matters to consider. Firstly, the behaviour of birds towards an aircraft in flight is highly unpredictable and varies greatly by species, some waterfowl species typically dive but such behaviour is not consistent and the birds may fly upwards, potentially into the path

[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 enables users to access the safety data made available on the websites of various aviation organisations - regulators, service providers, industry.» (https://www.skybrary.aero/index.php/About_SKYbrary).

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

of the aircraft initiating a go-around. Secondly, the greater the engine thrust, the greater the damage caused by ingesting birds - it is probable that less damage will be caused if the birds are hit while the engines are at low speed or idle.

Therefore, in the scenario described above, unless a go-around can be achieved with a reasonable degree of confidence that the aircraft will not hit birds, it is less hazardous to continue the approach to land.».

e) Boeing FCTM

An excerpt from the amendment introduced in the FCTM Boeing B737, issued after the present event, is shown below.

«Bird Strikes Experience shows that bird strikes are common in aviation. Most bird strikes occur 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 approximately 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. If 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:

- 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 final approach
- if birds are expected on final approach, plan additional landing distance to account for the possibility of no thrust reverser use if a bird strike occurs.

Note: The use of weather radar to scare the birds has 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 found 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 (e.g. 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 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) Operator Recurrent Training after the accident (Recurrent Simulator Training)

An excerpt from the recurrent training carried out on the simulator by the operator since 2009 is shown below.

«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 factor 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 resilience skills that are beyond the scope of prescribed emergency procedures.».

The following scenarios figure in the session:

- Birdstrike at 700 ft on final approach leading to double engine failure;
- Birdstrike on departure passing 6000 feet allowing a turnback 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 ava
in the **FCTM – Chapter 8 – Bird Strikes**

Figure 41: Ryanair bird strike hazard simulator recurrent training.

g) EASA

ANSV, within the mentioned survey on the subject, deemed necessary to ask several questions to EASA. The latter confirmed that there are no specific provisions on bird strike in the context of Air Ops, except the obligation to report them.

EASA also specified that mitigating actions in this context must be shown in the SOP, in the crew training context and in the operator's OM.

2.4.2. Human factor final considerations

The go around is a manoeuvre carried out for safety reasons, for example:

- no visual acquisition or loss of landing references;

- wind speed sudden change, such as to compromise the safely approach;
- evidence of a runway incursion;
- in case of a not-stabilised approach.

The failure to not carry out the go around, or to not carry out it promptly, are amongst the main factors that determine significant occurrences and runway excursions.

Nevertheless, the manoeuvre in itself and the management of the subsequent flying phase following this manoeuvre are not risk-free[14].

The go around manoeuvre ordered by the captain does not find anything against such decision in the training and operational documentation examined and in force at the time of the accident.

The set of regulations, in fact, emphasized the opportunity to proceed with a go around in case of unexpected events in landing final phases; consequently and consistently with this approach, no guidelines had been implemented as a result of a preventive assessment regarding the opportunity to go on with a go-around or to complete the landing manoeuvre in circumstances such the ones occurred in the accident.

The above was confirmed by the commander in his declarations, when he stated: «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 decision to go around in the very short final, following the bird strike, placed the aircraft in a very critical situation, much more critical than, with "hindsight" evaluation benefit, the aircrew would have faced in case of an immediate landing.

We could consider, for instance, a case in which the aircraft has begun to lose height outside the airport boundaries or, following an initially positive variometer reading, the crew has decided to retract the landing gear.

In such scenarios, with a possible failure of both engines to provide the thrust needed, whilst the aircraft is at an height and position no longer suitable to guarantee an emergency landing

[14] «One of the largest contributing factors to fatal accidents overall and to all runway excursion accidents, is the failure to successfully execute a go-around or and/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 on https://www.skybrary.aero/index.php/Go-around_Execution.

on the airport runway, the risk associated with the decision to go around is higher than to land.

The theoretical preparation to execute the go around manoeuvre and its practical training cannot ignore to identify specific scenarios where the risk associated with the decision to go around changes significantly.

Among these scenarios, it seems useful to consider and characterize a bird strike scenario on approach phase.

An assessment of the literature analysed, leads to consider that, in circumstances such as the ones occurred, it would have been less risky to land than to go around.

Such assessment is based on the fact that, from an energy viewpoint, the landing of the aircraft (at 7/8 seconds from touchdown) was assured.

It has been also considered that the process leading to the decision to perform a go around took place in few seconds (likely 2) and in a flight phase where the crew, at least the FO PF, was prepared for an imminent landing.

This decision-making process took place without any precursor or warning, as can be deduced from the relaxed climate in the cockpit during the final phases of the approach, the absence of exclamations/comments indicative of a warning/alarm situation.

The Captain's sudden exclamation of surprise is indicative of a degradation of situational awareness, typical of the "surprise effect"[15].

Questions were raised regarding the possibility that a "go around minded" pilot in similar cases can proceed very likely with a go around, not properly assessing the consequences of such manoeuvre, in order to avoid marginal damages during landing, which could be later attributed to the pilot's decision to not go around.

This can lead to the consequence that the pilot, doubtful and with very little time available for decision making, decides to go around, without an adequate risk assessment.

In the analysis of the present case, it has been considered that the go around decision could be due to one or more of the following reasons:

1. an attempt to avoid the flock of birds;
2. a loss of visual contact with the runway;

[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 (see: *Startle and Surprise on the Flight Deck,* already mentioned in note 6).

3. a verified or suspected failure, to be assessed and resolved before landing;
4. a loss of stabilisation from the approach path following an birds avoidance manoeuvre.

The interview with the Captain allowed to eliminate the first two hypothesis, the decision to go around was rather justified with a combination of the last two.

The decision was certainly influenced by:

- the awareness to land on an airport with a limited runway length (2207 m) with an aircraft almost fully loaded with passengers and with a tailwind component, a situation in which every significant deviation from the approach parameters or destabilisation entails a go around;
- having an alternate airport, such as Fiumicino, available in the immediate vicinity with a runway of 3 kilometres, with optimal meteorological conditions and with no concerns about the fuel available;
- the fear that, following multiple impacts, the braking system could have been damaged or functionally limited;
- the possible conditioned reflex caused by the training received, where in case of doubt it is better to go around together with the awareness that accidents often are cause by the decision to continue a not stabilized approach rather than proceed with a go around.

It is assumed as highly improbable to be able to conduct an adequate and sound risk assessment in situations like the one the aircrew faced, due to lack of available time to decide which course of action to adopt.

Such risk assessment should be carried out preferably before the approach.

In absence of specific norms and guidelines on the matter (as confirmed by EASA to ANSV) it is considered essential to provide flight crews with specific guidelines, in the theoretical and simulator phase of training, with reference to the different possible scenarios, by operators.

In fact, differently from what happens, for example, with the take-off phase when many considerations are made in the FCOM and FCTM of most aircraft regarding when to abort or not, for landing phase there were no such instructions in the B737 FCTM at the time of the accident; they were only introduced in the same manual after the EI-DYG accident.

The accident operator deemed opportune to introduce a training aimed at managing such scenarios, but only after experiencing this event.

In conclusion and in light of the previous considerations, it is considered essential that guidelines similar to the ones introduced by Boeing in the FCTM on bird encounter and bird strike in critical flight phases, such as take-off approach, and landing, are extended by the manufacturers to all types of similar aircraft and become part of the operators theoretical/practical training for flight crews.

The event is characterised (at least for the EI-DYG flight crew) by the absence of warning signs, in a phase where the aircrew was mentally prepared to land, close to transition from the “approach phase” to the “landing phase”.
Such situation most probably generated a “surprise effect”, confirmed by the captain not standard exclamation («Ahi!» repeated about 10 times) rather than a less instinctive verbal communication (e.g. “birds ahead”).

The “startle effect” can also explain the instinctive reaction that led to exceed (for reasons the pilot could not explain) in selecting the flaps lever to the 10° position instead of 15°, as requested by the go around procedure, passing the physical detent that prevents the 15° position from being overcome.

The “surprise effect” and “startle effect” negatively impact situational awareness which, with little time available, generates inability to correctly carry out the information processing, decision making and problem solving: cognitive science teaches us that the reactions and decisions taken instinctively are not necessarily the most correct.
Such negative impact should be eliminated/minimized through a specific training.
In particular, the negative effect should be addressed in the most critical phases of flight.
In such phases, possible unexpected scenarios (although plausible) should be considered, against which to develop procedures and strategies able to mitigate the negative effects.
The above training should prepare flight crews to properly respond to the unexpected events.
Among these training tools, also clear and positive communication techniques should be developed to indicate a “threat”.

In the subject case, the event of “bird encountering on final" should generate, i.e., a call out by the pilot who first acquires the “threat”, like: “birds at 12 o'clock”, rather than an instinctive and too generic expression as “Ahi, ahi…!”.

Such standard phraseology, in a CRM perspective, could take the other crew members at the same level of situational awareness, for better decision making and actions. (i.e.: “I land” or “Go around”).

It is believed that types of training aimed at managing the “surprise/startle effect” should be proposed in a way that permits to properly deal with non-routine situations.

The BEA, following more recent events[16], highlighted the following: “Initial and recurrent training as delivered today does not always promote and test capacity to react to the unexpected. Indeed, the exercises are repetitive and well known to crews, and do not enable skills in resource management to be tested outside of this context”.

For such reasons BEA sent to EASA the following recommendation:

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

BEA refers to a situation taking place at high altitude and during cruising, hence different from the one investigated here; however it is believed that the principle included in the above recommendations, to have a specific training for unexpected events, it is also applicable to the present event.

It is believed that in more “time critical” phase of flight such take-off and landing, such training should be considered as essential.

[16] See on the matter the Final Report On the accident on 1st June 2009 to the Airbus A330-203 registered F-GZCP operated by Air France flight AF 447 Rio de Janeiro-Paris.

CHAPTER III
CONCLUSIONS

3. GENERAL

This chapter shows the facts ascertained during the investigation and the causes of the event.

3.1. EVIDENCE

- The flight crew held the necessary aeronautical qualifications to carry out the accident flight.
- It was the first flight of the day for the crew.
- The FO (CM-2) was PF and the Captain (CM-1) PM.
- The start-up, taxiing, take-off and climb were carried out uneventfully.
- The meteorological conditions at the destination airport were optimal.
- The PF carried out a thorough approach briefing, including the missed approach procedure.
- The Ciampino Airport AIP, in the “additional information”, warned only about the presence of hooded crows on the airport all year round.
- The NOTAM in force did not report any warning regarding the presence of birds on Ciampino Airport.
- The crew had not been informed by any means about birds presence/risk; consequently they did not deal with this aspect in the briefing.
- The Airport Manual comprised the bird dispersal procedures in accordance with the ENAC APT-01A circular.
- The ENAC APT-01A circular indicated that BCU should have intervened not only in case of bird dispersal but should also provide continual vigilance on the environment and disturbance of the fauna, in such a way as to make the latter perceive the airport as un unpleasant and unsafe place.
- The Airport Manual (section MOV/11) dictated the execution of scheduled inspections (sunrise, 01.00 pm and sunset), on request inspections (with the intervention of the BCU limited to the time necessary to perform inspection and bird dispersal) or assessments following a reported presumed bird impact.
- The first of the three scheduled inspections, dictated by the Airport Manual in force at the time of the accident, had been duly carried out between 05.20 and 05.55 on the accident day, without any significant birds sighting.

- According to the communications between the TWR and the BCU, the latter had carried out the morning inspection not interesting the runway.
- Before the accident, 16 movements (take-off or landings) were recorded for RWY 15 at Ciampino Airport (8 movements after the BCU inspection, which ended at 05.55); the last of these flights landed about 4’ before the event;
- It is reasonably possible that the flock positioned itself in the place from where it later took off, between the landing of a Saab 340 aircraft and the moments immediately preceding the impact with the EI-DYG.
- None of the crews of the 8 flights that interested the runway after the end of the BCU inspection reported any presence of birds affecting the operations.
- The approach to Ciampino was flown manually (no autopilot, no autothrust, no FD) to train the CM-2, with an ILS-Z procedure for RWY 15.
- The ILS was flown as a stabilised approach consistent with the requirement of the operator’s approved procedures.
- The manual approach showed some deviations from the localizer, corrected by the CM-2 following verbal input from the Captain.
- The final configuration for the landing with flap selection at 40° was reached at 06.54.52, at a radio altimeter altitude of 996 ft and a distance of about 2.5 NM from the field.
- On the “MINIMUMS” synthetic callout, there were the almost simultaneous call outs of the Captain («Continue») and the FO («Land»).
- At a radalt height of 136 ft and a distance of about 300 m from the runway, the Captain, having visually acquired the birds on the flight trajectory, started to exclaim “Ahi”, repeated in rapid sequence.
- At a radalt height between 136 and 112 ft and a distance of about 100 m from the runway, the TO/GA pushbutton was activated.
- The FO gave the acknowledge: «Go around, flaps 15», setting the go around attitude.
- Both engines stalled and the CVR recorded a loud bang at the same time as the TO/GA was activated.
- The “bang” corresponds to the impact with the flock of birds, which occurred when the aircraft was about 100 m from the RWY 15 threshold, with the aircraft position just overhead the area were the maximum concentration of bird corpses was found.
- On go around, the flap lever was positioned at 10° instead of position 15°, required by the go around procedure with two engines.

- On TOGA, both engines, instead of increasing rpm, experienced a drop, from 62% N1 to about 41%.
- When the TOGA was applied, the vertical speed decreased rapidly; a slight increase in the radalt (from 112 ft to 173 ft radio altimeter) has been recorded until 06.56.01; the aircraft then continued to lose height, despite the nose-up command.
- There was a progressive speed reduction and an increase of the angle of attack until the activation of the stick shaker, recorded at 21 ft radalt.
- The aircraft hit the ground in aerodynamic stall conditions, near taxiway “AC”, about half way along the total length of the runway, with a landing mass of 61,100 kg and 3800 kg of fuel, with flaps transiting from 40° to 10° (position actually reached 12.1°) and a vertical acceleration of 2.66g.
- 9 seconds after the contact with the ground, the unsafe left landing gear indication was activated.
- The aircraft decelerated by means of brakes, spoilers and thrust reverse of the left engine only.
- The aircraft came to a stop on the runway at 06.56.38, about 50 metres from THR 33.
- The passengers were disembarked by means of mobile stairs and, on the Fire Brigade’s orders, one of the rear slides, unlike the Captain’s previous orders.
- Until the time of the accident, neither the manufacturer nor the operator had provided guidelines or procedures in the applicable manuals (FCOM, FCTM and OM) referring to the actions to take in the case of bird encounter or bird strike in the approach/landing phase.
- After the event, the aeronautical literature underlined through articles the risks associated with a go around after a bird strike, providing reasons and considerations shown below:
  - the full extent of the damage to the aircraft, and particularly the engines, might not be apparent until it is decided to apply power;
  - after a missed approach manoeuvre, the pilot could be in a situation where the runway is disappearing beneath the aircraft’s nose and, at the same time, the aircraft is not in a condition to fly;
  - at an engine rpm typical of the approach phase, the damage can most probably be confined to engine fans and does not affect the cores;
  - the high rpm, resulting from a missed approach manoeuvre, while penetrating the flock of birds, could cause greater damage to the engine and consequent loss of thrust.

- The literature considered, suggests to land after a bird strike when in the approach/landing phase and not to carry out a go around.
- After the event, Boeing with B737 FCTM introduced a “recommended technique” as prevention strategies and guidelines, to be followed by the crew in the event of bird impact in the take-off and landing phases. The concepts expressed herein agree with the ones in the above-mentioned aeronautical literature.
- There is no evidence of guidelines adopted by other aircraft manufacturers in their flight and training manuals, guidelines similar to the ones introduced by Boeing in case of bird strike.
- After the event, the operator developed specific training for birds encounter and bird strike on take-off and landing.
- There are no guidelines at regulatory level (EASA) covering specific training for such scenarios to be followed by operators.
- At the time of the event, there were no training guidelines aimed at managing and mitigating the “surprise” and “startle” effects, effects that influenced the actions carried out by the flight crew.

3.2. CAUSES

The accident has been caused by an unexpected loss of both engines thrust as a consequence of a massive bird strike, during the go-around manoeuvre.

The loss of thrust has prevented the aircrew from performing a successful go around and has led the aircraft to an unstabilized runway contact.

The following factors have contributed to the event:

- the inadequate effectiveness of bird control and dispersal measures put in place by the airport operator at the time of the accident;
- the captain decision to perform a go around, when the aircraft was at approximately 7 seconds from touchdown. The above decision was significantly influenced by:
    1. the lack of instructions to flight crew concerning the most suitable procedures to adopt in the case of single or multiple bird strikes in the landing phase;
    2. the absence of specific training in the management, by the flight crew, of the “surprise” and “startle” effects in critical phases of the flight.

CHAPTER IV

SAFETY RECOMMENDATIONS

4. RECOMMENDATIONS

In light of the evidence collected and the analyses carried out, the ANSV considers it necessary to issue the following safety recommendations.

4.1. RECOMMENDATION ANSV-12/1525-08/1/A/8

Type of recommendation: SRUR/SRGC.

Reasoning: during the investigation, it has been considered that the training and operating instructions might not always provide sufficient elements to enable pilots to make decisions in time critical situations, based on previous theoretical analysis of the possible scenarios, taking into account risks and psychological conditions associated.

The subject accident can be characterized as a flight through a flock of birds, in the very short final, with the aircraft fully configured for landing and stabilised on the descent path.

During this phase of flight, the engines are selected at a relatively low thrust level, at which possibly ingested birds may very likely not affect the core of both engines (however, in the subject accident the stall happened at a relatively low rpm) therefore reducing the chances to cause significant damage to them and to permit the aircraft to land safely with the selected approach thrust.

In such conditions, the decision to carry out a go around manoeuvre, where maximum thrust is applied to engines, could increase the likelihood to cause engine damages and malfunctions with consequent loss of available thrust, which could prevent the go around manoeuvre from being safely completed.

The lack of clear indications to aircrew regarding the opportunity to carry out the go around manoeuvre in this kind of scenario, can lead the crew to apply, “uncritically” (and without the necessary awareness about the potential consequences) such manoeuvre which might present greater risks than landing the aircraft.

The above considerations are consistent with the ones expressed and recommended, for instance, by Boeing, Airbus ,UK CAA, all related to the above scenario.

Following the event, Boeing introduced in the FCTM of the B737 a “recommended technique” referred to the case of bird strike, providing both prevention strategies and guidelines concerning the actions to be implemented by the flight crew in case of bird impact in take-off or landing phases.

Addressee: EASA and FAA.

Text: ANSV recommends to provide flight crews with guidelines and/or operational and training procedures, based on a careful assessment of the risks associated with the conduct of the aircraft in approach in case of birds encounter or single/multiple bird strikes.

These guidelines should include the following topics:

- to discuss bird strike risks during take-off and approach briefings when operating at airports with known or expected bird activity;
- in case of single/multiple bird strikes in the final approach phase, if landing is assured, it is preferable to land maintaining the lowest engine power setting possible rather than carrying out a go-around procedure (in case of birds ingestion, especially a massive one, the engines damages can be greater at high engine rpm, the latter typical of a go-around manoeuvre);
- to consider that engines damages or malfunctions might prevent the go-around manoeuvre from being completed safely and consequent impossibility to land on the runway.

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

Type of recommendation: SRUR/SRGC.

Reasoning: the initial and recurrent training currently provided, does not seem to optimize, promote or develop skills to manage unexpected situations able to generate "surprise" and "startle" effects.

Following the event, the accident operator developed and implemented specific training on the matter, however ANSV has not found, at regulatory level, indications aimed at adopting such type of training.

At training level, therefore, particularly for critical phases of flight, should be identified unexpected but plausible events, capable to generate such "surprise" and "startle" effects.

Crews should be trained to deal with such events, through visualization and conditioning exercise.

Training to cope with the negative consequences of these effects would be considerably valuable in helping to minimize the likelihood to adopt inadequate decisions by flight crews as, for instance, in case of bird strike / bird encounter during approach and landing phase.

Addressee: EASA and FAA.

Text: ANSV recommends to provide indications in order to adopt specific trainings for flight crews, to cope with the "surprise" and "startle" effect, particularly in critical phases of flight such approach and landing.

APPENDIX

In line with international and EU regulation regarding safety investigations, comments have been received by the following authorities on a draft of the final report (in English) submitted by ANSV:

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

Some comments received are related only to the English version.

Comments agreed by ANSV have been integrated in the report, while non-agreed comments are shown below.

COMMENTS RECEIVED FROM AAIU

Ref.	Reason proposed change	Proposed amendment
Page 99 of this report.	The report discusses the startle effect and 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 finding.