CIAIAC

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report A-029/2012

Accident involving a Cessna 500, registration EC-IBA, operated by AIRNOR, on approach to the Santiago de Compostela Airport (LEST) (A Coruña, Spain), on 2 August 2012

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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n.º 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1, 4 and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

00°	Degree(s)
00 °C	Degree centigrade(s)
ACAM	Aircraft Continuing Airworthiness Monitoring
ACC	Air Control Center
ADI	Attitude Director Indicator
ADF	Automatic Direction Finder
AESA	State Aviation Safety Agency
AGL	Above Ground Level
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMT	Aircraft Maintenance Technician
AP	Auto Pilot
AOC	Air Operator's Certificate
AOM	Airport Operations Minimums
APP	Approach
ARC	Airworthiness Review Certificate
ARO	ATS Reporting Office
ATC	Air Traffic Control
ATS	Air Traffic Services
BRNAV	Basic Area Navigation
CAME	Continuing Airworthiness Management Exposition
CAMO	Continuous Airworthiness Management Organization
CFIT	Controlled Flight Into Terrain
CPL(A)	Comercial Pilot Licence (aircraft)
CRE	Class Rating Examiner
CRI	Class Rating Instructor
CRM	Crew Resource Management
CRS	Certificate of Release to Service
CVR	Cabin Voice Recorder
DH	Decision Height
DME	Distance Measuring Equipment
DVOR	VOR Doppler
ELT	Emergency Locator Transmitter
EOBT	Estimated Off Block Time
ETA	Estimated Time of Arrival
FAA	Federal Aviation Administration
FAP/FAF	Final Approach Point/Fix
FAR	Federal Aviation Regulations
FD	Flight Director
FI	Flight Instructor
FPL	Flight Plan
ft	Foot
Ft/min	Feet per minute
GND	Ground
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
GS	Ground Speed
h	Hour(s)
HDG	Heading
HSI	Horizontal Situation Indicator
IAS	Indicated Air Speed
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Condicions
ILS	Instrument Landing System

Abbreviations

ITT	Interstage Turbine Temperature
l	Liter
lb	Pound(s)
LEST	Airport of Santiago
LEVT	Airport of Vitoria
LH	Left Hand
LOC	Localizer
LPPT	Airpot of Porto
LVP	Low Visibility Procedures
kg	Kilogram(s)
km	Kilometer(s)
kt	Knot(s)
m	Meter(s)
Mhz	Megahertz(s)
min	Minute(s)
MEL	Minimum Equipment List
MEP	Multi Engine Piston
METAR	Meteorological Aerodrome Report
MTOW	Maximum Take Off Weight
N/A	Not apllicable
NM	Nautical Miles
NOTAM	Notice to AirMen
OJTI	On the Job Training Instructor
ONT	National Transplant Organization
PF	Pilot Flying
PNF	Pilot Not Flying
PM	Pilot Monitoring
QNH	Atmospheric Pressure at Nautical Height
RCA	Spanish Air Traffic Regulations
RCC	Rescue Coordination Centre
RD	Royal Decree
RFFS	Rescue and Fire Fighting Service
RH	Right Hand
RPM	Revolutions per minute
RVR	Runway Visual Range
SACTA	Air Traffic Control Automation System
SANA	Safety Assesment of National Aircraft Programme
SAR	Search and Rescue
SB	Service Bulletin
SEP	Single Engine Piston
SMR	Surface Movement Radar
S/N	Serial Number
SOP	Estándar Operational Procedures
S/P	Single Pilot
STC	Suplementary Type Certificate
TCDS	Type Certificate Data Sheet
TLB	Technical LogBook
TWR	Tower
UTC	Coordinated Universal Time
VERT	Vertical
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
VOR	Very High Fequency Omnidireccional Range

Synopsis

Owner and operator:	AIRNOR (Aeronaves del Noroeste)
Aircraft:	Cessna 500, registration EC-IBA
Date and time of accident:	Thursday, 2 August 2012; at 04:18 UTC[1]
Site of accident:	On approach to the Santiago Airport
Persons onboard:	2, captain and first officer. Both fatal
Type of flight:	Commercial air transport – Other-Emergency medical services
Date of approval:	June 24th 2015

Summary of accident

The aircraft took off from the Santiago Airport (LEST) on 1 August at 21:55 for the purpose of providing a service for the National Transplant Organization (ONT) by transferring a medical team[2] from the Asturias Airport (LEAS) to the Porto Airport (LPPR). Once in Porto, the crew waited for the medical team (a cardiac surgeon and an instrument nurse) to complete its task, at which point they returned to the Asturias Airport. The crew then took off from said airport at 03:45 to return to the Santiago Airport. Ten minutes later, the crew established contact with Santiago approach control, which gave them the 03:30 weather information and later cleared them to make an ILS[3] approach to runway 17 at the Santiago Airport. At 04:15 the crew contacted the tower controller, who informed them that the wind was calm and cleared them to land on runway 17. Two minutes later the aircraft, configured for landing[4], impacted the ground 200 m before the Santiago VOR, approximately one mile before the runway 17 threshold. The aircraft's occupants died on impact and the aircraft was destroyed.

The investigation concluded that the crew made an unstabilized ILS approach and did not follow the Santiago Airport glide slope, using distance references to the VOR instead of the runway. There was fog in and around the airport which could have affected suddenly the crew's ability to see the ground.

[1] All times in this report are in UTC unless otherwise specified. To obtain local time, add 2 hours to UTC.
[2] Transfer of a surgical team for the purpose of extracting organs for a transplant.
[3] ILS: Instrument Landing System.
[4] Flaps set to approach and landing gear down.

1. FACTUAL INFORMATION

1.1. History of the flight

Based on the information available, at 20:40 the ONT (National Transplant Organization) informed the Santiago Airport (LEST) that they were going to make a "hospital flight"[5].

The aircraft was refueled at the Santiago Airport with 1062 liters of fuel. According to communications, the crew of aircraft EC-IBA contacted the Santiago tower at 21:46 to request permission to start up and information on the weather and the runway in use at Asturias. At 21:54 they were cleared to take off.

According to the airport operations office, the aircraft landed in Asturias (LEAS) at 22:27. The hospital flight service commenced at 22:15. The RFFS accompanied the ambulance to the aircraft at 22:30 and at 22:44 the aircraft took off en route to Porto. The aircraft was transferred from Madrid control to Santiago approach at 22:52 at flight level 200 and cleared straight to Porto (LPPR).

Based on the information provided by Porto Airport, the aircraft landed at 23:40. While waiting for the medical team to return, the crew remained in the airport's facilities. According to some of the personnel there, the crew made some comments regarding the bad weather. There was fog, especially on the arrival route. At 01:34 and again at 02:01 the crew was supplied with the flight plan information, information from the ARO-LPPR office and updated weather data. The aircraft was refueled at the Porto Airport with 1,000 l of fuel and took off at 02:34. At 02:44 the aircraft contacted approach control at Santiago to report its position. Four minutes later the crew contacted the Santiago tower directly to ask about the weather conditions at the field (see Appendix C).

The aircraft landed once more in Asturias at 03:28. At 03:26 the RFFS was again activated to escort the ambulance to the aircraft. The service was deactivated at 04:00. The crew requested updated weather information from the tower, which provided the information from the 03:00 METAR[6].

According to the flight plan filed, the estimated off-block time (EOBT) for departing from the Asturias Airport was 03:45, with an estimated flight time to Santiago of 40 minutes. The alternate destination airport was Vitoria (LEVT). The aircraft took off from Asturias at 03:38.

At 03:56 the crew established contact with Santiago approach control, which provided the crew with the latest METAR from 03:30, which informed that the runway in use

[5] ONT: flight designator for the transfer of organs or a medical team to extract them.
[6] Aviation Routine Weather Report.

was 17, winds were calm, visibility was 4,000 m with mist, few clouds at 600 ft, temperature and dew point of 13° and QNH of 1,019. The aircraft was then cleared to conduct an ILS approach to runway 17 at the Santiago Airport. At 04:15 the crew contacted the tower controller, who reported calm winds and cleared them to land on runway 17.

At 04:18 the COSPAS-SARSAT system[7] detected the activation of an ELT[8]. The system estimated the position for the beacon as being in the vicinity of the LEST airport.[9]

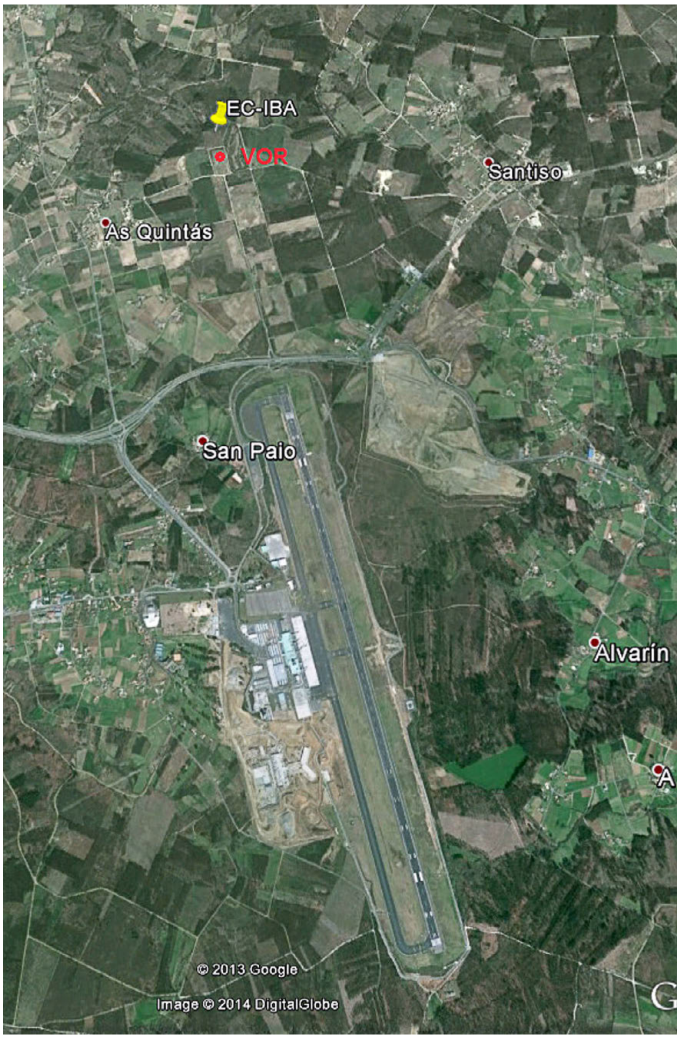


Figure 1. Location of the aircraft wreckage in relation to the Santiago Airport[9]

At 04:38 the tower controller informed airport operations of a call he had received from SAR that a beacon was active in the vicinity of the airport, and requested that a marshaller go to the airport where the airplane normally parked to see if it was there. At 04:44 the marshaller confirmed that the aircraft was not in its hangar and the emergency procedure was activated, with the various parties involved in the search for the airplane being notified. At 05:10 the control tower called the airport to initiate the preliminary phase (Phase I) before activating the LVP. At 05:15 the RFFS reported that the aircraft had been found in the vicinity of the VOR. At 05:30 the LVP was initiated (Phase II). At 07:51 the LVP was terminated.

The last flight to arrive at the Santiago Airport before the accident had landed at 23:33, and the next flight to arrive following the accident landed at 05:25.

[7] The COSPAS-SARSAT satellite system is a space-based system that receives the distress signal from aviation ELTs to guide search and rescue (SAR) operations.
[8] ELT: Emergency Locator Transmitter.
[9] Images taken from Google Earth.

1.2. Injuries to persons

Injuries	Crew	Passangers	Total in the aircraft	Others
Fatal	2		2	
Serious				
Minor				N/A
None				N/A
TOTAL	2		2	

1.3. Damage to aircraft

The aircraft was destroyed as a result of the impact (see Section 1.12).

1.4. Other damage

On its final flight path the aircraft impacted several pine and eucalyptus trees, damaging them to various extents.

1.5. Personnel information

1.5.1. *Crew*

Captain

The captain, who was the pilot flying (PF) at the time of the accident[10], was a 35 year old Spanish national. He had a commercial pilot license (CPL) with a multi-engine rating (MEP) that was valid until 31/08/2012, and a Cessna 501/551 rating valid until 30/06/2013. He also had an A320 first officer rating, an SA226/227 rating and an instrument rating, all valid and in force. He likewise had single-engine (SEP) and flight instructor (FI) ratings, though both had expired two days before the accident. He had valid and in force class 1 and 2 medical certificates. The captain's updated logbook was not available, but according to information from the operator, he had over 3,600 total flight hours, 2,700 as the pilot in command, 2,000 in IFR conditions and over 554:55 on the type of aircraft involved in the accident.

[10] Based on the technical log book and judging by the fact that communications were being handled by the first officer, who would have been the PNF.

The captain first joined the company in 25 June 2007. He made 189:05 in the Citation fleet, leaving the company voluntarily due to familiar reasons. His re-entry in the company was on 20 June 2010, having 29:30 h in the Citation fleet, 28 of them with the accident aircraft.

The captain had taken the following courses:

- Operator's conversion course:
  - Ground training and checks, including airplane systems and normal, abnormal and emergency procedures.
  - Training and checks on onboard equipment and safety.
  - Training on Crew Resource Management (CRM).
  - Flight training and checks (operator check).
- Line training and check
- Route and airport training course

He was certified as a captain on 20/07/2012 by the chief instructor. The requirements for captain were contained in Chapter 5.2 of the operator's Operations Manual (as per EU OPS sections 1.955 and 1.965): completion of 10 sectors, proficiency check and line check. A class rating examiner (CRE) renewed the pilot's Cessna 501 rating on 4 June 2012 and did the operator's check on 21 June 2012. In the flight logs there is no record that the 10 sectors were supervised by personnel duly authorized by the Authority. On 2 July 2012, after completing the ten sectors, the accident crew made a two-sector flight. The captain's proficiency check was also signed on that day by the CRE. The flight logs did not show his name as a member of the crew neither as a passenger. The last requirement for making captain was a line check, which was done on 20 July 2012 by the chief CRI. The flight log did not list his name among those of the crewmembers.

First officer

The first officer, who was the pilot monitoring/pilot not flying (PM/PNF) at the time of the accident, was a 37 year old Spanish national. He had a commercial pilot license (CPL) with a multi-engine rating (MEP) that was valid until 30/11/2012, and Cessna 501/551 and instrument ratings valid and in force until 30/04/2013. He had valid and in force class 1 and 2 medical certificates. The copilot's updated logbook was not available, but according to information from the operator, he had over 650 total flight hours, 470 as the pilot in command, 500 in IFR conditions and over 475:00 on the type.

The first officer had joined the company on 5 March 2012 and flown 61:40 h on the Citation fleet, all on the accident aircraft.

The copilot had been given the following courses by the operator:

- Operator's conversion course:
  - Ground training and checks, including airplane systems and normal, abnormal and emergency procedures.
  - Training and checks on onboard equipment and safety.
  - Training on Crew Resource Management (CRM).
  - Flight training and checks (operator check).
- Route and airport training course.

Before starting the flight from the Santiago Airport on 1 August, the crew had made a two-sector flight one month earlier.

1.5.2. *Maintenance personnel*

The AMT who maintained the aircraft was a 54 year old Spanish national who had valid and in force B1.2[11] and C[12] category licenses, both with Cessna 500/501/551 (PWC JT15D) ratings. He did not have a B2 license with avionics maintenance privileges.

The post of technical director of maintenance at the operator had been approved by the Civil Aviation General Directorate (the Spanish authority at the time).

1.5.3. *Air traffic controllers*

The ATC station offered two control services provided by two air traffic controllers working simultaneously but with operationally different tasks and functions:

- Approach control to the La Coruña, Santiago and Vigo airports, and route control of aircraft up to 24,000 ft.
- Aerodrome control at the Santiago de Compostela Airport.

The night shift had four controllers with no supervisor (unlike the morning shift). The night shift was from 22:00 to 08:00. There were no predetermined or pre-assigned activities during the night shift.

[11] The full B1 category includes maintenance on airplanes with turbine and piston engines (subcategories B1.1 and B1.2) and maintenance on helicopters with turbine and piston engines (subcategories B2.1 and B2.2). Category B2 includes the avionics in the aforementioned cases.

[12] Category C includes privileges to carry out major inspections in various subcategories.

Approach controller

The approach controller (APP), a 41 year old Spanish national, had a valid and in force air controller license with the relevant endorsement rating for the station. He had a valid class 3 medical certificate. He had seven years of experience as a controller and more than one in the sector where he was working at the time of the accident. He also had an on-the-job training instructor (OJTI) endorsement and had been trained as a supervisor.

He had worked the night of 30 July, going on duty at 21:51 and off duty at 04:02, according to the information in the GENIUS[13] system.

Aerodrome controller

The aerodrome or tower (TWR) controller was a 47 year old Spanish national. He had a valid and in force air controller license with the relevant endorsement rating for the station. He had a valid and in force class 3 medical certificate. He had 19 years of experience as a controller and 18 in the sector where he was working at the time of the accident. He had an on-the-job training instructor endorsement and had been trained as a supervisor.

He had worked the night of 31 July. According to his statement he was on duty from 22:00 until 04:30-05:00, at which time he was relieved. The GENIUS system did not log his duty hours, though they were verified later through the turnover and signature sheets.

1.6. Aircraft information

1.6.1. *General information*

The accident aircraft belonged to the company AIRNOR. It was a Cessna Citation 500 (Cessna 501/SP), registration EC-IBA and serial number (S/N) 500-0178. It had been built in 1974 and was equipped with two Pratt & Whitney JT15D-1 engines. Its maximum take-off weight (MTOW) was 5216 kg and it had a range of 3:30 hours (2056 liters of usable fuel). It could carry six passengers in addition to the crew. Its wingspan and the width of its undercarriage made it a category B aircraft. It was certified to make category I ILS approaches (see Appendix A). The aircraft did not have a GPWS[14] nor was one required.

[13] GENIUS: System that tracks a controller's duty time on a post by using an identification card.

[14] Annex 6 Section 6.15: All airplanes with turbine engines with a maximum certified take-off weight in excess of 5.700 kg or authorized to transport more than nine passengers shall be equipped with a ground proximity warning system. In this case the take-off weight was lower.

Figure 2. Picture of the aircraft[15]

The aircraft had a registration certificate, an aircraft station license, a noise level certificate and an insurance certificate, all valid and in effect. It also had a certificate of airworthiness dated 4 March 2005 and the corresponding airworthiness review certificate (ARC) issued by AESA on 3 March 2010. The ARC had been extended twice by the company's own CAMO and expired on 2 March 2013.

Based on the TCDS[16], the Cessna 500 Citation was required to have a minimum flight crew of two people on all flights (pilot and copilot). According to the aircraft's records, it had Exception N.º 6480E[17] C500 Single Pilot dated 28/05/2004, which authorized it for single-pilot operations as long as the following requirements were met: autopilot/flight director (AP/FD) operational, voice-activated headset with microphone and transponder "ident" switch on the pilot's controls.

The aircraft had a technical log book (TLB) that documented the flights made, crews, PF/PNF, aircraft and engine hours, amount refueled, oil changes and any abnormality/malfunction and its relevant maintenance action. It also had specific sections to record the completion of the pre-flight check and the aircraft acceptance. These entries were not always filled out in their entirety.

[15] Image taken from Jetphotos.net.
[16] TCDS: Type Certificate Data Sheet.
[17] FAA: Supplemental Type Certificate (STC). An STC is a Type Certificate issued when an applicant receives FAA approval to modify an aircraft from its original design.

1.6.2. *Maintenance information*

The aircraft had a maintenance program whose last revision had been approved by AESA in September 2010. This program had not been updated yearly as specified in the program itself, nor did it incorporate the latest documentation from the manufacturer, though for those aircraft inspections made after the last edition of the manufacturer's documentation the operator was using the latest versions of said documentation.

According to the maintenance program, the operator complied with the recommended Continuous Inspection Program, which defined the phases, frequencies and tasks to be performed.

Item 1.2.5 in the sequence to prepare the aircraft for flight specified the following: *pre-flight inspections shall be made by authorized personnel, who will note and record any anomalies observed. If necessary for aircraft airworthiness, they shall be repaired before the next flight; if not, they may be deferred if required by maintenance center spare part or aircraft operating needs.* [...] *the pilot in command of the aircraft shall sign the technical log book and accept the aircraft in the space provided for this purpose.*

The maintenance program was divided into five main phases (from 1 to 5) that covered all of the inspections required up through the 1,200 h check. The remaining phases (from 6 to 50) included all other inspections, carried out individually or in combination with one of the main phases. According to this program, at the time the aircraft did not have any damage (item 10. Map of damage to the aircraft). Any damage that was found would by identified using a damage map and referring to the relevant stations.

List of inspections performed on aircraft EC-IBA

The table below shows every inspection carried out at the various maintenance centers until the last one in May 2012. The primary phases corresponding to different 300 h phases and the 1,200 h phase are shown as complete (see figure 3).

From the time Airnor took over the aircraft's maintenance, it had flown 41.9 h. According to the CRS[18] for the last aircraft inspection made, it had 9,410 h at the time, with 9,019 h on the n.º 1 engine and 6,010 h on the number 2.

The aircraft's log book specified that the next maintenance inspection would be conducted on 13 December 2012.

According to the operator, the phase 20 inspection was specific to the altitude reporting instruments. The altimeters had been checked as part of this phase on 23/9/2010. The

[18] CRS: Certificate of release to service.

AIRNOR ANW AVIONES Y HELICOPTEROS
OPS 1 Nº.: E-AOC-019 / CAMO Nº.: ES.MG.019
OPS 3 Nº.: E-AOC-H-027 / CAMO Nº.: ES.MG.H03
EASA PARTE 145 Nº.: ES.145.089

LISTA de REVISIONES EFECTUADAS

Página 1 de 1

Aeronave: CESSNA 500		S/N: 500-0178	Matrícula: **EC-IBA**	
Horas	Revisión	Expediente	Taller	Fecha
8.615:50	Fases 1, 2, y 10	IBA 2/02	AERAC	19-07-2.002
8.779:40	Fases 3, 4, 5, 8, 10, 49, 50	IBA 1/03	AERAC	24-04-2003
8.828:55	Fases 1, 2 y 10	IBA 2/03	AERAC	01-08-2.003
9.019:50	Fases 3, 4, 8, 10, 24	OT 04/06	C.N. AIR	28-05-2.004
9.166:25	Fases 1, 2, 10, 20	OT 04129	AERAC	30-11-2.004
9.318:50	Fases 3, 4, 8, 10, 18 y 20	IBA 06/1 EXT	AERAC	13-04-2.006
9.348:55	Fases 20, 53 y XPDR CK Instalación XPDR y ELT	IBA 08/3EXT	A&M	22-09-2.008
9.348:55	Fases:1,2,3,4,5,8,10,22,23,26, 47,49 y 50. W&B + tros	IBA 08/1 EXT	SPORAVIA	22-09-2.008
9.368,40	Fases 8, 10, 18, 34 y 53	IBA 10/2 INT	AIRNOR	30-04-2010
9.368,7	Fases 41, 49, 50	IBA 10/3 INT/EXT	AIRNOR/SEMASA	02-09-2010
9.368,7	Fase 20	IBA 10/4 EXT	AGROAR	23-09-2010
9.377,2	Fases 1, 2, 3 y 4	IBA 10/4 INT/EXT	AIRNOR	14-12-2010
9.378,7	Fases 10,18,34,53(anuales)	IBA 11/1 INT	AIRNOR	20-05-2011
9.378,7	Fase 5 y 22	IBA 11/2 INT	AIRNOR	21-10-2011
9.410,3	Fase 10,18, 34, 53	IBA 12/1 INT	AIRNOR	15-05-2012

Figure 3. List of completed inspections

next check of the altimeters was required to be performed in two years and was scheduled for 22/9/2012.

The operator reported that there were no deferred items pending for the aircraft. The corresponding deferred item list had two entries:

- *Fuel low level indicating system:* opened on 17/7/2012 and closed on 19/7/2012
- *RH landing light inoperative:* opened on 20/7/2012 and closed on 23/7/2012.

Both the aircraft and engine log books were destroyed in the accident.

On 29 June 2012 the captain had sent an e-mail to the operator informing of certain discrepancies he had noticed in the aircraft that were not recorded in the technical log book. In the e-mail he requested that they be checked while the aircraft was in Santiago, which was close to the operator's base. The external aspects listed included general corrosion and problems with the de-icing boots. The aspects involving the anomalies present in the cockpit are shown in their entirety below:

Cockpit

- DOOR NOT LOCKED on in the annunciator panel.
- Constant Morse code ringing in the headset.
- Instrument flag always displayed on N1 even though the instrument works well.
- Right ITT off scale sometimes.
- First officer's altimeter reads 80 feet higher than captain's.
- RH fuel quantity does not go above 1,400 lb.
- RH windshield bleed air is broken and does not open or close.
- Captain's HSI indicates up and the first officer's to the left at the VORs.
- First officer's horizon GYRO flag always displayed.
- Foot warmers do not close properly and let out a lot of air.
- Pressurization noise at 13,000 ft even though all pressure instruments read normally.
- COM2 not heard from the captain's seat.

1.6.3. *Information on the instruments onboard the aircraft*

So as to describe later the approach made by the crew into the Santiago Airport, what follows next is a brief description of the navigational instruments of interest to the investigation.

Navigation equipment

The aircraft had two conventional navigational equipment units. Unit 1 (NAV1) supplied information to the captain's HSI, while unit 2 (NAV2) supplied information to the first officer's HSI and could also provide navigational information to the captain's.

HSI (Horizontal Situation Indicator)

The aircraft had two HSI units, one for the captain, located in the center part of the LH instrument panel, and another for the copilot, located in the center part of the RH instrument panel. Both were Bendix models, with part number 1925757 2.

The HSI is a navigational instrument that allows the crew to navigate by instruments between two VOR stations and to make both precision and non-precision instrument approaches. During an ILS approach the pilot can see the aircraft's deviation with the respect to the glide slope and the localizer.

Figure 4. HSI

The top left window shows the selected course and the right window the distance to the station, as long as the frequency selected is operational. The HDG flag indicates that the instrument is not powered or that the course indication is out of service, while the VERT window indicates that the instrument is not powered or that the ILS glide slope is not operational.

DME (Distance Measuring Equipment)

On the right side of the instrument panel was an RCA AVQ85 DME unit, part number 585011 1. This allowed the crew to determine the distance in nautical miles to the VOR or ILS whose frequency was selected in the navigational units, as long as these frequencies had a DME associated with them and they were functional.

The DME installed on the aircraft had different modes of operation:

Figure 5. DME

- **OFF.** Unit off.
- **NAV1.** The DME shows the distance to the VOR or ILS whose frequency is selected in NAV1.
- **HOLD.** Indicated with a red light that turns on when this option is selected. The unit shows the distance to the station for the last selected frequency.
- **NAV2.** The DME shows the distance to the VOR or ILS whose frequency is selected in NAV2.

The top window on the unit shows the distance to the selected station and the screen at the bottom can be selected to display the speed in knots (KTS) or the ETA to the station in minutes (MIN).

ADI (Attitude Direction Indicator)

The aircraft had two Bendix ADIs, part number 1925756 2, one for the pilot, located at the top center of the LH instrument panel, and another for the first officer, located at the top center of the RH instrument panel. This instrument shows the pilot the airplane's attitude by using the signals sent by the laser gyroscopes on the aircraft.
The ADI provides the following indications:

- Pitch angle
- Bank angle
- Combination of both: airplane's attitude with respect to the natural horizon.
- Alignment indication in navigation (NAV) mode, both for altitude and heading, with respect to the point currently selected.

Figure 6. ADI

- Alignment indication in ILS mode for both the glide slope and localizer.
- Indication of the various modes of operation of the flight director (FD) and the autopilot (AP).

The flight director and the autopilot can work jointly or separately. When both are engaged, the autopilot controls the aircraft using the data from the flight director. If the flight director is disengaged, the autopilot would continue in the selected flight mode but there would be no command bars from the flight director. If the autopilot were disengaged, the pilot would be able to control the aircraft in manual following the indications from the flight director bars on the ADI.

1.7. Meteorological information

1.7.1. *Weather conditions in Porto*

The information collected indicates that the weather conditions at the Porto Airport during the flight from Asturias to Porto were as follows:

SPECI LPPR 012302Z 36004KT 320V030 0200 R17/0600 FG VV/// 17/17 Q1018
SPECI LPPR 012307Z 35005KT 310V030 0200 R17/0550 FG VV/// 17/17 Q1018
METAR LPPR 012330Z 020004KT 360V060 0150 R17/0750 FG VV/// 17/16 Q1018
SPECI LPPR 012346Z 01005KT 330V040 0200 R17/0900N FG VV/// 17/17 Q1018

When the aircraft arrived in Porto, weather conditions were worsening. Several SPECIs were issued warning of the degrading visibility due to fog at the runway 17 threshold, which varied from 600 m at 23:02 to 900 m at 23:46.

Low-visibility procedures (LVP) went into effect at the Porto Airport at 21:24 on 1 August and were terminated at 05:48 on 2 August.

1.7.2. *Weather conditions in Santiago*

The aviation weather data gathered for the Santiago Airport showed that the weather conditions were as follows:

METAR LEST 020400Z 00000KT 5000 BR FEW006 13/13 Q1019 NOSIG=
METAR LEST 020430Z 00000KT 5000 R17/0450V1700U BR FEW006 13/13 Q1019 NOSIG=

METAR LEST 020500Z 00000KT 1000 R17/0300V0600N R35/0325N BCFG FEW006 13/13 Q1019 NOSIG=

At 04:00 UTC the prevailing visibility at the airport was 5,000 m, with haze and few clouds at 600 ft.

At 04:30 UTC, although the prevailing visibility at the airport was 5,000 m, the runway visual range (RVR) at the 17 threshold was yielding a visibility of between 450 m and 1,700 m. There was haze and few clouds at 600 ft.

At 05:00 UTC the prevailing visibility had dropped to 1,000 m, the RVR at the 17 threshold varied between 300 m and 600 m and the RVR at the 35 threshold was 325 m. There were fog banks and few clouds at 600 ft.

The wind during this period was calm, the temperature and dew point were 13 °C and the pressure (QNH) was 1,019.

The aerodrome forecast in effect at the time of the accident for the Santiago Airport, issued at 23:00 by the National Center for Aeronautical Forecasts in Santander, was as follows:

TAF LEST 012300 0200/0224 22007KT 9999 SCTO2O
TX22/0214Z TN13/0206Z
PROB4O TEMPO 0200/0208 4000 BR BKNOO8
PROB4O TEMPO 0202/0207 0500 FG BKN003=

This indicated a 40% probability of a temporary reduction in visibility to 4,000 m due to haze between 00:00 and 08:00, and a 40% probability of a temporary reduction in visibility to 500 m due to fog between 02:00 and 07:00. The low-level significant weather chart for 06:00, which showed significant weather events between 03:00 and 09:00, also forecast haze and fog in the Santiago area.

According to the weather office at the Santiago Airport, there were intervals of reduced visibility caused by fog banks, a situation aggravated by the fact that it was occurring at night. This condition is very common at this airport. Fog banks are created in the valleys around the airport that come into visual range at various times and from different directions. These banks are usually confined to the bottoms of neighboring valleys and are not visible from the airport until they move in one direction or another. They move and change rapidly, carried by slow, variable winds.

According to RVR data taken from the sensors at the airport, the average RVR[19] measured at 1 minute intervals at the two thresholds (17 and 35) and at the runway midpoint around the time of the accident were as follows:

[19] The value 2,000 means 2,000 m or more.

FECHA	HORA (UTC)	RVRMD1CAB17	RVRMD1CAB35	RVRMD1CABPM
02/08/2012	02:50:00	2000	2000	2000
02/08/2012	03:00:00	2000	2000	2000
02/08/2012	03:10:00	2000	2000	2000
02/08/2012	03:20:00	2000	400	2000
02/08/2012	03:30:00	2000	2000	900
02/08/2012	03:40:00	2000	2000	2000
02/08/2012	03:50:00	2000	2000	2000
02/08/2012	04:00:00	2000	2000	2000
02/08/2012	04:10:00	2000	2000	550
02/08/2012	04:20:00	1500	2000	2000
02/08/2012	04:30:00	800	350	900
02/08/2012	04:40:00	450	200	2000
02/08/2012	04:50:00	550	300	500
02/08/2012	05:00:00	450	300	250
02/08/2012	05:10:00	300	250	300
02/08/2012	05:20:00	250	200	250
02/08/2012	05:30:00	250	350	1700
02/08/2012	05:40:00	400	300	225
02/08/2012	05:50:00	550	300	400
02/08/2012	06:00:00	300	450	700

Figure 7

At the time of the accident (approximately 04:20 UTC), the RVR at the 17 threshold was 1,500 m. Sunrise on 2 August in Santiago de Compostela was at 07:26, and there was a full moon that night.

1.8. Aids to navigation

At the time of the accident the aircraft was on approach to runway 17 at the Santiago de Compostela Airport. According to the AIP, the aids to navigation present on that runway are as follows:

ILS CAT III

LOC 17 ***IGO***
GP 17
DME (ILS) 17 ***IGO***
L 17 ***SO*** (L- LOCATOR BEACON)

DVOR/DME *STG*

The airport provided information on the status of the aids at the time of the accident. Readings were taken from the air navigation components involved: parameter readings from the ILS 17 (LOC, GP and DME) and the DVOR, the status of the CD-30[20] communications system, the status of the recording system and readings from the transmitters and receivers for the in-service frequencies [APP (120.2 MHz), TWR (118.75 MHz), GND (121.7 MHz) and emergency (121.5 MHz)]. The operational status of the communications equipment and the navaids was correct and no alarms were recorded on the equipment monitoring these units.

The activation of the ELT was detected at 04:18 by the COSPAS SARSAT system on a frequency of 406 MHz. The network of geosynchronous satellites (GEOSAR), located some 36,000 km in Earth's orbit, detect immediately the activation of the 406 MHz signal although they don't receive any data from the location of the ELT unless it has incorporated a GPS to provide this information. Then, the polar orbit satellites (LEOSAR), at an altitude of about 1,000 km, pinpoint the location of the distress signal and relay this information to a ground station, though there may be some delay in the detection of the ELT. The ELT signal contains a code that the ground station uses to retrieve the aircraft's contact information from an AESA database to determine if the aircraft is either airborne, either on the ground or if it is a false alarm. In this case the aircraft was not included in the database[21]. When the aircraft's position was known, the RCC contacted the Santiago ATC station to see if the signal from the ELT was actually being received on the 121.5 MHz frequency. Nevertherless this signal was not detected by the control tower on the emergency frequency (121.5 MHz) even though the ELT started transmitting from the time of the accident. Later it was confirmed that the ELT had been transmitting but at a very low power. It was only recorded once when another aircraft transmitting on 121.5 allowed the transmission from the ELT to be heard under his audio.

1.9. Communications

Below is a summary of the communications between the crew of the accident aircraft and the different stations involved (Santiago, Asturias and Porto TWR, Madrid ACC and Santiago APP). The messages of most relevance to the investigation are shown in their entirety in Appendix B.

Based on these communications, the crew of aircraft EC-IBA contacted the Santiago tower at 21:46 to obtain start-up clearance and information on the weather conditions and the runway in use at Asturias. At 21:54 they were cleared to take off. After picking up the medical team in Asturias, the aircraft took off at 22:44 and was transferred from Madrid ACC to Santiago Approach at 22:52 at flight level 200 and cleared through to Porto. Once identified on radar, ATC reported the following to the crew: "132 PORTO

[20] From the controller's post.
[21] On the date of the accident, the international regulations (Annex 10) recommended an ELT register and the national regulations urged the operators to send the pertinent information to the authority to be included in the database but within AESA there was not a checking procedure and subsequent inspection of the right execution of this process.

CONFIRMS FOR YOUR INFORMATION THAT LOW-VISIBILITY PROCEDURES ARE IN EFFECT, RIGHT NOW THE CEILING IS AT ONE HUNDRED FEET AND RUNWAY ONE SEVEN RVR IS FIVE HUNDRED METERS”. The crew requested that the message be repeated, which ATC did in its entirety. The crew acknowledged “COPY 132”.

At 23:24 Santiago Approach informed the crew of the Porto frequency so as to communicate with them. At 02:44 the crew established contact once more with APP to report its position. Four minutes later the crew contacted Santiago TWR to ask about the weather conditions at the airfield. At 03:04 the crew contacted Asturias TWR, which provided wind, weather and QNH information and cleared them to descend at their discretion to the runway requested by the crew (29). At 03:21 the TWR controller cleared the aircraft to land on runway 29 and provided information on the wind at the threshold. The crew asked the TWR for the last METAR from Santiago, saying they would write it down once on the ground. At 03:26 the crew again contacted the TWR to copy the weather information for Santiago. The controller said, “WELL, THE METAR I HAVE NOW IS FOR 03:00. WIND CALM, OVER 10 KM, LAYER DISPERSED AT 800 FT, TEMPERATURE 13, DEW POINT 13 AND QNH 1019”. At 03:43 the aircraft was cleared to take off from runway 29 at the Asturias Airport. At 03:53 the Asturias TWR asked the crew to change frequency to Santiago approach.

Three minutes later (03:56) the crew contacted Santiago approach. The controller gave them weather information from the last METAR (03:30) and cleared them to the 10-mile fix. At 04:14, after two descent clearances the controller instructed them to contact the Santiago tower. At 04:15 the crew contacted the Santiago tower, reporting that they were en route to mile 10 on final to runway 17. The controller cleared them to land on runway 17 at 04:15 and gave them wind information (wind calm).

At 04:34 Madrid SAR called the tower controller to ask if a beacon was emitting in the area because the system was reporting that an ELT was active within a 5 km radius. The controller then tried to contact the aircraft three times but received no reply.

The controller then contacted the airport coordinator to request that a marshaller be sent to the hangar to see if the aircraft was there. After it was confirmed that it was not, search and rescue procedures were activated at 04:44. The ATC audio tapes did not reveal any communications on the 121.5 MHz emergency frequency.

1.10. Aerodrome information

The Santiago Airport (LEST) is located 10 km northeast of the city of Santiago at an elevation of 370 m (1,213 ft). It is open 24 h a day (24H). It has two 3,200 m long and 45 m wide runways in a 17/35 orientation. Runway 17, subject to the availability of the corresponding approach and landing aids, is available for Cat II/III operations for those air operators whose operating minimums have been approved by the civil aviation authority. By default, Category I is in effect on either runway, the other categories being available only on runway 17 when the low-visibility procedures (LVP) are activated. These procedures and the requirements for activating them may be found in Appendix A. The landing minimums include the so-called aerodrome operation minimums for approach and landing (in line with the precision approach minimums) at the Santiago Airport for the different categories.

According to the LVP, precision approach operations will only be initiated if the aircraft and its crew are properly qualified for the type of operation anticipated, except in case of an emergency.

At the time of the accident the LVP were not in effect. They were activated at 05:10.

The airport informed that the runway lights were turned on by the TWR on 2 August at 04:08:20 in standard configuration 3 in category I (nighttime, RVR > 4,000 m). The lights remained in that configuration until 05:13, when they were placed in standard configuration 1 in categories II/III (night, RVR < 800 m), when the LVP checks were made.

One mile away from the Santiago Airport runway and in line with it is the STG DVOR/DME. The lighting system for this navaid consisted of three independent red light. There was no perimeter lighting.

The Asturias Airport (LEAS) is 13 km west of the city of Avilés at an elevation of 127 m (417 ft). It has one 2,200 m long and 45 m wide runway in an 11/29 orientation. This airport is open during daylight hours (05:30 to 21:45), though on the night of the accident its hours of operation were expanded due to the ONT flight, at the conclusion of which the airport was closed. During this special operation period the refueling service was available if requested in advance. It was also available on a moment's notice but with the subsequent delay due to the notification and travel time for the personnel.

1.11. Flight recorders

There were no flight recorders onboard nor were they required for this aircraft type[22].

1.12. Wreckage and impact information

1.12.1. *Description and distribution of the wreckage*

The main aircraft wreckage was found along the path toward the runway 17 localizer, 1 NM before the threshold and about 200 m before the STG DVOR/DME at an elevation of 1,200 ft (see photograph 1). During the descent the aircraft first struck the tops of

[22] ICAO Annex 6 Sec. 6.3: All turbine-powered airplanes with a maximum certificated take-off mass of 5.700 kg or less are not required to be equipped with flight recorders.

Figure 8. Impact trajectory

some pine trees before shearing a line of these trees that flanked the north side of a local road. On the other side of the road was a slight incline populated by eucalyptus trees. Along its 40 m long impact trajectory starting at the beginning of the road, as it impacted these more robust trees, the aircraft began losing parts of its wings from the tips to the root, the landing gear and the right engine.

Finally the cockpit impacted one of the eucalyptus trees. The airframe was turned sharply by the force of the impact, ending up oriented toward 230°. The left engine remained attached to the airframe (see Appendix C). The cockpit was destroyed. The instruments on the control panel were found buried in the ground below the remains of the airframe. The first officer was found ejected from his seat. The harness was not fastened though it was verified to still be attached to the seat and that the fastening system worked properly.

According to information from firefighters and forensic police who responded to the site of the accident, there was a strong odor of fuel. There was no smoke or heat emanating from either the fuselage or the surrounding terrain, but as a precaution several fire extinguishers were taken to the site of the main wreckage and a length of hose was extended to the wreckage.

1.12.2. *Inspection of the wreckage*

The engines were inspected onsite. Both showed signs of having been operating at the time of the accident. The throttle levers were in the forward position. The autopilot was off. An inspection of the flaps system revealed that they were selected to an intermediate position (flap app). The gear was down. It was not possible to determine the continuity of the controls due to the damage. The antenna for the ELT, which was inside the airframe, was bent.

The gauges in the cockpit were dug up. Many exhibited significant damage and some were not found. ADF 1 was on and selected to a frequency of 390 (corresponding to SO at the Santiago Airport). ADF 2 was on and selected to a frequency of 418 (the closest frequency in use was 417 for the Santiago NDB). The altimeters were severely damaged and their readings were different and unreliable. The reference mark on the radio altimeter was set to 200 ft. The communications and navigation equipment was turned on. The exact setting of the DME could not be determined. The HSI and ADI for both the captain and copilot were so damaged that they provided no information. A sticker was found on the control panel that read "F/D FLAG INOPERATIVE". The reference altitude reading indicated 1600 ft.

The readings (ITT, RPMs and fuel flow) for both engines were in the green arc and were consistent with the positions of the throttle levers. The oil pressure and temperature readings were also in the green arc. The left and right fuel tank gauges read 1,000 and about 850 respectively.

1.13. Information on the approach made (radar trace)

The radar information on the approach path to Porto supplied by the ATS provider in Portugal shows that during the last segment there were variations consistent with changes in the aircraft's pitch angle indicative of a manual, and not automatic, approach, even though visibility conditions were worsening.

What follows is a description of the approach made by the crew to the 17 threshold at Santiago and a comparison with the information provided on the Jeppesen approach charts that were used during the approach (see Appendix D). The radar trace was used to reconstruct the approach, shown in red in Appendix E. The path it should have taken, as determined by the ILS approach charts, is shown in green, and parallel to that is the same path but assuming the aircraft was heading to the VOR instead of to the runway threshold. The minimums according to the approach charts for the aircraft category (B) are OCA/H 1,406 ft (radio altitude of 236 ft). If the approach is made only using the localizer, this minimum increases to 1,600 ft (radio altitude of 244 ft). The descent rate once established on the localizer should have been about 900 ft/min considering the aircraft's speed. The Jeppesen charts include the ILS Z and LOC Z approaches on the same chart.

The aircraft had been cleared to the 10-mile fix (based on VOR DME/11 NM based on ILS DME), but it flew directly to the 6-mile point (coinciding with the final approach fix (FAP)).

According to the radar information, 5 NM out from the threshold the aircraft was at 3,200 ft and had not started to descend. Based on the references in the chart it should have been at 2,890 ft. 4 NM out the aircraft lined up with the ILS localizer at 2,700 ft and a descent rate of 1,331 ft/min. At that point it should have been at 2,560 ft.

Starting at 3.8 NM out the aircraft descended below the glide slope and continued at a high descent rate in excess of 2,000 ft/min. 3 NM out the aircraft was at 1,900 ft and a descent rate of 2,300 ft/min. At that point it should have been at 2,230 ft (1,890 ft if the crew had thought they were a mile closer).

2 NM out the aircraft was at 1,700 ft with a descent rate of 744 ft/min. Based on the charts they should have been at 1,890 ft.

According to the ILS approach charts, 0.6 NM out the crew should have made a go-around when they failed to reach the minimums (1,406 ft). The aircraft impacted the ground before reaching this point.

1.14. Medical and pathological information

The autopsy report concluded that the immediate cause of death of the aircraft's occupants was trauma to the head and chest. The same report also found that neither crewmember was under the influence of alcohol or mind altering drugs.

1.15. Fire

There was no fire after the impact.

1.16. Survival aspects

Given the characteristics of the accident there was little chance that the aircraft's occupants would survive. However, it should be noted that the first officer was found far away from his seat with no evidence that he was restrained by the safety harness, meaning his likelihood of surviving any impact would have been lower than the captain's.

1.17. Tests and research

1.17.1 *Check of the status of the altimeters*

As a general rule, avionics equipment is "On Condition[23]", except for altimeters, the transponder and altitude indicating equipment, which, pursuant to FAR 91, "General

[23] On Condition: By means of periodic inspections, checks, service, repair and/or preventive maintenance.

Operating and Flight Rules", must be calibrated every 24 months. There is no analogous European regulation in this regard, meaning that compliance with this regulation is not required. Even so, the last check of this equipment was made on 23 September by an outside company. The operator had scheduled the next review for 22 September 2012.

1.17.2. *Check of the operation of the flight director (using "F/D flag inoperative")*

According to the operator the "F/D flag inoperative" warning had been displayed at the top of the copilot's ADI for a long time, though the cause was not really known. The maintenance records for the flight director were collected and maintenance files were found that made reference to a fault with the first officer's FD flag, which was not fully displayed when the equipment was completely turned off (Master Off) even though the system was working. The maintainer (external maintenance center) noted this during the release to service, but eventually the operator proposed its replacement, which was done. After this repair no one noticed that the flag continued to be displayed as a warning in the cockpit, and even the operator accepted it as an additional check to be made when turning off the equipment, even though the system had been repaired and should have functioned properly.

1.17.3. *Inspections of aircraft components*

Navigational equipment

The NAV2 unit was verified to have had modification 11 done as per bulletin SB KN53-11, associated with FM immunity[24]. This was marked on its casing. The NAV1 unit had not been modified. This modification could be implemented in one of two ways: by replacing the navigation unit (normally the display was preserved) or by inserting a filter (K55) between the receiver (NAV unit) and the display (HSI). Therefore, even though NAV1 had not been modified, it is not known whether the filter was inserted for some reason (the filter was not found). FM immunity would only have affected communications and the localizer signal for an ILS operating in the 100 MHz range. The glide slope signal, which was in the 300 MHz range in this case, would not have been affected by the modification.

The NAV1 unit was energized to see the frequencies selected by the captain at the time of the accident. The active frequency was 10.30 MHz (the ILS frequency), and the standby frequency was 116.40 MHz (the Santiago VOR).

[24] This immunity is due to the fact that commercial FM stations were allowed to double their power output, which could interfere with the signals sent to aircraft. Crew statements were used to make a map of this interference.

Figure 9. Frequencies selected on NAV1 (captain)

This model of navigational unit has the glide slope converter in the unit itself, meaning the quality of the glide slope signal being received by the NAV1 unit could be evaluated. The centering, deflection and flag activation parameters were checked with their respective tolerances and found to be working properly.

The NAV2 unit was likewise energized to see the frequencies selected by the first officer at the time of the accident. In this case the display was of worse quality. The legible active frequency was 111.90 MHz (not associated with the ILS frequency) and the standby frequency was 116.40 MHz (Santiago VOR). The active frequency did not correspond to any known frequency. The signal quality was evaluated and it was determined that the actual frequency selected (though the reading on the display was not clear) was 111.30 MHz. The closest frequency to this was 111.35 MHz, in use at the Biarritz Airport, which was not included in the crew's planning and does not have 24 hour service. As with the other unit, the proper frequency was selected (110.30 MHz) and the centering, deflection and flag activation parameters were checked with their respective tolerances and found to be working properly.

The signal from the VOR/LOC converters was likewise checked. These units were found in the wreckage after the fact and sent in by the operator. The results for the VOR converters on both units were acceptable (centering normal and deflections below the specifications in the Manual but the information provided was correct). The LOC converter in unit 1 gave good results and the LOC converter in unit 2 resulted in the flag always being displayed even if the centering and deflection information was good.

Figure 10. Frequencies selected on NAV2 (copilot)

DME

Figura 11. Inspection of the DME unit

The wiring diagram was used to check the various positions on the switch for the DME unit (NAV1-HOLD-NAV2). All had continuity. The OFF position did not give a signal, since there was no continuity. In other words, the switch worked correctly.

During the inspection the control used to select the various switch positions was one position out of phase, meaning that when it was set to OFF, it was in reality set to NAV1, and when it was in the NAV1 position it was actually in HOLD (see photograph). The switch was disassembled and the shaft on which it rotated was slightly scuffed by the fixing screws. This can occur if the switch is forced to either extreme, and leaves it out of phase with the actual position on the switch.

The operation of the HOLD indicating lamp was tested by powering the light directly and then through the corresponding wiring on the DME. The lamp turned on in both tests.

1.18. Organizational and management information

1.18.1. *Information on the operator. Provision of service*

The company AIRNOR had had a valid and in force Air Operator Certificate since July 2008. Its AOC included the Cessna Citation 500 aircraft with registrations EC-IBA and EC-JXC. In this case the operation types authorized were passenger and cargo. The areas of operation were AFI and EUR, and there was a special authorization for basic navigational (BRNAV)[25] operations.

Rev. 4 of its Operations Manual had been accepted by AESA in 2008. It was also authorized as a continuing airworthiness maintenance organization (CAMO) in 2007, this authorization being limited to the aircraft included in its AOC. Its Operator Aircraft Maintenance Program[26] had been accepted by AESA in 2010.

The operator had two Cessna 500 (501/SP) aircraft and seven crewmembers (four captains and three first officers). As the operator informed, their typical service procedures[27] did not require the crew to be physically based at any one location; instead, whichever crew was on call had to be reachable by telephone. The on-call schedules rotated monthly and were planned at least 15 days in advance so that crews could plan their rest times. The duty rosters were created taking into account crew ratings, limitations, medical certificate expiration dates and so on, as well as the duty tables. These schedules reflected both on-call days and rest days. As a general rule crews were on call from 13:00 until 23:00 local time[28], subject to change as required to meet the needs of both the company and the crews. The operator had apartments in Santiago for use by on-call crews. The maximum daily flight time was set at 13 h, reduced by 30 minutes for each segment after the third segment, with a total maximum reduction of two hours.

The schedule for August called for a new captain on 1 August. The new captain had been off for four days. On the day of the accident the first officer had been on call for three days out of a total of five and had not flown on any of those days.

The limits on flight time, duty time and rest requirements are established in RD 1952/2009 and Subpart Q of EU OPS.

In the specific case when the National Transplant Organization (ONT) requested a flight, the procedure was as follows:

[25] E1 was not included (CAT II).
[26] Ref. ANW Cessna Citation 500 (Ed1; Rev6; 06/2010).
[27] Procedure pending AESA approval for inclusion in the Operations Manual.
[28] 11:00-21:00 UTC during the period when the accident took place.

1. Confirm service viability (availability of crew and aircraft, response time, etc.).
2. If the service is feasible, communicate with LANCELOT[29] for the corresponding flight dispatch (FPL, Meteo, NOTAMs, etc.).
3. Receive and print out all required documentation.
4. Crew travels to airport, holds briefing and prepares the flight.
5. Pre-flight inspection, refuel if needed and take off.

The ONT reported that the last four flights made using the accident aircraft had been on the following dates:

- 27/07/2012: Santiago-Asturias-Santiago.
- 26/07/2012: Santiago-Coruña-Alicante-Coruña-Santiago.
- 24/07/2012: Santiago-Pamplona-Santiago.
- 20/07/2012: Santiago-Santander-Alicante-Santander-Santiago.

The structure and contents of an operator's Operations Manual (see Appendix E) are specified in the EU OPS. 1.1040 contains the general rules for writing the manual and 1.1045 provides the structure and contents of the Manual, which must be accepted by the Authority. Appendix 1 to OPS 1.1045 specifies the contents of the Manual, dividing it into four sections:

A. General/B.
B. Airplane operating matters.
C. Route and aerodrome instructions and information.
D. Training.

Part A was complete, though there were inconsistencies among the operator's core positions.

Part B of the Operations Manual was a transposition of the manufacturer's Flight Manual and contained checklists, but not procedures or functions specific to the members of the crew. It did not include the Standard Operating Procedures (SOP) and in general it lacked information on other aspects addressed in the regulations.

Part C did not comply with the requirements in EU OPS 1.1045 regarding route and aerodrome instructions and information.

Part D of the Manual, on training, did not specify where, how or when crew courses and training were held.

[29] Specialized external flight planning service that provided the crew with the documents necessary to prepare and carry out the flight.

1.18.2. *Information on the Authority. AESA inspections*

Operational inspections (company)

According to AESA, the documentation for the inspections of the operator did not reveal any deficiencies. As AESA reported, there are established procedures for carrying out inspections. Everything is not always inspected, but rather selected areas are selected for inspection.

Various inspections were made in 2011 and 2012 as part of the Continuous Monitoring Plan. These detected discrepancies or findings that were closed out after the relevant corrective actions were taken. Some involved missing entries or signatures, or the non-performance of specific operational tasks. None of them involved the lack of distinct crew functions or the lack of standard operating procedures.

The operator was inspected several times in August and September 2012 as a result of the accident. The latter of these detected various discrepancies involving the lack of training programs in the course records, missing flight inspection signatures in the TLB, missing signatures to confirm the start of crew duty times, etc. One entry noted that "For a single-pilot airplane, the operator does not have its own multi-crew procedures for normal, abnormal and emergency operations in Part B of the Operations Manual".

On 15 November 2012 the Authority started proceedings to suspend or revoke the operator's AOC and operating license based on the discrepancies found during the inspections conducted in September 2012, and referenced the following discrepancy: *"One of the discrepancies detected is that the checklists on the airplane are for a single pilot, but operations must be multi-pilot in order to comply with EU OPS 1.940 (b). The aircraft is certified for single-pilot operations and therefore the lists carried onboard are those published by the manufacturer, which do not consider the task allocation required for the types of operations carried out".*

The operator regained its AOC on 13 December 2012 after creating SOPs and familiarization courses.

Airworthiness inspection (aircraft)

According to the applicable regulation[30], the Authority on several occasions delegates the technical inspections for issuing and renewing airworthiness certificates to other

[30] Part 21/ Annex I N.º 1194/2009 of 30 November 2009 amending Regulation (EC) N.º 1702/2003 laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances as well as for certification of design and production Organisations.
Parte M. Commission Regulation 2042/2003 of 20 November 2003 on the continuing airworthiness of aircraft and aeronautical products, parts and appliances, and on the approval of organisations and personnel involved in these tasks.

organizations. Its main task is to supervise the process. The physical inspection or in-flight test of an aircraft is almost never conducted by the Authority. The Authority does, however, engage in various inspections not directly associated with airworthiness certificate renewals:

- Scheduled: ACAM[31].
- Unscheduled: SANA[32] on-ramp inspections.

The ARC (Airworthiness Review Certificate) was issued pursuant to the applicable regulation based on the favorable report issued by a CAMO++ organization with privileges Subpart I (CAMO+ from now on). The company itself, as an authorized CAMO with privileges Subpart G, could have extended its ARC twice as per its internal procedure. The ARC was valid until 2 March 2013. The next ARC would have to be issued based on the other favorable report issued by a CAMO +CAMO+.

During the last audit by the Authority to the usual CAMO (Continuous Surveillance Plan), carried out in June 2012, discrepancies were detected involving the lack of an updated manufacturer-approved maintenance program, not specifying in the CAME[33] where to record the flight inspection in the log book, and the absence of updated MELs. The initial deadline for the corrective actions associated with these discrepancies was 25 September 2012.

No information was provided about product inspection (wich could include physical inspections to aircraft) made by AESA. According to documentacion provided by AESA there was no information about discrepancies noted regarding a lack of log book entries made by the crew involving anomalies in the aircraft, nor how these were resolved by maintenance.

In April 2012 a SANA inspection of the aircraft detected discrepancies involving aircraft documentation that should have been onboard (it had been left behind in Santiago). The flight plan and load sheet were not signed or printed out since the captain had them on his personal electronic device. It was also noted that the checklists did not match those in the Operations Manual and did not have revision dates. The navigational charts were not up to date. Not all the items on the inspection list were evaluated.

An inspection of the fleet's other aircraft in June 2012 revealed signs of corrosion, chipped paint and various other defects on the aircraft that apparently had not been reported and/or evaluated.

[31] Aircraft Continuing Airworthiness Monitoring.
[32] SANA: Safety Assessment of National Aircraft Program.
[33] CAME: Continuing Airworthiness Management Exposition.

1.18.3. *Human factors and fatigue*

There are numerous studies that analyze fatigue factors in crews. "Pilot Fatigue Barometer" contains a study based on crew surveys that concludes that fatigued pilots are more likely to fall asleep, experience micro-sleep episodes and feel drowsy during flights. Insufficient rest or sleep periods and long duty shifts cause crews to be particularly prone to fatigue. The study indicates that pilots subject to fatigue have a higher probability of making mistakes at critical moments.

1.18.4. *Stabilized approach criteria*

The elements recommended for making a stabilized approach, as per the criteria published by the Flight Safety Foundation[34], include the following:

- Sink rate is no greater than 1,000 ft per minute; if an approach requires a sink rate greater than 1,000 ft per minute, a special briefing should be conducted.
- Specific types of approaches are stabilized if they also fulfill all of the following; ILS approaches must be flown within one dot of the glideslope and localizer.

Based on these criteria:

- An approach that becomes unstabilized below 1,000 ft above airport elevation in instrument meteorological conditions (IMC) requires an immediate go-around.

1.19. Additional information

1.19.1. *Fuel*

The aircraft took on 1,062 l of fuel at the Santiago Airport, meaning that it had 3,500 pounds of fuel before starting the ONT service, as per the crew's annotations.

LEST-LEAS Segment

According to the flight plan, the aircraft should have consumed 777 pounds in this segment and would have arrived in Asturias with 2,723 lb of fuel. According to the crew's calculations, written down in the flight plan, the aircraft reached the Asturias Airport with 3,000 lb of fuel. The duration of the flight and the taxi phase was verified to have been longer than calculated by the crew.

LEAS-LPPR segment

According to the flight plan, the aircraft should have consumed 1,548 lb in this segment and would have had 1,175 lb of fuel after landing in Porto. Based on the crew's entries,

[34] http://flightsafety.org/files/alar_bn7-1stablizedappr.pdf.

the aircraft consumed 1200 lb, meaning that according to their calculations they arrived in Porto with 1,800 lb. At Porto the aircraft took on 1,585 lb of fuel, and would thus have departed with 2760 lb (3,500 lb per the crew's annotations).

LPPR-LEAS segment

Only the calculations in the flight plan were available for this segment. The original carried by the crew was not recovered. Based on these calculations, the aircraft would have consumed 1,227 lb in this segment and would have had 1,533 lb remaining after landing in Asturias.

LEAS-LEST segment

According to the flight plan, the aircraft should have consumed 782 lb in this segment and would had 751 lb of fuel remaining. Had the crew needed to divert to the alternate (LEVT), they would have needed 1,108 lb of fuel to fly 1:01 h + 471 lb to fly an additional 30 minutes, as required by regulations (a total of 1,579 lb).

In light of the data considered by the crew (which would have been subject to cumulative errors), the aircraft would have arrived in Santiago with 1,376 lb (instead of 751 lb). The minimum legal required to go to the alternate would have been 1,579 lb.

The fuel gauges read 1,000 and approximately 850 lb in the left and right tanks respectively.

1.19.2. *Landing control and alert phases*

Airport officials reported that the area for exiting runway 17 is screened by the old control tower, as a result of which a security camera was installed to resolve this problem. The images from this camera are displayed on the SACTA system.

Figure 12. View from the control room in the tower of the runway 17 exit and images from the camera

The information regarding the alert service that must be provided to aircraft is contained in Chapter 5 of Spain's Air Traffic Regulations (RCA), which is reproduced in Appendix F. Based on this information, the alert phase, or ALERFA, will be activated when an aircraft is cleared to land and does not do so in the five minutes following the expected landing time and contact cannot be reestablished with the aircraft.

1.20. Eyewitness statements

1.20.1. *Air controllers*

The approach controller reported that on the night of 1 August he worked the night shift, as per the duty schedule. At around 04:00, aircraft EC-IBA (call sign ENW142), an ambulance flight originating in LEAS and headed for LEST, established radio contact with him over point ROXER. He then identified the aircraft on the radar and gave the crew information on the Santiago Airport, offering them to proceed to mile 10 on the approach to runway 17, which the crew accepted. After a few minutes the crew requested to descend and the controller cleared them to 6,000 ft and then to 3,000 ft to make the ILS approach to runway 17. The aircraft continued to descend and as it neared the localizer, he transferred communications to the tower controller.

According to the approach controller when runway 17 is in use, it is common practice for traffic to be cleared to make the ILS approach straight in from the published 10 mile fix on the VOR (11 DME ILS), which is familiar to pilots based at the airport or that routinely fly into it. This avoids delays by not having to execute the full procedure.

The tower controller explained that at 04:14 the aircraft with call sign ENW142 called on his frequency and he cleared it to land on runway 17. The wind was calm. Some time after issuing the clearance, and given that it was an aircraft that normally proceeded to its usual parking stand without assistance from the marshaller, he attempted to verify through the airport's coordination office that the aircraft was indeed parked at its stand. Simultaneously SAR reported that they were receiving a signal from an emergency beacon north of the airport (within 5 km). This signal was not received on the tower equipment despite being tuned in to the correct 121.5 MHz frequency. The marshaller confirmed that the aircraft was not in its usual parking stand, at which point the search and rescue procedure went into effect. In his statement the controller said that he could not visually confirm whether the aircraft had landed due to the visibility problems caused by the fog, and also because the old tower screens the runway exit that the airplane would have taken to go to the hangar. Since the crew was based in Santiago and normally did not need or request aid from a marshaller to guide them to the hangar, he thought that perhaps they had already taxied to the hangar as they had on other occasions.

1.20.2. *AIRNOR crews*

Four of the seven pilots who worked for the operator (one was actually the owner and only piloted as required) were interviewed. In general all agreed that the main aircraft for operations was EC-JXC, with 99% of flights being to transfer organs. The company had been in business for 20 years. They made two or three monthly flights for the ONT. The accident aircraft had been inoperative for about six years and in use some six months. Its approach category was I. There were a total of seven pilots, all of whom were qualified captain since the airplane was single pilot, although when transporting passengers they needed to have two pilots, as per EU OPS. Four acted as captain and three as first officer. Each aircraft had three crewmembers assigned to it. They had a company telephone that was rotated to the on-call crew. The operator had apartments for on-call crews. The dispatch was subcontracted to Lancelot, and they had the means necessary to receive the documentation in the apartments or in the hangar. When the service was activated they had to be at the airport 45 minutes ahead of time. The handling service was provided by the crews themselves. In general the discrepancies were noted in the technical log book and maintenance was informed of any problem. The operator's staff all trusted one another. It was a small company and they all communicated in person, either on the phone or by email. There was no record of any problem with the aircraft. It had had a fuel leak and a low oxygen level but that was normal for an old aircraft. They did not recall the F/D flag ever being operative. One of the pilots had asked maintenance about the presence of the "F/D flag inoperative" and he was told that in fact the flag was for the directional gyro (GYRO). This flag did appear while taxiing and would later clear. When shown the list of discrepancies send by the accident captain to the operator, another pilot admitted that some existed, though they had been corrected.

The aircraft had been out of service due to a SANA inspection at the Torrejón Airport after discrepancies were found involving documentation that had been left behind at the hangar in Santiago. After this inspection it was decided not to remove the documentation from the aircraft and to notify all crews of this by means of an operating circular.

There were no standard operating procedures (SOP) at the operator but they were being written. Crew operations were generally standard in keeping with the Manual. The proficiency checks were carried out by an AESA-authorized CRE. The checks of the operator were done by the CRI, who was also a crewmember. As a result, the non-existence of the SOPs was offset by the fact that the individual who did their checks was always the same person, who instilled standard procedures in every crew.

The standard approach procedure relied on the autopilot, which was disengaged when everything was confirmed or when the flaps were in the landing position (about 2 NM out).

50-100 NM before commencing the descent the approach is briefed (review of minimums, NOTAMs, expected approach type).
15 NM before the descent the "Before descent" checklist is done.
10 NM before the descent the "Approach" checklist is done. Flaps are selected to the approach position (202 IAS).
6 NM out (FAP) the gear is lowered (176 IAS).
2 NM out full flaps are selected and the autopilot is disengaged.

The reference altitude selector was normally checked and selected again at:

- The FAP.
- 500 ft above minimums. Missed approach reviewed and missed approach altitude set.
- 200 ft above minimums, final check.

Approaches in IMC were done in automatic (A/P). The autopilot in approach (APP) mode takes care of capturing the localizer and glide slope and in navigation (NAV) mode it intercepts the selected radial. One of the pilots stated that the capture was "sluggish" because it was very old. The NAV mode would normally be used first and then APP once established on the localizer. 500 ft above minimums they selected the go-around altitude and the autopilot was disengaged at the altitude minimums (decision altitude).

The approach could be made:

- in manual with and without the F/D (the latter only in VMC), and
- in automatic with and without the F/D.

In general the difference between the tasks of the pilot flying and the pilot not flying (PF and PNF) was that the former would handle the tasks associated with flying while the latter took care of communications and read the procedures. During an ILS approach if the PNF had the VOR frequency on his HIS, he would say it so that both crewmembers were aware of the fact that the readings would be different. The DME was normally set to NAV1. Its HOLD mode was not typically used.

In the opinion of his coworkers, the accident captain used to fly more in manual due to the experience he had on the aircraft. The first officer made more use of the A/P and F/D. On arriving in Santiago they normally reported to the controller "runway clear" and "marshaller in sight".

That night, while waiting in Porto, the first officer spoke with one of the operator's other pilots to solve a problem with the use of the company's card to pay for the fuel, and noted that they had been in a bind and had to descend below the minimums a bit to land in Porto.

1.20.3. *Other statements*

One of the members of the medical team that travelled on the day of the accident with the crew recalled that the flight had been normal, noting only that they had encountered a lot of fog when landing in Porto. In general they did not notice anything unusual with the crew or the aircraft and the return flight to Asturias was normal.

In contrast, several people familiar with the aircraft (either directly or as passengers) stated after the accident that the aircraft had some problems, it was very old and its instruments were at the limit. Several of these accounts agreed with the list of discrepancies sent by the captain to the operator involving differences in instrument readings and the operation of the engines.

1.21. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

2.1. Status and condition of the crew

The crew had been on call from 11:00 until 21:00 and was called in to make a flight for the ONT at 20:40. The service consisted of flying a medical team from Asturias to Porto, where it would extract an organ. The aircraft took off from the Santiago Airport at 21:54 en route to Asturias and then to Porto, where it landed at 23:40. Once the medical team completed its task, the aircraft took off from Porto at 02:34, dropped off the surgical team in Asturias and returned to Santiago. At 03:56 the crew made contact with Santiago approach, which provided the crew with the 03:30 METAR and cleared them to make the ILS approach to runway 17 at the Santiago Airport. At 04:15 the crew contacted the tower controller, who reported that the wind was calm and cleared them to land on runway 17. At 04:18 the COSPAS-SARSAT system detected the activation of an ELT. The aircraft had crashed to the ground in the vicinity of the airport's VOR, one mile before the runway threshold.

The operator's on-call procedure was not included in its Operations Manual, though it had been sent to the Authority for approval and subsequent inclusion in the Manual. Even so, this procedure was in use on the date of the accident and abided by the flight and duty times and rest requirements specified in RD 1952/2009 and in Subpart Q of the EU OPS. As a general rule the on-call time lasted from 11:00 until 21:00 during the period of the accident. The crew was called in at 20:40, twenty minutes before they were scheduled to go off-call. Despite being in line with regulations, it should be noted that the course of events for the crew during that day had been normal in terms of their typical sleep and rest activities, meaning that calling in the crew just a few minutes before their on-call cycle was due to expire for a service that would last more than six hours and take place at a time of day more associated with sleep (Circadian rhythm) could have greatly contributed to an increased sensation of fatigue and drowsiness in the crewmembers. The last segment from Asturias to Santiago may have been characterized by excessive fatigue in the crewmembers, in combination with the complacency caused by arriving at their destination. Crew fatigue studies have shown a propensity toward more errors under these circumstances.

Based on the information available from previous flights, the accident flight (from Santiago) was the second time that these crewmembers had flown together. The first officer had been at the operator since March and the captain had just started working there in late June, though he had worked for the operator previously.

According to information provided by the operator, there were irregularities in the records of the captain's proficiency checks. There were signed checks on days when no record existed of the examiners/instructors having been onboard. The ten sectors needed to become a qualified captain had not been flown with an examiner, instructor, inspector or supervisor who was duly qualified by the aviation Authority, as required by EU OPS 1.955.

The previous flight made by the crew of the accident had taken place when, according to the captain's training records and the requirements of the Operations Manual, he was not yet a qualified captain.

2.2. Condition of the aircraft

The aircraft was a Cessna 500 Citation I. It had an exception that allowed it to be flown by a single pilot (S/P 501). In its Operations Manual, the operator did not have Standard Operating Procedures (SOPs). Since the aircraft could be flown by a single pilot but had two crewmembers onboard (as required by passenger transport regulations), there was no distinction between the duties of the PF and PNF nor procedures to coordinate their actions.

The aircraft's airworthiness review and maintenance documentation was in order. The information taken from the aircraft's maintenance records, the list of discrepancies sent by the captain to the operator, information from the other crews, accounts from people who had flown or had had access to the aircraft, and the findings from the SANA inspection reports (some of which involved the other aircraft in the fleet but which shared common deficiencies in terms of corrosion, paint and general condition) were analyzed and compared. The aircraft had two deferred items that had been corrected. There were no discrepancies annotated in any of the log books by the crews, which always signed for the pre-flight inspection and the acceptance of the aircraft. Based on all this information the investigation has concluded that the aircraft had several deficiencies, though their existence and resolution by maintenance could not be confirmed through the entries made by crews in the log book (TLB). The aircraft did not have flight recorders, nor were they required. As a result there was no information available from the onboard equipment that could have shed any light on any faulty readings in the cockpit. The inspection of the navigational units recovered showed no evidence of a malfunction in how the localizer or glide slope signals were received, except for the flag permanently displayed on the copilot's localizer. The altimeters, which according to several eyewitnesses gave different altitude readings, were in very bad condition. It was thus impossible to draw any conclusions as to whether or not these differences had any effect on the accident. They had passed the legally required inspection for instruments (phase 20) on 23 October 2010. The next required inspection was due 24 months later, and the operator had scheduled it for 22 September 2012. The AMT who maintained the aircraft had a B1.2 and C category aircraft maintenance license with a Cessna 500/501/551 (PWC JT15D) rating. He did not have a B2 license with an endorsement to maintain the avionics suite, meaning that any fault with that equipment had to be referred to another center and could not be handled immediately, which was the typical procedure, as stated by the crews. In this regard a safety recommendation is presented later in this report.

As for the accounts involving faulty equipment readings, outdated labels warning of malfunctioning equipment in the aircraft, the lack of entries in the TLB on malfunctioning equipment, and the information contained in the list of discrepancies sent by the captain to the operator, one might infer that even though the aircraft's checks and inspections were completed as required, there was a mistrust among the crews about the readings provided by the equipment in the cockpit.

The program used to maintain the aircraft had not been updated annually, as required by the program itself, nor did it reflect the latest documentation from the manufacturer, although for the checks made after the last edition of said documentation the operator did use the most recent versions of this documentation.

Based on the information in the operator's Operations Manual, part B was a copy of the manufacturer's Flight Manual, which contained checklists for a single pilot but not specific procedures or functions. There was no clear distinction between the duties of the two crewmembers. Though it was in the process of writing them, the operator did not have the SOPs in its Operations Manual. This might have compensated for the lack of assigned tasks. There were also no standard training procedures. The only standardization was provided by the fact that they all had the same chief instructor, who taught common practices to all the crews.

2.3. Inspections by the Authority

The aviation Authority AESA had conducted several inspections in 2012 and earlier of both the aircraft and operator. The SANA inspection of the aircraft was of its paperwork only. Since the Authority delegates the ground and flight inspections to the relevant CAMO (though not the competencies of the inspections themselves), the ACAM/SANA inspections should, in some way, compensate for this lack of knowledge of the real condition of the aircraft beyond its documents. The operations inspections review different parts of the operator's structure and documentation. It should be noted that these inspections did not reveal any glaring deficiencies, though once the accident occurred, the Authority conducted a series of extraordinary audits that did reveal a multitude of deficiencies, including the absence of SOPs in a single-pilot airplane operated by a two-pilot crew. It was as a result of this discrepancy that the process of revoking the operator's AOC was commenced. This sequence of events reveals that AESA's oversight was unable to detect those deficiencies that weighed most heavily on safety. This is the reason for the issuance of the safety recommendation that is presented later in this report.

2.4. Conduct of the flight

Based on the information on the weather conditions at the Porto Airport, the low-visibility procedures (LVP) were activated at 21:24 on 1 August and terminated at 05:48 on 2 August. At the time of the flight's arrival in Porto, weather conditions were worsening. Several SPECIs were issued informing of the deteriorating visibility due to fog at the runway 17 threshold, which ranged from 600 m at 23:02 to 800 m at 23:46. While flying from Asturias to Porto, the crew had been informed by Santiago Approach that the airport had activated its LVP and that the cloud ceiling was 100 ft and the RVR on 17 was 500 m shortly before. In light of this information, the aircraft and crew were limited to making a Cat I approach (RVR 500 m and DH 60 m (200 ft)). Though by the time they arrived in Porto conditions had improved noticeably and the minimums for Cat I were met, the crew admitted to another of the operator's pilots that it was "tight" landing in Porto. The radar trace from this approach also shows that the last part was done in manual, with constant adjustments to the pitch angle to stay on the glide slope.

The crew refueled the aircraft in Santiago at the start of the flight and then in Porto. Based on the entries in the flight plan involving taxi and flight times, the crew arrived at the Asturias Airport with 2,723 lb (3,000 lb annotated by the crew) and at Porto with 1,175 lb (1,800 lb according to the crew). After refueling in Porto, the aircraft would have reached Asturias with 1,533 lb (the entries made by the crew were not available for these final two segments). In light of the fuel data being considered by the crew, with their cumulative errors and less conservative than the calculations made using the taxi and flight times, the aircraft would have reached the vicinity of Santiago with 1,376 lb. The minimum legal required to go to the alternate would have been 1,579 l. The crew, then, should have refueled once more in Asturias before starting the flight to Santiago or stayed there overnight, since they did not have sufficient fuel to proceed to the alternate and have the additional required reserve. Had they decided to refuel, they would have had to wait for the fuel supply company personnel to reach the Asturias Airport since the service was not staffed at that hour as they had not requested it ahead of time. Once the crew decided to take off from Asturias, the airport closed down. The fact that they did not have sufficient fuel to reach the alternate could have left the crew without options, forcing them to land at the Santiago Airport. In fact the crew, when requesting weather information from the Santiago tower, expressed their concern over having to divert to the alternate. The fuel gauges read 1,000 and about 850 lb the left and right tanks respectively, 1,850 lb in contrast to the 1,376 lb figure (with the errors accumulated by the crew), which is not reliable considering the data annotated and the earlier fuel use. This fact reinforces the hypothesis regarding the crews' mistrust of the information provided by the equipment in the cockpit.

The Santiago Airport at the time of the accident, as described in the last METAR before the same (04:00), was in VMC. The LVP were not in effect. The weather information in the 04:30 METAR (not available to the crew), gathered from the 10 minutes prior to its issue time, would have reflected the conditions that the crew most likely faced at the time of the accident. The prevailing visibility in the airport at that moment was 5,000 m, the runway visual range at threshold 17 was yielding visibilities of between 450 m and 1,700 m. Conditions degraded gradually after that at the airport, meaning that in the vicinity, where the accident occurred, a mist might have existed of the kind that typically forms in the valleys around the airport. Even though there was a full moon and it was almost dawn, this mist could have suddenly obscured the crew's view of the ground as they neared the airport, causing conditions on the runway to degrade to the point where the LVP were activated.

2.5. Navaids at the Santiago Airport and condition of the aircraft's equipment

According to information provided by the airport, there were no faulty VOR or ILS signals nor any alarms associated with the equipment monitoring these systems. There were no warnings from the aircraft that landed either before or after the accident informing of an irregular signal. Based on this it may be concluded that there were no faults in the signals provided by the navaids. Also considered was the possibility that the crew made a visual approach to the VOR, confused by the lights on this navaid in the fog. This hypothesis was ruled out by the obvious differences in the lighting arrangement.

The aircraft had a DME unit installed in the right half of the instrument panel that allowed the crew to determine the distance in nautical miles to the navaid whose frequency was selected on the navigational equipment, as long as these frequencies were associated with the DME and they were operational. As other crews reported, this unit was not normally modified and would normally have been selected to NAV1 mode, meaning it would have displayed the distance to the navaid selected by the captain. The inspection of this unit, whose original markings could not be determined at the crash site, revealed that there was continuity in the switch except for the OFF position, meaning that the unit worked and that the switch on the unit was one position out of phase with the position that was actually selected. The HOLD mode warning light also worked.

The navigation units (and associated GS converters) were recovered, as were the VOR/LOC converters. They were energized and inspected and verified to be in calibration. Investigators were also able to see the frequencies selected on each navigation unit:

- The first officer had the ILS frequency set to 111.30 MHz instead of 110.30 MHz, which is not associated with any nearby navaid. The display, however, was subject to interpretation and it may have been set to 111.30 MHz believing that the actual frequency selected was 110.30 MHz. The standby frequency was for the VOR (116.40 MHz). The ADF indication selected on the first officer's panel also differed from the real one by one digit (418 instead of the 417 of the Santiago NDB) (SNO).
- The captain had the ILS frequency correctly set to 110.30 MHz, the standby frequency set to the VOR (116.40 MHz) and the ADF to 390 (Santiago NDB) (SO).

2.6. Probable approach and impact sequence

Based on all the information gathered and subsequently analyzed during the investigation, the series of events that could have resulted in the aircraft's impacting the ground without its crew losing control of it (CFIT) is presented below.

The main aircraft wreckage was found along the path to the runway 17 localizer, 1 NM before the threshold and some 200 m before the VOR/DME, at an elevation of 1,200 ft, similar to the reference elevation of the airport (1,213 ft).

The readings for both engines (ITT, RPMs and fuel flow) were in the green arc and were consistent with the positions of the thrust levers. The oil pressure and temperature gauges were also in the green arc. The subsequent inspection of the engines concluded that they were in operation at the time of the accident.

The aircraft had been cleared to the 10-mile fix (per the VOR DME/11 NM per the ILS DME). The navaid that the crew would have used initially to fly to the fix would have been the VOR, though they ended up going directly to about the 6-mile point, where the FAP is. By that point they should have captured the localizer and just started to capture the glide slope (see Appendix E). Later ATC cleared them to make the ILS approach straight in to runway 17 at LEST, whose published minimums were 1,406 ft (236 radio altitude).

The crew had selected 200 ft on the radio altimeter and 1,600 ft on the reference altitude selector in the cockpit. The 1600 ft figure was determined by the altitude minimums for the LOC Z approach instead of the ILS Z approach, the two numbers being close to each other on the chart. This indicator was located on the first officer's side. It is not known why these minimums were selected. The first officer's ADF frequency was off by one digit. It is possible that the accumulated fatigue from all the flights played a role in diminishing the first officer's attention span and increasing his error rate. The active frequency on the navigation unit was 111.30 MHz (instead of 110.30 MHz) and did not correspond to that of any known navaid. This unit's display was not good and it was hard to distinguish the digits. This would have meant that the first officer would have had the localizer and glide slope bars centered on his HSI and that both flags would have been displayed. The inspection of the LOC converter unit after the accident revealed that the localizer flag on the HSI was always displayed even if the centering and deflection information was correct. In other words, the localizer flag was usually displayed but not the glide slope's. The fact that the glide slope flag was displayed probably alerted him to check if his indication differed from that on the captain's HSI. In the case of the first officer both bars would have been centered with the flags displayed. In the captain's case, the bars would have been moving toward the center (they were looking for the localizer and above the glide slope) and no flags would have been displayed.

This inconsistency would have aggravated their mistrust of the cockpit instruments (presence of the "F/D flag inoperative" which did not correspond with reality, GYRO flag displayed when taxiing, different altimeter readings and contradictory HSI readings, as noted by the captain). It may also have confused them to the extent that it increased their workload significantly during the approach phase, which had already been shortened to the FAP, with the ensuing accumulation of tasks. The crew probably noted the discrepancy and the copilot may have attempted to troubleshoot the equipment, as the pilot monitoring (PM), while the captain flew the aircraft.

The pilot flying was the captain, who was more used to making approaches in manual than in automatic. According to the company's usual procedures (not reflected in the Operations Manual), the approach was flown in automatic until about 2 NM before landing, at which point the autopilot was disengaged. One of the operator's pilots stated that the A/P was slow to capture because it was very old. Given the fact that the approach was being made to a familiar airport on a night with a full moon and good visibility, conditions were probably well suited to making the approach in manual before capturing the glide slope with the course already captured on the localizer. The crew had made a similar approach to Porto in manual despite being at the limit for operating in Category I conditions. The investigation was unable to determine if the glide slope indicator in the HSI failed. The signal converters were verified to have been working properly.

Based on accounts from the remaining operator crews, the DME unit was not operated and was kept in the NAV1 position, providing information on the selected navaid. In this case no one would have noticed that the switch indication was out of phase with reality if it was not normally used. While attempting to confirm the cause of the glide slope flag being displayed and the lack of indications on his HSI, the first officer may have selected NAV2 on the DME to see if a distance was displayed. But the improper frequency would have yielded no distance, meaning he may then have selected the VOR frequency from standby to active to see if a distance reading was displayed, then returned the DME unit to its original configuration (on NAV1). Due to this problem with the switch, he would actually have activated HOLD mode; that is, the distance shown from then on in the captain's HSI would have been to the last navaid selected (VOR2 STG). In this case the light on the unit would also have turned on but again, due to their mistrust of the cockpit's displays or due to fatigue, they may not have given it the proper attention.

After that point, the captain would have suddenly believed he was one mile closer to the runway, which could have made him increase their descent rate sharply to capture the glide slope. It is not known why the captain decided to make the approach without the aid of the glide slope and to go by distances and altitudes only. A comparison of the radar trace and the approach charts (Appendices D and E) shows how the aircraft's descent rate increased sharply when it was 4.5 miles out, reaching a value of 2,300 ft/min by mile 3. The aircraft dropped below the ILS glide slope while looking for the imaginary parallel glide slope from the VOR as if the runway were 1 NM closer, at which point he zigzagged in an effort to establish on the slope. The first officer could not see the exact maneuver carried out by the pilot and was unable to warn him that he was below the glide slope because there was no indication on his HSI.

When they were 0.6 NM away from the threshold they would have checked the minimums (1,600 ft or 200 radio altimeter as set, 1,406 ft according to the ILS approach chart). Considering the hypothesis proposed that they confused the distance to the VOR with the distance to the threshold, they would not have noticed the differences between the altitudes at various points of the approach and those on the approach chart. In this case, 0.6 NM away from the VOR, where the crew would have gone around had the minimums not been met, the aircraft would have been at an altitude of 1,500 ft as per the radar trace, when the minimum altitude indicated on the chart was 1,406 ft (1,600 ft on the cockpit reference altitude). The lowered landing gear probably started impacting some of the tree tops before the DH was reached. However, in keeping with the published criteria on stabilized approaches, the crew should have executed a go-around on reaching 2,200 ft (1,000 ft AGL in IMC) since the descent rate was greater than 1,000 ft/min and they were not within one dot of the glide slope, meaning their approach was not stabilized. As a result of this finding a safety recommendation is issued to the operator.

The activation of the ELT was detected on the 406 MHz frequency but not on the emergency frequency (121.5 MHz) in the tower, even though it started transmitting from the time of the accident. Later it was verified that the ELT had been transmitting but at such a low power that it was not able to overcome the opening threshold for the receivers. The antenna on the aircraft was bent, meaning that it was likely that the antenna broke and the ELT transmitted without a radiative element, preventing it from overcoming the excitation threshold of the receivers.

The ELT signal contains a code that the ground station uses to retrieve the aircraft's contact information from an AESA database to determine if the aircraft is either airborne, either on the ground or if it is a false alarm. In this case the aircraft was not included in the database. International regulations (Annex 10) recommends having an ELT register and national regulation informs operators how to send the information to the authority AESA so as to include the information in the data base. Nevertheless there is no obligatory nature on this respect, so, a safety recommendation is issued later in the report.

There were two open control positions in the tower being manned by two different controllers. There were four controllers on the night shift (two on duty and two rotating assistant controllers). There was no supervisor. The tower controller cleared the aircraft to land at 04:15. At 04:34 SAR notified the controller that there was a beacon transmitting in the vicinity of the airport. The controller tried to raise the aircraft several times and at 04:38 requested airport operations that a marshaller be sent to the hangar where the airplane usually parked to see if it was there. At 04:44 the marshaller confirmed that the aircraft was not in its hangar and the emergency procedures were activated. The typical procedure according to the operator was, after landing at Santiago and starting to taxi, to report "runway clear" and marshaller in sight to the controller. The tower controller stated that he thought the aircraft had landed because the operator was based there and crews normally proceeded to the hangar without the aid of the marshaller. He also stated that he could not visually verify that the aircraft had landed due to the visibility problems caused by the fog and by the old control tower, which screened the part of the runway where the aircraft would have exited to head to the hangar.

Airport officials acknowledged the visibility problem caused by the old tower but said that the deficiency had been addressed by installing a security camera whose images were displayed on a screen in the control tower. As Section 4.5.1.3 of the RCA states: "Aerodrome controllers shall constantly monitor all flight operations that take place in and around the aerodrome, as well as all vehicles and personnel who are in the movement area. They shall be monitored using visual means, which are to be improved particularly during low-visibility conditions through the use of an ATS system, if available". In this case the controller did not confirm the aircraft's landing, as a result of which he was left without any time references for activating any type of alert. The alert phase, or ALERFA, must be activated when an aircraft has been cleared to land and does not do so within five minutes after the expected landing time and contact cannot be re-established with the aircraft. The alert phase was initiated at 05:10:07 when, according to the RCA, it should have been initiated about ten minutes after the final communication from the aircraft, already cleared to land some five minutes before landing. Had the alert been declared earlier, emergency crews would have reached the survivors sooner, though the probability of survival in this case was very low. A safety recommendation is issued in this regard.

3. CONCLUSION

3.1. Findings

In light of the information available and its analysis, the investigation has drawn the following conclusions:

- The aircraft's documentation was valid and in order.
- The aircraft had been used on several flights the month before and for three segments of the accident flight.
- The aircraft had an exception to be flown by a single pilot and its procedures reflected this type of operation.
- The operator did not have the standard operating procedures (SOPs) in its Operations Manual. As a result, there were no procedures for allocating functions and coordinating between the crewmembers.
- Both pilots had valid and in force licenses, ratings and medical certificates.
- Both pilots had experience on the aircraft type.
- The crew had flown two segments before the accident flight.
- The crew had been on call from 11:00 until 21:00, in line with regulations.
- The crew was called in at 20:40, near the end of its on-call cycle, for an operation that would last more than six hours and extend into their sleep schedule, and this after having engaged in normal activities during the day.
- There were irregularities in the operator's records of the captain's verification.
- There were irregularities in the discrepancies noted by the captain and those actually logged by the operator.
- There were no entries made in the technical log book by the crews documenting deficiencies in the aircraft even though they signed to accept the aircraft.
- AESA conducted several operational inspections of the operator.
- AESA did not detect the lack of SOPs in its inspections of an aircraft authorized to be operated by a single pilot but operated by two crewmembers.
- AESA only detected this absence in the extra audits carried out after the accident for revoking the AOC.
- AESA conducted a SANA inspection of the aircraft.
- AESA did not detect the presence of the "F/D flag inoperative" or noted the abnormal operation of any equipment on the aircraft.
- According to the flight plan, and based on the fact that the first officer was talking to ATC on the radio, the pilot flying was the captain.
- The crew was concerned about the worsening weather conditions at the Santiago Airport.
- The amount of fuel was not sufficient to proceed to the alternate.
- The crew shortened the approach to mile 6, the FAP, by which point the localizer should be captured and the glide slope be in the process of being captured.
- At that point the aircraft started to zigzag to capture the localizer.

- The captain made the approach in manual.
- It was nearing dawn and there was a full moon with few clouds at 600 ft.
- The crew was used to operating at the Santiago Airport.
- There is no evidence of faults in the signals provided by the VOR/ILS navaids.
- The inspection of the converter for the glide slope signal concluded that the signals received by the aircraft were correct.
- The crew had already made an approach in manual in reduced visibility conditions barely within minimums at Porto.
- The captain was more accustomed to flying in manual.
- The inspection of the converters for the localizer signal concluded that the localizer flag was always displayed even if the HSI bars were indicating correctly.
- The first officer had selected the wrong frequency for the ADF and ILS.
- The numbers on the navigation unit display were not clear.
- The first officer's HSI would have shown the bars centered with both flags displayed.
- The DME unit indicates the distance to a selected navaid. In HOLD mode it shows the distance to the last navaid selected.
- The switch on the unit was one position out of phase.
- The crews did not typically adjust this unit.
- The copilot may have used the DME to check the distance to the navaids and left it in HOLD mode believing he was leaving it in its original position (NAV1).
- The captain would have seen the distance to the runway shortened by one mile on his HSI, not realizing that the distance was to the VOR. This would have caused him to accelerate the descent rate heading to the runway.
- The radar trace shows the aircraft capturing the imaginary glide slope from the VOR at a high rate of descent.
- The weather information and its pattern at the airport indicates that at some point the crew may have entered a fog bank while on approach, causing them to lose all ground references.
- The crew, using the VOR as a reference, would have reached the 0.6 mile point at an altitude of 1,500 ft without hitting the ILS approach minimums (1,406 ft).
- At 2,200 ft (1,000 ft AGL in IMC) the aircraft had a descent rate well in excess of 1,000 ft/min and it was not following the glide slope.
- The crew should have gone around given the unstabilized nature of the approach.
- The aircraft was cleared to land at 04:15:06.
- The tower controller did not visually verify that the aircraft had landed.
- According to the RCA, the tower controller should at all times visually monitor all flight operations that take place in and around the airport.
- The SAR service called the controller at 04:34:10.
- The alert phase was initiated at 05:10:07.
- According to the RCA, the alert should have been initiated about ten minutes after the final communication from the aircraft, already cleared to land some five minutes before landing.

3.2. Causes

The ultimate cause of the accident could not be determined. In light of the hypothesis considered in the analysis, the most likely scenario is that the crew made a non-standard precision approach in manual based primarily on distances. The ILS frequency set incorrectly in the first officer's equipment and the faulty position indicated on the DME switch would have resulted in the distance being shown on the captain's HSI as corresponding to the VOR and not to the runway threshold. The crew shortened the approach maneuver and proceeded to a point by which the aircraft should already have been established on the localizer, thus increasing the crew's workload. The crew then probably lost visual contact with the ground when the aircraft entered a fog bank in the valleys near the airport and did not realize they were making an approach to the VOR and not to the runway.

The contributing factors were:

- The lack of operational procedures of an aircraft authorized to be operated by a single pilot operated by a crew with two members.
- The overall condition of the aircraft and the instruments and the crew's mistrust of the onboard instruments.
- The fatigue built up over the course of working at a time when they should have been sleeping after an unplanned duty period.
- The concern with having to divert to the alternate without sufficient fuel combined with the complacency arising from finally reaching their destination.

4. SAFETY RECOMMENDATIONS

The aircraft's airworthiness review and maintenance documentation was in order. Nevertheless, when reviewing the information contained in the Technical Log Book of the aircraft, and taking into account the list of discrepancies sent by the captain to the operator, the information from the other crews, the accounts from people who had flown or had had access to the aircraft and the findings from the SANA inspection reports it could be concluded that, in general, crews did not annotate discrepancies in the technical logbook (TLB) of the aircraft although they always signed for the pre-flight inspection and the acceptance of the aircraft. The following safety recommendation is issued in this regard:

REC 09/15. It is recommended that AIRNOR develop a specific plan that would ensure that the crews annotate all the discrepancies of the aircraft in the TLB at the moment they are detected.

A very important contributing factor in this accident was the lack of standard operating procedures (SOPs) to adapt the operation of an aircraft flown by a single pilot to dual-pilot operations. The crewmembers were not aware of their shared situation and ignored information that in this case was essential. AESA had inspected the operator on several occasions but it did not detect this shortcoming in the previously accepted Operations Manual. After the accident the operator was subjected to extraordinary audits that did detect this missing element and led to proceedings to suspend the company's AOC.

In the preceding months AESA had also conducted an audit to the usual CAMO and SANA inspection of the aircraft and only found some documentary deficiencies. It did not note the presence of labels in the cockpit involving non-operational options, the operation of equipment in general or the external condition of the aircraft. The ground and in-flight inspection of an aircraft is delegated practically in its entirety to the CAMO and CAMO+, with the ACAM/SANA inspections being the only direct supervision of the aircraft by the Authority, which retains competency over the inspection. The fact that such significant discrepancies were found after the accident and not before, both during the inspections of the operator and during the ACAM and SANA inspections, indicates that AESA's inspection and supervision system was not able to efficiently oversee the operation and condition of both companies and aircraft. As a result, the following safety recommendation is isued:

REC 10/15. It is recommended that AESA revise its supervisory policies (for both operations and aircraft (ACAM/SAFA)) to establish criteria and define procedures for inspections in line with the objectives that are actually being pursued in terms of safety standards.

The crews did not have SOPs and used similar practices put in place solely by the chief instructor. Specifically, the type of unscheduled service rendered to the ONT did not allow for much prior planning. The lack of such procedures suited to the actual instrumentation in the cockpit and the absence of clear guidelines in terms of the actions to take in weather conditions at the aircraft category's limits and in terms of stabilized approaches contributed significantly to the increased workload in the cockpit and to faulty decision making. As a result, the following safety recommendation is issued:

REC 11/15. It is recommended that AIRNOR establish the operational procedures required to operate in each of its aircraft based on the equipment specific to each, and on clear and common criteria for weather conditions, fuel planning and stabilized approaches.

The COSPAS-SARSAT system[35] detected the activation of an ELT on a frequency of 406 MHz. The ELT signal contains a code that the ground station uses to retrieve the aircraft's contact information from an AESA database to determine if the aircraft is either airborne, either on the ground or if it is a false alarm. In this case the aircraft was not included in the database. International regulations (Annex 10) recommends having an ELT register and national regulation informs operators how to send the information to the authority, AESA, so as to include such information in the data base, but there is no obligatory nature to this respect. As a result, the following safety recommendations are issued:

REC 12/15. It is recommended that AESA take the initiative so as to establish as mandatory, following international orientations from ICAO Annex 10, for all operators the registration of the data from ELT.

REC 33/15. It is recommended that DGAC, at the initiative of AESA, establish as mandatory, following international orientations from ICAO Annex 10, for all operators the registration of the data from ELT.

The tower controller did not ensure that the aircraft had landed safely. As a result he was unable to initiate the alert phase until he was notified by SAR when, according to regulations, he should have been constantly monitoring the aircraft until it landed and initiated the alert phase if it failed to do so within five minutes after the expected landing time. As a result the following safety recommendation is issued:

REC 13/15. It is recommended that ENAIRE[36] establish the procedures needed to remind control personnel during refresher training of the emergency phase and of the obligation to monitor the operation of aircraft operating in and around the airport.

[35] The COSPAS-SARSAT satellite system is a space-based system that receives the distress signal from aviation ELTs to guide search and rescue (SAR) operations.
[36] Formerly AENA Air Navigation.

APPENDIX

APPENDIX A
CAT I approach minimums for an ILS approach and low-visibility procedures at LEST

PRECISION ILS APPROACH CATEGORIES

As per ICAO Annexes 6 and 14, the following categories exist for ILS approaches (see table):

- **Category I operation.** Precision instrument approach and landing with a decision height not lower than 60 m and with either a visibility not less than 800 m or a runway visual range (RVR) not less than 550 m.
- **Category II operation.** Precision instrument approach and landing to a decision height lower than 60 m but not lower than 30 m and a RVR not less than 350 m.
- **Category IIIA operation.** Precision instrument approach and landing to a decision height lower than 30 m or no decision height and a RVR not less than 200 m.
- **Category IIIB operation.** Precision instrument approach and landing to a decision height lower than 15 m or no decision height and a RVR less than 200 m but not less than 50 m.
- **Category IIIC operation.** Precision instrument approach and landing with no decision height and no RVR limitations.

The low-visibility procedures (LPV) are intended to provide for the safe and orderly movement of all traffic (aircraft, vehicles and personnel) in the airport's movement area under reduced visibility conditions.

LOW-VISIBILITY PROCEDURES (LVP)

1. General

- Runway 17 is equipped with a CAT II/III ILS and CAT III B approaches are authorized.
- Reduced visibility takeoffs are authorized on runways 17/35.
- CAT I is usable on runway 35 for landings at the pilot's request or when dictated by local weather conditions.

2. Criteria for applying and cancelling the procedures

2.1. Preparation phase

The preparation phase for the procedures will go into effect when either of the following conditions exists:

- When the RVR at points A and B is equal to or less than 1,000 m or the same visibility value if the transmissometers are out of service, or
- when the cloud ceiling is at or below 90 m (300 ft).

2.2. Activation phase

In addition to the general procedures, the Low-Visibility Procedures (LVP) will be applied when any of the following occurs:

- When the RVR at points A and B is equal to or lower than 600 m or the same visibility value if the transmissometers are out of service, or
- when the cloud base is at or below 75 m (250 ft), or
- when so dictated by rapidly degrading weather conditions.

2.3. Cancellation phase

The LVP will be cancelled when the following cumulative values are met:

- RVR above 1,000 m at every transmissometer or the same visibility value if these are out of service.
- Height of the cloud base equal to or greater than 90 m (300 feet).
- Steadily improving trend in weather conditions.

Meteorological minima for LVP

LVP PHASES	VISIBILITY-RVR	CLOUD CEILING-DH
PHASE I (PREPARATION)	RVR POINTS A AND B ⩽ 1,000 m	DH ⩽ 90 m
PHASE I (ACTIVATION)	RVR POINTS A AND B ⩽ 600 m (rapid degradation of weather conditions)	DH ⩽ 75 m
PHASE I (CANCELATION)	RVR POINTS A, B AND C ⩾ 1,000 m (improvement expected)	DH ⩾ 90 m

Note: the activation of LVP at RVR = 600 m does not affect CAT I approach operations, which can continue normally until the RVR falls to 550 m.

Landing operations are subject to the following conditions:

a) the aerodrome operating minimums (AOM) for approach and landing at the Santiago Airport in reduced visibility conditions are as shown in the following table:

Tabla 2.1 (AOM for arrivals)

AERODROME OPERATING MINIMUMS (AOM) BY APPROACH CATEGORY	RUNWAY
CAT I **DH: 60 m** **RVR: 550 m** **Visibility: 800 m**	17/35
CAT II **DH: 30 m** **RVR: 300 m**	17
CAT III **DH: < 15 m** **RVR: > 75 m**	17

b) The minimums based on visibility are only applicable if there is no RVR reading (RVR U/S)(CAT I).
c) The operational category (I, II or III) for each runway shall be defined in the AIP.
d) The variations in operational category published by the AIS via a NOTAM.
e) The conditions that may affect the ILS in CVR operations are listed in Appendix I.

In addition, precision approach operations will only be initiated if the aircraft and its crew are properly qualified for the type of operation expected, except in emergency cases.

Appendix 1 to EU OPS 1430
Aerodrome operating minima

c) Precision approach: Category I operations:

1) General. A Category I operation is a precision instrument approach and landing using ILS, MLS or PAR with a decision height not lower than 200 ft and with a runway visual range not less than 550 m.
2) Decision height. An operator must ensure that the decision height to be used for a Category I precision approach is not lower than:

   i) The minimum decision height specified in the Aeroplane Flight Manual (AFM) if stated;
   ii) The minimum height to which the precision approach aid can be used without the required visual reference;

iii) The OCH/OCL for the category of aeroplane; or

3) Visual reference. A pilot may not continue an approach below the Category I decision height, determined in accordance with subparagraph (c)2. above, unless at least one of the following visual references for the intended runway is distinctly visible and identifiable to the pilot:

i) elements of the approach light system,
ii) the threshold,
iii) the threshold markings,
iv) the threshold lights,
v) the threshold identification lights,
vi) the visual glide slope indicator,
vii) the touchdown zone or touchdown zone markings,
viii) the touchdown zone lights, or
ix) runway edge lights.

APPENDIX B
Communications

(Actual communications were held in Spanish; English translation is provided for understanding purposes)

Communications on the 121.7 MHz frequency (Santiago TWR)

Time	Freq.	Station	Contents
02:44:08	120.20	SAN APP	Previous communications with Santiago APP (120.20 MHz)
02:48:30	121.7	ENW141	SANTIAGO TOWER GOOD EVENING FROM ENW141 SANTIAGO TORRE BUENAS NOCHES DEL ENW141
02:48:42	121.7	ENW141	SANTIAGO GOOD EVENING ENW141 SANTIAGO BUENAS NOCHES ENW141
02:48:48	121.7	TWR	HELLO, REPEAT CALL SIGN PLEASE HOLA BUENAS, REPITA INDICATIVO POR FAVOR
02:48:51	121.7	ENW141	YES, THIS IS ENW141 SI, SOMOS EL ENW141
02:48:52	121.7	TWR	GOOD DAY ENW141, GO AHEAD BUENOS DÍAS ENW141, ADELANTE
02:48:58	121.7	ENW141	I'M WITH TWENTY-TWO BUT I'M INTERESTED IN THE WEATHER CONDITIONS IN YOUR AIRPORT BECAUSE (GARBLED) ASTURIAS AND SO, WE WILL HAVE TO RETURN TO SANTIAGO SOON AND WE DON'T KNOW WHETHER TO STAY THERE OR RETURN DUE TO THE FOG BANK ESTOY CON VEINTE DOS PERO ME INTERESA BASTANTE LAS CONDICIONES METEREOLÓGICAS DE SU CAMPO PORQUE(ININTELIGIBLE) ASTURIAS Y NADA, EN SEGUIDA TENDREMOS QUE VOLVER A SANTIAGO Y NO SABEMOS SI QUEDARNOS ALLÍ O VOLVER POR EL BANCO DE NIEBLA
02:49:13	121.7	TWR	WELL RIGHT NOW THE METAR MUST BE EITHER LOADING OR THERE'S AN ERROR BECAUSE WE DON'T HAVE A METAR, I'LL GIVE YOU THE LATEST DATA I HAVE ON THE SCREEN FROM THE PREVIOUS ONE, RVR GREATER THAN TWO THOUSAND, CLOUD CEILING ON ONE SEVEN IS ONE THOUSAND SEVEN FIFTY, WEATHER IS CLEAR, TEMPERATURE THIRTEEN, DEW POINT THIRTEEN, LAST QNH THOUSAND NINETEEN AND THAT'S THE INFORMATION WE HAVE RIGHT NOW. FROM HERE WE CAN SEE THE ROADS PERFECTLY (01:00 METAR) BUENO PUES AHORA MISMO DEBE DE ESTAR PUES CARGANDO EL METAR O HAY UN FALLO PORQUE NO TENEMOS METAR, LE DOY LOS ÚLTIMOS DATOS QUE HAY EN LA PANTALLA REFLEJADOS ANTERIORES, EL RVR SON SUPERIORES A DOS MIL, EL TECHO DE NUBES EN LA UNO SIETE ES MIL SIETE CINCUENTA, EL TIEMPO ESTA CLARO, TEMPERATURA TRECE, EL ROCIO TREC,E, QNH ÚLTIMO MIL DIECINUEVE Y ESA ES LA INFORMACIÓN QUE TENEMOS Y BUENO AHORA MISMO DESDE AQUÍ SE VEN LAS CARRETERAS PERFECTAMENTE (01:00 METAR)
02:49:54	121.7	ENW141	THE BANKS MUST BE (GARBLED) SI SERÁN BANCOS QUE (ININTELIGIBLE)

Time	Freq.	Station	Contents
02:50:00	121.7	TWR	IT'S HARD TO SAY, THE FOG CAN ROLL IN HERE IN NO TIME SO I WOULDN'T GO SO FAR AS TO SAY THEY'RE BANKS BECAUSE, WELL THE WEATHER IS UNPREDICTABLE AQUÍ ES DIFÍCIL DE DECIR AQUÍ SE METE LA NIEBLA EN MUY POCO TIEMPO O SEA NO ME ATREVERÍA A DECIR QUE SON BANCOS POR QUE BUENO LA METEO ES COMPLICADA
02:50:12	121.7	ENW141	THANK YOU VERY MUCH MUCHAS GRACIAS
02:50:14	121.7	TWR	THE PROBLEM HERE IS THAT THE DEW POINT NOW, THE TEMPERATURE AND DEW POINT ARE THE SAME IF THE WIND IS CALM, SO THAT'S NOT A GOOD SIGN AQUÍ EL PROBLEMA ES QUE LOS ROCÍOS AHORA LA TEMPERATURA Y EL PUNTO DE ROCÍO ESTÁN IGUAL SI EL VIENTO ESTA CALMA O SEA QUE ESO NO ES BUENA SEÑAL
02:50:22	121.7	ENW141	THE BAD THING IS OUR ALTERNATE IS VITORIA WHICH WOULD BE A MESS LA PUTADA ES QUE EL ALTERNATIVO NUESTRO ES VITORIA ENTONCES SERÍA UNA FAENA
02:50:29	121.7	TWR	WELL BUT IF YOU THINK, IF YOU'RE IN THE ASTURIAS AREA JUST CALL. I DON'T KNOW WHAT TIME IT'LL BE BUT IF THE TOWER OR SOME FREQUENCY IS OPEN JUST CALL AND ASK, NO PROBLEM. PERO BUENO SI CREÉIS, SI ESTÁIS POR LA ZONA DE ASTURIAS Y TAL CON LLAMAR, NO SÉ A QUÉ HORA VA A SER ESTO, PERO BUENO SI ESTÁ ABIERTA LA TORRE O ALGUNA FRECUENCIA Y QUE NOS LLAMEN Y CONSULTAR SIN PROBLEMAS
02:50:42	121.7	ENW141	THANK YOU VERY MUCH MUCHAS GRACIAS
	120.20	SAN APP	Continuation of communications with Santiago APP

Communications on the 120.20 MHz frequency (Santiago APP)

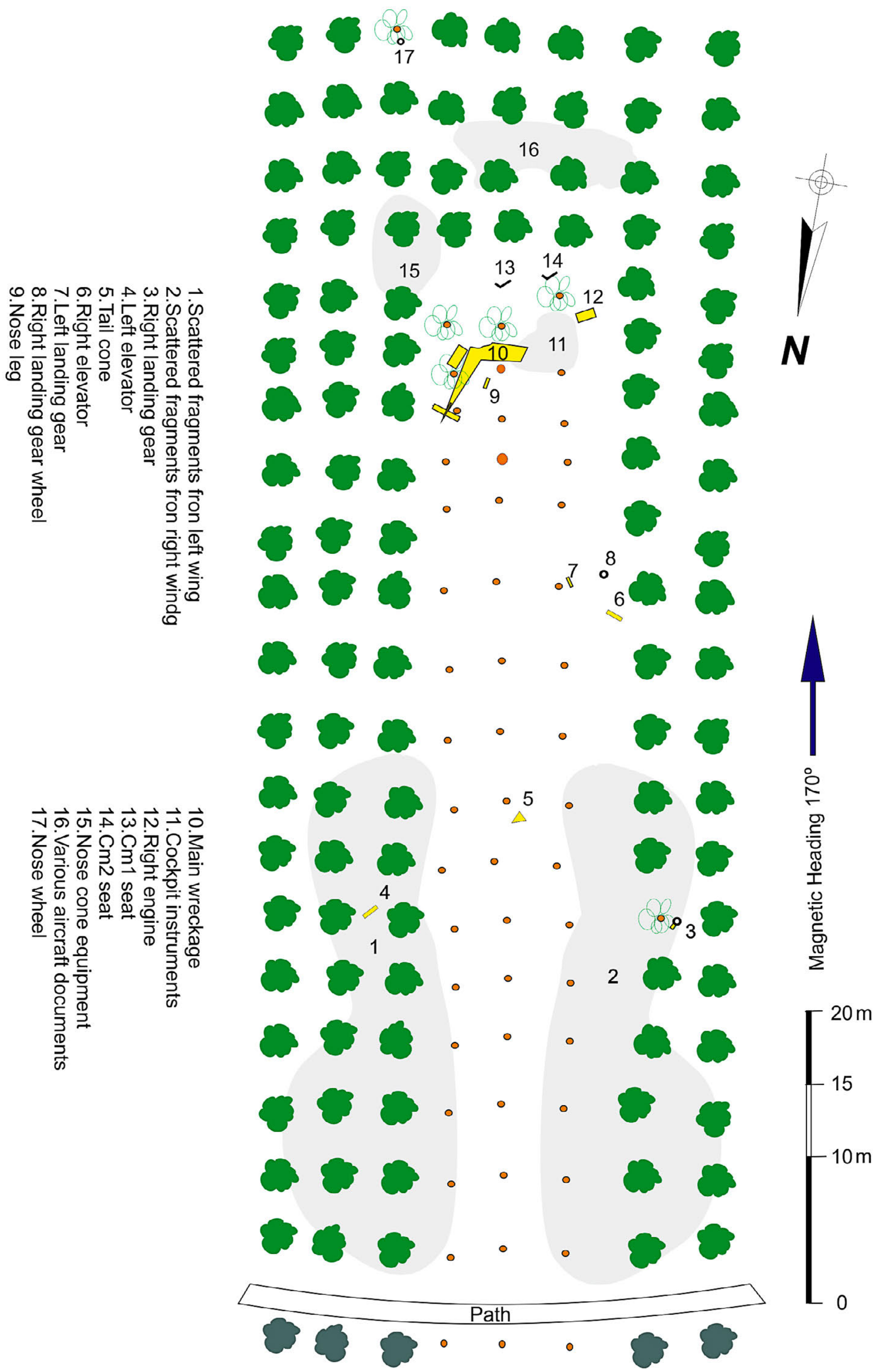
Time	Freq.	Station	Contents
03:56:41	120.20	ENW142	CONTROL GOOD EVENING ENW142 ONCE MORE CLIMBING TO TWO ZERO ZERO EN ROUTE TO SANTIAGO. CONTROL BUENAS NOCHES DE NUEVO ENW142 EN CURSO A SANTIAGO EN ASCENSO PARA DOS CERO CERO

Time	Freq.	Station	Contents
03:56:51	120.20	SAN APP	ENW142 GOOD EVENING EXPECT RUNWAY ONE SEVEN IN SANTIAGO, WIND CALM, VISIBILITY IS FOUR… FOUR THOUSAND METERS WITH MIST, FEW AT SIX HUNDRED. TEMPERATURE THIRTEEN AND DEW POINT THIRTEEN (03:30 METAR) ENW142 MUY BUENAS ESPERE LA PISTA UNO SIETE EN SANTIAGO. CON VIENTO CALMA, LA VISIBILIDAD ES CUATRO ... CUATRO MIL: METROS CON NEBLINA, FEW A SEISCIENTOS, TEMPERATURATRECE Y ROCIO TRECE (METAR 03:30)
03:57:09	120.20	ENW142	THE RUNWAY WOULD BE ONE THREE FOR ENW143… 142 LA PISTA SERÍA A LA UNO TRES DEL ENW143 ... 142
03:57:57	120.20	SAN APP	ENW142 CAN FLY TO THE TEN-MILE FIX ON FINAL TO RUNWAY ONE SEVEN ENW142 PUEDE VOLAR AL FIJO DE LA MILLA DIEZ EN FINAL DE LA PISTA UNO SIETE
03:58:03	120.20	ENW142	STRAIGHT IN TO FINAL THEN, TEN MILES TO FINAL ON ONE SEVEN ENW142 PUES DIRECTOS AL FINAL, DIEZ MILLAS AL FINAL DE LA UNO SIETE ENW142
04:04:39	120.20	ENW142	CONTROL ENW142 WE ARE READY TO DESCEND CONTROL ENW142 YA ESTAMOS LISTOS DESCENSO
04:04:44	120.20	SAN APP	ENW142 COPY, DESCEND TO SIX THOUSAND FEET, QNH ONE ZERO ONE NINE ENW142 RECIBIDO DESCENSO A SEIS MIL PIES QNH UNO CERO UNO NUEVE
04:04:50	120.20	ENW142	SIX THOUSAND FEET WITH ONE THOUSAND NINETEEN ENW142 SEIS MIL PIES CON MIL DIECINUEVE ENW142
04:12:00	120.20	SAN APP	ENW142 DESCEND TO THREE THOUSAND FEET CLEARED DIRECT TO ILS RUNWAY ONE SEVEN WITH ONE THOUSAND NINETEEN ENW142 DESCENSO A TRES MIL PIES AUTORIZADO A ILS DIRECTA. PISTA UNO SIETE CON MIL DIECINUEVE
04:12:09	120.20	ENW142	DESCEND TO THREE THOUSAND FEET AND CLEARED DIRECT TO ILS RUNWAY ONE SEVEN ENW142 THANK YOU DESCENSO A TRES MIL PIES Y AUTORIZADOS A ILS DIRECTA A LA UNO SIETE ENW142 GRACIAS
04:14:49	120.20	SAN APP	ENW142 YOU CAN CALL THE SANTIAGO TOWER NOW ON EIGHTEEN SEVENTY-FIVE, GOOD BYE ENW142 PUEDE LLAMAR YA A TORRE DE SANTIAGO EN DIECIOCHO SETENTA Y CINCO, ADIÓS
04:14:57	120.20	ENW142	EIGHTEEN SEVENTY-FIVE SANTIAGO TOWER, THANKS FOR EVERYTHING, GOOD NIGHT FROM ENW142 DIECIOCHO SETENTA Y CINCO TORRE DE SANTIAGO, MUY AMABLE POR TODO Y BUENAS NOCHE DE ENW142

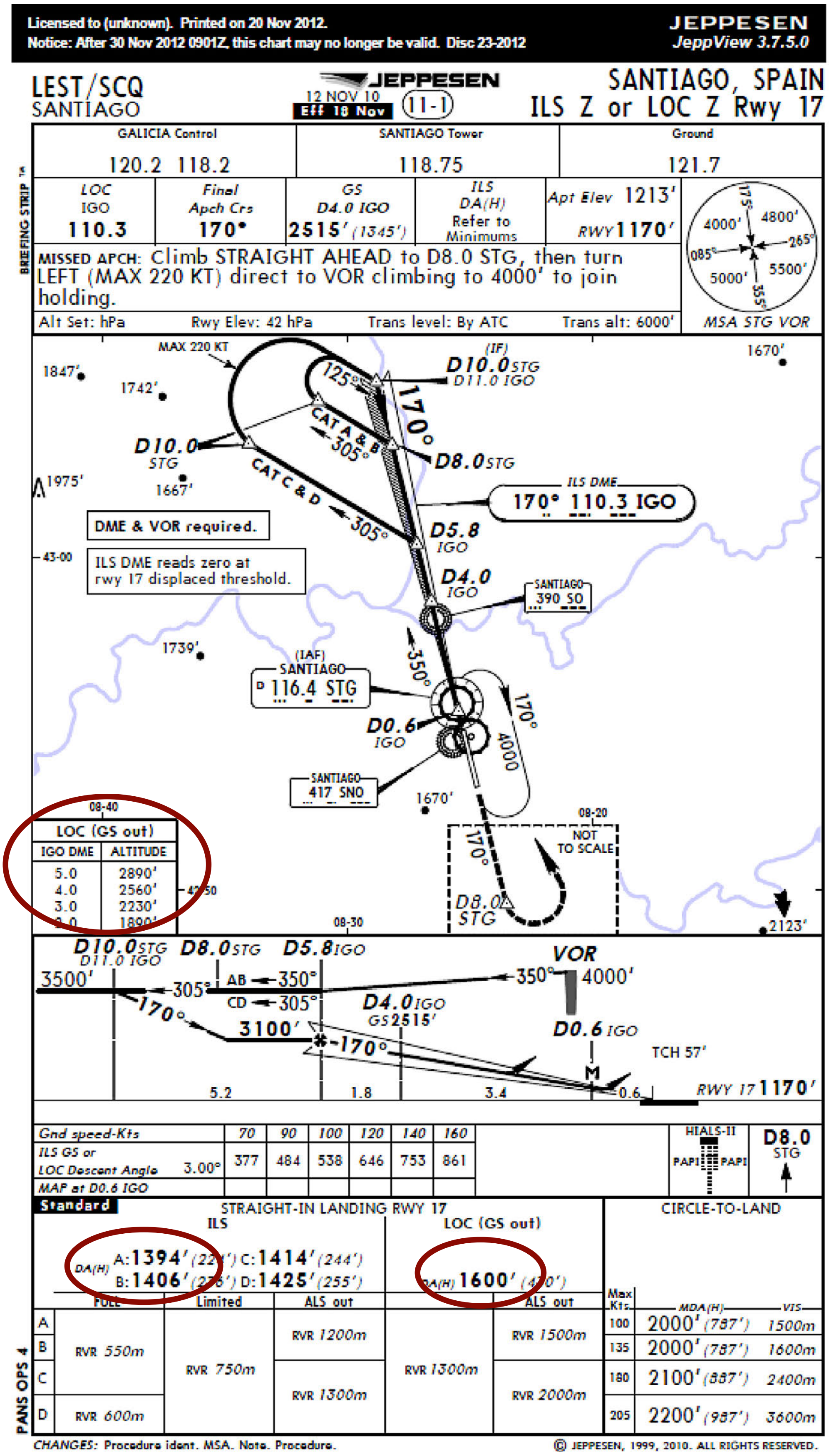
Communications on the 118.75 MHz frequency (Santiago TWR)

Time	Freq.	Station	Contents
04:15:06	118.75	ENW142	SANTIAGO CONTROL GOOD EVENING AGAIN ENW142 EN ROUTE TO MILE TEN ON FINAL TO ONE SEVEN SANTIAGO CONTROL BUENAS NOCHES DE NUEVO ENW142 EN CURSO A MILLA DIEZ EN FINAL DE LA UNO SIETE
04:15:14	118.75	TWR	ENW142 GOOD DAY CLEARED TO LAND RUNWAY ONE SEVEN WIND CALM ENW142 BUENOS DÍAS AUTORIZADOS A ATERRIZAR PISTA UNO SIETE VIENTO CALMA
04:15:19	118.75	ENW142	CLEARED TO LAND ONE SEVEN ENW142 AUTORIZADO A ATERRIZAR UNO SIETE ENW142
04:15:24	118.75	TWR	WIND CALM VIENTO CALMA
04:15:25	118.75	ENW142	WIND CALM ENW142 VIENTO CALMA ENW142
04:34:10	SAR NOTIFICATION		
04:35:41	118.75	TWR	ENW142?
04:35:54	118.75	TWR	ENW142?
04:37:33	118.75	TWR	ENW142?

APPENDIX C
Distribution of the wreckage


1.Scattered fragments fron left wing
2.Scattered fragments fron right windg
3.Right landing gear
4.Left elevator
5.Tail cone
6.Right elevator
7.Left landing gear
8.Right landing gear wheel
9.Nose leg
10.Main wreckage
11.Cockpit instruments
12.Right engine
13.Cm1 seat
14.Cm2 seat
15.Nose cone equipment
16.Various aircraft documents
17.Nose wheel
N
Magnetic Heading 170°
20 m
15
10 m
0
Path

APPENDIX D
ILS Z/LOC Z approach chart to LEST


Licensed to (unknown). Printed on 20 Nov 2012.
Notice: After 30 Nov 2012 0901Z, this chart may no longer be valid. Disc 23-2012
JEPPESEN
JeppView 3.7.5.0
LEST/SCQ
SANTIAGO
JEPPESEN
12 NOV 10
Eff 18 Nov
11-1
SANTIAGO, SPAIN
ILS Z or LOC Z Rwy 17
GALICIA Control
120.2 118.2
SANTIAGO Tower
118.75
Ground
121.7
LOC IGO 110.3
Final Apch Crs 170°
GS D4.0 IGO 2515' (1345')
ILS DA(H) Refer to Minimums
Apt Elev 1213'
RWY 1170'
MISSED APCH: Climb STRAIGHT AHEAD to D8.0 STG, then turn LEFT (MAX 220 KT) direct to VOR climbing to 4000' to join holding.
Alt Set: hPa
Rwy Elev: 42 hPa
Trans level: By ATC
Trans alt: 6000'
MSA STG VOR
BRIEFING STRIP
DME & VOR required.
ILS DME reads zero at rwy 17 displaced threshold.
ILS DME 170° 110.3 IGO
(IAF) SANTIAGO 116.4 STG
SANTIAGO 390 SO
SANTIAGO 417 SNO
NOT TO SCALE
LOC (GS out)
IGO DME | ALTITUDE
5.0 | 2890'
4.0 | 2560'
3.0 | 2230'
2.0 | 1890'
Gnd speed-Kts 70 90 100 120 140 160
ILS GS or LOC Descent Angle 3.00° 377 484 538 646 753 861
MAP at D0.6 IGO
Standard
STRAIGHT-IN LANDING RWY 17
ILS
DA(H) A:1394' C:1414'(244') B:1406' D:1425'(255')
LOC (GS out)
DA(H) 1600'
CIRCLE-TO-LAND
FULL | Limited | ALS out | ALS out
RVR 550m
RVR 600m
RVR 750m
RVR 1200m
RVR 1300m
RVR 1300m
RVR 1500m
RVR 2000m
Max Kts | MDA(H) | VIS
100 | 2000'(787') | 1500m
135 | 2000'(787') | 1600m
180 | 2100'(887') | 2400m
205 | 2200'(987') | 3600m
PANS OPS 4
CHANGES: Procedure ident. MSA. Note. Procedure.
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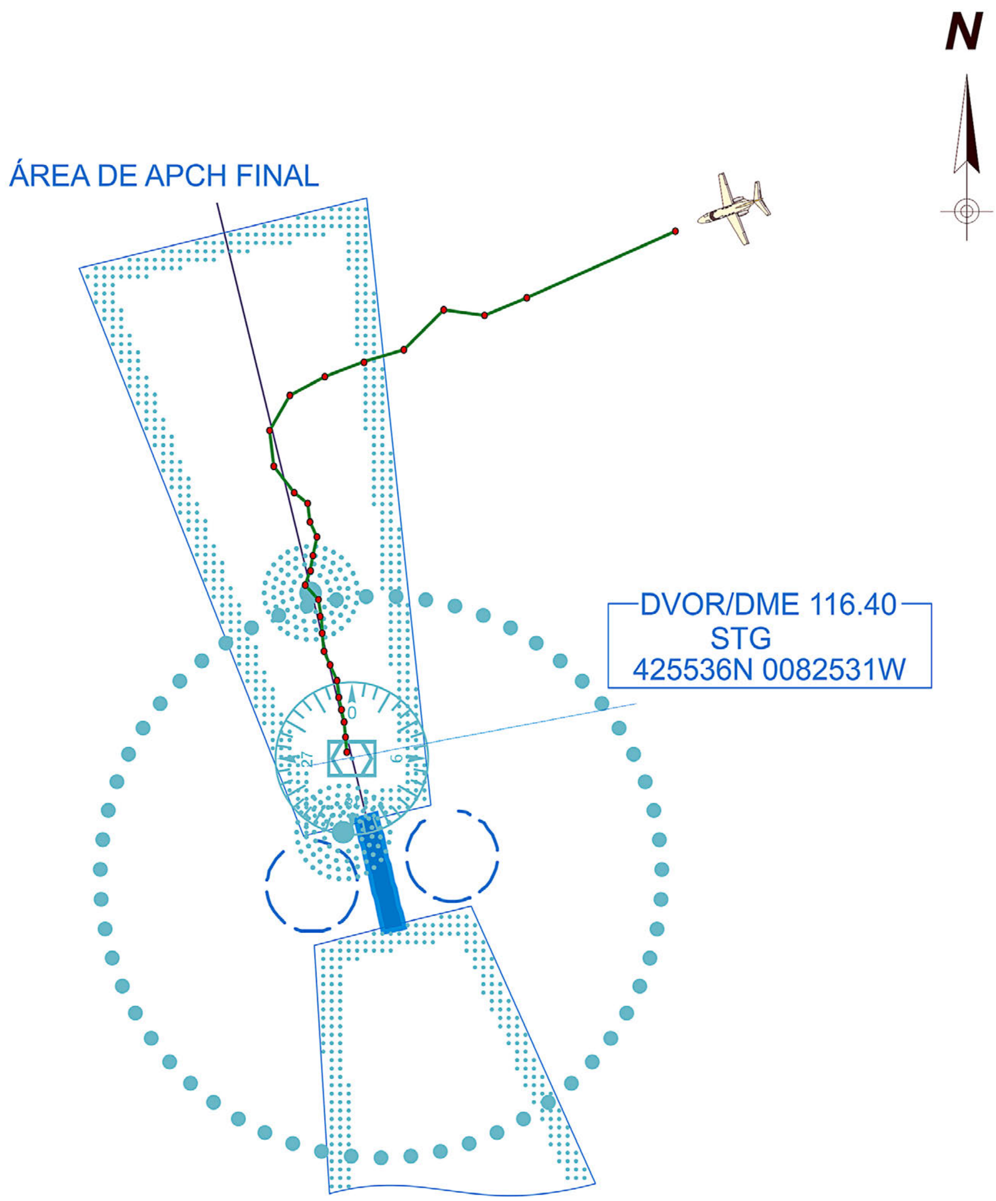
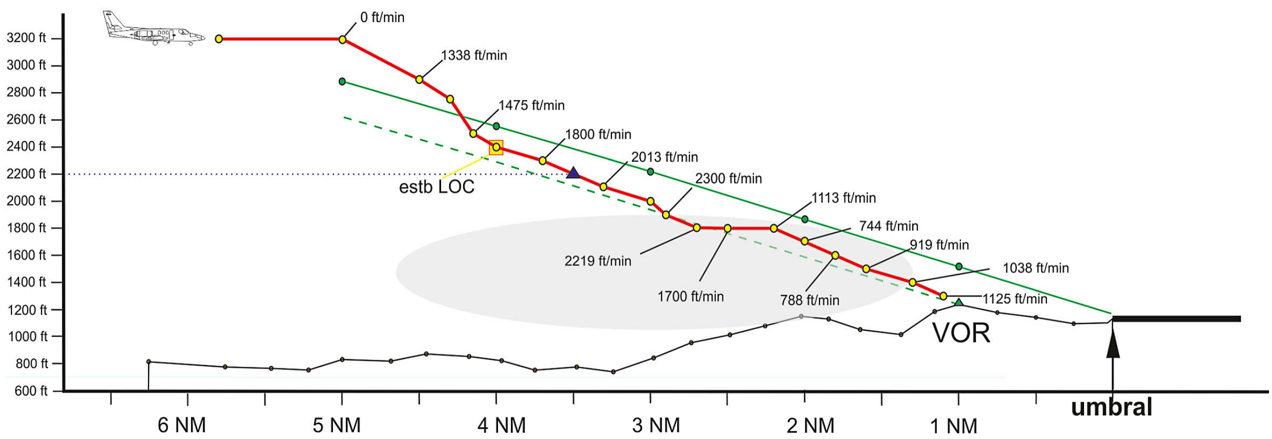
APPENDIX E
Aircraft's approach to the Santiago Airport


N
ÁREA DE APCH FINAL
DVOR/DME 116.40
STG
425536N 0082531W


3200 ft
3000 ft
2800 ft
2600 ft
2400 ft
2200 ft
2000 ft
1800 ft
1600 ft
1400 ft
1200 ft
1000 ft
800 ft
600 ft
0 ft/min
1338 ft/min
1475 ft/min
1800 ft/min
2013 ft/min
2300 ft/min
1113 ft/min
744 ft/min
919 ft/min
1038 ft/min
1125 ft/min
2219 ft/min
1700 ft/min
788 ft/min
estb LOC
VOR
umbral
6 NM
5 NM
4 NM
3 NM
2 NM
1 NM

APPENDIX F
EU-OPS information on SOPs

EU-OPS

OPS 1.1045 Operations Manual – structure and contents (see Appendix 1 to OPS 1.1045).

a) An operator shall ensure that the main structure of the Operations Manual is as follows:

Part A: This part shall comprise all non type-related operational policies, instructions and procedures needed for a safe operation.

Part B: Airplane Operating Matters. This part shall comprise all type-related instructions and procedures needed for a safe operation. It shall take account of any differences between types, variants or individual airplanes used by the operator.

Part C: Route and Aerodrome Instructions and Information. This part shall comprise all instructions and information needed for the area of operation.

Part D: Training. This part shall comprise all training instructions for personnel required for a safe operation.

b) An operator shall ensure that the contents of the Operations Manual are in accordance with Appendix 1 to OPS 1.1045 and relevant to the area and type of operation.

c) An operator shall ensure that the detailed structure of the Operations Manual is acceptable to the Authority.

APPENDIX 1 TO EU OPS 1.1045

B. Airplane operating matters – Type related

2. Normal procedures

2.1. The normal procedures and duties assigned to the crew, the appropriate checklists, the system for use of the checklists and a statement covering the necessary coordination procedures between flight and cabin crew. The following normal procedures and duties must be included:

a) pre-flight;
b) pre-departure;
c) altimeter setting and checking;
d) taxi, take-off and climb;
e) noise abatement;

f) cruise and descent;
g) approach, landing preparation and briefing;
h) VFR approach;
i) instrument approach;
j) visual approach and circling;
k) missed approach;
l) normal landing;
m) post landing, and
n) operation on wet and contaminated runways.

3. Abnormal and emergency procedures

3.1. The abnormal and emergency procedures and duties assigned to the crew, the appropriate check-lists, the system for use of the check-lists and a statement covering the necessary co-ordination procedures between flight and cabin crew. The following abnormal and emergency procedures and duties must be included:

a) crew incapacitation;
b) fire and smoke drills;
c) unpressurized and partially pressurized flight;
d) exceeding structural limits such as overweight landing;
e) exceeding cosmic radiation limits;
f) lightning strikes;
g) distress Communications and alerting ATC to Emergencies;
h) engine failure;
i) system failures;
j) guidance for diversion in case of serious technical failure;
k) ground proximity warning;
l) TCAS warning;
m) windshear, and
n) emergency landing/ditching, and
o) departure contingency procedures.

APPENDIX G
Information on aerodrome control and alert services

AIR TRAFFIC REGULATIONS

Book Three: Air Traffic Services

Chapter 5 3.5. Alert service

3.5.1. Applicability.

3.5.1.1. Alert services will be provided:

a) to all aircraft that are supplied air traffic control services;
b) insofar as possible, to all other aircraft that have filed a flight plan or that are aware of the air traffic services through other means; and
c) to all aircraft that are known or suspected to be the subject of illegal interference.

3.5.1.2. All flight information centers or area control centers will act as a central base for gathering information on the emergency situation affecting any aircraft that is within the associated flight information region or control area, and convey said information to the relevant rescue coordination center.

3.5.1.3. If an aircraft is confronted with an emergency situation while under the control of an aerodrome tower or an approach control station, whichever of these stations is currently controlling the aircraft will immediately report this fact to the relevant flight information center or area control center, which will in turn report it to the rescue coordination center.

If the nature of the emergency is such that this notification is superfluous, however, it will not be made.

3.5.1.3.1. However, when the urgency of the situation so requires it, the relevant control tower at the aerodrome or the approach control station will first alert and take any other measures necessary to mobilize the appropriate local rescue and emergency services that are able to render the immediate assistance required.

3.5.2. Notifying rescue coordination centers.

3.5.2.1. Except as specified in 3.5.5.1 and without prejudice to any other circumstances that may require said measure, air traffic service stations shall immediately notify rescue coordination centers of any aircraft they believe to be in an emergency as per the following:

a) *Uncertainty phase*

1) when no message is received from an aircraft in the 30 minutes following the time when a message should have been received from it, or immediately following the first time that an unsuccessful attempt was made to contact the aircraft, whichever occurs first; or
2) when an aircraft does not arrive in the 30 minutes following the last arrival time reported by its crew, or that calculated by the station, whichever is later, unless there is no doubt as to the safety of the aircraft and its occupants.

b) *Alert phase:*

1) when, after the uncertainty phase, no information is received from the aircraft during subsequent attempts to make contact with the aircraft or during inquests made involving other relevant sources; or
2) when an aircraft that was cleared to land has not done so within five minutes after the scheduled landing time and communications cannot be re-established with the aircraft; or
3) when reports are received indicating that operating conditions onboard the aircraft are not normal, but not to the point that a forced landing is likely, unless there are favorable signs concerning the safety of the aircraft and its occupants; or
4) when an aircraft is known or suspected to be the subject of illegal interference.

c) *Danger phase:*

1) when, after the alert phase, new attempts to make contact with the aircraft are unsuccessful and more extensive efforts to communicate, also unsuccessful, indicate that the aircraft is in danger; or
2) when the fuel onboard the aircraft is suspected of being exhausted or insufficient to allow it to reach a safe point; or
3) when reports are received indicating that operating conditions onboard the aircraft are abnormal to the point that a forced landing is likely; or
4) when reports are received or it is logical to presume that the aircraft is about to make a forced landing or has already done so, unless a great certainty exists that neither the aircraft nor its occupants are in imminent danger or that they require immediate assistance.

Book Four: Air navigation services procedures

Chapter 5 4.5. Aerodrome control service

Section 4.5.16 of this chapter contains the procedures for the use of surface aviation lights.

Functions of the aerodrome control service

4.5.1. General.

4.5.1.1. The aerodrome control service shall transmit information and issue clearances to aircraft under its control so as to attain the safe, orderly and expedient movement of air traffic in and around the airport for the purpose of preventing collisions between:

a) aircraft flying inside the control tower's area of responsibility, including the aerodrome's traffic circuits around the aerodrome;
b) aircraft operating in the movement area;
c) landing and departing aircraft;
d) aircraft and vehicles operating in the movement area;
e) aircraft in the movement area and the obstacles in said area.

4.5.1.2. The functions of the aerodrome control service may be assumed by various control or work posts, such as the:

a) aerodrome controller, normally responsible for operations on the runway and of those aircraft flying inside the aerodrome control tower's area of responsibility;
b) ground controller (1), normally responsible for traffic in the movement area with the exception of the runways;
c) clearance delivery, normally responsible for issuing start-up clearances, and ATC for departing IFR flights.

4.5.1.3. Aerodrome controllers shall constantly monitor all flight operations that take place in and around the aerodrome, as well as all vehicles and personnel who are in the movement area. They shall be monitored using visual means, which are to be improved particularly during low-visibility conditions through the use of an ATS system, if available. Traffic shall be controlled according to the procedures specified herein and to all applicable traffic stipulations specified by the competent ATS authority. If there are other aerodromes within the control area, the traffic of all the aerodromes inside said area shall be coordinated so as to avoid interference between the traffic patterns.

NOTE. Section 4.6.10 contains the stipulations involving the use of radar to provide the aerodrome control service. Section 3.3.9 and Attachment 3 to Appendix Z contains other stipulations involving the use of surface movement radar (SMR).

4.5.1.4. When parallel or nearly parallel runways are used for simultaneous operations, the operations on each runway will normally be the responsibility of separate controllers.