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COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Report A-043/2016

Accident involving a Beechcraft E90 aircraft, registration N-79CT, in Sotillo de las Palomas (Toledo, Spain) on 4 December 2016

GOBIERNO DE ESPAÑA

MINISTERIO DE FOMENTO

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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) nº 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.

CONTENT

Abbreviations

° ′ ″	Sexagesimal degrees, minutes and seconds
° C	Degrees centigrade
A&P	Aircraft and Powerplant
ACC	Area control center
ADI	Attitude Directional Indicator
AFCS	Automatic Flight Control System
AEMET	Spain's National Weather Agency
AESA	Spain's National Aviation Safety Agency
AGL	Above ground level
AIP	Aeronautical publication in formation
CAMO	Continuing airworthiness management organization
CR	Class rating
ETSIA	University of Aeronautical Engineering
FAA	United States Federal Aviation Administration
FL	Flight level
ft	Feet
ft/min	Feet/minute
g	Gravity
GPS	Global positioning system
h	Hours
hPa	Hectopascals
IA	Inspection Authorization
ICAO	International Civil Aviation Organization
IFR	Instrument flight rules
ILS	Instrumental Landing System
IMC	Instrument meteorological conditions
IR (A)	Instrument rating (airplane)
ISA	International Standard Atmosphere
JAR FCL	Joint Aviation Requirements Flight Crew Licensing
Km	Kilometers
Kt	Knots
LECU	ICAO code for the aerodrome of Cuatro Vientos
LPCS	ICAO code for the aerodrome of Cascais
m	Meters
METAR	Aviation routine weather report
min	Minutes
N	North
NAV	Navigation
PPL(A)	Private pilot license (airplane)
RGB	Reduction Gearbox
s	Seconds
SAR	Search and rescue
SEP	Single-engine piston rating (land) *Specific Excess Power*
TAF	Aerodrome forecast
UPM	Universidad Politécnica de Madrid
UTC	Coordinated universal time
VFR	Visual flight rules
VMC	Minimum control speed on one engine
VNE	Speed to not exceed
VY	Speed for best climb speed with two engines
VYSE	Best climb speed on a single engine
VOR	VHF Omnidirectional range
W	West
WAFC	World Area Forecast Center

Synopsis

Owner:	PA Scale Company of Florida[1]
Operator:	Privado
Aircraft:	Beechcraft E90, registration N-79CT
Date and time of accident:	4 December 2016, 16:17 h[2]
Site of accident:	Sotillo de las Palomas (Toledo, Spain)
Persons on board:	4, killed
Type of flight:	General Aviation - Private
Flight rules:	Z (VFR takeoff and subsequent flight in IFR)
Phase of flight:	En route – Climbing to cruise level
Date of approval:	

Summary of the event:

El On Sunday, 4 December 2016, a Beechcraft E90 aircraft, registration N-79CT, took off from the aerodrome of Cuatro Vientos (LECU) en route to the aerodrome of Cascais (LPCS) in Portugal. One of the reasons for the flight was to repair the weather radar at a Portuguese maintenance center that specialized in this equipment.

The pilot had to delay the takeoff until 15:57 due to the bad weather conditions. The aerodrome of Cuatro Vientos was in instrument conditions (IMC), which forced its closing from 09:00 until 14:44.

At 16:15, the aircraft was en route, climbing from flight level 190 to its authorized cruise level of 210.

Moments later, according to a detailed analysis of the data taken from the radar, there was a yaw to the left, and the aircraft started to turn in this direction and suddenly lose altitude.

After this event, the airspeed fell quickly and gradually until the aircraft stalled. The aircraft went into a spin, which after some time turned into a flat spin.

[1] This company was owned by the deceased pilot.

[2] All times in this report are local. To obtain UTC, subtract one hour.

As the airplane descended out of control, and with the spin fully developed, loads were placed on the horizontal tail that exceeded the design loads, causing the tail to break up in flight into five parts before the aircraft impacted the ground.

The aircraft was completely destroyed by the impact and subsequent fire, and its four occupants were killed in the accident.

The investigation has concluded that this accident was caused by the loss of control of the aircraft in flight due to a stall and subsequent spin

Due to the high degree of destruction of the aircraft's wreckage after the ground impact and subsequent fire, and the lack of other pertinent data to do so, it has not been possible to determine with precision the sequence of the process leading to the aircraft stall/spin.

The investigation identified the following contributing factors:

- The decision to make the flight with adverse meteorological conditions (IMC) along the planned route, considering the fact that the weather radar was not operational.

- The forecast of moderate to strong icing conditions in areas of the route (presence of cumulonimbus with layers of up to 35,000 feet and with temperatures between -17ºC and -19ºC at flight level FL180) suggests that the formation of ice or its accumulation on the aircraft has been a significant contributory factor in this accident

- The use of the autopilot and the failure to disengage it when the emergency situation arose, as it is concluded from the detailed analysis of the radar data, could have contributed significantly to the process that resulted in the loss of control of the aircraft.

- The inadequate training of the pilot (who lacked the type rating for the accident aircraft) in abnormal or emergency situations on the accident aircraft.

1. FACTUAL INFORMATION

1.1. History of the flight

On Sunday, 4 December 2016, a Beechcraft E90 aircraft, registration N-79CT, took off from the aerodrome of Cuatro Vientos (LECU) at 15:57 en route to the aerodrome of Cascais (LPCS) in Portugal. One of the reasons for the flight was to repair the weather radar at a Portuguese maintenance center that specialized in this equipment.

Due to the adverse weather conditions, the aerodrome of Cuatro Vientos was in instrument conditions (IMC) from 09:00 until 14:44. Since this aerodrome is only available to military and state aircraft in VFR conditions, and to light civil aircraft in VFR/special VFR conditions, during the time when IMC were in effect, no landings or takeoffs were possible at the aerodrome, and as a result, the pilot of N-79CT had to delay the takeoff.

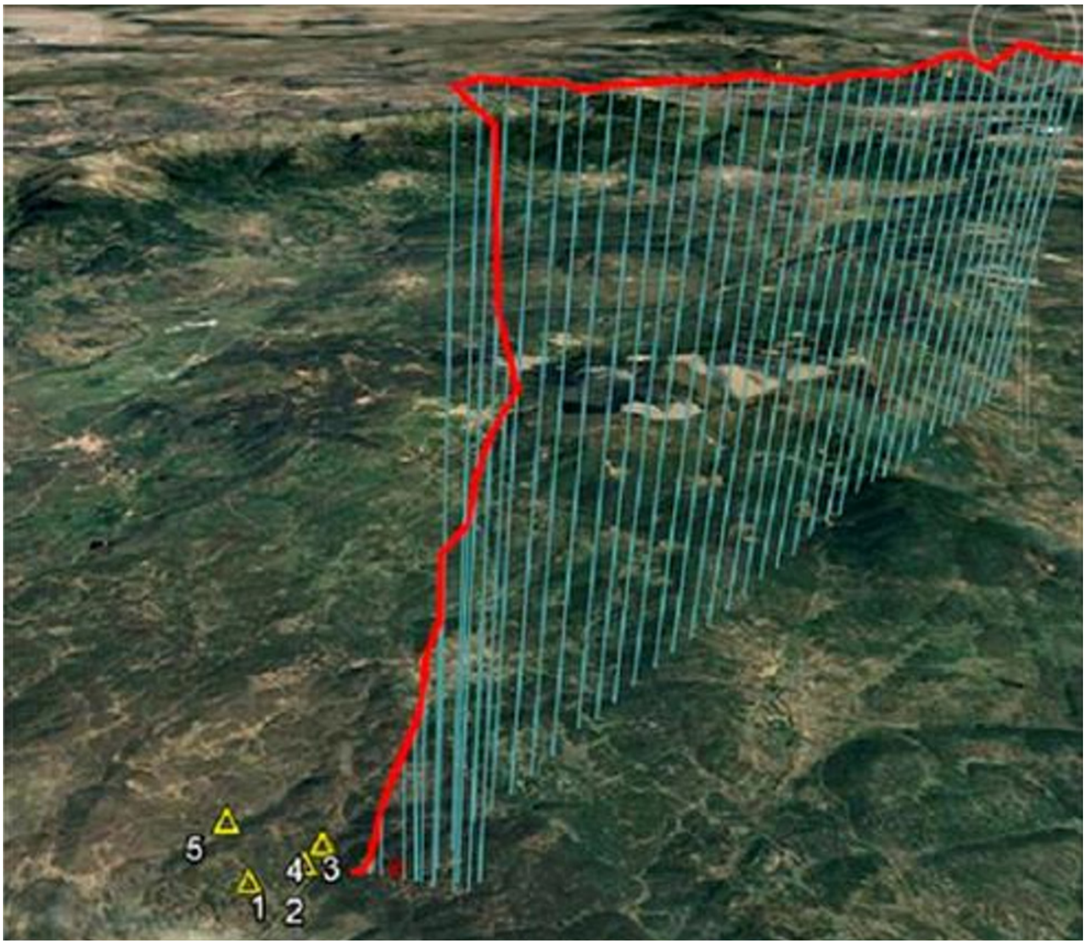
The flight was routine at first, as the aircraft maintained a constant climb slope with normal speed and heading parameters, as shown by the radar track for this initial phase.

Illustration 1: Aircraft's flight path until the time of the ground impact

AAt 16:15:57, the aircraft was climbing to its authorized cruise level at FL210. Moments later, as the radar data show, there was a yaw to the left, and the aircraft started to describe a downward trayectory rotating in that direction and lose altitude suddenly.

Following this event, the aircraft's speed fell quickly and gradually until its stall. The aircraft started to spin, a spin that after some time, turned into a flat spin.

During the uncontrolled descent, with the aircraft in a fully developed spin, loads were placed on the horizontal tail that were in excess of its design loads, which caused the in-flight fracture of the tail into five pieces before the impact with the ground.



Ilustration 2: Aircraft's flight path in the final moments before the ground impact

The aircraft was completely destroyed by the impact and resulting fire, and all four of its occupants were killed in the accident.

The main aircraft wreckage were located in the GPS coordinates: 40° 04′ 55.11″ N and 4° 51′ 03.32″ W

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	1	3	4	
Serious				
Minor				N/A
None				N/A
TOTAL	1	3	4	

1.3. Damage to aircraft

The aircraft was completely destroyed by the impact with the ground and the resulting fire.

1.4. Other damage

There was no other damage of any significance.

1.5. Personnel information

The pilot, a 68-year old Spanish national, had a private pilot license (PPL(A)) since 22 July 2009, issued by AESA[3] , along with NIGHT, IR(A) and CR(A)-SEP (land) ratings, the last two of which were valid until 31 January 2017.

He obtained his Spanish license after his private pilot license issued by the Argentine Civil Aviation Authority was validated. The instrument and multi-engine piston (land) ratings he also obtained by validating his Argentine license and taking theory classes and doing flight tests at the AEROFAN school, in compliance with JAR FCL Appendix 1 to 1015, Section 3.

However, piloting a Beechcraft E90 in Spain required a BE90/99/100/200 type rating, which the accident pilot lacked.

He had a class-2 medical certificate that was valid until 5 January 2017.

During the investigation, it was not possible to determine the number of flight hours that the pilot had on the day of the accident since the documentation that was on board, for both the aircraft and the pilot was destroyed in the fire after the impact.

1.6. Aircraft information

The Beechcraft E90 aircraft, registration N-79CT and serial number LW-303, was manufactured in 1978 and registered in the FAA registry to the company PA Scale Company of Florida, owned by the accident pilot.

[3] The pilot did not have a private pilot license issued by the United States Civil Aviation Authority (FAA). As specified in requirement 61.3, "Requirements for certificates, ratings, and authorizations," contained in FAR Part 61, "Certification: Pilots, Flight Instructors and Ground Instructors" of Title 14, when an aircraft registered in the United States is operated in a foreign country, the pilot license issued by that country is valid.

However, according to Regulation (EC) No 216/2008 - applicable to aircraft registered in a third country and used by an operator for which any Member State ensures oversight of operations or used into, within or out of the Community by an operator established or residing in the Community – the pilot must satisfy the requirements laid out in Annex III of the aforementioned Regulation in order to be able to pilot this type of aircraft. In other words, in the European Union, in addition to the PPL (A), a specific rating is required to operate this type of aircraft.

The aircraft was equipped with two PT6A-135A engines and two HC-D4N-3C propellers. The left engine's serial number was PCE-PZ0209, and its propeller's was FY-2774. The right engine's serial number was PCE-PZ0210, and its propeller's was FY-2776.

These engines had been installed in 2005, and replaced the old PT6A-28 engines, with the propellers replacing the old HC-B3TN-3 models. The engines were new and had been manufactured and assembled with all of their components and accessories by Pratt & Whitney Canada.

The accident aircraft had a Certificate of Airworthiness issued by the FAA. This certificate has no expiration date; however, according to American regulations, the aircraft's airworthiness is required to be inspected annually in order to certify that the aircraft is fit for service.

In order to conduct this annual inspection, the aircraft owner used the services of a CAMO who stated that it had a verbal and punctual spot contract with the owner of the aircraft to assist him in this activity.

The last annual inspection was conducted on 23 March 2016, at which time the aircraft had 6782.6 flight hours and the engines and propellers had 906.60 hours. During this annual inspection various tasks were performed, including the special Phase-3 and Phase-4 inspections described in chapter 05-21-05 of the Maintenance Manual, and the replacement of the right windshield and the main landing gear tires.

These maintenance activities were performed by a maintenance organization whose maintenance technicians did not have an A&P (Airframe and Powerplant) license nor, during the maintenance task, they had been personally supervised by a person with certificate of mechanic or repairman as required by the FAA[4] These maintenance activities were subsequently certified by a maintenance technician with A&P (Aircraft & Powerplant) certification and IA (Inspection Authorization) authorization from the FAA.

Later, in November 2016, the same maintenance organization performed corrective maintenance activities that involved replacing the left fuel tank and installing the SANDEL SA4550[5] avionics suite, which displays the airplane's attitude on a screen.

[4] The FAA issues A&P (Airframe & Powerplant) maintenance technician licenses, which allow working on any type of aircraft and powerplant.

FAA allows anyone to perform maintenance tasks as long as these tasks are directly supervised by a supervisor with a maintenance technician license or a repairman license.

[5] The SA4550 Primary Attitude Display replaces electromechanical ADIs with an LED-backlit display with pilot-configurable single or dual-cue flight director command bars and a glideslope/localizer deviation scale. It features a fast/slow indicator and mode annunciations. The SA4550 accepts inputs from existing sensors to provide a depiction of the aircraft's attitude in pitch and roll.

These maintenance tasks were neither personally supervised by a person with certificate of mechanic or repairman.

The owner of the aircraft decided not to hire the FAA certifier to certify these activities[6].

The maintenance organization does not have a record of the documentation for these maintenance tasks.

As concerns the replacement of the left fuel tank, the maintenance organization indicated that it took place on 22 November 2016. On a flight prior to that date, the owner had detected a loss of fuel in the left wing. The maintenance organization inspected the aircraft and noticed a break between the left tank and its fuel lines. Since it is all one component, it was decided to replace the entire fuel tank assembly.

After this replacement, a test was done to verify that the new tank had been correctly installed. This test involved taxiing at the airport. There is also no record of the documentation associated with this test[7].

After the fuel tank was replaced, the aircraft made two flights, one from the aerodrome of Cuatro Vientos to the aerodrome of Son Bonet on 22 November, and another from Son Bonet to Cuatro Vientos on 24 November. The pilot did not report any problems with the fuel supply to the left engine after these flights[8].

What the owner did identify during these flights was the incorrect operation of the weather radar. One of the reasons for flying to Cascais on 4 December was to repair the weather radar at a Portuguese maintenance workshop that specializes in this unit. The MMEL (Master Minimum Equipment List) requires that the weather radar be operational whenever operations are being carried out in known or forecast icing conditions. As a result, the aircraft did not meet the necessary conditions for this flight.

This document lists its repair category as C, meaning it has to be repaired within 10 days (240 h), excluding the day when the malfunction is detected. According to this MMEL requirement, the radar was not repaired within the required 10-day window.

[6] To maintain the aircraft's airworthiness, these maintenance activities should have been certified

[7] The documentation for the maintenance activities performed during the last annual inspection, done in March 2016, or for the maintenance activities done in November 2016, could not be obtained during the investigation. It is likely that the owner of the aircraft had the maintenance documentation on board, and that it was destroyed in the accident.

[8] These flights were not made under icing conditions.

The maintenance activities performed in November 2016 had not been certified by the FAA certifier; therefore, on the day of the accident the aircraft was not legally airworthy.

1.7. Meteorological information

The meteorological information forecast by the AEMET for the day of the accident was as follows:

General meteorological situation

The situation was characterized by the presence of an isolated Atlantic squall centered off the coast of Portugal, with an exit ridge over the northeast of the Iberian Peninsula and the Balearic Islands, a notable diffluence over the south of the peninsula and an intense southerly wind at all levels. On the surface, the squall was approximately under the low-pressure area aloft, with a pressure of 998 hPa at its center. There were several bands of heavy rain ahead of it, one coming in from the south of Portugal and another further ahead, extending from the east of Andalusia to the central part. Between the two, and practically stationary, was the most active band, affecting primarily Malaga and the east of Cadiz, areas where the intensity and the stalling benefit from the geographic features. There was generalized and locally heavy precipitation in the Costa del Sol. The band that penetrated from Portugal left precipitation in Huelva and Extremadura over the course of the afternoon.

Meteorological situation in the aerodrome of Cuatro Vientos

As concerns the weather situation at Cuatro Vientos before takeoff:

METAR LEVS 041430Z VRB02KT 9999 **FEW010 OVC020** 11/10 Q1011=

METAR LEVS 041500Z 09005KT 050V140 9999 **BKN020 OVC030** 11/09 Q1012=

The 15:30 (14:30 UTC) METAR indicated a first layer with few clouds with its base at 1000 ft, and a second layer with overcast skies and a base at 2000 ft. Half an hour later, the 16:00 (15:00 UTC) METAR indicated a first layer with broken clouds and a base at 2000 ft, and a second layer with overcast skies and a base at 3000 ft.

The TAF forecasts in effect were similar to the METARs:

TAF LEVS 041100Z 0412/0421 12008KT 9999 **SCT010 BKN020** TEMPO 0412/0421 3000 RA BR **BKN006** TEMPO 0412/0421 **RA=**

TAF LEVS 041400Z 0415/0424 12008KT 9999 **SCT007 OVC010** TEMPO 0415/0418 3000 RA BR **BKN006** TEMPO 0415/0424 **RA=**

At the moment of takeoff, 15:57 local time, the TAF indicated a first layer with scattered clouds and a base at 1000 ft, and a second layer with broken clouds and a base at 2000 ft. It also called for overcast intervals with a cloud base at 600 ft. It was also forecast to rain all day, from 13:00 until 22:00.

These weather conditions kept the aerodrome of Cuatro Vientos closed from 09:00 until 14:44.

Meteorological situation en route

The significant low-level maps (up to FL150) forecast the presence of broken low clouds (cumulus and stratocumulus) with bases around 1000 ft and tops above 15000 ft, possible moderate icing between 9000 and 12000 ft, and isolated cumulus congestus (towering cumulus) clouds.

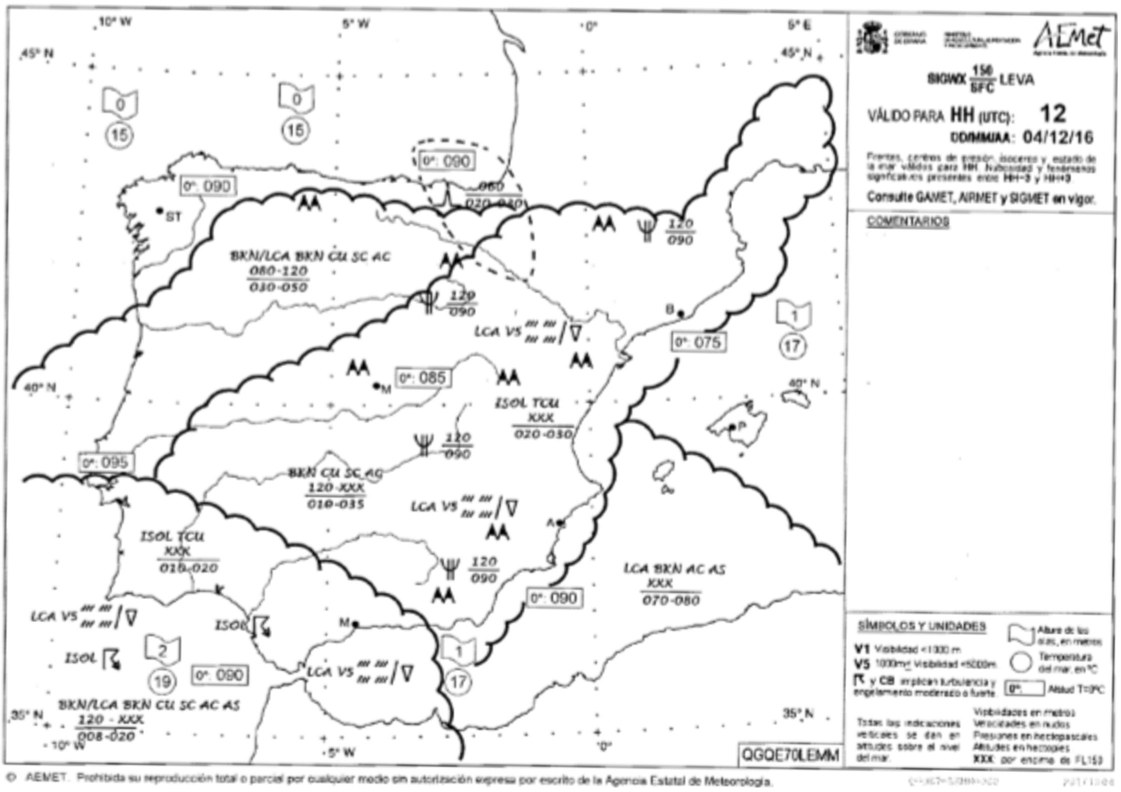


Illustration 3: Low-level map for 12:00 UTC

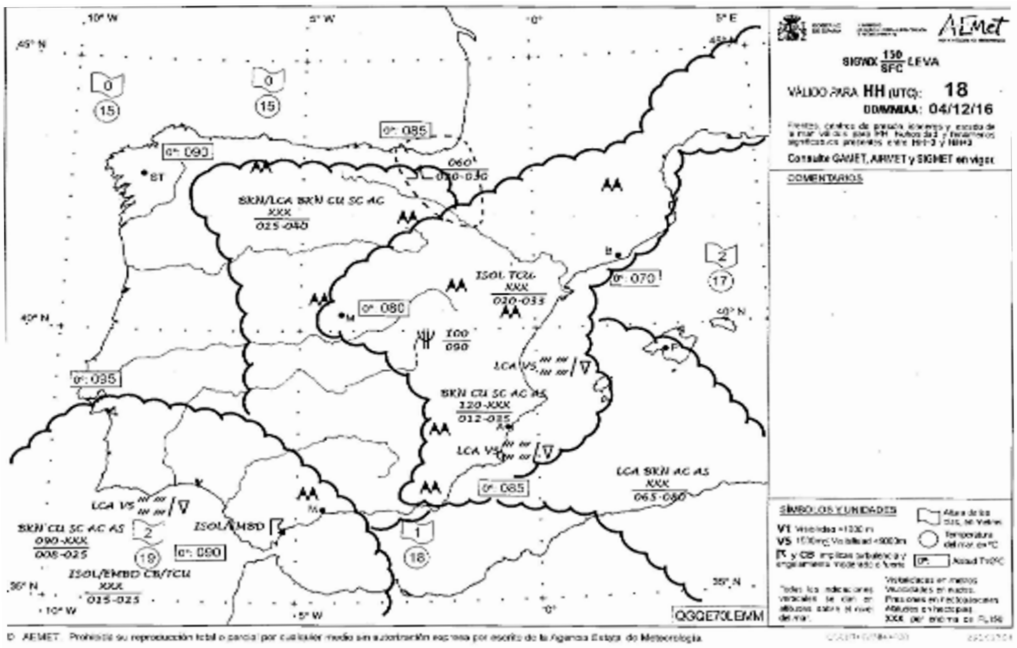


Illustration 4: Low-level map for 18:00 UTC

The high- and medium-level map from the London WAFC also forecast the presence of cumulonimbus embedded in the broken clouds, with tops at 35000 ft in the area where the flight took place.

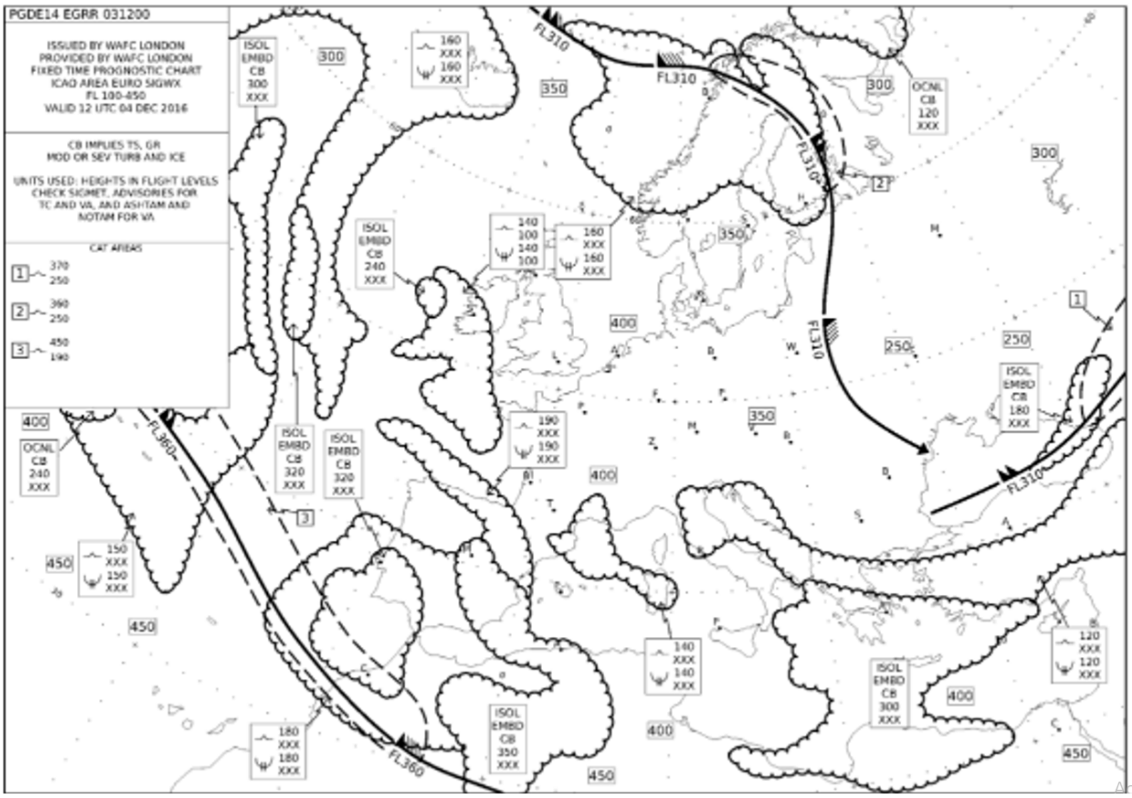


Illustration 5. Significant weather chart for EUR region for 12:00 UTC

The significant weather map shows the legend CB, which indicates the presence of turbulence or moderate or heavy icing at the center of the cumulonimbus.

According to the wind and temperature map for FL180, the temperature was between -17 and -19 degrees Celsius.

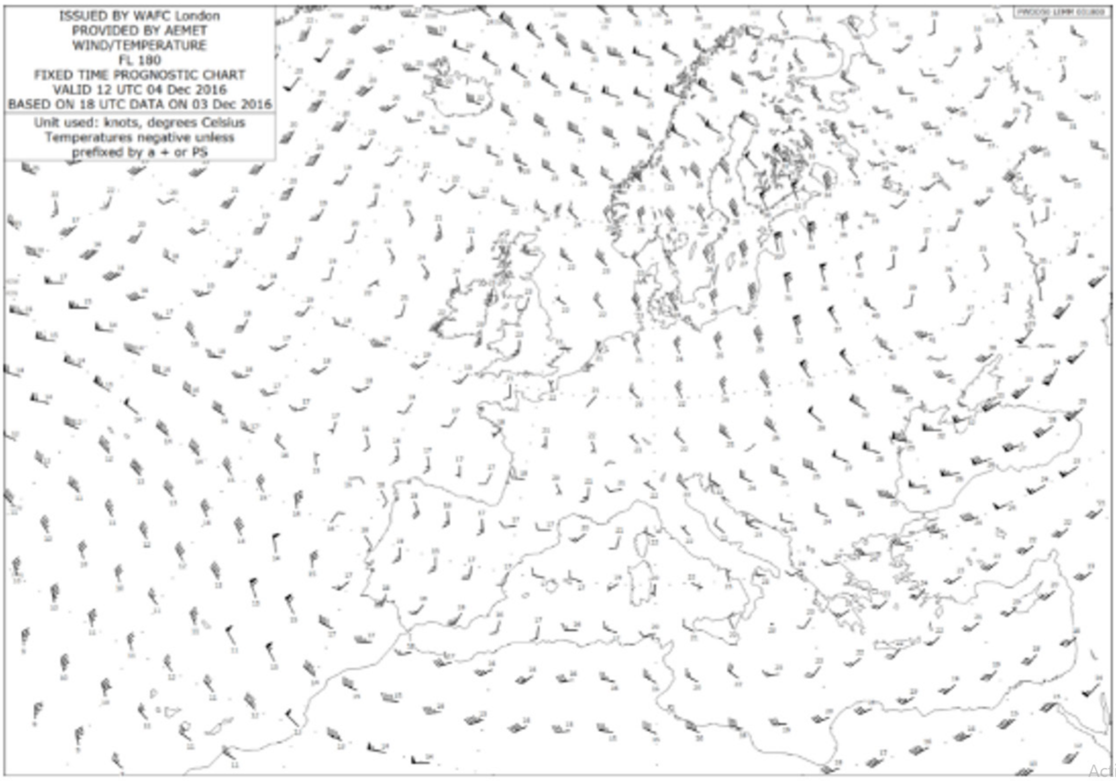


Illustration 6: Wind and temperature forecast for FL180 on 4 December at 12:00 UTC

Given this situation, the AEMET was asked about the possibility of ice forming during the flight of the accident aircraft. The AEMET answered that it does not have additional data or information that could be used to accurately determine the probability, the level of risk and the characteristics of icing conditions in the route followed. However, since the area was between two lines of instability where convective clouds were developing[9], and since there were broken clouds and given the temperatures forecast (about -12° C[10] at FL150 and -22° C at FL200), the AEMET believes that icing conditions could have been present at FL190. As a result, the formation of ice on that segment of the flight cannot be ruled out.

[9] For convective clouds, it is possible to state that moderate icing may occur.

[10] Icing is more likely at higher temperatures, closer to 0° C.

1.8. Aids to navigation

The investigation has determined that the aids to navigation were not relevant to this accident. It was confirmed, however, that there were no anomalies before, during or after the flight of the accident aircraft.

The radar track for the accident aircraft was available, the data from which were used to conduct a detailed analysis of this event. The coverage provided by ENAIRE is multi-radar, with the radars in Valladolid and Valdespina offering the best coverage of the accident area.

The most significant times in the analysis of the accident are shown below.

At 16:16:07, the aircraft was at FL190 and climbing to its cleared level of FL210. At that point, the aircraft's ground speed was 120 knots, it was on a heading of 245° and climbing at 1194 ft/min.

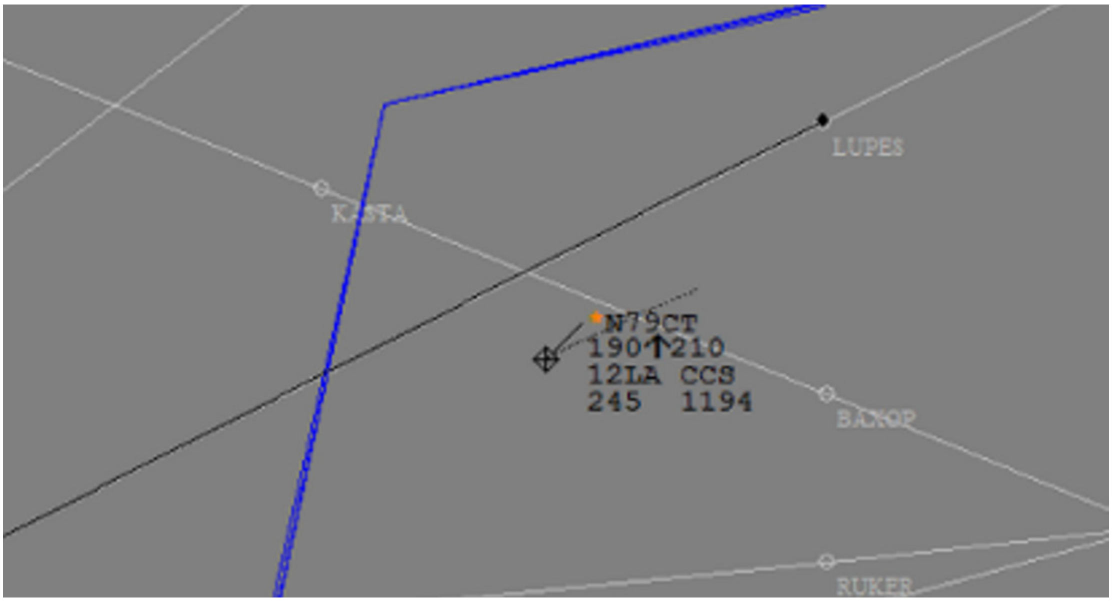


Illustration 7: Aircraft's position at 16:16:07 h

Two seconds later, the aircraft started to descend to FL190. At that point:

- The aircraft's ground speed fell to 80 knots.
- Its heading changed to 184°, meaning the aircraft turned 61° counterclockwise in 2 seconds, and
- Its descent speed was 663 ft/min.

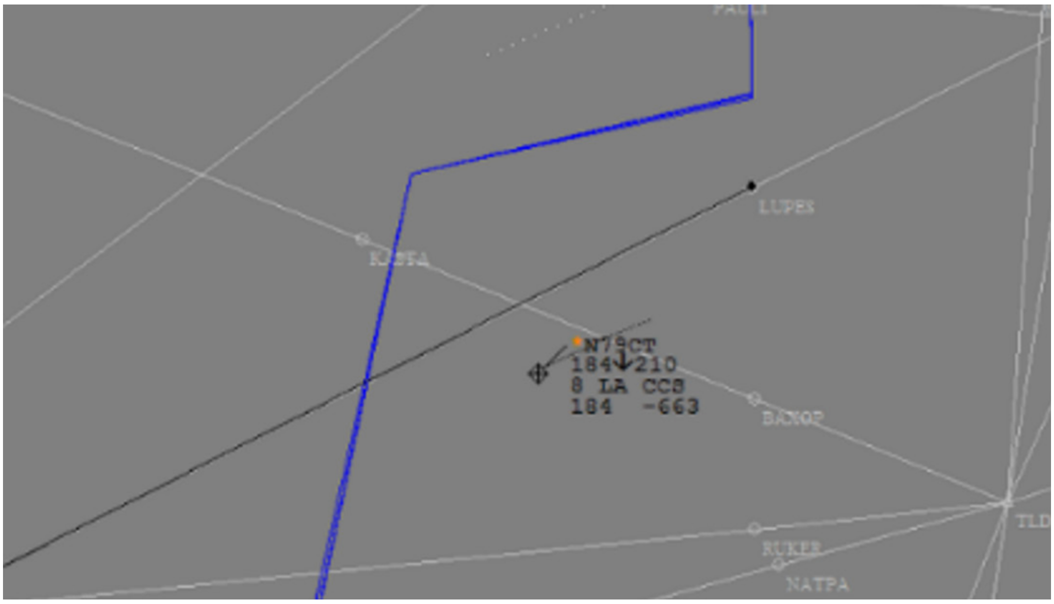


Illustration 8: Aircraft's position at 16:16:09

From 16:16:29, the aircraft's ground speed fell to 20 knots. Its descent speed was 663 ft/min and its heading changed to 353º.

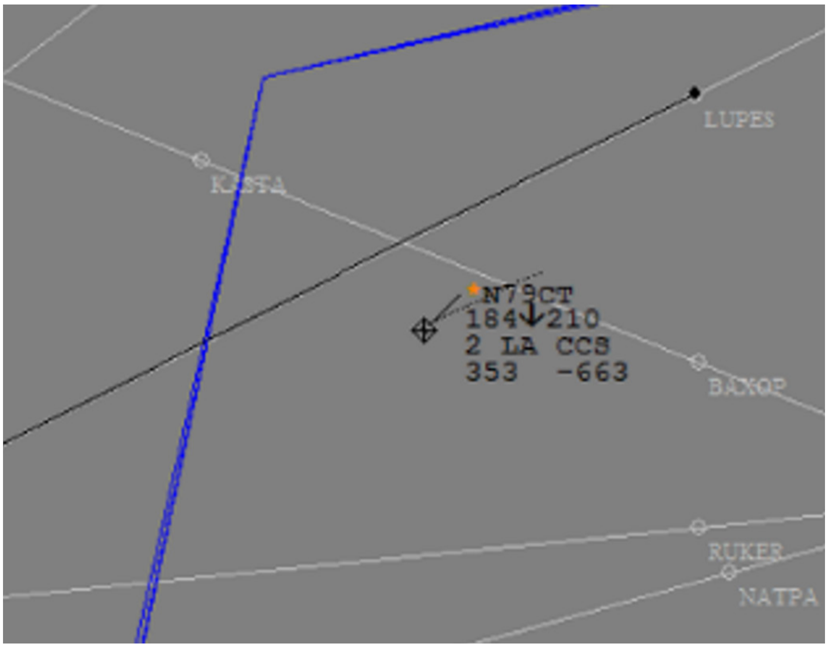


Illustration 9: Aircraft's position at 16:16:29

Later, at 16:16:51, there was an increase in the aircraft's descent speed, which at that time was 7144 ft/min.

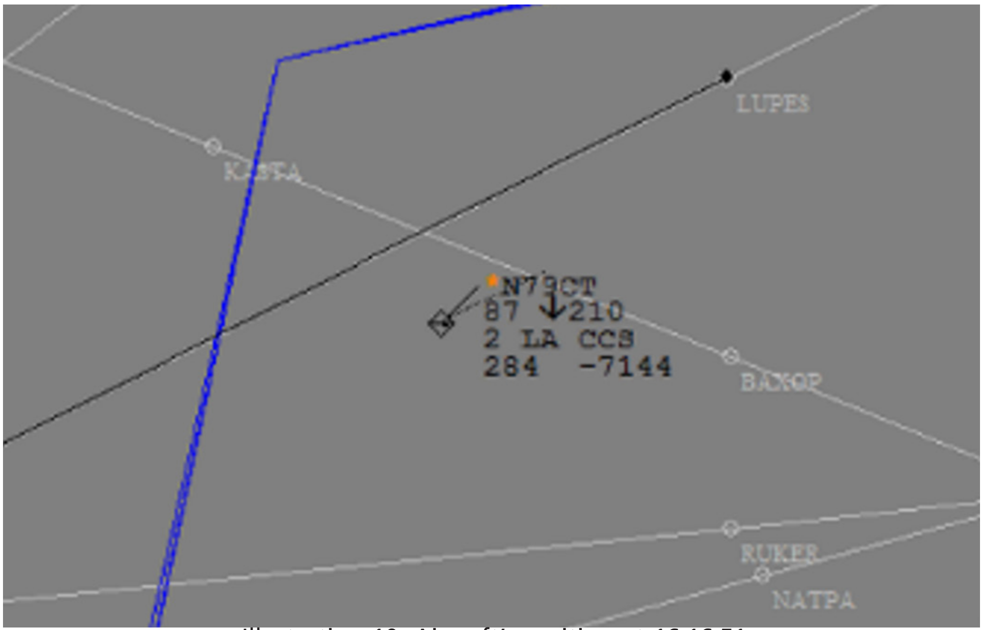


Illustration 10: Aircraft's position at 16:16:51

1.9. Communications

The communications between the pilot and air traffic control services involved the authorized flight level.

The last exchange occurred at 16:14:30. The pilot stated that he was climbing to FL210, with the controller replying he was in radar contact.

At 16:17, the aircraft's radar signal was lost.

At 16:26:46, which was 9 minutes after the loss of signal, air traffic control services in Portugal contacted the Spanish controller in an effort to locate the aircraft. The Spanish controller was unaware that the aircraft's radar signal had disappeared minutes earlier.

At 16:57:36, 40 minutes later, the Spanish controller contacted SAR, which informed him that the aircraft had been in an accident.

1.10. Aerodrome information

The aircraft took off from the aerodrome of Cuatro Vientos in Madrid and was heading to the aerodrome of Cascais in Portugal.

The AIP states that the aerodrome of Cuatro Vientos is only open to military and state aircraft in VFR and to light civil aircraft in VFR/special VFR.

On the day of the accident, the aerodrome of Cuatro Vientos was in instrument conditions from 09:00 until 14:44. Under these conditions, aircraft cannot take off from or land at the aerodrome of Cuatro Vientos. As a result, the pilot had to delay the takeoff.

1.11. Flight recorders

The accident aircraft was not equipped with flight recorders, as this was not required by law.

1.12. Wreckage and impact information

The aircraft was completely destroyed by the impact with the ground and the subsequent fire.

The figure below shows the debris field. The main wreckage of the aircraft was found at coordinates 40° 04′ 55.11″ N and 4° 51′ 03.32″ W.

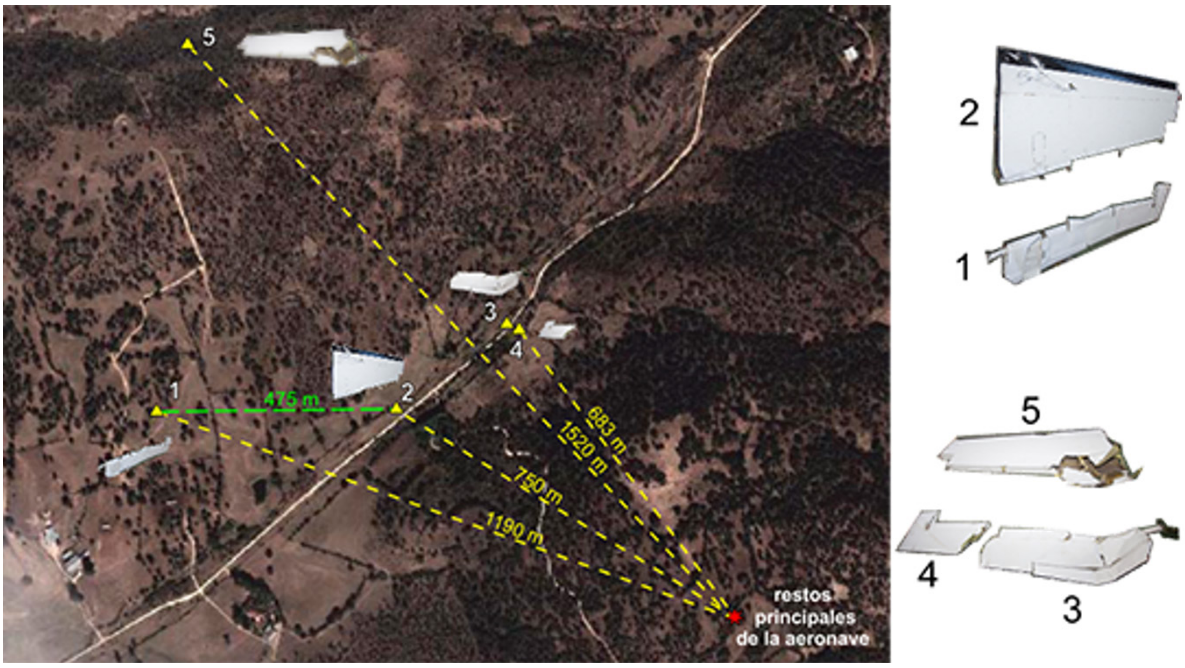


Illustration 11: Diagram of the debris field

The horizontal tail detached from the aircraft in flight, separating into five pieces that were located at different points:

- The right elevator (#1, in the figure of the debris field) was found at coordinates 40° 05′ 07.72″ N, 4° 51′ 50.43″ W, at a distance of 1190 m from the main wreckage.

- The right horizontal stabilizer (#2 in the diagram) was found at 40° 05' 07.72" N, 4° 51' 30.41" W, 750 m away from the main wreckage and 475 m away from the right elevator.

- As for the left elevator, it was found in two parts, one of them (#4 in the diagram) at coordinates 40° 05' 13.17" N, 4° 51' 21.07" W and the other (#3 in the diagram) at 40° 05' 12.86" N, 4° 51' 20.16" W. They were very close to one another and 683 m away from the main wreckage.

- The left horizontal stabilizer (#5 in the diagram) was found at 40° 5' 30.84" N, 4° 51' 47.52" W. It was the most distant component from the main wreckage, which was 1520 m away.

1.13. Medical and pathological information

There is no indication that physiological factors or incapacitation affected the pilot's actions.

1.14. Fire

The airplane caught fire after it impacted the ground.

1.15. Survival aspects

The pilot and occupants were killed in the accident due to the nature of the event.

1.16. Tests and research

Statement from eyewitness #1

Eyewitness #1 stated that at about 16:15 or 16:20, he was in the "La Fortiña" wetlands when he heard the sound of an airplane engine that seemed to be failing. He was unable to see the airplane due to the cloud cover. The sound seemed to be coming from the northeast of the wetlands, and he thought the airplane was at an altitude of 1 km over the ground.

Statement from eyewitness #2

Eyewitness #2 stated that at around 16:30, he was in La Cañada Real, part of the municipality of Sotillo de las Palomas, when he heard an airplane flying low overhead and making a strange noise.

He stated that the airplane was flying in circles, as if trying to land somewhere. At one point, he saw the airplane nose dive, losing it from sight behind a mount of oak trees on the Las Umbrias estate in the municipality of Sotillo de las Palomas. He then saw smoke rising from the place.

As he watched what was happening, he heard a thud near him, which he later confirmed could have been caused by a part of the airplane's fuselage falling in La Cañada Real.

Statement from eyewitness #3

Eyewitness #3 was with some friends on the road that connects the towns of Sotillo and Las Palomas de Segurilla. At 16:20, they heard a strange and very loud noise.

As they looked for the source of the noise, the saw what seemed to be an airplane in the sky flying at a low altitude. The aircraft was pirouetting downward, without leaning toward the nose or the tail, and circling at high speed in a fairly tight curve.

They did not hear it impact. They followed the smoke to the accident site and reported it to 112. They saw that the airplane was burning.

Statement from eyewitness #4

C He stated that at 16:15 he was with some friends on a path called Cabeza Alta, in the municipality of Sotillo de las Palomas, when they heard a very loud sound from an airplane that was flying over their location.

The airplane was rotating about its longitudinal axis while also moving in ever smaller circles at a high rate of speed until they lost it from view due to the terrain. They did not hear it impact.

They did not see anything detach from the aircraft.

They followed the smoke to the crash site and reported it to 112. They were unable to approach the airplane due to the flames. They were able to hear small banging sounds.

Statement from eyewitness #5

He stated that he was with some friends on the road that goes from Sotillo de las Palomas to Segurilla, when at about 16:20 they heard a strange sound. When they looked for the source, they saw what seemed to be a low-flying airplane in the sky.

The aircraft seemed to be rotating about its longitudinal and vertical axes at a high rate of speed.

They reached the accident site and called 112. They did not approach the aircraft because it was burning and there were explosions.

Statement from eyewitness #6

It was about 16:30 and he was shepherding a herd of cows in the "Palanquines" farm when he heard what sounded like a small airplane, though he thought nothing of it, since airplanes fly over the area every day. He could not see it because the sky was overcast.

Seconds later, he heard a louder noise coming from the airplane. It sounded like a bang, and he then heard an even louder noise. This got his attention and looking up at the sky, he saw the airplane falling while spinning with the nose of the airplane pointing down.

Seconds later he heard a loud impact against the ground.

He added that the aircraft was rotating about its longitudinal and vertical axes. Due to its speed, he could not tell if any parts detached from the aircraft. The noise that the aircraft made in the sky before it descended to the ground got his attention.

Inspection of the engines.

The photo below shows the condition in which the PT6-135A engines were found at the accident site after the crash and subsequent fire.

Illustration 12: Overview of the engines in the field

In order to determine the operating conditions of the engines, they were disassembled and inspected in detail with assistance from a representative of the manufacturer, Pratt & Whitney Canada.

1.- Inspection of the left engine

During the inspection of the left engine, with serial number PCE-PZ0209, its components were disassembled one by one. The following findings were made:

Illustration 13. Left engine at the crash site

1.- Compressor:

a. Mechanically the compressor was in good condition. All of its compression stages were good, meaning no foreign object damage was noted.

b. The compressor turbine blades were not broken. The tips of the blades were severely rubbed on the compressor shrouds

2.- Chip detector and filters:

a. There were no metal particles in the chip detector in the accessory reduction gearbox.

b. The oil filter that detects potential metal particles in the accessory box was clean, though it had been damaged by the post-impact fire.

3.- No damage was observed in the combustion chamber.

4.- Power Turbine:

a. The power turbine disc did not turn with the propeller.

b. There were scratches and circular marks on several elements caused by friction between moving and static parts.

c. The power turbine blades were broken and deformed in the opposite direction of rotation. Fragments of the blades were found inside the engine exhaust.

5.- The first stage carrier at the shaft radius in the reduction gearbox was broken by torsional overload.

In conclusion, the damage found outside and inside the left engine and the fractures to the various engine components did not occur in flight; rather, they were compatible with the impact with the ground and the subsequent fire that broke out. At the moment of impact, the engine was turning.

The fact that all of the compression stages were in good condition rules out ice ingestion into the left engine.

2.- Inspection of the right engine

Likewise, during the inspection of the right engine, with serial number PCE-PZ0210, its components were disassembled one by one, yielding the following findings:

Illustration 14: Right engine at the crash site

1.- Compressor:

a. There was no foreign object damage, as might occur with ice ingestion.

b. The compressor turbine blades were not broken. The tips of the blades were severely rubbed on the compressor shrouds.

2.- Chip detector and filters:

a. There was a small number of metal particles in the accessory gearbox chip detector.

b. Since the chip detector had particles, the screen filter was removed[11]. When this screen filter was taken out, a screw and washer were found, and there were more particles at the bottom.

Illustration 15. Close-up of metal particles found in the chip detector in the right engine

c. The main oil filter was clean, like the one in the left engine, with no particles but burned.

[11] The screen filter is used to detect potential metal particles in the reduction gearbox.

3.- No damage was observed in the combustion chamber

4.- Power Turbine:

a. The power turbine disc did not turn with the propeller.

b. As in the other engine, the power turbine blades were not uniformly broken. The power turbine blades exhibited the same deformation as the other engine and the turbine disc had circular scratches due to friction between moving and static parts.

c. Two of the four Nº 4 bearing bolts and their associated washers, from the power turbine shaft and its support bearing were missing. As described earlier, one of the two missing bolts and its washer were found in the screen filter that detects metal particles. The other bolt and its washer were found in a rear cavity in the RGB. The bolts were bent and threads exhibited material extracted from the power turbine shaft housing. These features suggest these damages occured during the impact. Their washers were undamaged.

Illustration 16: Close-up of gear box, showing only two of the four bolts

5.- The first stage carrier at the shaft radius in the reduction gearbox was broken by torsional overload.

In conclusion, the damage found outside and inside the right engine and the fractures to the various engine components did not occur in flight; rather, they were compatible with the impact with the ground and the subsequent fire that broke out. At the moment of impact, the engine was turning.

The fact that all of the compression stages were in good condition rules out ice ingestion into the right engine.

The P3 and Py pneumatic lines from both engines were too damaged by the impact and the subsequent post crash fire to determine if they contributed to this event.

It was not possible to determine if both engines accessories contributed to this event due to the extension of the damages produced by the same in the fuel system accessories.

The tests of both CSUs indicated that they had been adjusted to reduce the maximum propeller speed below the acceptance test procedure limit. During the investigation it was not possible to determine who had last adjusted the CSUs.

Inspection of the propellers.

The condition of the propellers on both engines after the aircraft's impact seemed to indicate they were feathered. To determine if the propellers were feathered in flight by the pilot or if they were feathered by the impact with the ground, they were inspected in detail.

As recommended by Hartzell, the propeller manufacturer, the propellers were disassembled and inspected at the facilities of Aerohelice in Portugal with assistance from Hartzell.

<u>1.- Inspection of the left propeller</u>

The left propeller, with serial number FY-2774, was disassembled piece by piece to check its condition. One of the four blades on this propeller broke in the accident. Another blade had its counterweight broken, most likely when the aircraft impacted the ground.

The heated area on blade #1 exhibited a localized burn mark. A lightning strike was ruled out since the metal parts on the propeller were not magnetized.

Illustration 17: Close-up of a blade on the left propeller

Following a visual inspection, the propeller was disassembled. The photos below show the condition of the spring and the absence of hydraulic fluid in the cylinder.

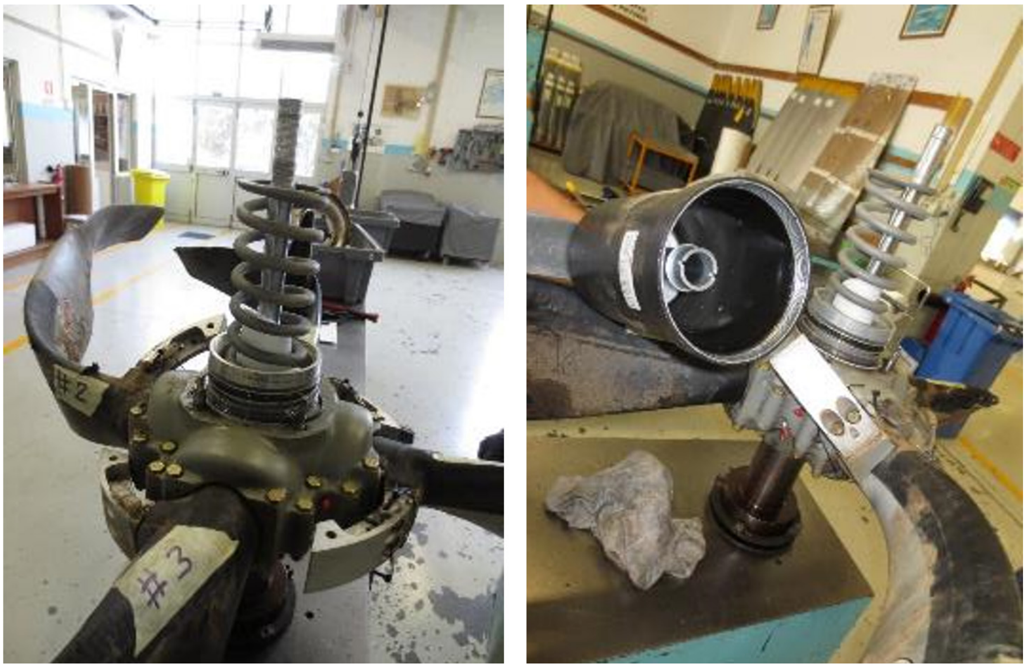


Illustration 18: Close-up of the spring and cylinder on the left propeller

The spring guide, made of a white plastic material, was broken. When the piston and each of the propeller blades were removed, several screws and stops were found to be broken.

By analyzing the heads on the blades, Hartzell was able to determine the pitch of the left propeller at the moment of impact:

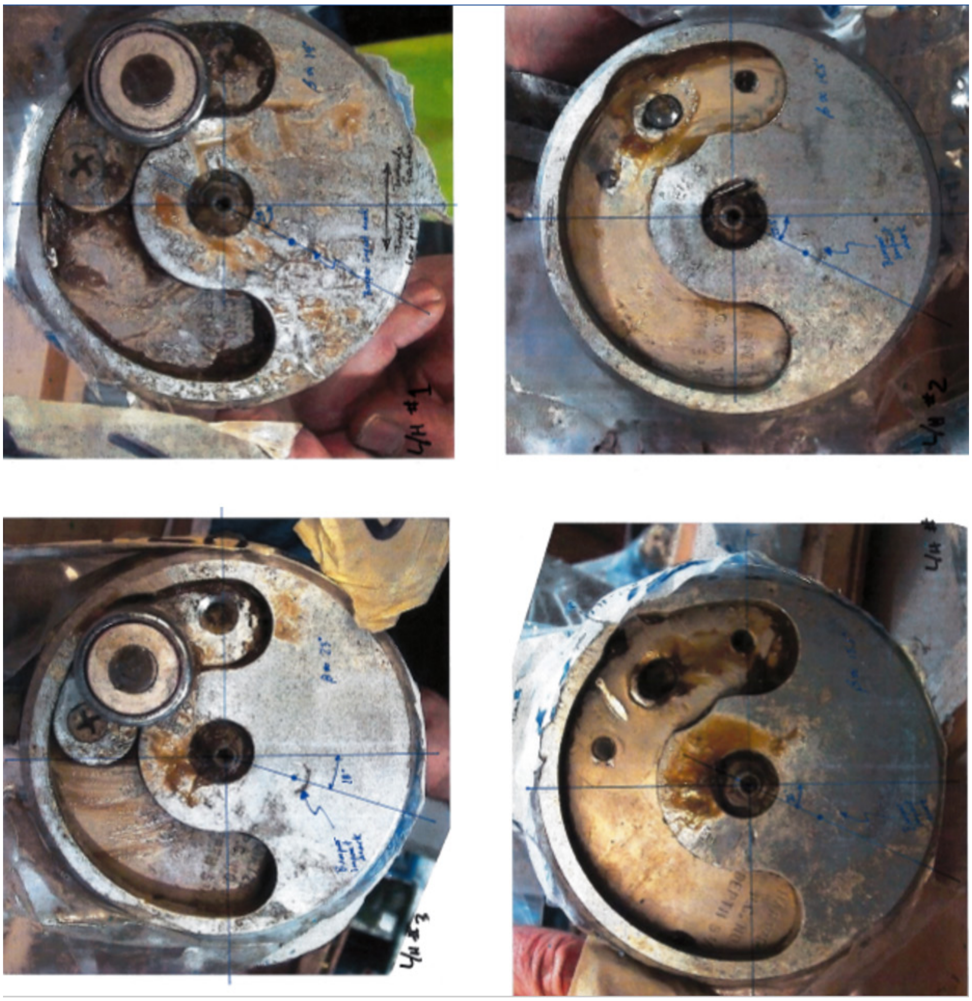


Illustration 19: Close-up of the four blades on the left propeller

The angle of impact of the bumper on the fork with the pre-load plates on the propeller indicates the angle of the blades. The blades were at a pitch angle between 14° and 23°. A pitch angle of 14° in flight corresponds to an idle or low speed/low power situation.

Considering the damage to the propeller and the fact that it seemed to be forced to a higher pitch angle, Hartzell believes that the propeller's pitch angle was more likely to be closer to 23°.

<u>2.- Inspection of the right propeller</u>

The right propeller, serial number FY-2776, was disassembled piece by piece to check its condition. This propeller was found apparently feathered during the onsite inspection, so it was considered important to the investigation to determine if this propeller was feathered in flight or by the impact with the ground.

The blades on the right propeller had numerous friction marks caused by the ground. It is obvious that this propeller was moving at the time it impacted the ground. The photos below show how the blades were deformed and the friction marks.

Illustration 20: Close-up of the four blades on the right propeller

Unlike the left propeller, the cylinder that houses the spring for the right propeller had broken, as the photos below show, allowing a large amount of dirt to be collected inside.

The cylinder was removed from the propeller to check the condition of the spring. The spring guide in this propeller was not broken.

Once the cylinder was removed, the piston shaft was found to be completely off-center as a result of the impact between the moving propeller and the ground.

Illustration 21: Close-up of the cylincer and piston shaft on the right propeller

The blades were then removed from the right propeller one by one. There was a large amount of lubricant in the cavity into which the propeller blades are inserted. This lubricant appeared normal.

As was done with the left propeller, the blade heads were analyzed by Hartzell, which allowed it to determine the pitch of the right propeller at the moment of impact:

In this case, the pitch angle of the blades was between 14° and 23°; however, Hartzell stated that it was hard to identify the impact mark on the propeller blade identified as R3.

Since three of the blades on this propeller were bent forward in the direction of thrust, and the fourth blade was bent into an S-shape, it was concluded that the impact occurred with the blades at a positive pitch angle and at higher power than for the left propeller.

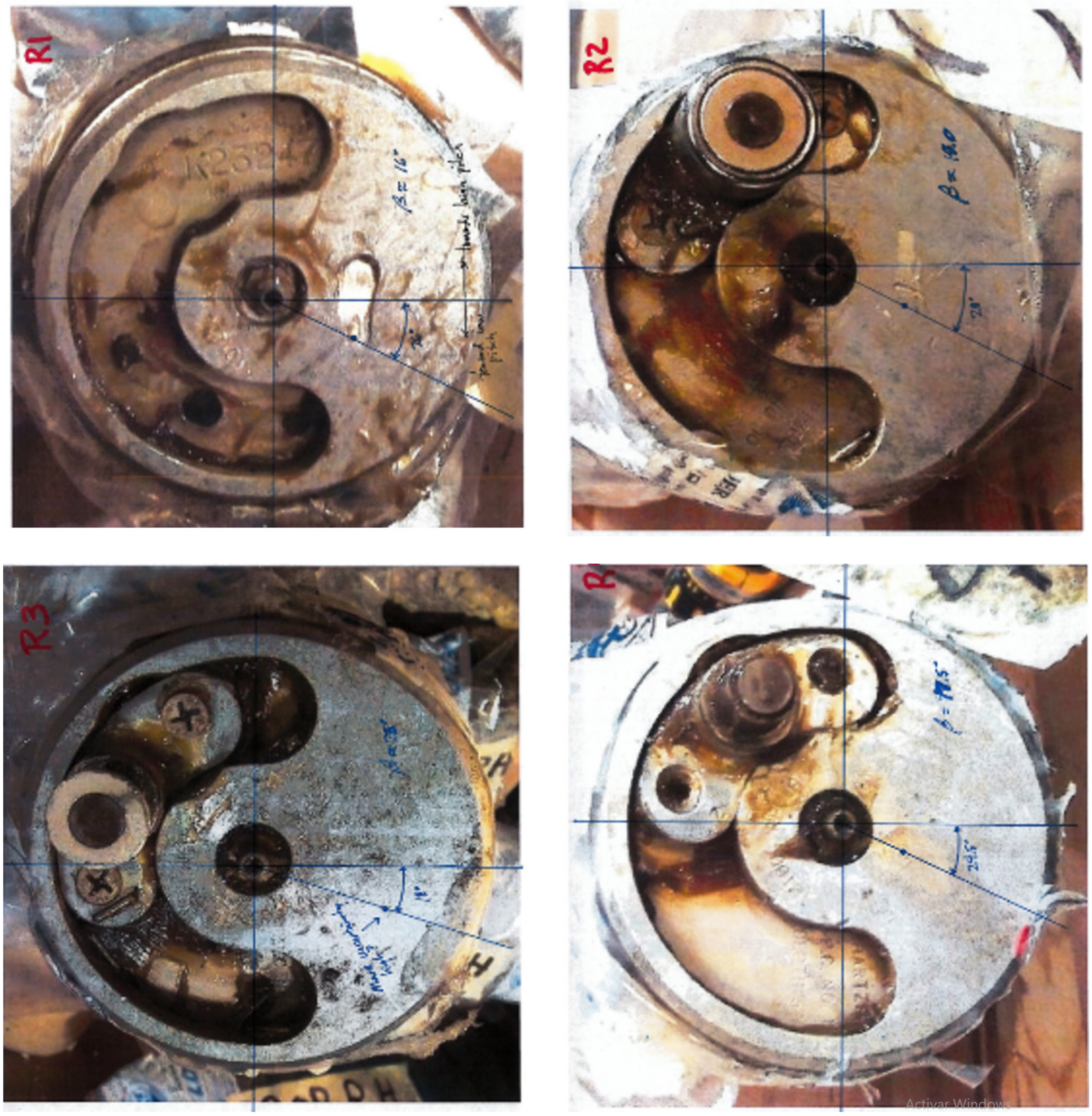


Illustration 22: Close-up of the four blades on the right propeller

Considering the damage to the propeller, Hartzell stated that the pitch angle would have been close to 23°, similar to the other propeller.

Analysis of fractures in horizontal tail

The fractures in the horizontal tail were analyzed at the Materials Testing Laboratory of the School of Aeronautical and Space Engineering at the Universidad Politécnica de Madrid (UPM).

The photos below show the fragments from the right part of the horizontal tail after the accident:

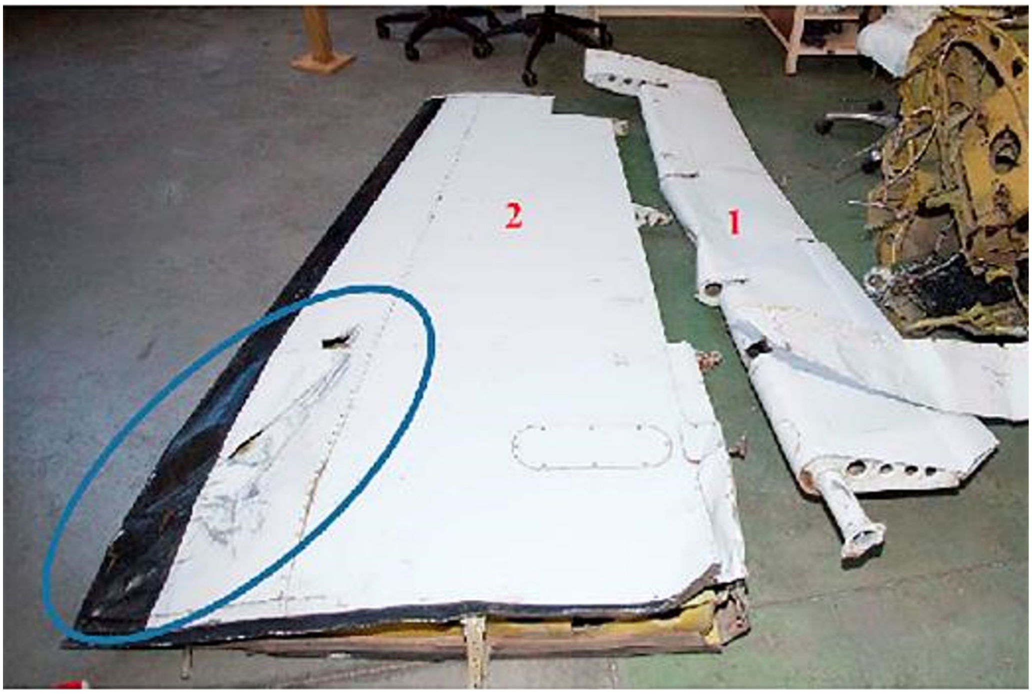


Illustration 23: Wreckage from the right side of the horizontal tail

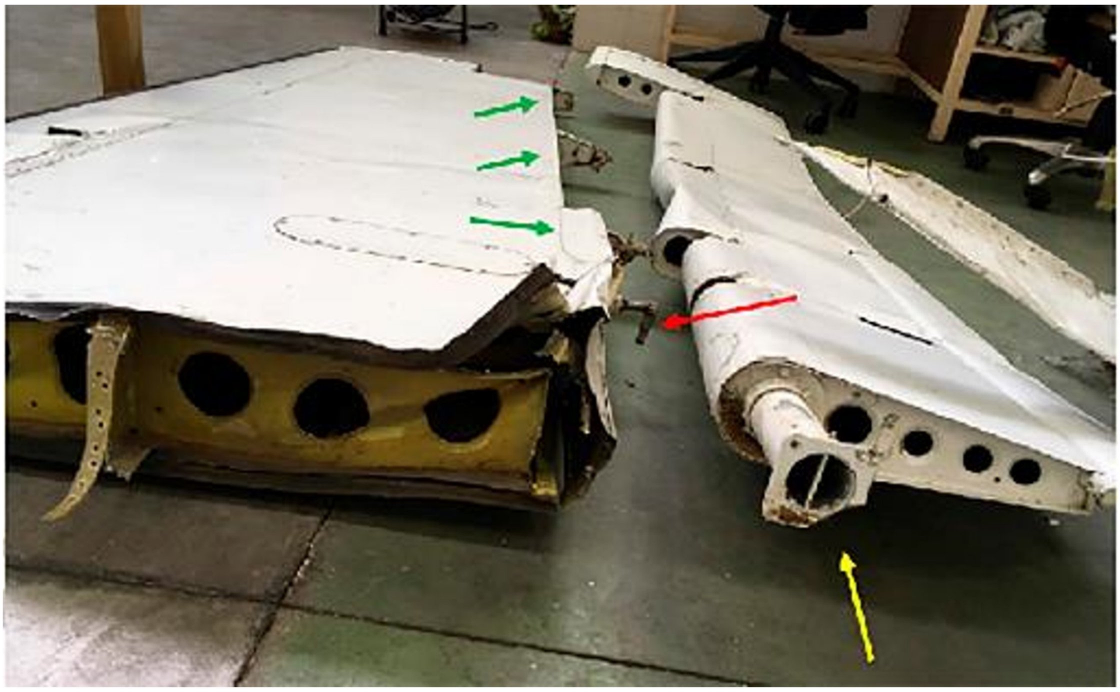


Illustration 24: Side view of the wreckage from the right part of the horizontal tail

The following observations were made involving the right part of the horizontal tail:

- The right stabilizer was not significantly bent. The dent in the top surface (shown in blue in Illustration 23, Wreckage from the right part of the horizontal tail) fit perfectly with the counterweight at the end of the rudder. It underwent an instantaneous ductile fracture under bending and torsional loads. Once the horizontal stabilizer detached upward, it struck the edge of the vertical stabilizer.

- The right elevator was clearly bent upward. It separated from the stabilizer due to the ductile failure of the fastening components at the three hinges (circled in green in Illustration 24 (Side view of the wreckage from the right part of the horizontal tail) that attach it to the stabilizer. Before it separated completely, there were strong oscillations (up and down) in the elevator with respect to the stabilizer.

- During the separation process, the right trim tab actuator fractured, most likely due to the application of one or more excessive forces to it, which caused it to eventually undergo ductile failure.

- The right elevator separated from the tail cone at the part where the rotating tube joins the actuator, caused by the instantaneous fracture of two screws, the tearing and pulling out of another screw, and the fracture of a fragment on the component.

The wreckage from the left part of the horizontal tail is shown in the photos below:

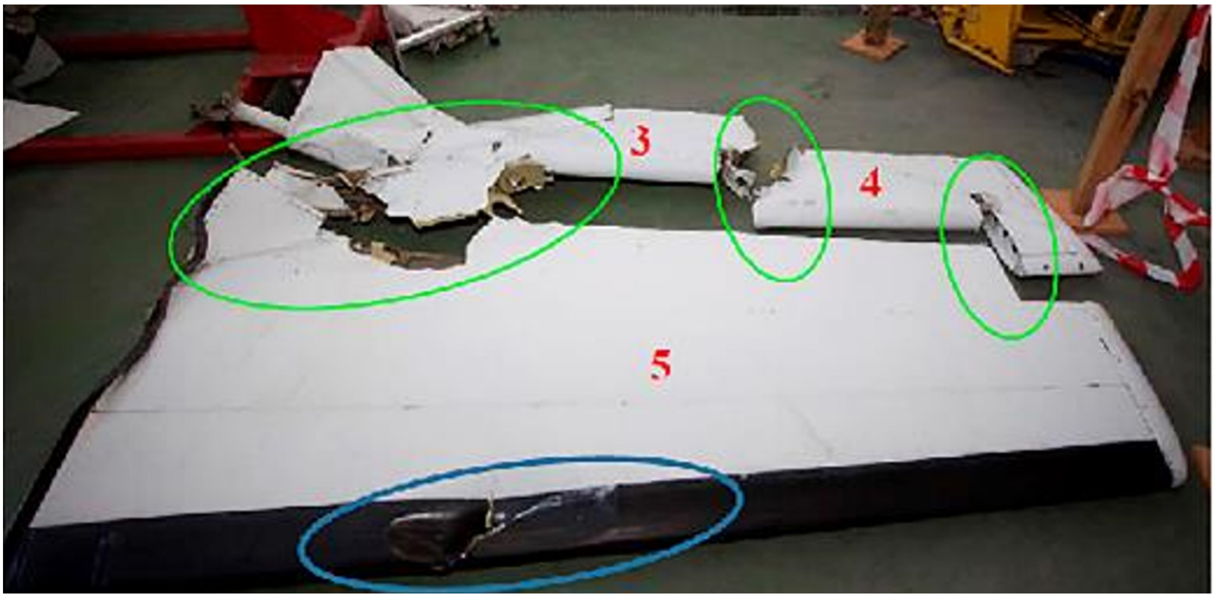


Illustration 25: Wreckage from the left part of the horizontal tail

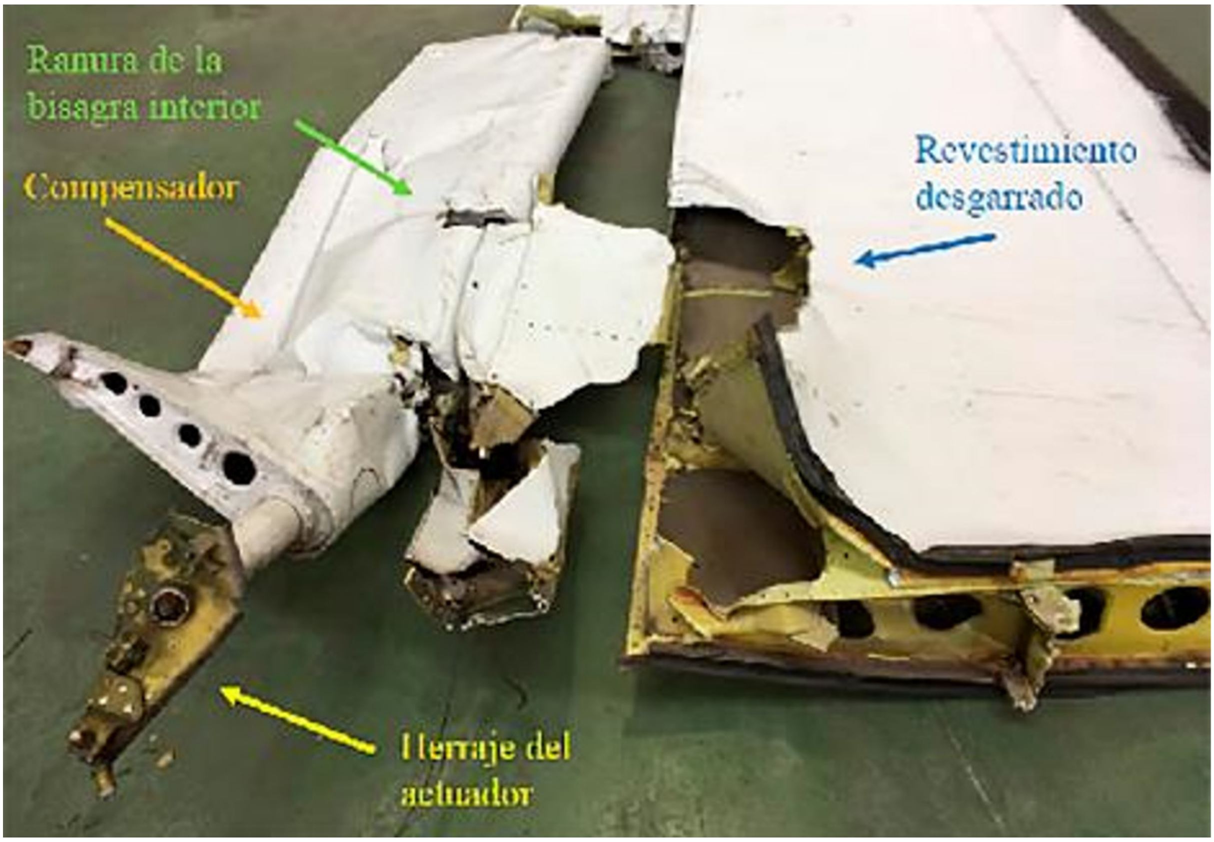


Illustration 26: Side view of the parts of the left stabilizer and elevator closest to the tailcone

- The left stabilizer was not significantly bent. The elongated dent (circled in blue in Illustration 28, Wreckage from the left part of the horizontal tail) on the top surface of the leading edge was compatible with an impact with a horizontal fin (antenna) located on the vertical stabilizer. This stabilizer experienced an instantaneous ductile failure and was subjected to upward bending and torsional forces.

- The left elevator separated from the stabilizer due to the ductile failure of the attaching elements in the area of the outboard and intermediate hinges, and to tearing of stabilizer skin in the inboard hinge. For this type of fracture to take place, the rudder and stabilizer surfaces must have been at a 90º with respect to one another in order to allow the stabilizer to shift relative to the rudder. This is compatible with the deformation and tearing observed in the area of the hinges.

- The separation of the left elevator into two pieces occurred due to tearing of the skin near the intermediate hinge. Since both pieces were found very close to each other after the accident, it is very likely that this separation took place during the impact with the ground or at a very low altitude.

- The left tab actuator assembly was still inside the elevator. The axis on the assembly was bent and the actuator cables were broken.

- The left elevator separated from the tailcone due to the instantaneous ductile fracture of the control tube to the actuator.

- Based on the findings of the analysis carried out at the UPM laboratory of the fractures in the horizontal tail on the accident aircraft, it was concluded that:

- All of the fracture processes studied involve instantaneous fractures that occurred in flight under the effect of external forces and moments that generated loads in excess of the structural design loads.

- As concerns the possible failure sequence of the two parts in the horizontal tail, it seems likely that the left stabilizer detached first, taking with it the associated elevator, which was torn from the tailcone. The right stabilizer and its elevator then separated together from the tailcone. After impacting the rudder, these two components separated.

1.17. Organizational and management information

Not applicable.

1.18. Additional information

Regulations applicable to maintaining an aircraft registered in the United States

Subpart E, "Maintenance, Preventive Maintenance and Alterations" of FAR Part 91, "General Operations and Flight Rules" of Title 14, specifies the following:

- Section 91.401(a) states that said Subpart E is applicable to all aircraft registered in the United States, independently of where they are operated.

- Section 91.403(a) states that the owner or operator of an aircraft is responsible for maintaining the aircraft in an airworthy condition.

- Section 91.403(b) specifies that no person may perform maintenance, preventive maintenance, or alterations on an aircraft other than as prescribed in this subpart and other applicable regulations.

- Section 91.407(a) states that no person may operate any aircraft that has undergone maintenance, preventive maintenance, rebuilding, or alteration unless it has been approved for return to service by a person authorized under §43.7 of this chapter.

FAR Part 43, "Maintenance, Preventive Maintenance, Rebuilding and Alterations", of Title 14 specifies the following:

- Section 43.1(a) states that said Part is applicable to all aircraft that have a U.S. airworthiness certificate.

- Section 43.3 specifies which people are authorized to conduct maintenance, preventive maintenance, rebuilding and alterations, which include, among others, the holder of a mechanic certificate, the holder of a repairman certificate, the holder of a repair station certificate or a person working under the supervision of a holder of a mechanic or repairman certificate if the supervisor personally observes the work being done to the extent necessary to ensure that it is being done properly and if the supervisor is readily available, in person, for consultation.

- Section 43.7 lists which people are authorized to approve an aircraft for return to service after maintenance, preventive maintenance, rebuilding and alterations, these being, among others, the holder of a mechanic certificate or an inspection authorization, or the holder of a repair station certificate.

Applicable regulation for an aircraft operating in Spain

Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency applies, as specified in Article 4.1, letter (c), to aircraft registered in a third country and used by an operator for which any Member State ensures oversight of operations or used into, within or out of the Community by an operator established or residing in the Community.

Article 7.1 states that pilots who operate this type of aircraft must comply with the relevant "essential requirements" laid down in Annex III of the Regulation. Moreover, Article 7.2 specifies that a person may only act as a pilot if he or she holds a license and a medical certificate appropriate to the operation to be performed

Annex VII, Non-Commercial air operations with other-than-complex motor-powered aircraft (Part NCO), of Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air, states, in requirement NCO.GEN.100 that if the aircraft is registered in a third country, the competent authority shall be the authority designated by the Member State where the operator is established or residing.

Elsewhere, requirement ARO.GEN.300, Oversight, states that the competent authority shall verify continued compliance with the applicable requirements of non-commercial operators of other-than-complex motor-powered aircraft.

Autopilot

The aircraft had a Bendix M-4D autopilot with the following modes of operation:

1 - Basic Horizon Attitude – used to fly with a wings-level attitude. It maintains the pitch angle that is present when this mode is selected.

2 - Heading. Used to select a heading

3 - NAV (Variable Intercept Angle) NAV (Fixed Intercept Angle). The autopilot intercepts the selected VOR radial

4 - Approach (Variable Intercept Angle) and Approach (Fixed Intercept Angle). The autopilot intercepts the selected ILS localizer or VOR radial.

5 - Holding (Localizer). Locks in the glide slope automatically when maintaining the localizer.

6 - Glide Slope Auto. Automatically captures the glide slope when the aircraft approaches it from below.

7 - GS Manual. Captures the glide slope when this mode is selected.

8 - Reverse (Variable Intercept Angle) and Reverse (Fixed Intercept Angle). In this mode, the aircraft will follow the outbound track from the previous course or the inbound track from the subsequent course for the localizer during the return procedure.

9 - Altitude Hold. Maintains the aircraft at the selected altitude. The human pilot must control the power.

10 - Pitch Sync Button. With the autopilot engaged, this button disconnects the pitch control and the pilot can manually adjust the airplane's pitch angle. When the

button is released, the pitch control is again engaged and the autopilot will maintain the new attitude.

11.- Automatic Pitch Synchronization. When the autopilot is engaged, the synchronizer will maintain the pitch angle present at that time.

12.- Go-Around. If the pilot decides to go around, this mode will allow him to turn to the selected heading.

The autopilot also has a yaw damper to improve the lateral/directional dynamic characteristics.

During a climb, when the autopilot is engaged, the pilot has two options:

- Use the “Pitch Sync” button to maintain the desired pitch attitude, or
- Use the “Horizon Attitude” mode, which performs the same function.

If the pilot wishes to also maintain a given heading, the “Heading” mode must be selected.

The pilot can disengage the autopilot in one of several ways:

a. Select the AFCS (Automatic Flight Control System) to OFF. The AFCS switch controls the primary power supply to the system.

b. Press the AP and YAW buttons on the control panel to disengage the autopilot and the yaw damper.

c. Pull on the automatic switch for the autopilot.

d. Use the AP-REL (autopilot release switch) located on the control stick, which will momentrily disengage the pitch, roll and yaw axes of the autopilot.

e. Press and hold the “Pitch Sync” button to momentarily disconnect the pitch servo.

This autopilot has the following operational feature:

If one engine becomes inoperative, adjust the rudder and aileron trim tabs to compensate for asymmetric power. The pilot has to offset this asymmetry since the autopilot will not do it.

In the event of a sudden engine failure, the pilot must provide the correct inputs to the flight controls (steering and roll) to keep the aircraft on the desired flight path.

The manual for the Bendix M-4D autopilot does not state that the autopilot must be disengaged to compensate for asymmetric power.

This document also states:

"do not manually override autopilot to produce or prevent pitch attitude changes or to increase bank angle. The autopilot will continue to trim the airplane and oppose the pilot's actions. This could give rise to a severe out-of-trim situation."

In the event of an emergency, the autopilot can be used to correct the attitude, but both the autopilot and the electrical trim must be immediately disengaged.

Spins

The Pilot's Operating Manual contains a section on spins that provides the following information:

"If a stall does not occur, a spin cannot occur. A stall can occurs if the controls are misused. It is important that the pilot acquire the skills to recognize when a stall is about to occur and to recover as soon as the first signs of a stall are evident. A spin is the result of a stall and yaw.

The aircraft has not been tested for spin recovery characteristics.

If the airplane is allowed to become fully stalled while one engine is providing lift – producting thrust, the yawing momento which can induce a spin will be present. Consequently, it is important to immediately reduce power on the operating engine, lower the nose to reduce the angle of attack, and increase the airspeed to recover from stall.

If application of stall recovery controls is delayed, a rapid Rolling and yawing motion may developm even against full aileron and rudder, resulting in the airplane becoming inverted during the onset of a spinning motion.

The generally accepted spin recovery procedure is: immediate move the control column full forward, apply full rudder opposite to the direction of the spin and reduce power on both engines to idle.

If a stall or spin occurs under instrument conditions, the pilot, without reference to the horizon, is certain to become disoriented. He may be unable to recognize a stall, spin entry, or the spin condition and he may be unable to determine even the direction of rotation.

Stall avoidance is your best protection against an inadvertent spin. MAINTAIN YOUR AIRSPEED".

Aircraft speeds

The Airplane Flight Manual lists the following speeds:

1 - Maximum operating speed Vmo: 226 knots

2 - Speed range for normal operations: 88 to 226 knots.

3 - Best climb speed on a single enginer VYSE: 111 knots

4 - Minimum control speed on one engine VMC: 88 knots

5 - Load factor: positive 3.7 g, negative: 1.8 g. It also states not to use the controls abruptly at speeds in excess of 175 knots.

6 - Speed for best climb angle with two engines: 102 knots

7 - Speed for best climb speed with two engines VY: 112 knots

8 – Cruise climb speeds

SL- 10000 ft	150 knots
10,000 ft to 20,000 ft	130 knots
20,000 ft to 25,000 ft	120 knots
25,000 ft to 31,000 ft	110 knots

Remarks from the aircraft manufacturer on the fracture and break-up of the horizontal tail

During the investigation, the aircraft manufacturer was asked about the loads that the horizontal tail is able to withstand before breaking, and what type of maneuver could break it.

The manufacturer stated that the horizontal tail was tested at 100% of its ultimate load and, in some cases, at 110%, without structural failures. The horizontal tail was never tested to the breaking point, and thus it could not say what load could break it. In any case, the load on the horizontal tail at the time of the accident must have exceeded its design load.

It also added that there are previous events in which the horizontal and vertical tail broke on this aircraft model due to descending at speeds above Vne.

As concerns when the horizontal tail would have fractured, the manufacturer believed it would have occurred at 2000 to 3000 ft AGL, considering the debris field.

Response from Alerting Service

Commission Implementing Regulation (EU) 2016/1185 of 20 July 2016 amended Implementing Regulation (EU) 923/2012 such that the alerting service, which must be provided by air traffic service units for all aircraft provided with air traffic control service, includes the following requirement in Section SERA.10001:

"Unless otherwise prescribed by the competent authority, aircraft equipped with suitable two-way radio-communications shall report during the period 20 to 40 minutes following the time of the last contact, whatever the purpose of such contact, merely to indicate that the flight is progressing according to plan, such report to comprise identification of the aircraft and the words "Operations normal"."

However, there is no requirement in European regulations for air traffic service units to ensure every so often that a flight is operating normally.

National regulations include a provision that air traffic service units immediately notify rescue coordination centers if they believe that an aircraft is in a state of emergency. The regulation differentiates between three emergency phases: uncertainty phase, alert phase and danger phase. To activate the alert phase, the uncertainty phase must have been activated and to activate the danger phase, the alert phase must have been activated. The uncertainty phase is activated when:

"1) no communication has been received from the aircraft within the 30 minutes after the time when a communication should have been received from it, or immediately after the first unsuccessful attempt is made to establish communication with said aircraft, whichever occurs first; or

2) when the aircraft does not arrive within 30 minutes after the estimated arrival time last reported by it, or that calculated by the units, whichever occurs later, unless no uncertainty exists as to the safety of the aircraft and its occupants".

Since an aircraft under radar coverage is constantly being tracked, the control unit providing ATS to the aircraft should have identified this event as soon as it occurred. In this specific case, neither the uncertainty nor the alert phase was activated.

NTSB/FAA support during the investigation

During the investigation into this accident, the CIAIAC requested assistance from both the NTSB and the FAA in order to clarify certain aspects involving the interpretation of and compliance with US aviation regulations as they apply to aircraft N-79CT in this case. After making several written requests, as of the date of publication of this report, no reply has been received.

1.19. Useful or effective investigation techniques

The milestones in the aircraft's flight path were identified using the methodology based on the change in specific energy (total energy of the aircraft per unit weight) as a function of time. The specific energy values were obtained using radar data.

2. ANALISIS

The following relevant aspects were considered during the investigation into this accident: the flight path taken, the powerplant and its associated systems, structural failures, the autopilot, the weather along the route, the human factors associated with the operation of the aircraft and the airworthiness of the aircraft and its operation. The analyses performed involving these aspects are detailed below.

2.1. Analysis of the flight path taken by the aircraft

The data from the variables described in Annex I were used to conduct a detailed analysis of the various segments of the flight path using the specific energy balance method for each segment, combined with other recorded information. The sequence of events can be summarized as follows:

At 16:13, the aircraft was en route climbing from flight level 150 to its cleared cruise level of 210. The flight was progressing normally until then.

At 16:13:52 h the climb speed increases slightly, while the airspeed starts to decrease. From that moment the airspeed continued to decrease progressively, while the climb speed remained sensibly constant. This fact was due, most likely, to the fact that the autopilot was activated in the modes to maintain constant the pitch angle and the heading during the climb.

Given that the variations, both of the specific energy and of the altitude, with time are significantly linear between the 16:13:52 and the 16:15:57 h, it is deduced that in that interval the variation rates of both variables are constant. Under these conditions, the analyses carried out show that the decrease in the airspeed is consistent with constant rates of variation of the specific energy and of the altitude.

The progressive decrease of the airspeed indicates: either a progressive decrease of the power / thrust available, or a progressive increase in the aerodynamic drag of the aircraft, or both at the same time.

The maximum values of specific energy and altitude were reached at 16:15:57 h. At 16:16:02, at a speed of 119 knots, in addition to a drop in altitude and specific energy, there was a significant change in the heading, which went from 245° to 183° in 5 seconds while the airspeed is reduced to 83 knots in this time interval, and the altitude decreases by 600 feet (182.9 m) from 19,000 feet.

After this separation of controlled flight (“departure”) occurred at 16:16:02, the airspeed continued to drop to a value of 22.7 knots at 16:16:27 h during the uncontrolled descent of the aircraft in a post-stall/turn post-stall/ oscillatory spin condition, which developed fully, leading to a non-recoverable flight condition. After this last moment, the speed was increasing to reach 94 knots at an altitude of 6,100 feet (1,859 m) at 16:17:02 h, this being the last reliable data recorded by the radar. There is no data from this point until the impact with the terrain.

The impact with the terrain occurred vertically in an almost horizontal attitude, which indicates that the spin turned into a flat spin at some point of the uncontrolled descent.

In order to try to identify the origins of the disturbance that caused the beginning of the sequence leading to the condition of stall/ post-stall/ spin and the consequent loss of control at 16:16:02 h, several possible scenarios were considered compatible with the trajectory followed by the aircraft, according to the radar trace data.

As a common background to these scenarios, we first considered the meteorological conditions present in the area flighted by the aircraft on its route.

Significant low-level maps (up to flight level FL150) predicted the presence of abundant cumulus or stratocumulus clouds; with bases around 1,000 feet and stops above 15,000 feet, with possible moderate icing conditions between 9,000 feet and 12,000 feet, and some "cumulus congestus" or isolated torrecumulus.

The map of medium and high level of WAFC of London also predicted the presence of cumulonimbus in the abundant cloudiness, with stops of 35,000 feet in the area where the flight passed. The significant weather map reflected the existence of moderate or strong turbulence or icing within the cumulonimbus. According to this map, the temperature at flight level FL180 was between -17ºC and -19ºC.

According to this meteorological information, the risk of icing in the route and in the flight levels in which the departure ("departure") of controlled flight of the aircraft took place was high. Therefore, it is necessary to consider the existing icing conditions as a significant factor in the possible scenarios related to this accident.

The difficulty related to the analysis leading to determine the influence of icing is the unavailability of data to be able to specify the type of ice found, its deposit and forms of accretion, and its effects. In particular, data on liquid water content (LWC), droplet size, existence and airborne content of supercooled water droplets (SLW / SLWG), etc. are not available.

As for the possible scenarios compatible with the trajectory recorded by the radar, the following have been considered:

1. Appearance of a significant yaw moment to the left, when the aircraft was climbing with wings level. In this case, two cases must be considered:

- "Mechanical" failure of the left engine, producing a sudden power asymmetry at the same time as a 50% decrease in the available power. This is ruled out since after the inspection of the engines it was determined that both engines were producing the same power at the moment of the impact against the ground, although it has not been possible to determine the level of the same.

- Possible "momentary malfunction of the left engine due to the transient effect of the presence of ice crystals in the air". These power losses have been observed on several occasions, recovering the engine affected by itself, which-hypothetically-would explain why the two engines were working in this case.

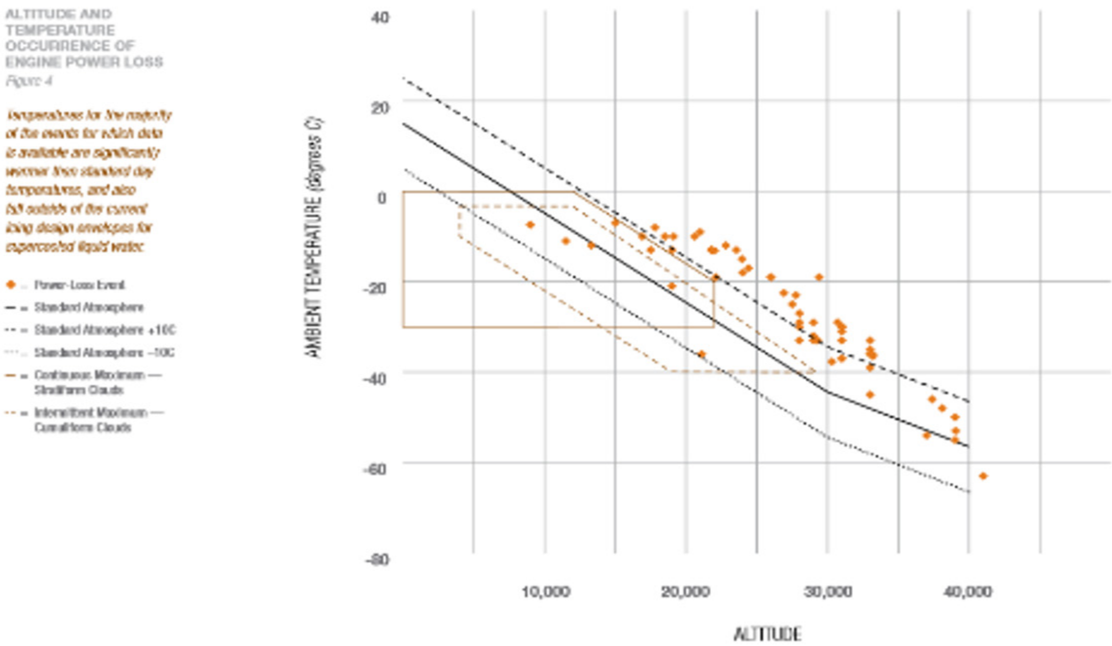


Ilustración 27: Engine power loss in icing conditions

This possible scenario can not be demonstrated (for the same reasons as all the others that have been considered) but it is not ruled out either.

2. Important / severe ice accumulation (white or light) on the supporting surfaces (wing and tail), with the following effects:
   - Increase of CD
   - Decrease of CL
   - Decrease of "aerodynamic efficiency" CL / CD
   - Decrease of αSTALL
   - Decrease of CLmax
   - Increase of the weight of the aircraft

These effects, altogether or separately, would explain that the airplane diminished its speed until stalling with symmetrical power in the engines, at a speed superior to the Vs without ice ($\Delta Vs \approx 20$ knots) as it happened in this case. The wing drop to the left can be explained by:

- Asymmetry in the ice forms of the wing
- Effect of the engines (the propellers turn to the right, seen from behind)
- Balance disturbance due to ice formation in the ailerons area ("roll upset")

This sharp drop to the left could also explain the sudden change of heading ("yaw to the left") without there being a moment of yaw to the left.

In the analysis related to this ice accretion scenario, the effect on the aircraft performance was calculated, having obtained results concordant with the deceleration observed in the radar data.

This possible scenario turns out to be the most probable, although, like the previous case, it can not be demonstrated in a reliable way. The reasons are the following:

- No availability of accurate meteorological data.
- Not having FDR data.

- Not having information about the aircraft systems operation after the state of destruction in which their wreckages were left in the impact with the ground and subsequent fire. In particular, there has been no possibility of investigating the state of the filaments of the lamps related to the Notices, nor of obtaining information on the ice protection equipment.

Therefore, it is reiterated that it has not been possible to reliably determine the sequence leading to the stall / spin entry and subsequent loss of control of the aircraft in this accident.

2.2. Analysis of the powerplant and its associated systems

Engines

After a detailed inspection and subsequent disassembly of the components in both engines, it was concluded that the damage on the outside and inside of both engines and the fractures found on their components did not occur in flight and are fully compatible with an impact with the ground and the fire that broke out afterwards.

Both engines were operating at the time of the impact although the power they provided could not be determined.

Propellers

Both propellers were turning at the moment of impact and neither was feathered. The apparent feathered position of the blades was due to the feathering springs, which in the absence of hydraulic fluid in the cylinders in both propellers after the impact rotated the blades into that position: in the case of the left propeller, due to the return of the fluid, and in the case of the right propeller, due to the loss of fluid after the cylinder ruptured.

The propellers were provided with a constant speed system. The pitch angle of the propeller is automatically adjusted according to the selected engine power. The inspection of both propellers revealed that both pitch angles were about 23°. This suggests that both engines produced a symmetrical power at the moment of impact.

Auxiliary systems

After the engines and propellers were inspected, and a mechanical failure of these components was ruled out, investigators tried to determine the operational status of the auxiliary systems at the time of the event.

The damage caused by the impact and subsequent fire in the pneumatic and fuel systems prevented to determine if they contributed to the accident.

Another potential explanation for a hypothetical fuel supply failure involves the anti-icing system since, on the day of the accident, on the route and in the altitude range where the accident aircraft was flying, icing conditions were present. Specifically, investigators tried to determine if the anti-icing system was operational (System No. 30, Ice & Rain Protection, Page No. 30-1, FAA MMEL Beechcraft Model 90 Series) during the accident flight. Special attention was paid to component no. 7, heated fuel vents, the "Remarks and Exceptions" section for which states that they "May be inoperative provided aircraft is not operated in known or forecast icing conditions". However, for the reasons listed above and due to the condition of the wreckage after the impact, the operational status of this component could not be determined either.

Therefore, from the analysis of the power plants and associated systems it has not been possible to conclude whether a power reduction in the propulsive system could have occurred and, if this hypothesis is true, what could have originated

2.3. Analysis of the structural failures

The results of the analysis of the fractures in the accident aircraft's horizontal tail, performed at the ETSIAE laboratory, allowed investigators to conclude that all of the fracture processes involved instant fractures that occurred in flight under the effect of external forces and moments that generated loads in excess of what the tail was able to withstand.

The fracture and detachment of the horizontal tail components occurred during an uncontrolled descent in a fully developed spin at an estimated altitude of about 1000 m AGL. This estimate is based on the dispersion pattern of the wreckage of the accident aircraft at the crash site.

2.4. Analysis of the function performed by the autopilot (AP)

The altitude track obtained from the radar data (practically in a straight line until the start of the triggering events) indicates that the autopilot on the accident aircraft was engaged during the climb phase. The constant heading (245° ± 1°) corroborates this assertion.

During the climb, the pilot has the following options: use the “Horizon Attitude” mode, which keeps a constant pitch angle and the wings level, or use the “Pitch Sync” button, which provides the same pitch function, or the “Automatic Pitch Synchronization” mode.

It is most likely that the “Horizon Attitude” mode was engaged, along with the “Heading” mode to maintain heading. In any event, from the standpoint of the effect that having the autopilot engaged and controlling the pitch angle, the result would be the same.

Since what the autopilot does in these modes is to keep a constant pitch angle, Θ, and since:

$$\Theta = \alpha + \gamma$$, where:

- α is the angle of attack
- γ is the flight path angle

By keeping the pitch angle constant, it is verified that:

$\Delta\Theta = \Delta\alpha + \Delta\gamma$, then $\Delta\alpha = -\Delta\gamma$

As of 16:16:00 h, the flight path angle goes from being positive (aircraft climbing) to being negative (aircraft decreasing). This fact implies a $\Delta\gamma < 0$, and consequently a positive $\Delta\alpha$.

In these conditions, the autopilot, if engaged, would increase the angle of attack, which would cause the aircraft to stall.

An analysis of the flight path shows that this condition was present when this event was triggered.

2.5. Analysis of the weather along the route

During the investigation, it was not possible to obtain accurate data of the weather situation at the time of the accident. Only the weather forecasts provided by AEMET were available, according to the available data, at the time of the accident, there were conditions for theformation of moderate or strong ice along that segment of the flight.

2.6. Analysis of the human factors in the operation of the aircraft

An analysis of the radar track shows that the pilot was flying with the autopilot engaged, as was his usual practice during flights.

When the disturbance that started the event sequence occurred, the pilot was unable to correct it. The reasons for not being able to correct it couldhave been:

a. The possibility of the pilot carrying out aggravating actions

b. Not disengaging the autopilot. The pilot may have tried to correct the yaw unsuccessfully by not disengaging it.

c. The pilot, who lacked the type rating for this aircraft, may have been overwhelmed by the emergency situation and been unable to react as needed. It is important to remember also that IMC were in effect.

Any of these three factors above by itself, or in combination, would explain the stall/post-stall/spin conditions attained by the accident aircraft and that, in these flying conditions, made recovery impossible.

2.7. Analysis of the airworthiness of the aircraft

The accident aircraft was registered in the United States and had a certificate of airworthiness issued by the FAA; therefore, it was subject to American regulations on maintenance. According to these maintenance regulations, the aircraft's owner is responsible for maintaining the aircraft in an airworthy condition.

At the time of the accident, the aircraft was not airworthy since:

- The corrective maintenance tasks performed in November 2016 were carried out by maintenance technicians who were not properly authorized to do so

- They were not certified as required by law.

As a result, the aircraft's owner hired the services of maintenance technicians who were not properly authorized to perform maintenance on this aircraft; therefore the pilot should not have operated the aircraft in these conditions.

Despite this, the FAA certifier stated during the investigation that he thought the maintenance had been carried out correctly by the maintenance technicians, and had he been hired by the aircraft's owner to certify these maintenance tasks, he would have done so.

During the investigation, the maintenance organization that carried out the last maintenance tasks indicated that it had taken the following measures:

- Keep records of maintenance work carried out together with FAA certifiers on US registration aircraft

- Request the FAA for approval as a repair organization.

These measures have been considered sufficient by the investigation and no recommendation will be issued in this area.

2.8. Analysis of the aircraft's operation

EThe owner of the aircraft was a Spanish citizen living in Spain who used it on his private flights; therefore, he was subject to Regulation (EC) No 216/2008 of the European Parliament and the Council of 20 February 2008, according to which, a person may only act as a pilot if he or she holds a license and a medical certificate appropriate to the operation to be performed.

The accident pilot lacked a license with a type rating for the accident aircraft, and was therefore piloting an aircraft that he was not authorized to pilot.

The European regulation, Commission Regulation (EU) nº 965/2012 of 5 October 2012, states that AESA, the Spanish authority, shall verify continued compliance with the applicable requirements of non-commercial operators of other-than-complex motor-powered aircraft.

In order to comply with this responsibility, the ARO.GEN.305 requirement of the aforementioned European regulations requires, from August 25, 2016, to implement an inspection program for general aviation aircraft by AESA. Therefore, AESA is urged to urgently establish this inspection program to comply with the aforementioned requirement and as many measures as it deems appropriate.

No recommendation will be issued in this regard since there is existing legislation that if fulfilled could avoid this type of situation.Analysis of the European Regulation that regulates the occurrences reporting

Regulation (EU) No. 376/2014, which regulates the reporting of occurrences in civil aviation, establishes in Article 4 Mandatory reporting: "a person engaged in designing, manufacturing, continuous airworthiness monitoring, maintaining or modifying an aircraft, or any equipment or part thereof, under the oversight of a Member State or of the Agency" shall report the occurrences referred to in paragraph 1 of said article.

The accident aircraft had a US registration and, therefore, its airworthiness and its maintenance were not under the oversight of the Spanish authority. The people who participated in the last maintenance tasks performed on the aircraft were not obliged, by European regulations, to notify that the aircraft was flying without being airworthy.

It is considered necessary to amend the European Regulation in order to extend the scope of aircraft on whose airworthiness status to notify and also include aircraft operated by an operator for which a Member State guarantees the oversight of operations or by an operator established in the Union.

3. CONCLUSIONS

3.1. Findings

- Due to the weather conditions, the aerodrome of Cuatro Vientos was in instrument conditions (IMC) from 09:00 until 14:44. The pilot had to delay taking off until the weather conditions at the aerodrome of Cuatro Vientos permitted it.

- The pilot did not have the type rating required to pilot the aircraft.

- The pilot had a valid medical certificate.

- The maintenance technicians who performed the last maintenance tasks on the aircraft were not authorized to carry them out according to US regulations.

- The corrective maintenance tasks performed in November 2016 were not certified by a maintenance technician with an A&P (Airframe & Powerplant) and an IA (Inspection Authorization) issued by the FAA, as required by American regulations, meaning that the aircraft was not airworthy at the time of the accident.

- The MMEL required that the weather radar be operational for this type of flight. The weather radar was not operational and one of the reasons for the flight was to repair it.

- The pilot did not report any type of technical failure to air controllers during the flight.

- The pilot did not maintain a speed higher than 140 knots in the last minutes of flight (according to the recommendation of the Flight Manual for flights in icing conditions)

- The controllers did not realize there had been an accident for more than 40 minutes.

- The engines were running at the time of the impact with the ground.

- The propellers were not feathered in flight.

- The horizontal stabilizer broke in flight due to the appearance of loads during the spin that significantly exceeded its design load limit.

3.2. Causes/Contributing factors

The investigation has concluded that this accident was caused by the loss of control of the aircraft in flight due to a stall and subsequent spin

Due to the high degree of destruction of the aircraft's wreckage after the ground impact and subsequent fire, and the lack of other pertinent data to do so, it has not been possible to determine with precision the sequence of the process leading to the aircraft stall/spin.

The investigation identified the following contributing factors:

- The decision to make the flight with adverse meteorological conditions (IMC) along the planned route, considering the fact that the weather radar was not operational.

- The forecast of moderate to strong icing conditions in areas of the route (presence of cumulonimbus with caps of up to 35,000 feet and with temperatures between -17ºC and -19ºC at flight level FL180) suggests that the formation of ice or its accumulation on the aircraft has been a significant contributory factor in this accident

- The use of the autopilot and the failure to disengage it when the emergency situation arose, as it is concluded from the detailed analysis of the radar data, could have contributed significantly to the process that resulted in the loss of control of the aircraft.

- **The inadequate training of the pilot (who lacked the type rating for the accident** aircraft) in abnormal or emergency situations on the accident aircraft.

4. SAFETY RECOMMENDATIONS

The pilot was operating an airplane that was not airworthy and for which he also did not have the rating required to pilot it. The civil aviation regulation provides that, AESA, as the Spanish Authority, verify continued compliance with the requirements applicable to general aviation operators through an inspection program.

Therefore, AESA is urged to urgently establish such an inspection program to comply with the aforementioned European requirement and as many measures as it deems appropriate

Since the air traffic controllers did not identify the fact that an accident had occurred for over 40 minutes, the following recommendation is issued:

REC xx/2018. It is recommended that ENAIRE emphasize to controllers during refresher courses the importance of constantly monitoring radar tracks in order to avoid situations like the one described in this report.

Regulation (EU) No. 376/2014, which regulates the occurrence reporting in civil aviation, establishes who is obliged to report. It is considered necessary to amend the European Regulation in order to extend the scope of aircraft on whose airworthiness status to notify and also include aircraft operated by an operator for which a Member State guarantees the oversight of operations or by an operator established in the Union. So that:

REC xx / 2018. It is recommended that EASA modify the Regulation that regulates the occurrence reporting in order to establish the mandatory reporting of non-airworthy aircraft operated by an operator for which a Member State guarantees the oversight of operations or by an operator established in the Union.

ANNEX I

DETAILED ANALYSIS OF THE FLIGHT PATH TAKEN BY THE AIRCRAFT

The data on the accident aircraft's flight path were available. They were taken from the readings recorded every 5 seconds, primarily by the radars located in Valladolid and Valdespina, which are the ones that provide the best coverage of the accident area, although ENAIRE uses multiple radars to track aircraft.

The relevant analyses relied basically on the following parameters: time (t), altitude (h), ground speed (V), path (ϴ) and climb speed (Vz) from radar data. Two parameters were used to calculate a third parameter derived from them in order to allow for a detailed study of the flight path. Specifically, the altitude and speed parameters were used to calculate the specific energy (e) (total energy per unit weight) of the aircraft and its change over time.

Between the takeoff at 15:57 and approximately 16:13, the flight was uneventful as the aircraft climbed constanty toward its assigned cruise level (FL 210), as shown in Illustration 1, Aircraft's flight path until the time of the ground impact, and the figure below A.1, which shows the altitude, speed, climb speed, specific energy and heading between 16:00:03 and 16:17:02 (last reliable radar reading).

The following figure A.1 shows a stable speed once a constant climb rate to the cruise level is established, with a linear change in altitude, a noticeably constant climb speed and a heading of 245°. Given these flight conditions, the trend in specific energy over time shows a constant linear increase, indicative of normal conditions.

A 1 Altitud, velocidad, velocidad ascensional, energía específica y rumbo a lo largo del vuelo

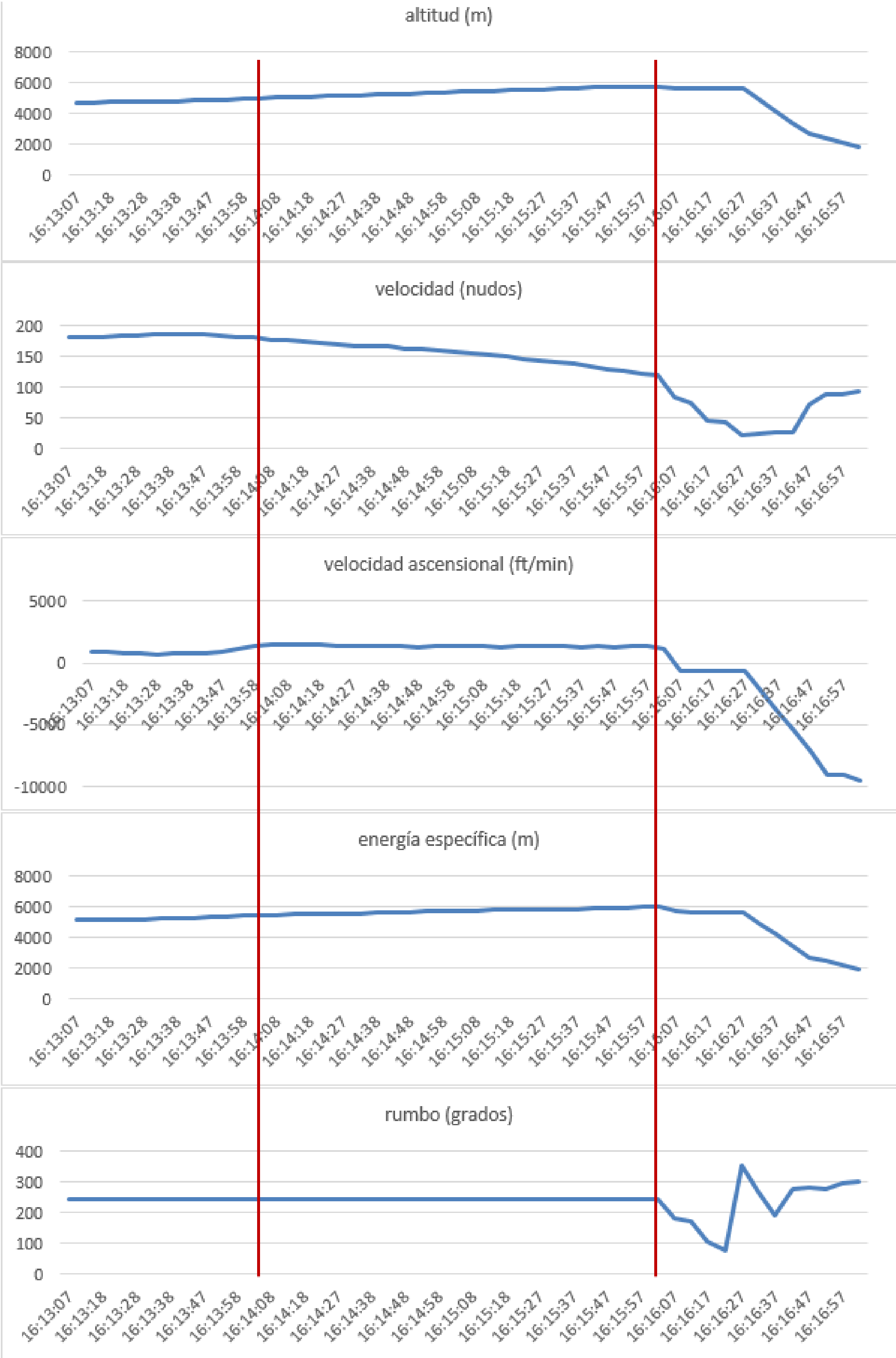
The final figure shows the altitude, speed, climb speed, specific energy and heading from 16:13:07 to 16:17:02, that is, in the final minutes of the flight for which reliable radar readings are available.

Note that the specific energy (e) rises in a noticeably linear fashion until 16:15:52, achieves a maximum value at 16:15:57 and starts to decrease sharply starting at 16:16:02, continuing to drop until the last reliable radar reading (at 16:17:02, at an H=1859 m / 6099 ft). From that last point on, the trend in this parameter could not be determined, as the aircraft descended uncontrollably and impacted the ground.

The airspeed, V, which at 16:13:53 was 185 knots, starts to decrease gradually until it reaches 123 knots at 16:15:57, at which point "e" reaches its maximum value and starts to drop significantly. It continues decreasing (at 16:16:02 its value is 119 knots), reaches 88 knots (the aircraft's VMC) at approximately 16:16:05, and at 16:16:32, the radar records the minimum speed reached during the uncontrolled descent of 23 knots. From then on, the speed increases gradually to a value of 94 knots at 16:17:02, at an H=1859 / 6099 ft (last reliable radar reading). It was not possible to determine how this variable increased during the descent between this point and the impact with the ground.

The climb speed, VZ, whose value during the climb stayed in the range of 850±50 feet per minute, begins to increase starting at 16:13:58 to 1400±100 ft/min until 16:16:02, when it starts to decrease rapidly, becoming negative (descent speed of 663 f/min) 5 seconds later. From then on, the descent speed increases gradually until it reaches a value of 9419 ft/min at 16:17:02 at an H=1859 m / 6099 ft (last reliable radar reading). It was also not possible to determine the trend in VZ until the impact with the ground.

The heading, ψ, en route remained practically constant from shortly after takeoff, its recorded value being 245±1° until 16:16:02, at which point there is a sudden left yaw that changes the heading 61° in 5 seconds (angular yaw rate r=-12.2 degrees/s), until it reaches ψ = 184°. The left yaw continues until ψ = 171° at 16:16:12 (r=-2.6 degrees /s); ψ = 106° at 16:16:17 h (r=-13.0 degrees /s); ψ = 77° at 16:16:22 h (r=-5.8 degrees /s); ψ = 352° at 16:16:27 h (r=-17.0 degrees /s); ψ = 268° at 16:16:32 h (r=-16.8 degrees /s); ψ = 190° at 16:16:37 h (r=-15.6 degrees /s). At that point it changes direction (now to the right), reaching ψ = 278° at 16:16:42 h (r=17.6 degrees /s). The right turn continues and at 16:16:47 the heading is ψ = 284° (r=1.2 degrees /s). The direction of rotation changes once more (to the left again), with the heading again returning to ψ = 278° at 16:16:52 (r=-1.2 degrees /s), at which time the aircraft again reverses its direction of rotation (again to the right), reaching ψ = 298° at 16:16:57 h (r=4.0 degrees /s) and ψ = 304° at 16:17:02 h (r=1.2 degrees /s). Since this is the last reliable radar reading, as is the case with the other parameters, it was not possible to determine the trend in the aircraft's heading until the impact with the ground.



A 2 Altitud, velocidad, velocidad ascensional, energía específica y rumbo en los últimos minutos de vuelo