CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE **A**CCIDENTES
E **I**NCIDENTES DE
AVIACIÓN **C**IVIL

Report A-016/2018

Accident involving a Mooney M20K aircraft, registration D-ETFT, in the municipality of Flix (Tarragona), 12 May 2018

GOBIERNO DE ESPAÑA

MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA

Edita: Centro de Publicaciones
Secretaría General Técnica
Ministerio de Transportes, Movilidad y Agenda Urbana ©

NIPO: 796-20-134-4

Diseño, maquetación e impresión: Centro de Publicaciones

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63 E-mail: ciaiac@mitma.es C/ Fruela, 6
Fax: +34 91 463 55 35 http://www.ciaiac.es 28011 Madrid (España)

Notice

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.

Contents

ABBREVIATIONS 4
SYNOPSIS 5
1. FACTUAL INFORMATION 6
1.1. History of the flight 6
1.2. Injuries to persons 9
1.3. Damage to aircraft 9
1.4. Other damage 9
1.5. Personnel information 9
1.6. Aircraft information 9
1.7. Meteorological information 12
1.8. Aids to navigation 14
1.9. Communications 20
1.10. Aerodrome information 20
1.11. Flight recorders 20
1.12. Wreckage and impact information 20
1.13. Medical and pathological information 24
1.14. Fire 24
1.15. Survival aspects 24
1.16. Tests and research 24
1.17. Organizational and management information 30
1.18. Additional information 30
1.19. Useful or effective investigation techniques 33
2. ANALYSIS 34
2.1. Analysis of the impact at 13:40 34
2.2. Analysis of the flight from 13:23 to 13:34 36
2.3. Analysis of the flight from 13:34 to 13:40 39
2.4. Analysis of the engine failure at 13:34:45 41
3. CONCLUSIONS 44
3.1. Findings 44
3.2. Causes/Contributing factors 46
4. SAFETY RECOMMENDATIONS 47

Abbreviations

º	Degrees
ACC	Area control center
AGL	Above ground level
AEMET	Spain's National Weather Agency
AIP	Aeronautical information publication
ATC	Air traffic control
CAMO	Continuing airworthiness management organization
EASA	European Aviation Safety Agency
FI	Flight instructor
FL	Flight level
ft	Feet
GS	Ground speed
h	Hours
IFR	Instrument flight rules
IMC	Instrument meteorological conditions
IR	Instrument rating
kg	Kilograms
kt	Knots
km	Kilometers
l	Liters
LELL	Code for the Sabadell Airport (Spain)
LERS	Code for the Reus Airport (Spain)
LPCS	Code for the Cascais Airport (Portugal)
m	Meters
METAR	Meteorological aerodrome report
min	Minutes
NM	Nautical miles
No	Number
RCA	Spain's Air Traffic Regulation
s	Seconds
S/N	Serial number
SERA	Standardized European Rules of the Air
SIGMET	Significant meteorological information
TAF	Terminal aerodrome forecast
UTC	Coordinated universal time
VFR	Visual flight rules
VMC	Visual meteorological conditions

Synopsis

Owner and operator:	Private
Aircraft:	Mooney M20K, registration D-ETFT
Date and time of accident:	Saturday, 12 May 2018 at 13:40 UTC[1]
Site of accident:	Flix (Tarragona)
Persons on board:	1 pilot, killed
	2 passengers, killed
Type of flight:	General aviation - private
Phase of flight:	En route
Date of approval:	22 April 2020

Summary of accident

At 13:40 on Saturday, 12 May 2018, after flying for 3 h 12 m, aircraft D-ETFT, with three persons on board, suffered an accident while on a private flight between Cascais and Reus. The aircraft impacted the terrain in a mountainous area in the municipality of Flix (Tarragona), 40 km west of its destination. Five minutes earlier the pilot had reported an engine failure, and 17 minutes earlier, the pilot had been informed that the destination airport was closed to VFR traffic.

The investigation has determined that the accident of aircraft D-ETFT was caused by destabilization and loss of control while attempting an emergency landing on a mountain road that was narrower that the aircraft's wingspan. The following contributed to the accident:

- The loss of engine power, which forced the emergency landing and which was caused by the complete fracture of the nozzle distribution line to the #3 cylinder on the fuel manifold valve.
- Deficient flight planning in terms of analyzing the weather and the area of the flight, which caused the aircraft to prolong its flight and fly away from the destination airport and into a mountainous area where the engine failure occurred.

This report contains one safety recommendation, issued to Continental Motors, the manufacturer of the engine.

[1] All times in this report are in UTC, obtained from air traffic services.

1. FACTUAL INFORMATION

1.1. History of the flight

On Saturday, 12 May 2018, a Mooney M20K single-engine aircraft, with German registration D-ETFT, took off at 10:28 from the Cascais Airport (LPCS - Portugal) on a private flight en route to the Reus Airport (LERS - Spain). On board were three individuals, who had departed on a leisure tour four days earlier (Wednesday, 9 May) from Germany, where the aircraft was based.

Since the start of the journey on the 9th, the aircraft and the three persons on board had flown the following legs:

- Wednesday, 9 May: Mainz-Finthen (Germany)-Lille (France)
- Thursday, 10 May: Lille –Bourdeaux (France)
  Bourdeaux (France)- Cascais (Portugal)
- Saturday, 12 May: Cascais (Portugal) – Reus (Spain) (accident flight)

After arriving in Cascais on Thursday the 10th, the aircraft was refueled with 151 l of fuel[2]. No further activities were logged until Saturday. On Saturday, 12 May, a flight plan was filed at the Cascais Airport to fly from Cascais to Reus under visual flight rules (VFR). The flight had an estimated duration of 4 h at a speed of 150 kt and a cruise level of FL115. The range was 5 h 30 min and the alternate airport selected was Sabadell (LELL).

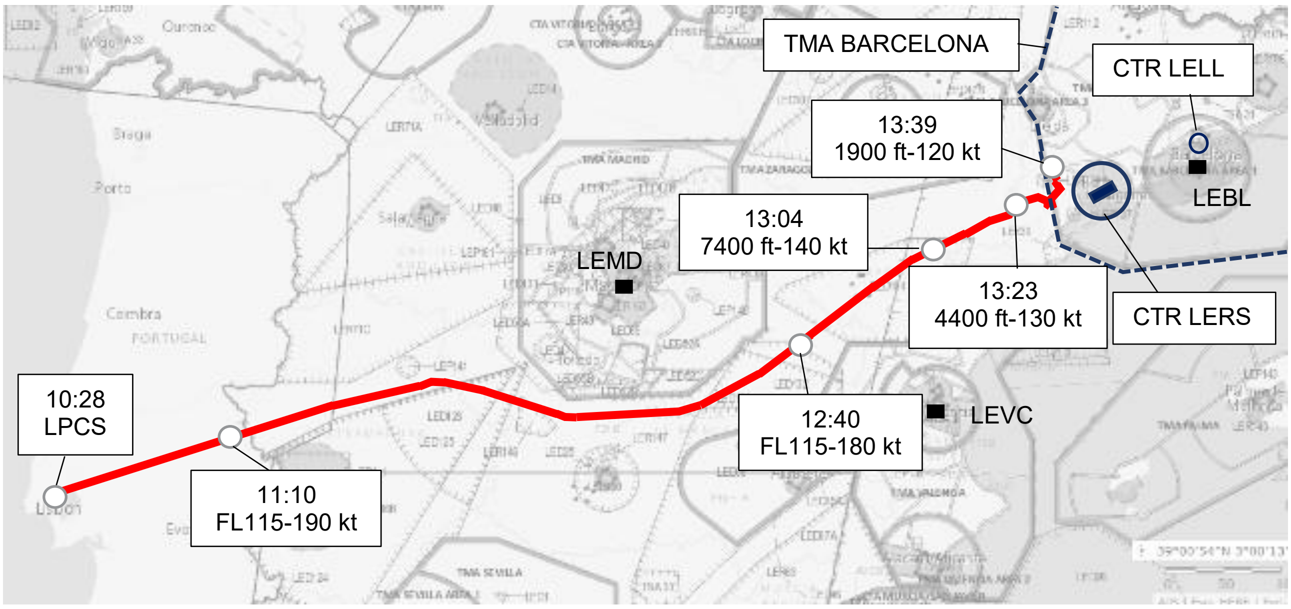


Figure 1. Complete flight path

[2] Information provided by the fuel supply company at the airport.

The aircraft took off at 10:28. At 11:10, the aircraft was at FL115 and 190 kt[3] and was transferred to the Madrid ACC. It remained at that altitude until 12:40, when it began to descend. At 13:04, it was transferred to the Barcelona ACC while at 7400 ft and 140 kt.

From this moment on, two events occurred: a change in weather conditions at the destination airport, and the pilot's report of a problem with the engine.

Worsening weather conditions:

At 13:24, with the aircraft at 4400 ft and 130 kt, the pilot was informed that Reus, the destination airport, was in IMC. The pilot reported he would go to the alternate, Sabadell, following the coastline (shown with a dashed red line in figure 2). Even though ATC informed him that he could not fly that route because it crossed the airspace associated with the Barcelona Airport, the pilot repeated his initial intentions on up to three occasions. Finally, while in contact with Reus TWR, the pilot changed his mind and requested vector guidance.

At 13:29, the pilot was again in contact with Barcelona ACC, which, to vector him north, gave him instructions to climb to FL70 and change course to 040º. At 13:31, the aircraft began to climb.

For 3 min, from 13:31 to 13:34, the aircraft climbed on heading north from 4400 to 6400 ft.

Notification of engine problem:

At 13:34, the pilot reported that he needed to descend due to an engine problem ("we have trouble with the engine"). In addition to this initial report, the pilot made three more, each more serious than the last, before reporting "loss of engine power".

The pilot again requested radar vectors to the nearest airfield. The controller informed him that Reus, 22 NM away, was the nearest one. The pilot replied they could not reach Reus and again requested an airfield on which to land. The final message from the pilot was intermittent and took place at 13:38, with the following content: "I…road…below". The last radar return was received at 13:39 and placed the aircraft at 1900 ft and 90 kt.

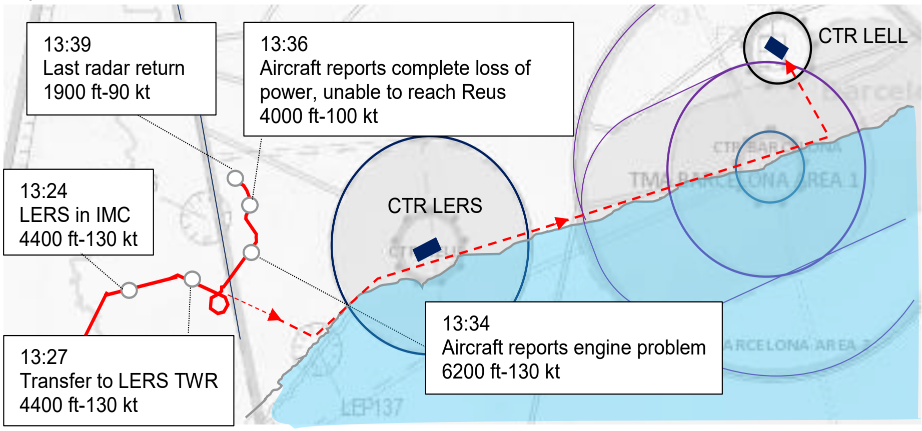


Figure 2. Flight path from 13:23

[3] All speed figures refer to the ground speed (GS), taken from the radar track.

The aircraft impacted the ground in a mountainous area in the municipality of Flix (Tarragona), at kilometer marker 9.5 of road T2237. This point was 2.9 km south of the last radar return. After impacting the ground, a fire broke out that was seen by a couple that was traveling on road T2237 and that called emergency services. All three occupants of the aircraft were killed in the accident.

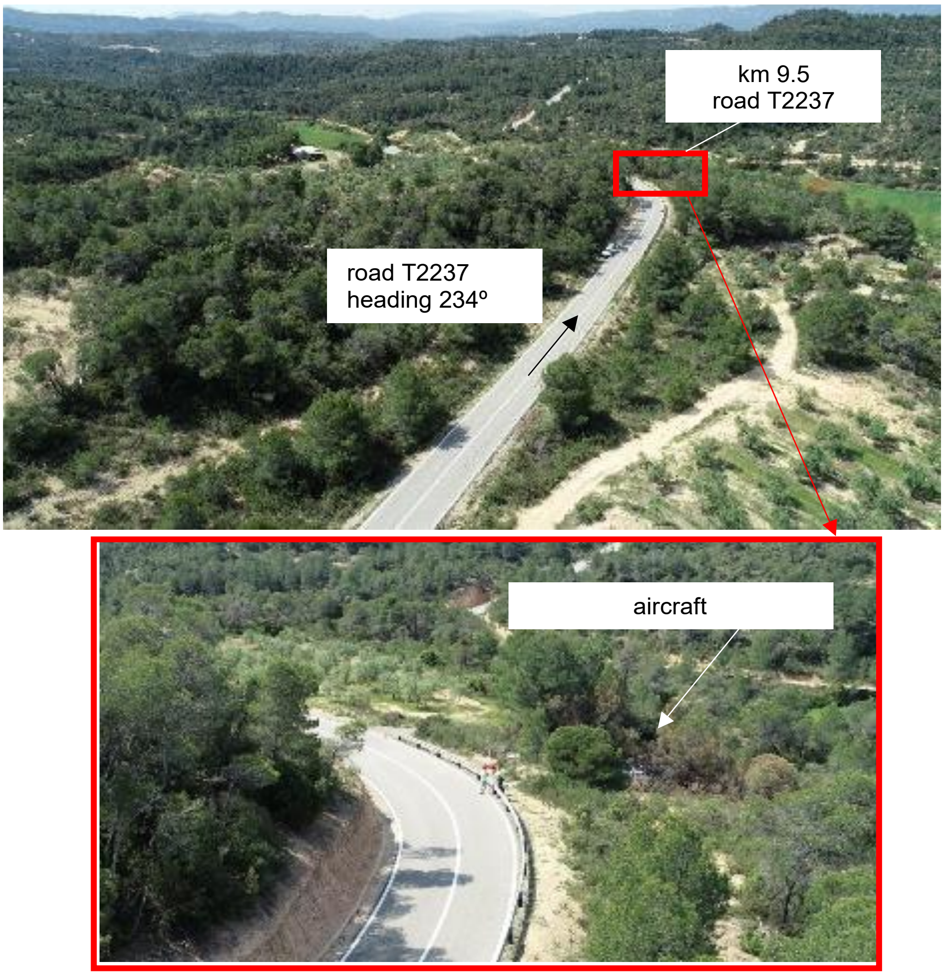


Figure 3. Position of the aircraft relative to road T2237

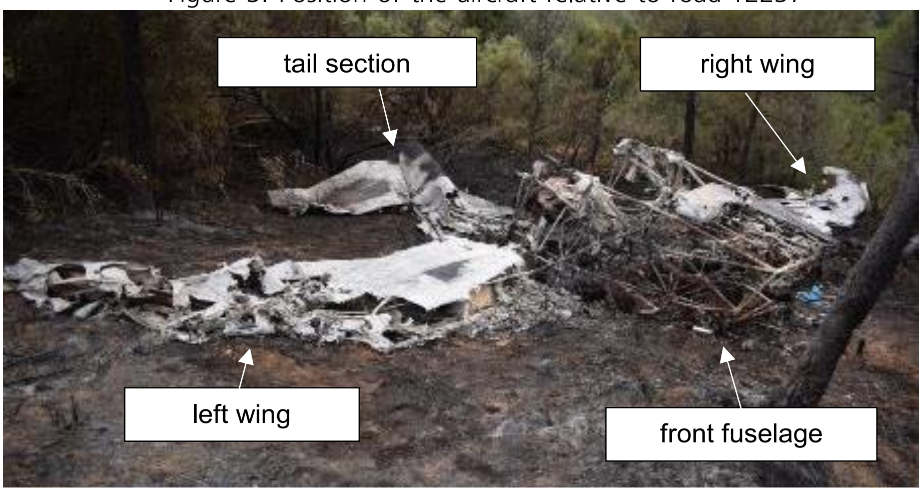


Figure 4. Aircraft upside down and burned after the accident

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Other
Fatal	1	2	3	
Serious				
Minor				
None				
TOTAL	1	2	3	

1.3. Damage to aircraft

The aircraft was destroyed as a result of the impact and the subsequent fire. It was found upside down and the engine had completely detached from the aircraft. The ends of the left and right wings had broken off from the main aircraft body and were the only components that were not affected by the fire.

1.4. Other damage

A surface area of 150 m2 around the aircraft containing trees and shrubs was burned.

1.5. Personnel information

The person listed as the pilot in command in the flight plan, and who was in the front left seat, was a 61-year-old German national. He had a commercial pilot license (CPL) issued by Germany's civil aviation authority. He had an instrument rating (IR) that was valid until 31 May 2018 and private pilot flight instructor (FI), single engine and nighttime ratings that were valid until 31 October 2019.

According to information provided by one of the owners, the pilot had around 2000 total flight hours and 1000 hours of experience on the Mooney aircraft, having previously been the co-owner of an aircraft of the same model. He had also flown on the accident aircraft as a safety pilot, accompanying the last owners who, after the purchase, agreed to receive training to become familiar with the aircraft.

The two passengers, seated in the front right seat and rear left seat, were German nationals aged 61 and 64, respectively.

1.6. Aircraft information

The Mooney M20K aircraft, S/N 25-1227, had been manufactured in 1990. In 2008, it was purchased by the last owners, of German nationality, who had registered it as D-ETFT[4]. At the time of the accident, it had a six-cylinder Continental TSIO-360 MB-Spec 1 engine installed, S/N 317241. It was equipped for IFR.

[4] It had previously been operated in the United Kingdom with registration G-GJKK.

The aircraft was based at the Mainz-Finthen Airport (Germany). One of the aircraft's owners had lent it to the pilot to go on a leisure flight with two friends. Since being registered in Germany, the airworthiness had been managed by a CAMO (DE.MG.1007).

1.6.1 Data taken from the Flight Manual

The Flight Manual, provided by the owner, included the following information of interest to the investigation. The procedures listed below are not complete:

- Maximum takeoff weight: 1315 kg.
- Total fuel capacity: 298 l, of which 286 l is usable.
- The aircraft's wingspan and height are 10.99 m and 2.54 m, respectively.
- Emergency procedures:
    - Best glide speed (1315 kg): 87 kt.
    - Graph of maximum glide distance versus altitude AGL (1315 kt): for 5600 ft, approximately 11 NM.
    - Landing run (for the conditions of the flight): 690 m.
    - Speed if power lost: 85 kt.
    - If the engine cannot be started and there is an engine fire, make an emergency power-off landing:

POWER OFF-GEAR RETRACTED OR EXTENDED

Emergency Locator Transmitter	ARMED
Seat Belts and Shoulder Harnesses	SECURE
Cabin Door	UNLATCHED
Fuel Selector	OFF
Mixture	IDLE CUTOFF
Magneto/Starter	OFF
Flaps	Full DOWN (33 Degrees)
Gear	DOWN or UP Depending on Terrain
Approach Speed	75 KIAS
Master	OFF, prior to landing

1.6.2 History of the aircraft for the past three years

Based on the information provided by the owner about the aircraft's maintenance, the following figures were estimated for before the start of the final flight:

- The aircraft had 2331 h.
- The engine had 50 h since its last overhaul.
- The aircraft's certificate of airworthiness had been renewed 1 month earlier and it had flown 21 h since.

The aircraft's history of activity for the last three years:

- average fuel economy: 50 l/h
- activity 2018: 21:46 h
- activity 2017: 28:10 h
- activity 2016: 00:22 h (due to an impact with the propeller while taxiing)
- activity 2015: 95:23 h

date		aircraft hours	
2015	28/05/2015	2221	Certificate of airworthiness
	29/05/2015	2221	New battery installed
	12/06/2015	2221	50-h check
2016	18/02/2016	2281	100-h check
	February 2016	2281	While taxiing to the hangar, a propeller blade impacted the ground, which rendered the aircraft inoperable for a year.
	28/05/2016	2281	Certificate of airworthiness not renewed due to the continuing repairs.
	27/07/2016	2281	Purchase of a three-blade propeller.
	05/09/2016	2281	Engine overhauled.
2017	10/02/2017	2281	Engine overhauled and installed on aircraft Three-blade propeller[5] installed New oxygen bottle installed
	02/04/2017	2283	Certificate of airworthiness
	21/08/2017	2300	JPM730 installed in the cockpit GAMI injectors installed ELT battery replaced
2018	04/04/2018	2310	Certificate of airworthiness

1.6.3 History of the fuel manifold valve

The nozzle distribution line that was found broken after the accident (Section 1.16.2) connected the fuel manifold valve, P/N 646508-4A10M S/N K238801C, to the injector for the #3 cylinder. Maintenance on these lines is "as required". They are replaced as determined during the periodic 50-h, 100-h and annual engine checks, or if any problems associated with the fuel system, and more specifically, with the distributor, are identified.

In this regard, the manufacturer had included service bulletin SB95-7 Fuel Flow Divider Leaks as part of the periodic checks, which was intended to check for fuel leaks.

[5] This modification was covered by a supplemental type certificate (STC) from the German civil aviation authority which stated that this propeller was suitable for installation on this aircraft model.

The maintenance of the fuel system, and of the fuel manifold valve, which was a part of it, was as follows:

- On 25/07/2016, an authorized release certificate was signed by Great Planes Fuel Metering Inc. in the United States certifying the overhaul of the fuel manifold, P/N 646508-4A10M S/N K238801C, which had been done by the authorized repair center Certified Engines Unlimited Inc. This company, in addition to being approved by the FAA, is also approved by EASA (EASA.145.4301).
- On 05/09/2016, an ARC was signed by Nikolaus Ghönert GmbH DE.145.0047 in Germany, certifying the overhaul of the TCM TSIO-360-MB Spec 1 engine, S/N 317241.
- On 10/02/2017, this part, along with the engine, was installed on the aircraft. The time between overhauls is 1800 h.
- On 02/04/2018, 29 h after installation, the fuel manifold was checked for leaks as per service bulletin SB95-7 Fuel Flow Divider Leaks. This SB is applicable every 100 h or 12 months.
- On 12/05/2018, the accident occurred after 50 hours of operation of the fuel system since its last overhaul.

The documentation gathered during the investigation does not mention any problems identified involving the nozzle distribution lines. When asked about similar cases, the manufacturer stated that its database, which contains information going back to the year 2011, did not identify any similar problems.

1.7. Meteorological information

1.7.1 Weather conditions at the accident site

The weather information for the general area of the accident showed that there was an active front exiting the northeast of the Spanish mainland, which was forecast on the significant low-level charts. AEMET (Spain's National Weather Agency) estimated the following weather conditions at the accident site based on the readings from three nearby stations[6] and satellite imagery:

- Wind form the south at around 10 km/h, gusting at times to nearly 40 km/h.
- Overcast skies.

[6] Cabacés (11 km east-northeast), Massaluce (20 km south-southwest) and Rasquera (25 km south).

1.7.2 Forecast weather conditions

The weather observations (METAR) and forecasts (TAF) for the destination airport (Reus) issued before and during the flight indicated the following conditions:

- Observations before takeoff. The observations at Reus indicated a visibility of 8000-9000 ft and variable winds up to 7 kt. At the time of takeoff, the cloud ceiling was at 2800 ft, compatible with visual flight, although hours earlier it had been at 500 ft, below the minimums for VFR.

- Observations during the flight. Starting at 12:30, conditions at Reus were below minimums for visual flight (visibility of 5000 m and cloud ceiling at 1500 ft). Conditions continued to worsen until well after the accident. In fact, four SPECI[7] reports were issued from 12:30 until 14:00 to report the following conditions:

  - Visibility decreased to 1500 m.
  - Appearance of fog and drizzle.
  - Appearance of cumulonimbus, increased clouds and lower cloud ceiling.
  - Specifically, the 13:21 SPECI stated that the cloud ceiling (BKN) was at 600 ft and that visibility was 1500 m, at the limit of the conditions for special visual flight (1500 m visibility and 600 ft cloud ceiling).

- Aerodrome forecasts before takeoff. Before takeoff, two TAF reports were issued, at 02:00 and at 08:00. Both called for a 30-40% chance of worsening conditions at Reus throughout the day:

  - reduced visibility to 3000 and 2000 m.
  - cloud ceiling between 800 and 3000 ft.
  - presence of mist, rain, showers and storms.
  - appearance of cumulonimbus and increased cloud layers.

The en-route low-level chart of expected phenomena (SIGMET chart up to FL150) for the time period of the flight[8] showed worsening conditions with respect to the previous SIGMET, and called for conditions to deteriorate even further, which they did:

- mountain obscuration.
- visibility from 1000 to 5000 m.
- rain at unspecified altitudes, showers and storms with embedded cumulonimbus between the clouds from 2000 ft to an unknown altitude.

[7] Special observation report that highlights significant changes with respect to the last published report.

[8] 12:00 SIGMET valid from 09:00 until 15:00. This map was prepared at 00:00 on 12 May 2018 and issued at 05:00 UTC, five hours before the flight started.

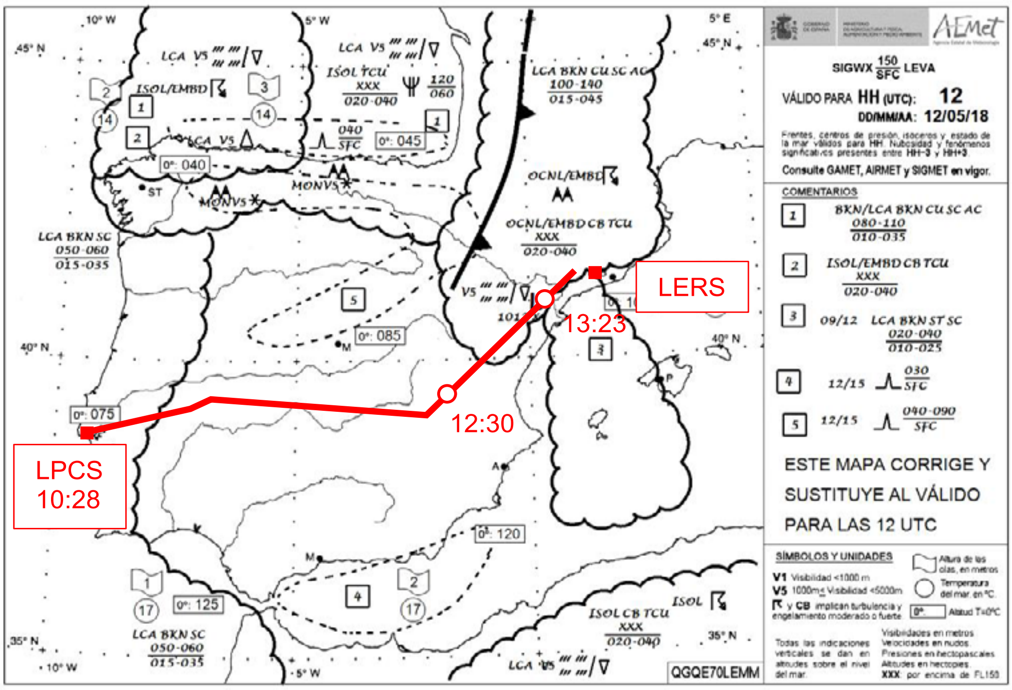


Figure 5. 12:00 UTC SIGMET, issued at 05:00 UTC, and applicable to the flight

The service provider at the Cascais Airport weather office confirmed that the pilot had not made any requests involving the expected weather along the flight path or at the destination and alternate airports, although there are other ways (internet) to find that information.

1.8. Aids to navigation

This section combines all the information (communications and radar) recorded by the air traffic control services, in order to provide a description of the flight that is easier to understand. These records are the only source of information on the progress of the flight.

The flight was tracked by ATC services for 3 h 11 min, between 10:28 and 13:39:05. The progress of the flight during the first 3 hours (from 10:28 and 13:23) is described in Section 1.1, History of the Flight, which was uneventful. This section focuses on the flight after 13:23, which is when the pilot was informed that the destination airport, Reus, was in IMC.

1.8.1 Flight between 13:23 -13:31: intention to go to the alternate, LELL, along the coast

The communications in these initial moments were as follows:

UTC time	Station	Message
13:24:26	ACC	DETFT Barcelona.
13:24:30	D-ETFT	DETFT go ahead.
13:24:32	ACC	DFT IMC conditions at Reus, report instructions.
13:24:38	D-ETFT	(unintelligible) Sabadell, so we have to go to Sabadell. The latest weather for Sabadell is available?
13:24:51	ACC	I will call you back with that information in a minute.

Seconds later the pilot asked about the possibility of flying along the coast to Sabadell. Even though this path was not feasible (see Section 1.18.2), as explained by the controller, the pilot reiterated his intention to proceed along the coast

UTC time	Station	Message
13:25:26	D-ETFT	DETFT is approved to follow the coastline?
13:25:33	ACC	DFT I am afraid not. You would have to avoid the Barcelona Terminal Area, sir. It's… I mean you could follow the coastline until 30 miles before BCN, sir.
13:25:50	D-ETFT	Ok, we'll be turning right to the coastline right now, DETFT.
13:26:41	ACC	DFT I confirm Sabadell is open. Ceiling is 2000 ft, 2500 ft.
13:26:48	D-ETFT	(unintelligible) and we will descend below the Barcelona airspace in… we reach the coastline.

The aircraft was transferred to Reus at 13:27:25, to which the pilot would convey his intention, for the third time, to follow the coastline. It was this station that changed the pilot's mind about his intended flight path. The pilot, who had an IR rating, asked about the possibility of going IFR, but he seemed to rule out this possibility:

UTC time	Station	Message
13:27:35	TWR LERS	I have bad news for you, we have instrumental flight conditions at Reus, so we cannot accept visual flights.
13:27:46	D-ETFT	OK, is IFR (unintelligible) possible?
13:27:50	TWR LERS	Could you say that again?
13:28:52	D-ETFT	Ok, we have to decide to divert to Sabadell. It's OK, and we are turning right for the shoreline and then we descend below the… the Barcelona airspace and then to Sabadell.
13:28:08	TWR LERS	Ok, you would have to stay outside Reus CTR and over the sea 12 miles outbound Reus, which is quite deep into the sea. You need to maintain maximum 2000 feet (*altitude of sector VFR*). Do you think you'll be able to do that with the clouds? You're gonna have to cross the clouds.
13:28:29	D-ETFT	Ok, sounds not so good. So we should avoid to the north. Any radar vectoring available from your side?
13:28:39	TWR LERS	I can't. You need to contact Barcelona see if they can help you.

The pilot again contacted the Barcelona ACC to request radar vectors from the controller, who, in an effort to direct the aircraft to the north, instructed the pilot to turn heading 040° (which is why the aircraft made a 360° turn) and climb to FL70. The instructions were completed at 13:31:11 and acknowledged by the pilot who, seconds later, began to climb. During all this time (13:23 to 13:31), the aircraft remained at 4400 ft and 130 kt.

1.8.2 Flight between 13:31:50 -13:34:50: climb

After acknowledging ATC's instructions, the pilot climbed for 3 min, gaining 2000 ft, from 4400 to 6400 ft. He maintained an average climb rate of 623 fpm on a heading of 35°.

1.8.3 Flight between 13:34:59 -13:39:05: emergency report and descent

At 13:34:59, during an exchange with the ACC, the pilot reported a problem with the engine and the need to descend. The aircraft was at 6200 ft and 130 kt and had turned left to the north-northwest. The pilot made a total of four reports involving the engine problem, each one more serious than the last. The controller decided to return the pilot to Reus, 22 NM away, to which the pilot replied that he could not make it.

UTC time	Station	Message	Altitude AGL
13:34:53	ACC	DETFT Barcelona.	
13:34:59	D-ETFT	(unintelligible) we have trouble with the engine. We have to descend.	5600 ft
13:35:10	ACC	Roger, what are your intentions sir?	
13:35:14	D-EFTF	Descending and we (unintelligible) down to the…	
		…try to…	
		We have smoke from the cowling so, eh, is there any radar vector to the next field? We would appreciate very much.	3923 ft
13:35:43	ACC	DFT you need any radar vectors to any field confirm?	
13:35:50	D-ETFT	Yes, and we have…. We have trouble… no engine power. Loss of engine power.	3467 ft
13:36:08	ACC	DTFT turn right heading 100º direction to Reus.	
13:36:23	D-ETFT	How many miles to Reus?	
13:36:35	ACC	It's 22 miles.	
13:36:39	D-ETFT	Negative, no chance.	
13:36:47	D-ETFT	No chance to Reus, we have totally loss of power.	2920 ft

The pilot requested a closer airfield, but ACC informed him that Reus was the closest. At the same time, the control room supervisor initiated communications to find alternatives.

UTC time	Station	Message	Altitude AGL
13:37:01	D-ETFT	So we have to look for an airfield anyway.	
13:37:10	ACC	Roger sir, we are looking for an alternative here but Reus is the nearest to your position.	
13:37:18	D-ETFT	No chance for Reus, no chance.	2177 ft

The controller attempted to offer a solution and suggested a highway, an alternative that the pilot accepted, judging by his last message.

UTC time	Station	Message	Altitude AGL
13:38:24	ACC	DFT There should be a motorway in the area from Reus to Lleida, do you have any roadmaps available?	
13:38:41	D-ETFT	…OK I (unintelligible) road… eh …. Below *(it was 530 m away from km 13 of road T2237)*	1250 ft
13:39:05		Last radar return	893 ft

1.8.4 Flight between 13:39:05 and contact with the road at 13:40

The last valid radar return was recorded at 13:39:05, and showed the aircraft was 893 ft AGL. Assuming the aircraft maintained its final recorded speed of 90 kt[9] until the time of impact, it is estimated that the aircraft may have made contact with the ground 62 s[10] later, at 13:40:07.

During this final minute before impact, the aircraft descended 100 ft, since the road was at an elevation of 238 m (793 ft), meaning that this final descent was carried out at a rate of 100 fpm. Figure 6 shows the flight path over the ground during the last two minutes of the flight. The altitude, AGL (in parenthesis) and ground speed (GS) are shown at certain significant points.

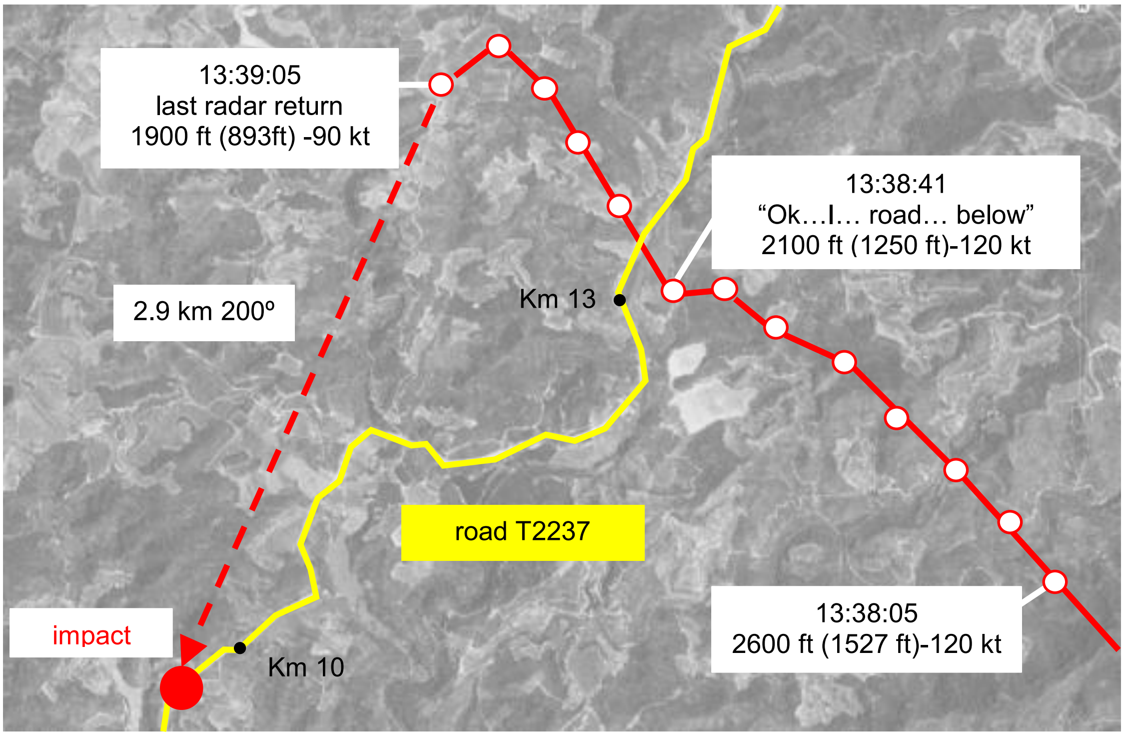


Figure 6. Flight after 13:38:05 (altitude AGL shown in parentheses)

1.8.5 Flight profile from the emergency until the accident

Figure 7 shows the aircraft's flight profile from the time the pilot reported the engine problem until it made contact with the road. The total distance traveled was 9.5 NM. The ground speed (GS) is shown in gray, the altitude in red and the descent rate in blue. In addition to these three parameters, the graph includes:

[9] Flight Manual: best glide speed: 87 kt.
Flight Manual: speed in case of engine failure: 85 kt.
Flight Manual: approach speed for power-off landing: 75 kt.
[10] Assuming an IAS of 75 kt, it would take 75 s to travel the distance to the impact point, meaning the impact would have occurred at 13:40:20.

- Horizontal marks and brown shading representing the elevation of the terrain at the most significant moments.
- The most relevant messages sent by the pilot.
- An estimate of the descent between the last valid radar return until contact with the ground.

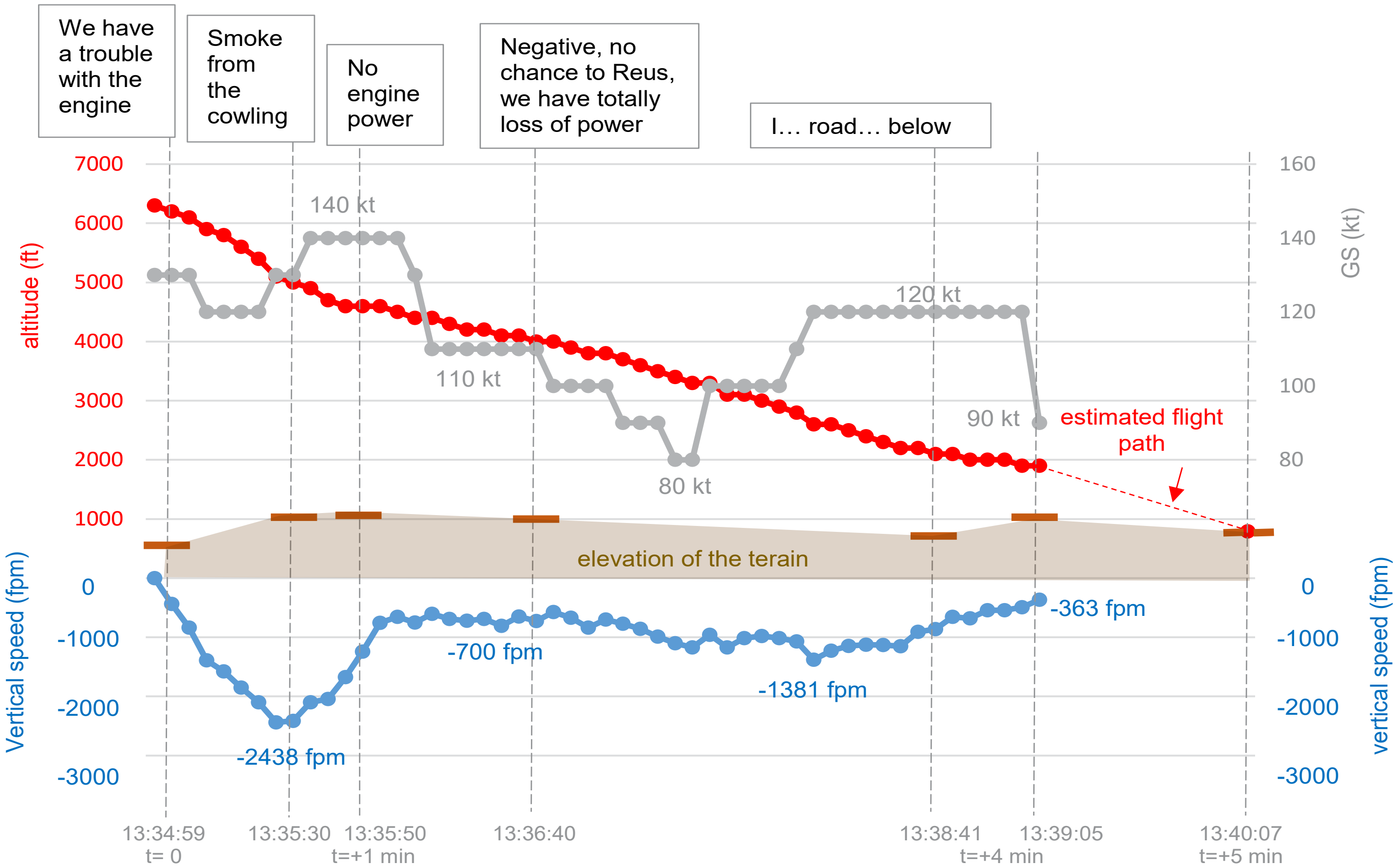


Figure 7. Flight profile after engine failure report

The main conclusions drawn are as follows:

- In the first minute after declaring the emergency, the aircraft descended sharply, with a descent rate that almost reached -2500 fpm, during which the airspeed also increased to 140 kt. The altitude AGL was in excess of 4000 ft.
- Over the next three minutes, the aircraft's vertical speed decreased until its value stabilized at around -1000 fpm. Its GS during this time ranged between 80 and 120 kt. The altitude AGL was greater than 1000 ft.
- In the next 30 s, after radioing the words "road" and "below", the aircraft's vertical speed fell from -700 fpm to the -363 fpm recorded during the final return. The speed for the entire segment was 120 kt, except for the last return, when it was 90 kt, coincident with a change in heading to the south, and thus into the wind. The altitude AGL was in excess of 893 ft.

- The estimated flight path until the end of the descent, as indicated earlier, must have lasted 1 min at a GS of around 90 kt and a descent rate of 100 fpm.

1.9. Communications

The aircraft was in radio contact with the Madrid ACC, Barcelona ACC and Reus TWR control services. The most relevant information regarding these communications is included in sections 1.1 and 1.8.

1.10. Aerodrome information

Not applicable.

1.11. Flight recorders

The aircraft did not have any flight recorders, as they were not required for this type of operation. The other devices found on the aircraft had been seriously damaged by the fire and did not yield any additional information.

1.12. Wreckage and impact information

The aircraft was found in a forested area on the right side[11] of road T2237. The road, 6 m wide (the aircraft's wingspan was 10.99 m), traveled along a section with elevation differences on either side, with the terrain going uphill on the left and downhill on the right, where the aircraft was found.

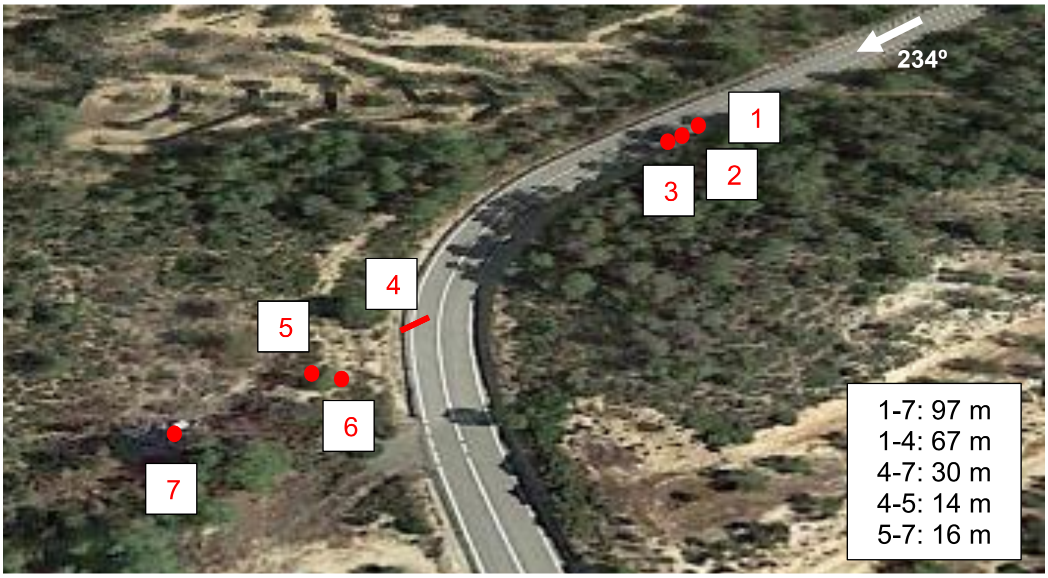


Figure 8. Location of the wreckage

[11] Right in the direction shown in the figure, and which was determined to be the aircraft's direction of motion, based on the location of the debris found.

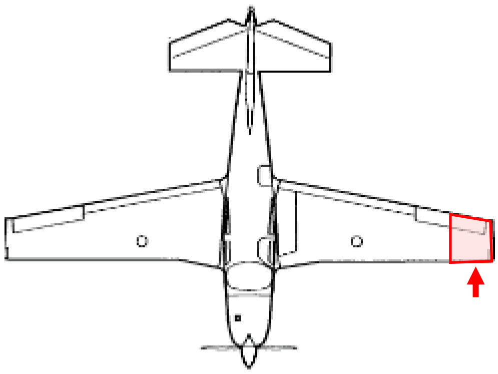
The aircraft's direction of motion was determined using the distribution of the debris and the marks found, as shown in the figure above. Marks 1-4 were oriented toward 220°, and marks 4-7 toward 240°. The distance between the most distant components of the wreckage (1-7) was 97 m.

The wreckage was distributed as follows:

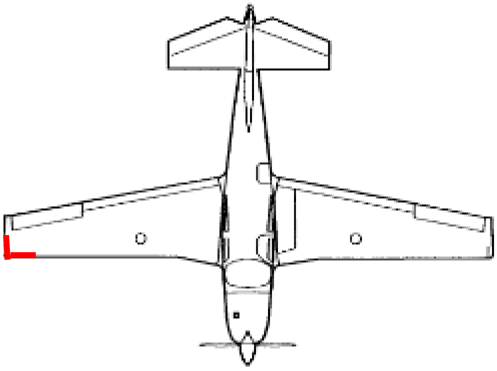
1 Tree #1 (pine), which was missing the branches found next to road T2237. This point, at an elevation of 238 m, was at the end of a straight 300-m section on a southwesterly heading (234°). The tree trunk and its upper branches were intact. The severed branches were at a height of 8.5 m above the road.

2 Tree #2 (pine), 3 m away from the first, which was also missing branches on the side facing the road at a height of 8.5 m.

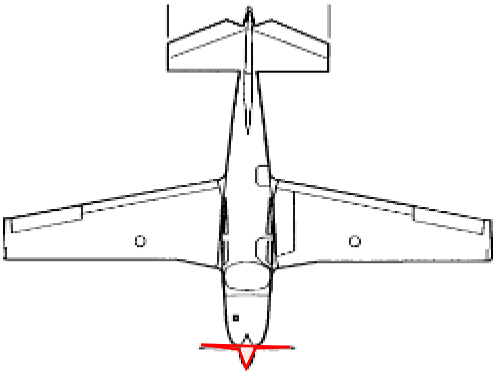
3 Branches ripped from trees 1 and 2 found on the left side of the road and after the last tree. The branches found were very leafy. Also found with these branches were two pieces that made up the final 90 cm of the left wingtip. There was a round deformation and compression marks on the leading edge, 45 cm away from the tip. The other fracture zone exhibited deformation toward the upper surface of the wing. The debris found in this area was not affected by the fire and still had the original paint.



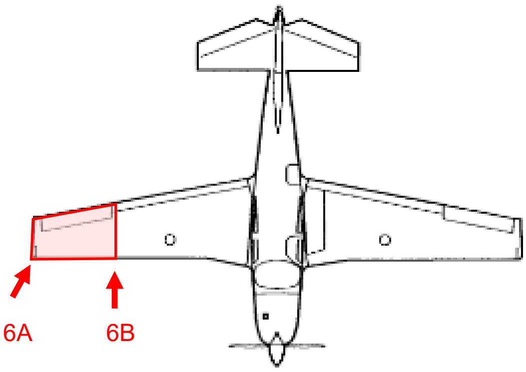
4 67 m away from point 1 there were friction marks on the asphalt, with small flecks of blue paint, that were oriented practically perpendicular to the length of the road. Continuing in the direction of this mark, there was similar abrasion on the guardrail. This point is at an elevation of 236 m, and the marks are believed to have been made by the right wingtip, and that the marks and deformations found in 6 were created here.



5 14 m away from mark 4, on the right slope, the debris from the propeller blades and spinner were found buried. The elevation of the ground at this point was 235 m.

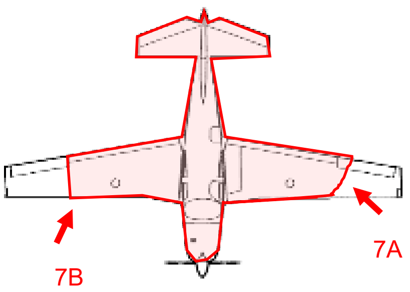


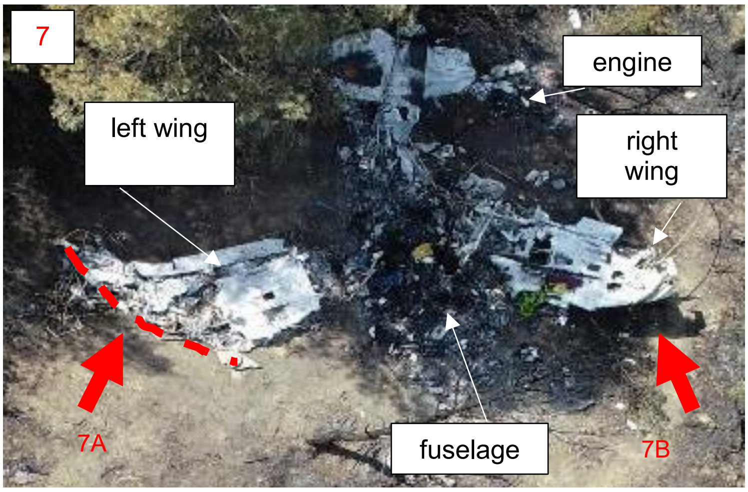
6 13 m away from 4 was a 1.8-m long section of the right wingtip, containing the aileron. It was not burned. It exhibited the following fractures and deformations:



- On the leading edge of the wingtip, there was intense deformation due to compression from the front to the back (6A).
- In the area where it joined the rest of the wing, there was a perforation on the wing that went from the leading edge to the trailing edge (6B). The material in the fracture zone was deformed and had large tears. The entire piece was deformed toward the lower surface of the wing.

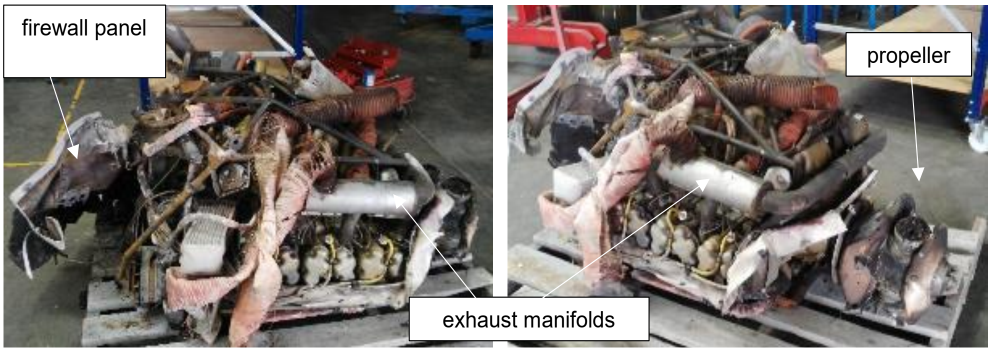
7 The aircraft was 30 m away from mark 4. It was upside down and completely burned. It was 97 m away from mark 1. The elevation of the ground at this point 231 m, 5 m below the road. The fire had been most intense in the area of the fuselage, of which there was nothing left, except for the metal structure. The fuselage pointed toward the north (344º). The extent of the destruction made it impossible to identify the position of any of the aircraft's controls.





The right wing was highly deformed and twisted near the tip (7B). The entire structure of this wing was deformed toward the lower surface and toward the back. These deformations matched those found on the wingtip that had detached, and which was found in mark 6, specifically those identified as 6B. The left wing had lost more material, and it also showed signs of compression and deformation along more than half of the wing along the leading edge. The tail assembly was attached to the fuselage and had also been exposed to the fire.

The aircraft's engine had detached and was found upside down between the right wing and the right horizontal stabilizer. It had intense burn marks along the rear and less intense at the front. The deformations and displacement of the firewall panel, which was driven into the rear of the engine, the deformation on the propeller plates and the lack of deformations at the bottom of the engine (such as on the exhaust manifolds or the turbocharger) indicated that this area had mainly been subjected to longitudinal forces acting toward the front. The engine was removed and preserved for disassembly and inspection, the results of which are presented in section 1.16.2.



1.13. Medical and pathological information

The occupants on the aircraft, who were seated in the front two seats and in one of the rear seats, were identified using dental records. The pilot in command, or at least the person who signed the flight plan as the pilot in command, was seated in the left front seat. The autopsy determined that the time of death was 15:42 local time (13:42).

1.14. Fire

A fire broke out that affected the entire aircraft, with the exception of the wingtips, which had detached earlier (marks 3 and 6 in Section 1.12). This fire burned for a long time, since it was even burning when firefighters arrived at the crash site.

1.15. Survival aspects

The accident was reported at 15:40 local time (13:40 UTC) to the emergency phone number by a couple that was traveling on road T2237, who first saw a column of black smoke and debris from branches on the road, before eventually identifying the burning light airplane.

After the 112 call was made, firefighters, medical services and the regional police reported to the scene.

1.16. Tests and research

1.16.1 Eyewitness interviews

Eyewitness 1: at around 15:40 local time (13:40 UTC), eyewitness 1 and his wife were driving on road T2237 from La Palma D'Ebre to Vinegre. They saw a black column of smoke and branches in the middle of the road. They stopped, thinking it was due to a car accident, and they saw that it was a light airplane. They initially saw black smoke, followed by flames. Since they could not approach the airplane and provide assistance, they called 112 and waited for emergency services to arrive.

Eyewitness 2: stated that at around 15:30 local time (13:30 UTC), he was working on a farm when a light airplane passed overhead in the direction of Mora D'Ebre to Figuera. He stated that he heard the noise of the airplane but did not see it at any point, since the sky was very cloudy. He stated that the engine noise was normal at first, but that it grew softer and that he finally heard 3-4 bangs (some louder than others) spaced 3-4 seconds apart. After the last bang, he no longer heard the sound of the engine. He went to his house and after hearing the news about the airplane accident, he called 112.

The location of eyewitness 2 is consistent with the flight path and airplane's direction of travel to the north. It is estimated that the aircraft must have passed over eyewitness 2 between 13:34:55 and 13:35:30, just as the pilot was reporting engine problems to ATC. At that point, its speed was 130 kt and it was some 5000 ft AGL.

1.16.2 Inspection of the engine

The results of the Continental TSIO-360 MB-Spec 1 engine, S/N 317241, were as follows:

- Turbocharger: removal and check of the assembly. No damage to turbine, no damage to charger, which rotated freely without friction. The shaft between the rotors had lubricating oil, as did the oil supply and return lines. A small leak was identified in one of the joints, but it is not thought to have affected the operation of the turbocharger.
- Oil filter: removal and section of the filter to inspect the filter element. No particles observed. Oil drained to verify that the engine had oil.
- Spark plugs: removal and inspection. The condition of the spark plugs revealed they had been in use a short time. None exhibited any defects that could have affected the operation of the engine.
- Crankshaft rotation: check of the rotation. Once the friction with the pulley that drives the alternator was removed, the crankshaft was verified to turn freely and drive the connecting rods, pistons and accessories.
- Magnetos: operational check and removal. The pulses in the two magnetos were clearly audible. The shaft on both magnetos turned freely. The internals of the left magneto had been destroyed by the fire. The right magneto had also been affected by the fire, but the contact breaker opened and closed when the shaft was turned.
- Propeller: disassembly and inspection of the propeller hub. No marks were found on the bolts fastening the hub to the engine shaft, or in the orifices of the crankshaft flange. There was no deformation between the propeller and engine.
- Fuel intake and control: removal of the multiple intake assembly and set of fuel throttle-control valves. The intake was not blocked and the throttle valve moved when actuated.

- Fuel manifold and nozzle distribution lines: removal and inspection. Upon inspecting the condition of this assembly, it was noticed that the connection between line #3 and the fuel manifold was loose, while the other lines were not. In fact, the line connecting the fuel manifold to the injector of the #3 cylinder was completely fractured at the connection between the two. The entire assembly was removed and preserved for subsequent analysis.

Figure 9. Fuel manifold and distribution lines

- Cylinder valves: borescope inspection. The condition of the intake valves in every cylinder indicated little use. The exhaust valves were indicative of normal engine operation: those in cylinder 2, 3, 4 and 5 had a slightly reddish color at the center and dark at the edge, while those in cylinders 1 and 6 were darker.
- Cylinders: borescope inspection. The condition of the cylinders was acceptable. No findings of note.

1.16.3 Inspection of the fuel manifold valve and the nozzle distribution lines

The fuel manifold valve is a cylindrical body with six orifices, one per cylinder. Inserted into each orifice is a nozzle distribution line, fastened with a washer, that directs the fuel under pressure to each injector in the engine cylinders.

Each end of the line, both the part that is inserted into the manifold and the part that goes into the cylinder, is terminated with an element with a larger cross section, called the head, that is welded to the line. In the case of the #3 cylinder, the attachment head to the manifold was completely fractured in the part with the changing cross section.

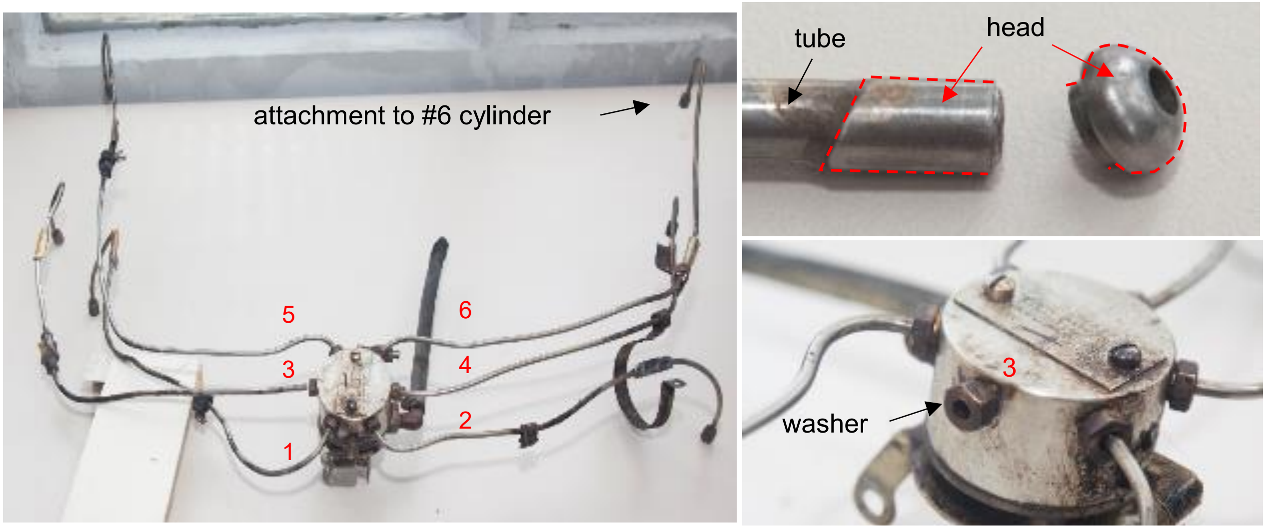


Figure 10. Fuel manifold line and nozzle distribution lines

Chemical, fractographic and metallographic tests were done. The heads were made up of austenite crystals with fine MnS inclusions, which is an easily machinable stainless steel. The line exhibited an austenitic structure with twin graining, and the welding material had a hypoeutectic structure. The relatively high hardness of the fractured head with respect to the line is indicative of a certain degree of work hardening (possible cold drawing or forming by plastic deformation).

Fractographic analysis:

The fracture occurred in a connecting piece (head) that was welded to the end of the line. The fracture surface was oriented across the length of the line and did not exhibit any apparent signs of tearing or plastic deformation. There were radial steps on much of the fracture surface that originated on the inner surface of the part, primarily in a zone where the wall thickness was 0.18 mm. At the other end, the thickness was 0.34 mm and there were signs of plastic deformation by material smashing after the fracture.

In addition to the radial steps, the scanning electron microscope images showed microsteps and transcrystalline microfaces with cleaving, which is characteristic of fatigue with a high number of cycles. All of these marks were indicative of multiple incubation points on the inner surface of the part. Most of the incubation regions exhibited tearing microdomes and other signs of plastic deformation of the material prior to the fracture. The final fracture zone showed signs of plastic deformation of the material caused after the fact.

Figure 11 shows images of the fracture surface. Figure 11.A shows part of the line, and 11.B the part where the diameter increases. Figures 11.B1 and 11.B2 provide amplified views of the fracture surface in 11.B. The images identify the start and end of the fracture, the difference in cross section and the direction of propagation of the fracture.

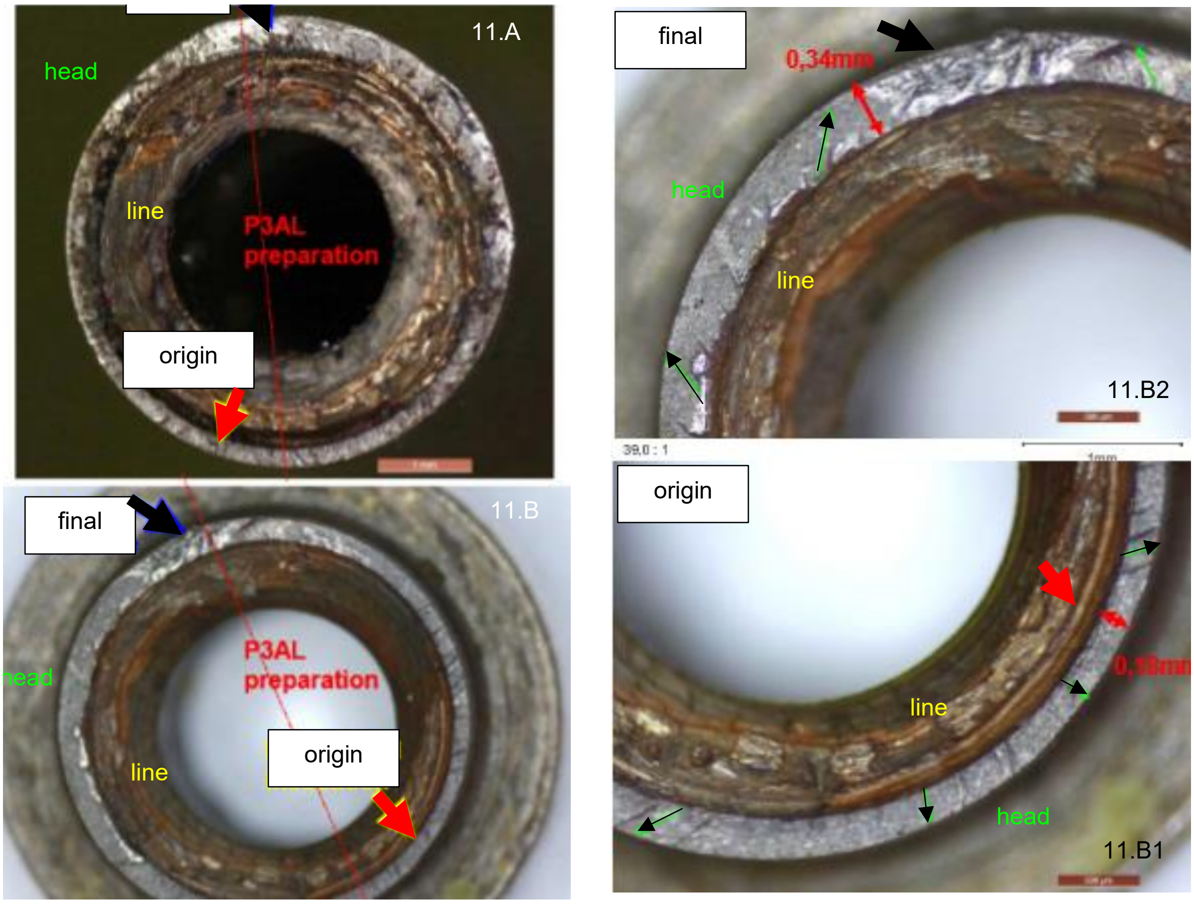


Figure 11. Fracture surfaces

Metallographic analysis:

Two metallographic samples of line #3 were prepared, one from the fracture zone and another from the other end of the line that was not fractured, where it attached to the cylinder.

The wall of the line was uniform, with a thickness of approximately 0.80 mm, while the thickness of the heads varied considerably:

- Fractured end: 1.04-1.29 mm in the zone with the normal cross section and 0.20-0.33 in the zone with the reduced cross section.
- Non-fractured end: 0.94-1.09 mm in the zone with the normal cross section and 0.18-0.39 in the zone with the reduced cross section.

Several regions of the inner surfaces of the heads showed signs of plastic deformation and material tearing. There were gaps caused by capillarity of the filler metal in broad regions of the tube-head weld. There were also folds on the inner surface of the heads. In some cases, the lack of filler coincided with the change in cross section of the head.

Figure 12 shows the results obtained when the following cross section was cut:

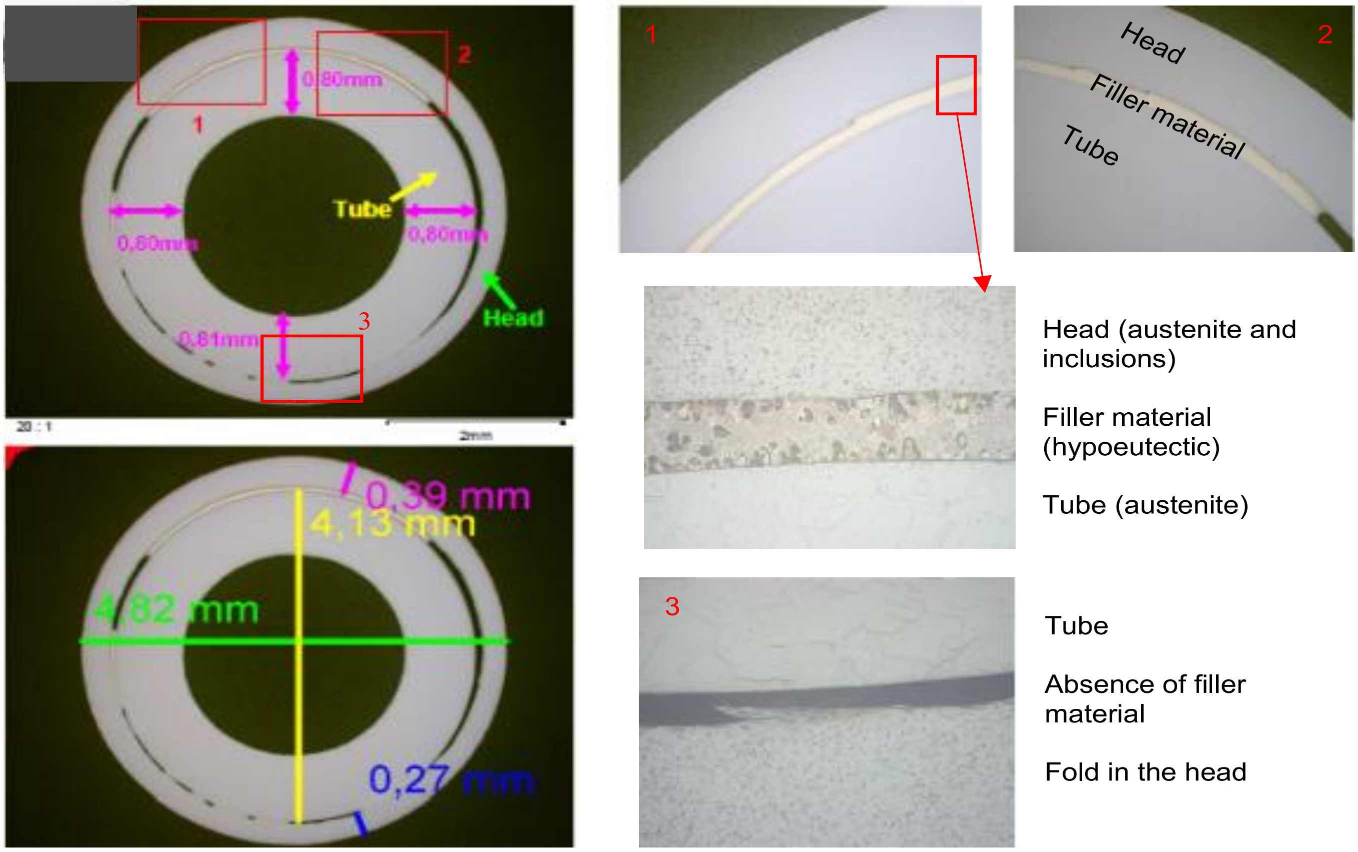


Figure 12. Cross section of the fractured end of line #3

Figure 13 shows the results of making a longitudinal cut at the fractured and non-fractured ends of line #3. These cross sections also exhibited a lack and irregularity of the filler material at the head-tube weld, as well as different dimensions.

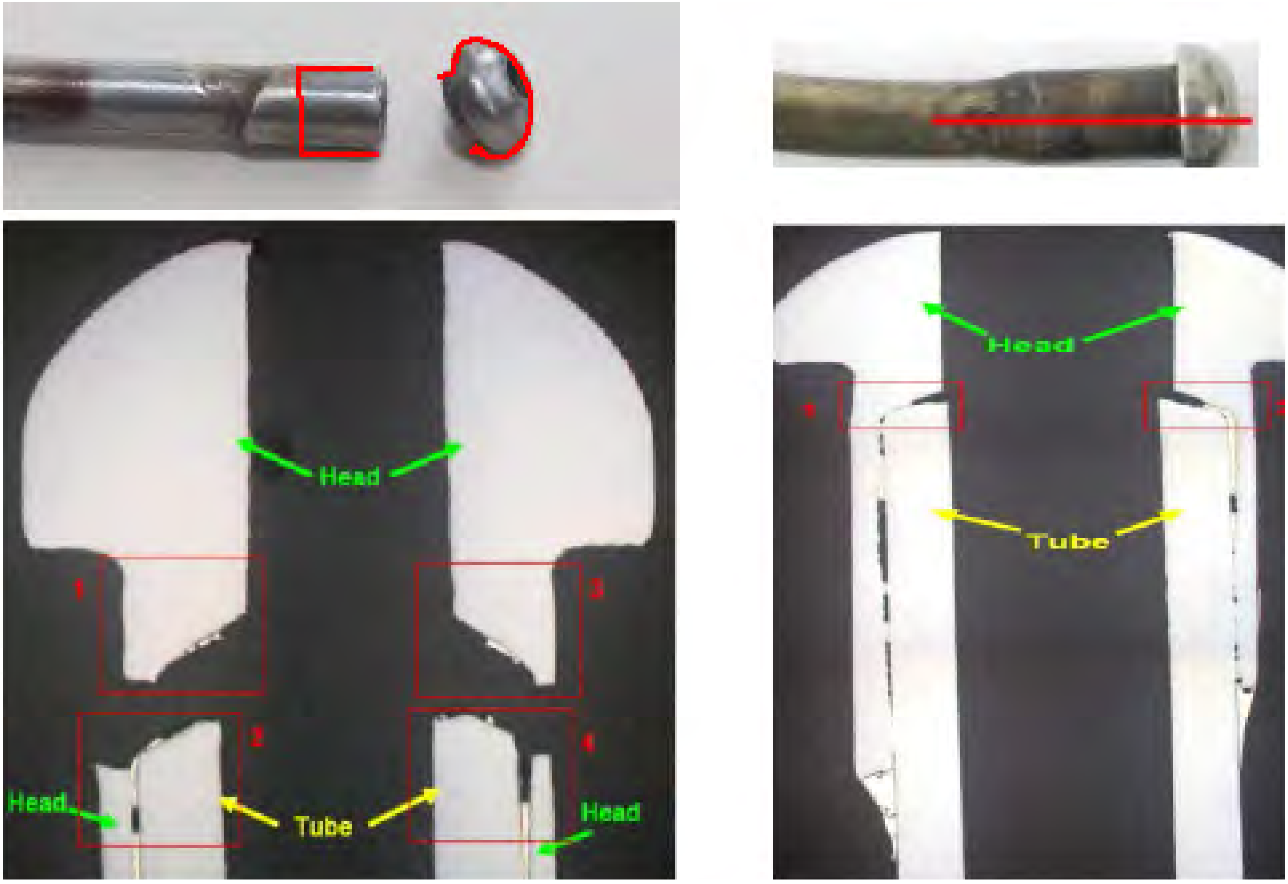


Figure 13. Longitudinal cross section of the fractured and non-fractured ends of line #3

1.17. Organizational and management information

Not applicable.

1.18.Additional information

This section provides information on the regulation applicable to VFR flights, on the viability of flying the route proposed for the aircraft to reach Sabadell along the coastline and, lastly, on the closest airports when the pilot declared the emergency.

1.18.1 Regulations for VFR flights

Below are some excerpts from the regulations (RCA, AIP and SERA) that apply to flights carried out under VFR rules as these pertain to flight planning and in-flight decisions.

WEATHER REPORTS AND FORECASTS (RCA 7.2.3.6)

Before starting a flight, the captain of the aircraft shall become familiar with all the available weather information that is pertinent to the flight that is to be made. The preparation for a flight that entails leaving the vicinity of the starting point shall include:
1) A study of any updated weather reports and forecasts that are available, and
2) Planning of alternative measures in anticipation of the possibility that the flight cannot be completed as planned due to bad weather.

LIMITATIONS IMPOSED BY THE WEATHER CONDITIONS-FLIGHTS MADE AS PER VISUAL FLIGHT RULES (RCA 7.2.3.7.1)

No flight shall be made that is required to be flown under visual flight rules unless it is a strictly local flight in VMC, unless the most recent weather reports, or a combination thereof and forecasts, indicate that the weather conditions along the route, or along that part of the route that must be flown as per visual flight rules, will be such at the appropriate time so as to allow compliance with these rules.

VISUAL FLIGHT RULES-VISUAL METEOROLOGICAL CONDITIONS (AIP ENR 1_2, SERA.5005)

Except when operating as a special VFR flight (…) VFR flights shall not take off or land at an aerodrome within a control zone, or enter the aerodrome traffic zone or aerodrome traffic circuit when the reported meteorological conditions at that aerodrome are below the following minima:

- the ceiling is less than 1500 ft or
- the ground visibility is less than 5 km.

AIRSPACE CLASSES (AIP ENR 1_4, SERA.6001)

Class D: IFR and VFR flights are permitted and all flights are provided with air traffic control service. VFR flights receive traffic information in respect of all other flights and traffic avoidance advice on request. All flights shall be subject to ATC clearance.
Class G: IFR and VFR flights are permitted and receive flight information service if requested. ATC clearance is not required.

WEATHER DETERIORATION BELOW THE VMC (SERA.8020)

When it becomes evident that flight in VMC in accordance with its current flight plan will not be practicable, a VFR flight operated as a controlled flight shall:
1) request an amended clearance enabling the aircraft to continue in VMC to destination or to an alternative aerodrome, or to leave the airspace within which an ATC clearance is required; or

2) if no clearance in accordance with a) can be obtained, continue to operate in VMC and notify the appropriate ATC unit of the action being taken either to leave the airspace concerned or to land at the nearest suitable aerodrome; or
3) if operated within a control zone, request authorization to operate as a special VFR flight; or
4) request clearance to operate in accordance with the instrument flight rules.

SPECIAL VFR IN CONTROL ZONES (SERA.5010)

Special VFR flights may be authorized to operate within a control zone, subject to an ATC clearance. the following additional conditions shall be applied:
a) such special VFR flights may be conducted during day only (…)
b) by the pilot:

1) clear of cloud and with the surface in sight;
2) the flight visibility is not less than 1 500 m (…)
3) fly at a speed of 140 kts IAS or less to give adequate opportunity to observe other traffic and any obstacles in time to avoid a collision; and

c) an air traffic control unit shall not issue a special VFR clearance to aircraft to take off or land at an aerodrome within a control zone, or enter the aerodrome traffic zone or aerodrome traffic circuit when the reported meteorological conditions at that aerodrome are below the following minima:

1) the ground visibility is less than 1 500
2) the ceiling is less than 180 m (600 ft).

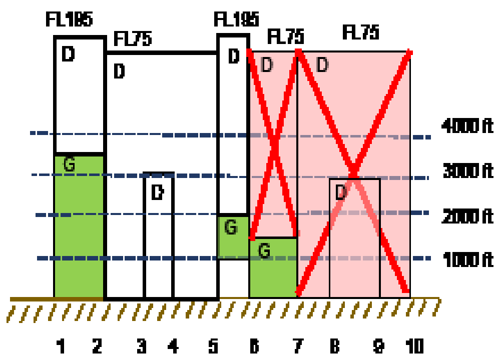
1.18.2 Flight path from Reus to Sabadell along the coast

The pilot intended to reach Sabadell by following the coastline. This route is not possible, since it crosses airspaces, like Area 2 of the Barcelona TMA, that prohibit VFR flights. The route would also fly over the Barcelona-El Prat international airport.

The aircraft was about to enter the Barcelona TMA when the pilot was notified that Reus was in IMC. The Barcelona TMA has several airspaces, each with different restrictions regarding VFR flights. This information is contained in the AIP, in the VFR traffic chart of the Barcelona TMA (AIP ENR 6.5). Figure 14 shows a vertical cross section (not to scale) of the different airspaces the aircraft would have to cross to travel along the coastline. It contains three types of airspaces (described in section 1.18.1):

- G in green, no restrictions for VFR traffic.
- D in white, subject to ATC clearance.
- D in red, no VFR traffic allowed.

- Barcelona TMA (1-2) (5-6)
- Reus CTR (2-3) (4-5)
- Reus ATZ (3-4)
- Barcelona CTR (6-7)
- Barcelona TMA Area 2 (7-8) (9-10)
- Barcelona-El Prat ATZ (8-9)



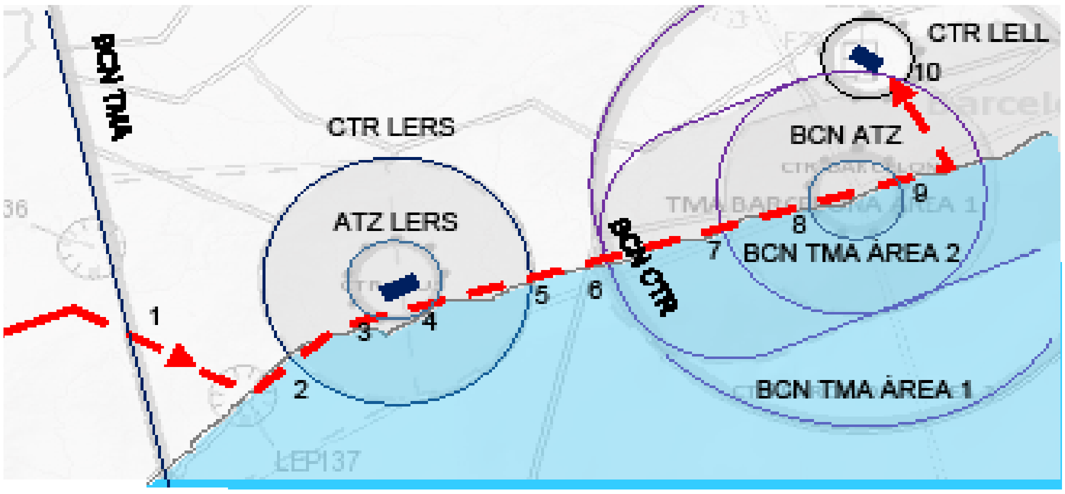


Figure 14. Viability of route to Sabadell along the coast

1.18.3 Location of airports near the aircraft

Listed below are the public and restricted airfields available in the vicinity of the aircraft. The nearest airfield was, in fact, Reus

Identifier	Airport	Distance and heading	Time at 140 kt
LERS	Reus	28 NM SE	12 min
LEDA	Lleida	32 NM N	14 min
LECJ	Castejón de Monegros	51 NM NW	22 min
LEIG	Igualada	58 NM NE	25 min
LECF	Sallavinera	58 NM NE	25 min

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

On Saturday, 12 May 2018 at 13:40, after flying for 3 h 12 m, aircraft D-ETFT, with three persons on board, suffered an accident while on a private flight between Cascais and Reus. The aircraft impacted the terrain in a mountainous area in the municipality of Flix (Tarragona), 40 km west of its destination. Five minutes earlier the pilot had declared an engine failure, and 17 minutes earlier, the pilot had been informed that the destination airport was closed to VFR traffic.

The analysis of the accident considers four phases:

- An analysis of the impact at 13:40.
- An analysis of the flight from the time the pilot was told that Reus was closed to VFR until the engine failure, that is, from 13:23 to 13:34.
- An analysis of the flight from the engine failure until the impact, that is, from 13:34 to 13:40.
- An analysis of the engine failure at 13:34:45.

2.1. Analysis of the impact at 13:40

Time of impact:

The impact is estimated to have occurred between 13:40:07 and 13:40:20, one minute after the last ATC contact. The lack of radio and radar coverage due to the low altitude and the mountainous terrain in which the flight was taking place prevented recording the full flight.

Landing attempt on road T2237:

The debris field indicates that the aircraft, seconds before impact, was on a southwesterly heading similar to that of road T2237, which in that area traveled on a heading of 234°. The first contact marks from the left wingtip on the trees on the left side of the road, as well as the height at which these marks occurred, suggest that in all likelihood the pilot was attempting to land on the road. This is backed up by the final communications held a minute and a half earlier.

Visibility before the landing attempt:

The facts listed below indicate that during the last minute and a half of flight, the pilot must have been in visual contact with at least the immediate surroundings:

- The precise alignment between the aircraft-road during the first impact with the trees in a mountainous area would require visual contact with the terrain (13:40).
- The change in course (from northwest to southwest) one minute earlier suggests the pilot acted intentionally in reaction to the road (13:38:55-13:39:05).

- The final message, in which he mentioned the words "road" and "below", indicates he was in visual contact with the road (13:38:41).

Pilot's ability and experience:

The turn toward the south had another consequence, namely that it positioned the aircraft in a more favorable situation for landing: into the wind. This fact, along with the aircraft's position with respect to the road, seems to rule out any type of incapacity involving the pilot, who had considerable experience in general and on the aircraft type. Moreover, the autopsy did not find any physical factor or condition that may have affected the pilot's capacity. The flight was controlled by the pilot until the end.

Size of the road and aircraft:

The width of the road (6 m) compared to the aircraft's wingspan (10.99 m), as well as the presence of trees and the slope on either side of the rode, provide a complex environment in which to make a landing. The damage to the left wingtip in fact shows that the aircraft, despite being lined up fairly accurately with the road, impacted the trees on the left shoulder. From the point of view of the landing run, the length of the straight segment available was clearly too short to accommodate an aircraft of those characteristics.

Therefore, the landing was highly compromised both by the width and the distance available to stop the aircraft.

Impact sequence:

The marks and the aircraft wreckage clearly lay out the following sequence:

1. The aircraft, initially level, impacted the trees with its left wing, causing a 90-cm segment of the wing to detach and the aircraft to lose control completely.
2. The aircraft continued advancing as it twisted upward to the right, reaching very high pitch and bank angles, close to 90°, as a result of which it impacted the road and guard rail with its right wing, causing a 1.8-m segment of this wing to break off.
3. The aircraft, in a highly vertical position, impacted the right side of the road with the front part of its fuselage.
4. The aircraft fell downhill, losing its engine and ending up in an inverted position.
5. Lastly, a fire broke out.

The aircraft first impacted two trees on the left shoulder of the road. The aircraft was 8.5 m above the road, meaning it was about to touch down on the road. The damage to the left wingtip indicates the aircraft was level in a normal flight position. This impact, which broke off the left wingtip, must have slowed the aircraft considerably. It also destabilized it completely.

After impacting the trees on the left side of the road, the aircraft travelled 67 m along the road until the leading edge of the right wingtip impacted the road. By this point, the aircraft must have been in an abnormal flight condition, as indicated both by the location of the damage to the right wing and by the absence of damage to the left wing, which, had the aircraft been level, would have impacted the trees on the left side since the wingspan far exceeded the road width. In fact, the aircraft must have had very high right bank and pitch up angles, both near 90°. When it impacted the road, the aircraft pivoted about the right wingtip, striking the guard rail as well. It was the contact with the guard rail that caused the hole on the leading edge of the right wing. The aircraft's motion while the right wing impacted the road and guard rail caused the deformations to both halves of the right wing, which bent until a 1.8-m long segment of it broke off.

This fragment was ejected and landed 13 m further ahead, on the right side of the road. Meanwhile, the aircraft continued with its twisting motion to the right, now off the road.

The next impact occurred 14 m away from the road and involved the front part of the fuselage (the nose) striking the ground in a position that indicated that the aircraft was highly vertical (pitch down angle close to 90º). This second impact left the propeller cone and fragments of the propeller blades buried in the ground.

The aircraft then continued to travel down the slope. The engine broke off and the aircraft ended up in an inverted position. A fire then broke out, the duration and intensity of which suggest that there was fuel in the aircraft. The calculations done, which assumed that the aircraft was refueled to capacity, indicate it would have had 127 l at the time of the accident.

The aircraft traveled a total of 97 m, practically on the same heading. Of this distance, after the impact with the road, the aircraft only traveled 30 m and descended 5 m, which indicates that its horizontal speed was not high. The small debris field and the extent of the damage in terms of deformations (not the damage produced by the fire) rule out a high-energy impact. These findings are consistent with the injuries exhibited by the three occupants, with the remaining indications suggesting the pilot attempted to make a power-off landing.

2.2. Analysis of the flight from 13:23 to 13:34

For almost three hours (10:28 to 13:23), the flight was uneventful. It was starting at 13:23, as it was about to reach its destination, when two situations occurred that would condition the subsequent progress of the flight:

- At 13:23, the pilot was informed that Reus was closed to VFR traffic, which the pilot had to deal with.
- At 13:34, the engine failed.

Between 13:23 and 13:34, almost 12 minutes, the flight continued without any problem in terms of the aircraft itself, though the change in destination underscored the deficient flight planning in terms of both the route and the weather.

Problem-free flight:

The flight between 13:23 and 13:34 did not involve any problems from the standpoint of the aircraft's operation or controllability. The radar returns showed a normal flight, with constant and uniform values of speed and altitude that were consistent for the aircraft type and with its position with respect to its imminent destination, and with coordinated turns. The instructions issued by ATC were understood and carried out immediately, and communications with ATC were smooth.

For 8 minutes, the aircraft kept a constant altitude of 4400 ft and a GS of 130 kt, before later climbing to 6400 ft at a GS of 140 kt. This final climb was executed at a constant climb rate and ground speed, which indicates that the engine was providing power normally. Until that point, the flight had been uneventful and there had been no previous communications involving the operation of the aircraft or the engine.

Several things of interest occurred during this almost 12-minute period:

- The decision to continue the flight under VFR despite having other options: change to IFR or special VFR, which would have allowed it to operate in Reus.
- The route proposed by the pilot to reach the alternate airport, which was impossible to execute.
- The deteriorating weather conditions, expected given the forecasts.

Decision to continue under VFR

The change to IMC at the Reus Airport was reported to the pilot once the aircraft was close to its destination. A few minutes later, the pilot was transferred to the controller in the Reus TWR, who was responsible for the CTR and ATZ. The weather conditions at Reus had worsened an hour earlier, and they were still bad 3 h later. When the pilot contacted this station at 13:27 after insisting on following the coastline, the visibility at Reus was 1,500 m, the cloud ceiling was at 600 ft and it was drizzling and hazy.

These were indeed VMC, and it was thus reported to the pilot, adding that the airport could not accept VFR flights. This requirement by the Reus TWR controller to leave the airspace of the CTR was made based on the fact that the CTR was class-D airspace, which requires ATC clearance to enter, and that the weather conditions were not VMC, a situation contained in the regulation.

When informed of this, the pilot, in his message at 13:27:46, seemed to ask if IFR flights were possible. When the controller asked him to repeat the question, the pilot did not and said nothing further about IFR operations.

In light of the fact that the pilot had a valid license to operate in IFR and that Reus was his initial destination, this seems to have been the most desirable option. Investigators were unable to determine the reason for not insisting in changing from VFR to IFR.

Another option would have been to request to operate under special VFR, which the pilot did not mention in this case. The weather conditions at Reus were at the limit for approving this operation (1500 m and cloud ceiling at 600 ft), but it would have been possible.

In any case, these two options for flying to Reus in IMC, either under IFR or special VFR, would have to have been requested by the pilot first and then authorized by ATC. Neither option was requested.

Route to reach the alternate airport:

At 13:32, when the pilot was informed that Reus was in IMC, the pilot had to change his initial plans. The decision he made, which he immediately reported to ATC, was that he would proceed to Sabadell, his alternate airport. While this entailed a change to his initial plans, it was a situation he had anticipated, as it was part of his pre-flight planning.

Even though his new destination was clear, the route for reaching it, judging by the communications with the pilot, was not properly planned. On three different occasions, twice with the Barcelona ACC and once with the Reus TWR, the pilot stated that his flight path would follow the coastline. This comment reflects that he knew geographically where Sabadell was with respect to Reus, but that he did not realize that it was inside the Barcelona TMA. Following the coastline was the fastest and easiest option for a VFR flight, from the point of view of obtaining visual references; however, in the case of this flight, it was not viable, since Reus and Sabadell are north and south, respectively, of the Barcelona Airport, an international airport that is surrounded by airspace where VFR operations are prohibited. As noted in section 1.18.2, VFR operations were prohibited inside Area 2 of the Barcelona TMA. Moreover, the published information for the Sabadell Airport indicated that the only VFR entry points were via the north and west, which in itself implies that entering from the south was not viable.

In other words, this route was not possible. This fact indicates that the planning that should have been carried out before starting the flight was incomplete. The pilot only identified the relative position of Sabadell with respect to Reus, and possibly the visual references along the route, but he did not consider any aspects involving the airspace and the environment where this airport is located.

In this regard, in terms of the flight planning for the alternate airport, subsequent communications with the pilot showed that once the route along the coast was ruled out, the pilot seemed to be out of options and was unfamiliar with the area in which he was flying. His only option was to resort to ATS to guide him (radar vectors) and give him solutions (find alternate airport), even though these tasks are not the responsibility of ATS.

Therefore, the planning, understood as an exhaustive study of all those aspects and conditions that could affect the safe conduct of a flight of these characteristics, is deemed to have been less complete than it should have been. The weather aspects present in this accident, analyzed below, also reflect this deficient flight planning.

<u>Deterioration of the weather conditions forecast before the flight:</u>

The weather forecasts for the en-route part of the flight (SIGMET) and for the arrival at the destination airport (TAFOR) were available two and five hours before the start of the flight. These reports indicated worsening weather conditions, both for the final part of the en-route segment (mountain obscuration, visibility between 1000 and 5000 m, showers and storms with embedded cumulonimbus clouds) and for the arrival in Reus (decreased visibility to 3000 and 2000 m, cloud ceiling between 800 and 3000 ft, increased cloud cover, haze, rain, showers, storms and cumulonimbus).

In other words, the information issued before the flight and available for consultation before takeoff, called for conditions that would very likely make it impossible to complete the flight in VMC. This forecast in effect came to pass due to the arrival of a front in the area, with reduced visibility, precipitation and clouds covering mountain summits.

It is not known what weather information the pilot used to plan the flight, since there are numerous online applications that provide access to this information. All that is known is that the pilot did not request weather information from the weather office in Cascais.

The only information that indicated VMC for Reus prior to the departure from Cascais was the METAR for the Reus Airport. Even though VMC did not exist early in the morning, they had improved just before takeoff, although they would worsen again during the flight. In any case, the METAR information for an airport is not a proper source of information for flight planning, since METARs provide current observations, not forecasts, which must be checked using TAFORs and SIGMETs.

2.3. Analysis of the flight from 13:34 to 13:40

After the change in plans involving the destination airport, the aircraft continued flying for 12 min without any problems. At 13:34:59, while stabilized in a constant, steady climb it had started 3 min earlier, the pilot first reported having engine problems.

This situation conditioned the rest of the flight. The flight profile changed at this point, with the aircraft commencing a descent that would last for the 5 min remaining in the flight.

The management of this new situation was characterized, on the one hand, by the proper handling of the aircraft, and on the other, by the pilot's dependence on the controller to look for an airfield in which to make an emergency landing.

Flight management:

The communications indicate that for 2 min, the problem with the engine worsened, eventually resulting in a complete loss of power. The energy of the impact was consistent with this situation, so it is likely that the engine was either completely stopped or at low power.

From the start, the pilot evaluated the situation, his options and capacities realistically and quickly: he reported the need to descend and the impossibility of reaching Reus due to the distance, which was more than twice the best glide distance away.

The first minute of flight after the initial notification saw the highest loss of altitude, reaching a maximum descent rate of -2500 fpm. This could have been because, during the initial moments of the emergency, the pilot was focused on identifying the problem and its progression.

After this first minute, the aircraft's descent rate was reduced to -1000 fpm, where it was maintained. The aircraft stabilized and minimized the loss of altitude. Over the entire glide, the aircraft was able to travel a total of 9.5 NM, a figure that is quite close to the 11 NM that, in theory and under ideal conditions, the Flight Manual lists as the best glide distance from 5600 ft.

The drop in the descent rate from around -1000 fpm to close to -300 fpm coincided with the messages about the road. The descent rate was lower still during the last minute of flight, when the value was calculated to be -100 fpm. This drop in the descent rate, the turn and the drop in speed in the final radar returns are thought to have been associated with the pilot's search for a section of road on which to land, which reinforces the conclusion that the flight was controlled until the impact and that the pilot's capacity was not diminished.

Finally, as concerns the speeds while managing the loss of power, the radar returns show considerable variability, with swings between 80 and 140 kt. These values are for ground speed, not indicated airspeed. The wind can be highly variable in mountainous terrain like the one where the flight was taking place, and so the estimates provided by AEMET (average speed of 10 km/h, gusting up to 40 km/h) were not considered accurate enough to calculate the indicated airspeed during the maneuvers. The 75-kt speed specified for a power-off landing could not be confirmed either due to the lack of radar data during the final minute of the flight. What was evident was a drop in GS to 90 kt when the pilot changed course to line up with the road.

In summary, during the 5 min that the aircraft was flown without power, the pilot handled the flight well and the aircraft was able to travel a distance that was close to the best glide distance. During this time, the pilot was able to identify, approach and adapt the aircraft's position and speed to a straight section of the road.

Reliance on ATC:

In keeping with his behavior during the previous 12 minutes of the flight, the pilot resorted to the controller, who was already giving him radar vectors to Sabadell, to find an airfield in which to land. The Barcelona ACC controller provided all the help he could to the pilot, both before and during this latest emergency.

Although looking for airfields is not part of ATC's tasks, the controller asked at the station in order to find alternate runways in an effort to aid the pilot. The reality was that the nearest airfield was in fact Reus, which was further away than the aircraft's best glide distance.

The area was very mountainous and did not offer many options for an off-field landing. The last option was the one suggested by the controller to land on a road. Due to the location, there were only secondary roads in the area, which were too narrow to accommodate an aircraft with an 11-m wingspan. The highway, which is wider, suggested by the controller was further away than Reus.

2.4. Analysis of the engine failure at 13:34:45

When the pilot reported having engine problems, he had been climbing for 3 min. The aircraft's speed and operating conditions had been normal and constant, so the engine should have been functioning correctly until that time. The maximum altitude reached during this climb was 6400 ft at 13:34:45. When the pilot sent the first message about the engine, at 13:34:59, the aircraft was at 6200 ft, meaning it had lost 200 ft. By that point, the engine would have already been behaving erratically and been unable to keep the aircraft climbing or even in level flight. As a result, the time of the engine failure was set at 13:34:45, when the descent began.

The information provided in the messages involving the engine problem were as follows: "trouble with the engine", "smoke from the cowling", "loss of engine power", "no engine power", "totally loss of power". This seems to indicate that the engine degraded until it stopped entirely.

An inspection of the engine revealed a complete fracture of the nozzle distribution line to the #3 cylinder where it joins the fuel manifold valve. This fracture is considered to have been the source of the loss of engine power.

<u>Nozzle distribution line as the source of the loss of power:</u>

The purpose of the fuel manifold valve, which is cylindrical in shape, is to receive fuel under pressure from the fuel pump and distribute it to the six nozzle distribution lines. Each of these lines, located around the valve's perimeter, is slotted within the body of the valve and directs the fuel, under pressure, to each of the injectors, located in the heads of the cylinders. In other words, this system has a direct effect on the combustion process, and therefore on engine power.

Since the fuel manifold acts as one assembly, the fracture of any of the lines affects not only that line, but all the others. The fuel is routed through the fractured line, since it will be easier for the fuel to exit there as it encounters less restrictions than at the injector orifices. In other words, the fuel will take the path of least resistance, which in this case is the broken line. Also, since the amount of fuel in the manifold is limited, the amount of fuel available for the remaining five lines will be greatly decreased.

Therefore, the break in the #3 distribution line would have resulted in a loss of power not only in the #3 cylinder, which was not receiving fuel, but in the other cylinders as well.

Moreover, the fact that fuel under pressure was exiting one of the lines to the outside would have placed this fuel in contact with the hot surfaces on the engine, which would undoubtedly have generated the smoke described by the pilot.

As a result, the damage found in the fuel manifold valve-nozzle distribution line assembly is consistent with the engine problems described by the pilot during the emergency.

<u>Cause of the fracture of nozzle distribution line #3:</u>

As explained in section 1.16.3, the nozzle distribution line consists of a tube, to both ends of which is welded another part called the head. The fracture was at one of these ends, where the tube is joined to the head.

The fracture was determined to have been caused by a gradual fatigue process that unfolded over a large number of cycles at low stress from the inside of the part to the outside. The preferential incubation sites coincided with the area with the changing cross section, which exhibited signs of plastic deformation and material tearing before the fracture. The development and incubation of the fatigue process had resulted from the simultaneous presence of:

- Excessively reduced wall thickness in the changing cross section. The slightly off-centered machining of the inner surface caused noticeable differences in the wall thickness, which was 0.18 mm in the starting area, and almost twice that at the other end.
- Discrepancies in the weld between the tube and the head: the lack of filler material in the area of changing cross section and the presence of microfolds on the inner surface of the part are elements that would have led to a build-up of stress.

Moreover, during operation, this element is subject to cyclic stresses, whether produced by engine vibrations and/or by changes in fuel pressure. This is in addition to potential stress applied to the tube by being forced into place, all of which could have contributed to its fracture. Its condition after the accident was such that this could not be confirmed to have been a contributing factor.

The defects in the weld between the head and tube were identified at both ends of the tube, and must have occurred during the manufacturing process. Maintenance activities involving these lines consist of replacing the element completely if a fuel leak or some other problem is identified. This means that the element is not subject to any repairs. As a result, a safety recommendation is issued to Continental, as the engine manufacturer, to have it review its procedure for manufacturing the nozzle distribution lines, and specifically the process of welding the tube and the head, so as to identify and correct the source of the manufacturing defects that have been identified in this investigation.

Problems in the nozzle distribution lines in the fuel manifold valve are identified through periodic inspections of other elements in the fuel system, or when the fuel system malfunctions. The fuel system as a whole had been overhauled 50 h earlier, and a leak check had been performed as per SB95-7 21 h earlier. Neither of these inspections identified any signs of the problem that would occur during the accident flight.

3. CONCLUSIONS

3.1. Findings

General:

- The aircraft and pilot had the licenses, certificates and clearances required for the flight.
- The aircraft had 2331 flight hours.
- The engine had 50 h since its last overhaul.
- The aircraft's certificate of airworthiness had been renewed a month earlier and it had flown 21 h since.
- The pilot had considerable flying experience and on the aircraft type as well.
- The full flight lasted 3 h 12 min, of which ATC recorded 3 h 11 min.
- The impact is estimated to have occurred between 13:40:07 and 13:40:20.
- The flight was controlled until the impact.
- There are no signs that the pilot's capacity was diminished during the flight.
- Fuel was not a significant factor in the accident.

On the emergency landing:

- The pilot probably attempted to land on road T2237.
- The pilot had visual contact with the ground during the last minute and a half.
- The pilot identified a straight section of road T2237 and accurately positioned the aircraft over it.
- The approach to the road was made with a headwind.
- The road was 6 m wide, which is narrower than the aircraft's wingspan (10.99 m).

On the impact sequence:

- The landing was attempted on a southwesterly heading that followed the direction of road T2237.
- The first impact occurred when the aircraft's left wing struck the trees on the left side of road T2237, which caused a 90-cm segment of the wing to break off.
- After this initial impact, the aircraft destabilized completely.
- The second impact, 67 m after the first, occurred when the leading edge of the right wingtip struck the road and the guard rail, which caused a 1.8-m segment of the right wing to break off.
- The third impact, 14 m after the second, occurred when the front part of the fuselage struck the ground, off the road, on the right shoulder.
- The aircraft then traveled 16 m downhill, during which the engine broke off and the airplane ended up in an inverted position.
- The aircraft caught fire after the accident.
- A high-energy impact is ruled out.

- The debris field was 97 m long, 67 m on the road and 30 m off the road, on the slope on the right side of the road.

On the flight from 10:28 to 13:23:

- The aircraft took off from Cascais (Portugal) at 10:28.
- The flight was uneventful, with no major changes, from takeoff until 13:23.

On the flight from 13:23 to 13:34:

- At 13:23, the pilot was informed that Reus Airport was closed to VFR traffic.
- The deteriorating weather conditions in the area had been included in the SIGMET and TAFOR LERS forecasts.
- The pilot decided to proceed to the alternate airport, Sabadell.
- For 12 minutes (from 13:23 to 13:34), the flight was uneventful from the standpoint of the aircraft's operation and controllability.
- The route proposed by the pilot to the alternate airport was not possible due to the characteristics of the airspace the aircraft would have had to cross.
- The pilot asked ATC for vectors to Sabadell.

On the flight from 13:34 to 13:40:

- At 13:34:59, the pilot first reported engine problems.
- He sent a total of four messages over two minutes, each one notifying of the worsening situation until he reported a complete loss of power.
- The emergency was reported when the aircraft was 5600 ft AGL.
- The aircraft continue to fly without power for 5 min.
- The aircraft traveled 9.5 NM, which is very close to the best glide distance specified in the Flight Manual under ideal conditions.
- During the final 5 min of the flight, the pilot properly handled the descent.
- The pilot assessed the situation adequately and correctly evaluated the options available.
- The pilot resorted to ATC to look for an alternate airfield.
- The location where the engine failure occurred and the aircraft's glide capacity did not allow flying to any aerodrome or airport.
- Every road in the vicinity of the aircraft was in the mountains and narrower than the aircraft's wingspan.

On the cause of the engine failure at 13:34:45:

- The engine failure occurred at 13:34:45, after a sustained 3-minute climb.
- By 13:45:59, the aircraft had initiated the climb, indicative that the engine was already failing.

- The symptoms reported by the pilot were problems with the engine, smoke and complete loss of power.
- The nozzle distribution line between the fuel manifold valve and the #3 cylinder was found to have fractured where it attaches to the valve.
- The fracture was caused by fatigue, which had started in the area where the tube and head are welded and which exhibited defects.
- The following defects were identified in the weld: lack of filler, microfolds on the surface, misalignment between the head and tube, and different thicknesses.
- Maintenance on the nozzle distribution lines is "as required", and they are replaced during periodic engine inspections or when problems are identified involving the fuel system.
- The fuel system had been satisfactorily checked 50 h and 21 h before the accident (overhaul and implementation of SB95-7).
- There is no record of any problems prior to the fracture of the distribution line.

3.2. Causes/Contributing factors

The accident of aircraft D-ETFT was caused by destabilization and loss of control while attempting an emergency landing on a mountain road that was narrower that the aircraft's wingspan. The following contributed to the accident:

- The loss of engine power, which forced the emergency landing and which was caused by the complete fracture of the nozzle distribution line to the #3 cylinder on the fuel manifold valve.
- Deficient flight planning in terms of analyzing the weather and the area of the flight, which caused the aircraft to prolong its flight and fly away from the destination airport and into a mountainous area where the engine failure occurred.

4. SAFETY RECOMMENDATIONS

The investigation identified defects in the tube-head weld in the #3 nozzle distribution line on the fuel manifold valve. The defects resulted in a fatigue process and eventual fracturing, which caused the engine to lose power.

REC 04/20. It is recommended that Continental Motors, as the manufacturer of the TSIO-360-MB engine, review the procedure used to weld the tube and head of the nozzle distribution lines in the fuel manifold valve in order to identify and correct the source of the following defects:

- Differences in wall thickness along the area of changing cross section. The slightly off-centered machining of the inner surface caused appreciable differences in wall thickness, which was 0.18 mm in the starting area and almost double that at the opposite end.
- Discrepancies in the weld between the tube and the head: lack of filler material in the area of changing cross section and presence of microfolds on the inner surface of the part.