CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Report A-037/2015

Accident involving a SOCATA TB-9 aircraft, registration EC-LIQ, in the municipality of Ronda (Malaga) on 24 December 2015

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

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SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

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Foreword

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

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) 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.

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Abbreviations

AESA	National Aviation Safety Agency
AEMET	National Weather Agency
AKI	Anti-knock index
ATC	Air Traffic Control
ºC	Degree centigrade
CLH	Compañía Logística de Hidrocarburos, S.A.
FAA	Federal Aviation Administration (United States)
ft	Feet
ft/min	Feet per minute
h	Hours
HP	Horsepower
hPa	Hectopascals
Hr	Hours
IC	Instruction Letter
kg	Kilograms
KIAS	Indicated airspeed in knots
km	Kilometers
km/h	Kilometers per hour
Kt	Knots
l	Liters
l/h	Liters per hour
m	Meters
MHz	Megahertz
m/min	Meters per minute
min	Minutes
m/s	Meters per second
PPL (A)	Private pilot license (airplane)
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
rpm	Revolutions per minute
SI	Service instruction
VFR	Visual flight rules

Synopsis

Owner and operator:	Private
Aircraft:	SOCATA TB-9, registration EC-LIQ
Date and time of accident:	Thursday, 24 December 2015 at 11:18 local time
Site of accident:	Municipality of Ronda (Malaga)
Persons onboard:	1 passenger, killed
	1 crew, killed
Type of flight:	General aviation - private
Phase of flight:	En route - cruise
Date of approval:	29 March 2016

Summary of the accident

On Thursday, 24 December 2015, a Socata TB-9 aircraft, registration EC-LIQ, took off from the Tomás Fernández Espada aerodrome in Villamartin (Cadiz) at approximately 11:00 with a pilot and one passenger onboard, to go on a local private flight to the city of Ronda (Malaga) and back to the aerodrome.

A little over fifteen minutes into the flight, the aircraft suffered an accident as it was flying over a field with oak trees and cattle near Monte Sauco, within the township of Ronda.

The aircraft was destroyed by the impact and subsequent fire. The pilot and passenger were killed.

The investigation has determined that the aircraft's engine was stopped at the time of the accident, and ruled out an engine stoppage for mechanical reasons. The most likely reason for the engine stopping was determined to involve the use of a fuel type not authorized by the manufacturer, aggravated by the fact that there was very little fuel onboard and by the execution of an aggressive maneuver that could have prevented fuel from reaching the engine.

The engine's deficient maintenance status and the fact that the flight was carried out at altitudes above the ground that were below those required contributed to the accident.

This report does not contain any safety recommendations.

[1] All times in this report are local.

1. FACTUAL INFORMATION

1.1. History of the flight

On Thursday, 24 December 2015, a Socata TB-9 aircraft, registration EC-LIQ, took off from the Tomás Fernández Espada aerodrome in Villamartin (Cadiz) at approximately 11:00 with a pilot and one passenger onboard to go on a local private flight.

On the day of the accident the pilot, who was also the aircraft's owner, was flying with a relative as a passenger and both had commented their intentions to their family and to people at the aerodrome. These intentions included flying to Ronda by way of Zahara de la Sierra (Cadiz) and returning to Villamartin. The pilot was very familiar with the route and he flew it quite frequently. On the Socata TB-9, the flight lasted about 45 minutes. They then planned to drive back to Ronda (where the pilot lived) at the conclusion of the flight.

During the flight from Villamartin to Ronda, the Grazalema mountains were to their right. They flew directly from Villamartin to Zahara de la Sierra (heading 098°, a distance of about 23 km), and then proceeded straight to Ronda (heading 109°, a distance of about 22 km).

A little over fifteen minutes into the flight, the aircraft suffered an accident as it was flying over a field with oaks and cattle near Monte Sauco, within the city limits of Ronda. The crash site is practically along a straight line between Zahara de al Sierra and Ronda, a little over 13 km from the former and almost 9 km away from the latter.

Figure 1. Flight path and accident site

The aircraft was destroyed by the impact and subsequent fire, and the pilot and passenger were killed.

There were no eyewitnesses to the accident, nor were any emergency reports from the aircraft heard on the radio frequency. There were eyewitnesses at the departure aerodrome and in the town of Zahara de la Sierra (who saw the aircraft fly over very low and slow). There was also a hunter who saw the aircraft fly near him very low shortly before it crashed.

Over the course of the 24th, as calls to the aircraft's occupants went unanswered and the aircraft failed to return to the aerodrome, search efforts were commenced. The aircraft was found on the next day, 25 December 2015, at 18:00.

Figure 2. Aircraft EC-LIQ after the accident

1.2. Injuries to persons

Injuries	Crew	Passengers	Total	Others
Fatal	1	1	2	
Serious				
Minor				
None				
TOTAL	1	1	2	

1.3. Damage to aircraft

The aircraft's right wing impacted the trunk of a large oak, and the aircraft's nose struck one of the branches, which was also of considerable size. Both the right wing and the assembly consisting of the two blades and the propeller cone detached from the aircraft.

The aircraft was destroyed by the impact and by fire that broke out afterward.

1.4. Other damage

There was minor damage to the oak tree impacted by the aircraft. When the aircraft caught fire, it burned part of the ground where the main wreckage was located, though the fire did not spread beyond the wreckage, meaning that only the sparse vegetation on the ground burned.

1.5. Personnel information

The 48-year old pilot had a private pilot license (PPL(A)) issued by Spain's National Aviation Safety Agency (AESA) on 4 March 1998. His single-engine land rating was valid until 31 March 2016. His class-2 medical certificate was valid until 20 March 2016, and he had a total of 98 flight hours, of which 46 had been on the type.

The last flight recorded in the pilot's flight log had been on 24 October 2015. It had been a local flight lasting one hour, departing from and landing at the Villamartin aerodrome, flown using the accident aircraft.

In 2015 he had flown nine times (not including the accident flight, which was the tenth), all of them using the accident aircraft, totaling 7 hours and 50 minutes of flight time. Of these flights, only those made on 1, 6 and 7 January 2015 were recorded in the airplane's log book. The last of these flights had been a local flight from the Villamartin airfield lasting 1 hour and 20 minutes. This flight was not recorded in the pilot's flight log, however. The next flight in his log took place on 3 April 2015. The pilot flew sporadically around once every month or month and a half, though some flights were made more than three months apart. The remaining flights made after 7 January are not recorded either in the aircraft log book or in the engine log book.

1.6. Aircraft information

The Socata TB-9 is a single-engine, low-wing aircraft with a dry weight of 668 kg and a maximum takeoff weight of 1,062 kg. It can hold four occupants. It has a 9.89-m wings-

pan. This aircraft was manufactured in 1980 and had serial number 141. It was registered in Spain on 24 January 2011 by the National Aviation Safety Agency. It had a Lycoming O-320-D2A flat-four engine, serial number RL-19398-39A, capable of supplying 160 HP at 2700 rpm. It also had a two-blade, fixed-pitch[2], 88-m diameter Sensenich 74.DM6. S8.0061 propeller, serial number A51993.

According to the Aircraft Flight Manual, each fuel tank (one in each wing) can hold 79 l of fuel, making for a total capacity of 158 l, 6 of which are not usable.

The engine rating plate states that the fuel to be used should be AVGAS 91/96 octane. The last entry in the aircraft log book was from 7 January 2015, with 2620:11 hours on the fuselage. The last entry in the engine log book was from the same date, with 430:05 engine operating hours.

The aircraft had a Certificate of Airworthiness issued by the National Aviation Safety Agency that was valid until 23 February 2015.

The aircraft documentation that investigators were able to access and examine did not include a weight and balance certificate or an insurance contract.

According to its last return to service certificate, the last maintenance check of the aircraft was on 19 February 2014. This check, performed as per Maintenance Program Ed. 0, Rev. 0 of October 2010, approved by AESA, involved a 50-hour and a 100-hour/annual check that were done with 2601:08 flight hours on the aircraft. The aircraft log book, however, showed that these flight hours were the same as the ones recorded for a flight that took place on 5 January 2013, departing from and landing at the Cordoba Airport. According to the same aircraft log book, the aircraft was not flown from the Cordoba Airport to the aerodrome in Casarrubios (Toledo), where the maintenance organization that conducted this last check has its base, until 14 February 2014.

This check involved 47 items, 13 of them of a general nature, such as a review of the aircraft and engine log books to carry out corrective maintenance, and to check for compliance with directives and service bulletins. The remaining items included checks of the cockpit, fuselage, landing gear, wings, engine, stabilizers, signs, engine rotables, airframe, air conditioning, electrical generator and instrument panel. Also checked were items ATA 12-10 PTO 1, ATA 25-60 PTOs 1 and 3, ATA 74-10 PTO 5, ATA 28-20 PTO 4, ATA 34-10 PTO 4, ATA 37-00 PTO 1 and ATA 71-60 PTO 4. The engine also underwent a special inspection as per IC 35-03B.

All of the post-inspection ground tests were satisfactory.

[2] When it is installed, the propeller's pitch is left at a setting that is optimized for cruise conditions, to the detriment of the small pitches that would boost climb performance.

This maintenance work was carried out by SINMA AVIACIÓN, S.L., an AESA-approved center, reference ES-145-113.

Between the last documented inspection (February 2014) and the accident date, the aircraft had flown under 50 hours, but a year had elapsed as of February 2015, meaning at least a 100-hr/annual inspection should have been performed, of which there is no record.

Section 1.18 Additional information, provides information on the aircraft performance taken from its Flight Manual.

1.7. Meteorological information

The information provided by Spain's National Weather Agency (AEMET) regarding the weather conditions at the Villamartin aerodrome for the time when the aircraft took off, and at the crash site when the accident occurred are:

At the Villamartin aerodrome, at around 11:00 and based on data for the Jerez de la Frontera Airport (Cadiz), located about 20 km southwest, as well as on satellite and radar images and adverse phenomena warnings, the most likely weather was:

- Wind: swirling from around 180º, very light, at around 4 km/h, or calm, and gusting to 6 km/h
- Visibility: good on the surface
- Clouds: few clouds or clear
- Temperature: 13º C
- QNH: 1030 hPa
- Relative humidity: 80%
- No precipitation or adverse phenomena warnings

At the crash site, at around 11:15 and based on data from an automated station in Grazalema (Cadiz), located about 12 km southwest, as well as on satellite and radar images and adverse phenomena warnings, the most likely weather was:

- Wind: very light from the east, at around 4 km/h and gusting to 8 km/h
- Visibility: good on the surface
- Clouds: few clouds or clear

- Temperature: 8 C

- QNH: 1026 hPa

- Relative humidity: 80%

- No precipitation or adverse phenomena warnings

Eyewitnesses also provided very detailed weather information for the various areas through which the aircraft flew for the times when the aircraft was in those areas.

a) At the aerodrome, eyewitnesses stated that the wind was very light, almost calm, visibility was unlimited and there were no clouds.

b) An eyewitness in Zahara de la Sierra stated that from his location, he was able to see the Zahara reservoir, the surface of which had frothy waves that indicated the wind was from the west (which would be a tailwind for the aircraft).

   The Beaufort scale was checked to determine the wind speed based on the wind's effect on the surface of the water, which resulted in a force 4 wind, meaning a speed of 11-15 kt (20-29 km/h): moderate breeze that generates small waves with frequent whitecaps.

c) Beyond the Zahara reservoir and the town of Montecorto (Malaga), in the direction of flight, there is a gas station where eyewitnesses stated that the flags atop masts outside the station indicated a wind from the west of "certain intensity", as the flags were visibly waving.

An expert glider who is familiar with the area and who had been flying for twenty-five years in the valley gave the following statement:

The easterly winds from the Mediterranean have little effect in the accident site, since they have to pass over the summits of the nearby Ronda mountains, which act as a natural barrier for these winds, drastically decreasing their speed and creating a wide variety of meteorological effects, most notably the strong updrafts over a wide area where easterly and westerly winds meet, or the formation of a large rotor zone (downwind) when the wind from the east is sufficiently strong.

Looking from east to west, the accident site is at the end of a valley formed by the Grazalema mountains and the start of the Ronda mountains, south the former and southeast the latter, and by the Gastor mountains and Malaver Mountain (Montecorto) to the north. At the center of this valley is the Zahara de la Sierra reservoir.

Seen from west to east, winds from the west enter the accident site via the El Bosque and Grazalema mountains to the right (south), and the Lijar, Gastor and Montecorto mountains to the left (north), creating a narrow passage in the area of the Zahara de la Sierra reservoir (located in the middle) that can significantly increase the wind's original speed before channeling it. The resulting wind is from the west, meaning it would have been a tailwind for the aircraft.

This highly peculiar effect in the area means that on most days at the Ronda mountains, when a moderate wind coming from the east meets a wind from the west that has already been channeled in the valley, large updrafts are created that are used by gliders in the area.

1.8. Aids to navigation

The flight was being conducted under visual flight rules and was not under the control of any ATC station.

1.9. Communications

The aircraft was not in radio contact with any station or with any other aircraft at the time of the accident.

1.10. Aerodrome information

The Tomás Fernández Espada aerodrome in Villamartin (Cadiz) is at an elevation of 328 ft (100 m). It has one 560x15 m asphalt runway in a 06/24 orientation. The aerodrome is 1.5 km north of the town of Villamartin.

The accident aircraft had been based at this aerodrome since March 2014, and had taken off from there on the day of the accident.

The aerodrome is used by ultralights and gliders. The only airplane based at the aerodrome was the accident airplane (EC-LIQ).

The aerodrome does not have refueling services.

1.11. Flight recorders

The aircraft did not have flight recorders or any other device for recording flight data, nor were such devices required for this aircraft type.

1.12. Wreckage and impact information

The aerial image below shows the aircraft's flight path before it impacted the tree, as well as the location of the wreckage.

The aircraft approached the impact site on an upward flight path from the valley that was practically perpendicular to the valley wall (arrow 1 in the figure below), which it cleared by a very narrow margin (as further explained below, this was determined by the marks left in the vegetation). From there the aircraft continued flying without touching the ground, but only a mere 1-2 m above it (arrow 2), before impacting the tree.

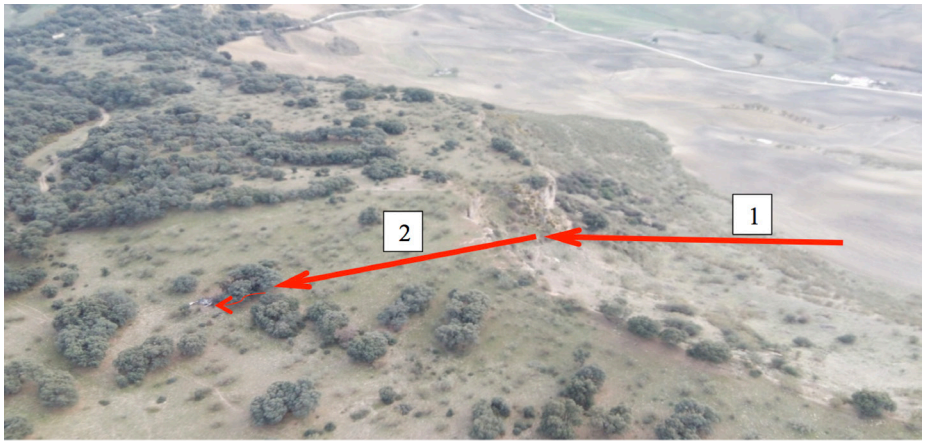

Figure 3. Final flight path and impact of the aircraft

The valley wall is separated from the tree by 97 m, along 80 m of which investigators noticed that the branches of plants had been cut by the aircraft flying 1-2 m above the ground along an area of the same width as the aircraft's wingspan, that is, some 10 m. The aircraft did not leave any marks on the ground during this portion of its flight before it impacted the tree. The ground between the valley wall and the tree that the aircraft impacted slopes downward at about 7%. This means that after clearing the valley wall, the aircraft flew in a downward trajectory.

The aircraft impacted the tree while banking to the right, which caused the right wing to strike the trunk and the front part of the aircraft to strike a large branch. The impact caused the right wing and the propeller and its cone to detach.

The damage evident on the propeller blades indicated that it was windmilling at the time of the impact.

After the impact, the aircraft traveled 15 meters forward and yawed approximately 90° to the right, stopping in an upright position.

A fire then broke out that charred the main wreckage and both occupants. The fire went out by itself and its effects were practically limited to the area occupied by the aircraft, not spreading to the surrounding vegetation.

Most of the wreckage was confined to an area very close to the impact site. Only a few fragments were ejected forward in the direction of motion.

The wristwatch of one of the occupants had stopped, indicating a time of 11:18.

The figure below shows the aircraft's final flight path from another vantage point.

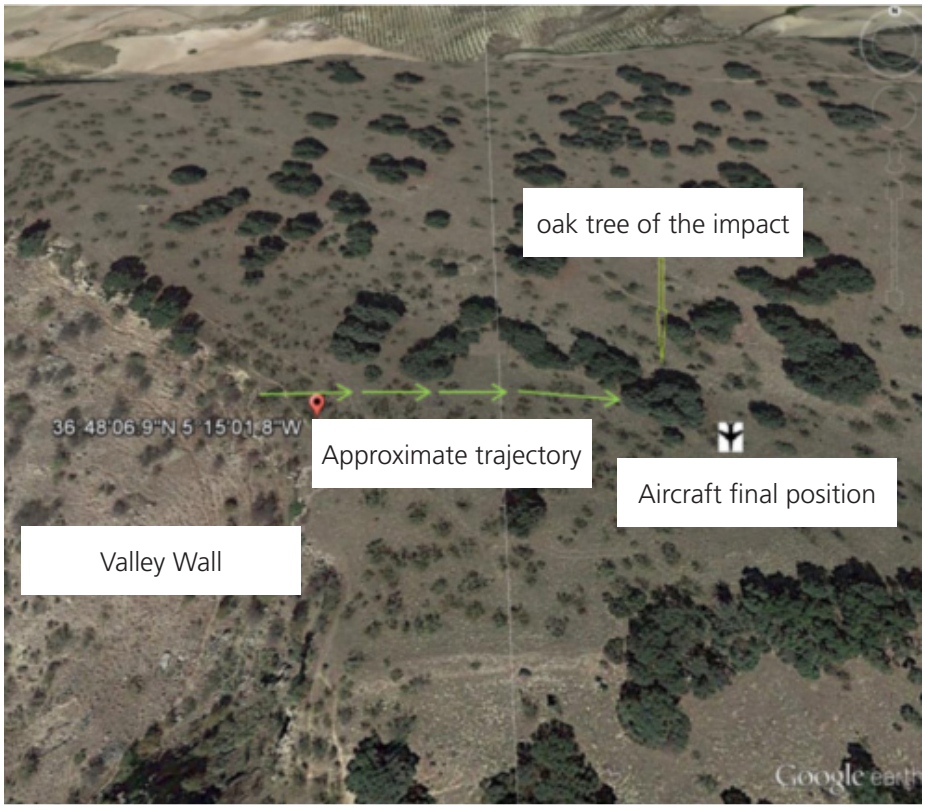

Figure 4. Final flight path and impact of the aircraft

The crash site was along a path on a direct heading from the Zahara reservoir to Ronda. To reach the crash site, the aircraft had to climb steadily since it had been flying low. To the right of the flight path, before reaching the valley wall, is a field where an emergency landing could be attempted if necessary. After clearing the valley wall, however, the area at the summit is full of oaks and shrubs and is not suited to making a safe emergency landing.

1.13. Medical and pathological information

The two people onboard perished after the impact due to trauma and to the ensuing fire.

1.14. Fire

A fire broke out after the impact that went out by itself without affecting much of the surrounding vegetation. The fire charred the main wreckage and its two occupants.

1.15. Survival aspects

The impact against the tree caused fatal injuries to both occupants.

1.16. Tests and research

1.16.1. Eyewitness statements

1.16.1.1. Statement from the owner of the Villamartin aerodrome

The accident aircraft had been based at the Villamartin aerodrome since March 2014. It was the only airplane operating at the airport, with all other aircraft being ultralights and gliders. That is why its operations were not recorded in the airfield's flight log (unlike ultralight and glider flights).

He was unfamiliar with the aircraft's maintenance and with how it was refueled (the aerodrome does not offer refueling services), though it was well known to everyone at the aerodrome that the pilot would take containers filled with automotive fuel (95-octane unleaded gasoline) to refuel the airplane. In fact, on the day of the accident the pilot took a 20-liter container full of automotive gas to refuel the aircraft (this was confirmed by other eyewitnesses who saw him). He did not know if the aircraft's engine was able to use that kind of fuel.

He also stated that the pilot used to fly once a month or so on short flights. He said that he used to fly by himself without a heavy fuel load, since the runway was to rather short for this type of aircraft. Even though, the aircraft still needed the entire length of the runway to take off (this was also confirmed by other eyewitnesses). He added that he was aware of the pilot's intention to fly with a relative (who was not known at the aerodrome) to Ronda, fly over (or near) a house known to them and return to the aerodrome.

They took off at around 11:00, and since they had not returned by lunch time, he thought something had happened.

1.16.1.2. Statement from an eyewitness in Zahara de la Sierra

This eyewitness was on the balcony of a home when he saw the airplane fly from the left to right across his line of sight at his same elevation some 60-70 m away.

He noted his great surprise at seeing an aircraft of that size flying over the town at the same altitude as his balcony, there being structures in the surrounding area that were above the aircraft's altitude. In fact, at first he thought it might have been a radio controlled scale model, but he was quickly able to make out the persons onboard given their proximity to him, and he concluded it was a manned aircraft.

The engine was not making much noise and they were flying toward the reservoir in the direction of Ronda.

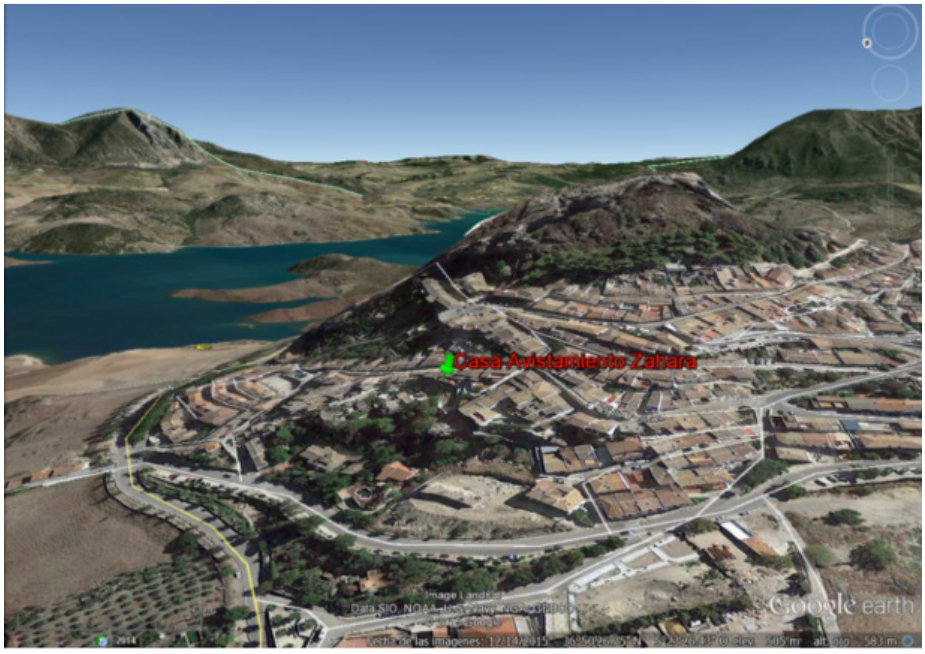

Figure 5. Location of the eyewitness

The eyewitness also stated that he was a weather buff and for that day, a weather application on his cell phone was reporting 11 km/h winds in Zahara. He clearly recalled checking the surface of the reservoir, the small whitecaps on which indicated the wind was from the west (toward Ronda) and, he thought, faster than the speed shown on this phone.

The elevation of the location from which he saw the airplane is approximately 510 m above sea level (which would also have been the aircraft's altitude). That location is approximately 23.2 km away from the aerodrome of departure and 13.5 km away from the crash site.

1.16.1.3. Statement from an eyewitness near Montecorto

Investigators were able to contact an eyewitness who was on a mountain close to the aircraft's flight path after it left behind the reservoir and Montecorto, en route to Ronda.

According to his statement, he saw the aircraft at 11:15. He had checked his watch earlier and was certain of the time. He also stated that the aircraft was flying very low (50 m above the ground, though he could not be certain). The engine sounded normal and he thought the aircraft was climbing, since the tail seemed to be lower than the nose. The wings were level and the airplane was not moving erratically.

He was surprised to see the aircraft so close.

This eyewitness was approximately 10.75 km away from the previous eyewitness. The airplane was flying over terrain that was at an elevation of 545 m.

This eyewitness was about 2.75 km away from the crash site. The elevation of the ground at the crash site was 878 m (the valley wall rises to an elevation of 885 m).

1.16.1.4. Statement from someone familiar with winds in the area

This person was not there the day of the accident, but he was an expert in the topography and winds in the area since he had been gliding (and doing powered flights) in the area for twenty-five years. The area is perfect for gliding and has hosted numerous regional, national and world free-flight championships.

His most relevant contribution is provided in Section 1.7, Meteorological information, which notes that the most likely wind situation in the entire valley from the reservoir to the accident site was a wind from the west (tailwind for the airplane) at around 25 km/h (13-14 kt), at least.

1.16.1.5. Statement from a pilot who knew the accident pilot

Investigators contacted the pilot of an aircraft similar to the accident aircraft who had spoken on several occasions to the accident pilot (owner of aircraft EC-LIQ).

This eyewitness stated that some time ago at the Villamartin aerodrome, he saw the accident pilot refuel aircraft EC-LIQ using automotive fuel in a bottle, which surprised him. He asked the accident pilot if that fuel type was approved by the manufacturer for that aircraft, and the accident pilot replied that he had been using that fuel type for a while and had never had any problems, plus it was very convenient because in the vicinity of the aerodrome it

was easy to find automotive fuel, but not airplane fuel. They discussed how automotive fuel could potentially harm the engine, but the owner of EC-LIQ was unswayed in his opinion.

On another occasion, the pilot and owner of EC-LIQ told him that the runway at Villamartin was very short and that he was just able to take off from it, which is why he took off with very little fuel onboard (plus he normally flew unaccompanied). The eyewitness replied that he would not fly that aircraft out of that aerodrome since the runway did not offer the conditions needed to do so safely.

1.16.2. Inspection of the engine

The engine of the accident aircraft was taken to a National Police facility in Ronda after the accident where it was preserved. After obtaining permission from the judge overseeing the case, the engine and its components were inspected.

Before disassembling it, the right side of the engine (as seen from the cockpit) was noted to be more heavily damaged.

The right magneto was detached from the assembly and was completely charred. The left one remained in its normal position, attached to the engine, but it was also charred.

The fuel pump was charred.

The carburetor was charred but continuity was confirmed in the throttle control up to the butterfly valve. The screws in the carburetor body were loose[3] (if this happens and is detected during maintenance, the mechanic must not tighten them; he must instead remove the carburetor and send it to the manufacturer for tightening, or air could enter that way, causing the engine to misfire). The gasket was in good condition, indicating that the screws had not become loose due to wear of the gasket.

The intake air filter was in place and correctly installed.

The carburetor was disassembled and verified to have no problems beyond the loose screws, which were indicative of improper maintenance.

The screw that regulates the mixture control was in place but its associated cable was broken and displaced, though this was determined to have been caused by the impact.

The oil radiator did not exhibit any problems.

[3] Sometimes screws will become loose in a fire; however, the inspecting mechanic, who was an expert on this type of engine, was of the opinion that many of the screws were not at the proper torque prior to the accident.

The gaskets on the intake manifold were very old and cracked, indicative of faulty maintenance, though they did not show obvious signs of seeping.

All of the exhaust valves had a whitish color. This usually happens when the engine is run lean or when unleaded gasoline is used.

In general, the screws located in hard to reach areas or that require special wrenches were insufficiently torqued. This is symptomatic of maintenance that is either deficient or conducted by a non professional.

Before the cylinders were removed, the crankshaft was turned to rule out the possibility that the engine had seized. The crankshaft turned correctly and there were no seized parts or stuck valves.

The gaskets on the poppets were removed on all four cylinders. A cursory inspection of the rocker arms on all four cylinders showed them to be in good condition (this was later confirmed).

The information obtained following the complete disassembly is provided below. The cylinders are as identified below, as seen from the cockpit:

- Cylinder 1: front right
- Cylinder 2: front left
- Cylinder 3: rear right
- Cylinder 4: rear left

After they were disassembled, the inspection of all four cylinders revealed practically the same thing:

- The rocker arms, rocker shafts and tappets were in good condition
- The cylinder heads and segments were in good condition
- There was no carbon build up, which indicates the use of unleaded gasoline over a sustained period of time
- Whitish valves, but in good condition
- Wrist pins were in good condition
- The eight spark plugs were almost new but improperly torqued, not professional
- The oil was in good condition
- The crankshaft was in good condition

1.16.3. Lycoming Service Instruction No. 1070S

The engine manufacturer (Lycoming) issued a service instruction on 24 April 2013, number 1070S, approved by the Federal Aviation Administration and titled "Specified fuels for spark ignited gasoline aircraft engine models".

This SI identifies the approved aviation and automotive fuels for Lycoming engines.

The part of the SI applicable to automotive engines specifies that as per the EN228:2008[4] standard applicable in Europe for unleaded automotive gasolines:

- Oxygenate content cannot exceed 1.0 volume percent
- Ethanol and methanol oxygenates are prohibited
- The minimum AKI (anti-knock index) is 93.

1.16.4. Query to CLH on fuels

The main laboratory of the company Compañía Logística de Hidrocarburos, S.A. (a fuel supply company) was asked about the possibility of finding automotive fuel in Spain that complies with the specifications in Lycoming service instruction 1070S.

The laboratory replied that most gasoline available in Spain has an oxygenate content in excess of 1% volume percent, and some has 3% ethanol.

Moreover, the minimum AKI value of 93 would only be satisfied by unleaded 98 gasoline, since the minimum AKI for unleaded 95 gasoline is 90.

This inquiry concluded that it is practically impossible for unleaded 95 gasoline bought at a gas station in Spain to comply with the requirements of Lycoming service instruction 1070S, and thus to be used in the engine in aircraft EC-LIQ.

1.17. Organizational and management information

Not applicable.

[4] EN228:2013 is currently in effect, meaning that fuels available in the domestic market must comply with it.

1.18. Additional information

1.18.1. Aircraft Flight Manual

The Aircraft Flight Manual specifies that the glide speed in the event of an engine failure is 86 KIAS. It also states to issue a MAYDAY call on the radio frequency 121.5 MHz (or on the most suitable frequency at the moment), reporting position and intentions. When a landing is guaranteed, the pilot must select the flaps to the landing position and make the approach at 65/70 KIAS.

The speed for the best climb rate is 78 KIAS, and for the best climb angle it is 67 KIAS, both with the aircraft in a clean configuration.

The stall speed with the engine stopped, wings level and 1060 kg is 58 KIAS with the aircraft in a clean configuration, 54 KIAS with the flaps in takeoff position and 50 KIAS with the flaps in landing position.

The climb performance for an 850 kg weight, 15º C, 2000-ft pressure altitude, a clean configuration and a speed of 73 KIAS is 4.05 m/s, equivalent to 800 ft/min or 243 m/min.

The estimated fuel consumption flying at 2000 ft would be:

- Economy cruise mode: 25 to 31 l/hr (at 2300 to 2550 rpm)

- High power delivery mode: 30 to 37.5 l/hr (at 2300 to 2550 rpm)

1.18.2. Air Traffic Regulations

Spain's Air Traffic Regulations specify that, in general, VFR flights shall not be flown:

a) over groups of buildings in cities, town or populated places, or over a gathering of people outdoors, at an altitude below 300 m (1000 ft) over the tallest obstacle located within a 600-m radius of the aircraft:

b) in any other part different from that specified in the point above, at an altitude below 150 m (500 ft) over land or water.

1.18.3. Irregularities detected during the investigation

As described in the relevant sections, the investigation into this accident revealed the following irregularities:

- Aircraft activity not recorded in the corresponding aircraft and engine log books.

- Failure to comply with the aircraft maintenance program specified in the approved maintenance program.

- Operating at an aerodrome whose runway length did not allow for the safe operation of the aircraft and required operating the aircraft with the minimum fuel possible.

- Prolonged use of a fuel type (automotive) that was not recommended for the engine.

1.19. Useful or effective investigation techniques

None.

2. ANALYSIS

The analysis of the accident of aircraft EC-LIQ considered the following aspects: pilot and aircraft documentation, aircraft maintenance, flight planning and execution and a possible engine failure during the final climb.

2.1. Pilot and aircraft documentation

The pilot had a valid pilot's license and class-2 medical certificate at the time of the accident.

An investigation of the pilot, aircraft and engine logs showed that the pilot had not flown for exactly two months and that the flights made in the accident aircraft had not been recorded in either the aircraft or engine log books since 7 January 2015. They had been recorded in the pilot log book.

The aircraft did not have a valid certificate of airworthiness, as it had expired 10 months earlier (February 2015) and had not been renewed.

2.2. Aircraft maintenance

At the time of the accident, the aircraft's maintenance status was not as required by its authority-approved manual. Its last annual (or 100-hr) and 50-hr inspections had been carried out in February 2014.

While the aircraft had not been flown for 50 hours since then, a year had elapsed in February 2015 since the last annual inspection, and thus the airplane should have undergone an annual inspection 10 months before the accident.

The inspection of the engine after the accident revealed deficient maintenance practices, and what little maintenance had been done to the engine lately, had not been done by a professional. Moreover, some of the deficiencies found (miscellaneous gaskets in bad condition, improperly tightened screws and spark plugs in the carburetor, engine parts whose condition indicated the use of unleaded gasoline) could result in unexpected engine failures, such as misfiring or intermittent power delivery.

Although the spark plugs and oil were in good condition, spark plug and oil changes are relatively simple maintenance operations that can be done by practically anyone. However, applying the necessary torque to the spark plugs requires using a tool that is not readily available to everyone. It also requires knowing the specified torque, a piece of information that is not common knowledge, except to a professional.

2.3. Flight planning and execution

According to the accounts gathered at the Villamartin aerodrome, the runway length was clearly insufficient to safely accommodate the accident aircraft, which used to require the entire length on takeoffs.

It was also the pilot's habit to fly with little fuel onboard and with no passengers in an effort to minimize the weight, and thus the takeoff run. On the day of the accident, the aircraft's weight, with two persons onboard and fuel, is estimated to have been around 850 kg.

In addition, both the eyewitnesses and the engine inspection confirmed that the fuel type normally used by the pilot in the accident aircraft was not approved by the engine manufacturer. The pilot refueled the aircraft from containers holding automotive fuel (unleaded 95 gasoline), instead of the aviation fuel required for this aircraft type.

Using unsuitable fuel (even if the engine continues to run) means that the engine is not working at its designed operating point, and that the deposits that are being generated (or not) are not as expected. The overall result of this is that the engine can fail suddenly without warning, or it may not perform as expected over long periods of time.

On the day of the accident flight, the pilot refueled the aircraft from a 20-l container with unleaded 95-octane automotive fuel. The amount left in each fuel tank is not known, but in light of the pilot's habits, it could not have been much. Moreover, for that day's flight (planned to last under one hour), the total expected fuel consumption would have been on the order of 30 to 35 liters, and so the pilot may have thought he had sufficient fuel for that flight. This decision was mistaken not only because of the incorrect fuel type, but by the failure to plan for some kind of contingency during the flight requiring a deviation from the flight plan. It is not good practice to fly with just the right amount of fuel without considering potential circumstances that could alter the pilot's plans.

As a result of the extra weight caused by the presence of a passenger, the accident flight was undertaken in conditions that were unfamiliar to the pilot. This extra weight meant that the airplane consumed more fuel than he was used to when flying alone. It also hampered the airplane's performance, especially when climbing. Moreover, the type of low flying that the pilot was doing places heavy demands on the engine, unlike cruise flying, when the engine can be adjusted to lower its performance. Flying so low also implies flying with a rich mixture at all times, which consumes more fuel.

The fire that broke out after the impact was small. It did not spread to surrounding vegetation and it went out by itself, which indicates that there was little fuel in the airplane at the time. From all of the above it may be concluded that the amount of fuel used by the pilot to make the flight was clearly very low.

As for the weather, it in no way limited the planned flight. If, however, the pilot planned to fly in valley areas at low altitudes, he should have expected to encounter local wind conditions that were very different from the general conditions. This was in fact the case when he had a westerly wind (of certain strength) at least from Zahara de la Sierra on. Since the pilot knew the area, he should have been aware of the presence of that channeled wind in the valley; however, in order to climb out of the valley with the extra weight he was carrying that day, he would have to push the aircraft to its limits, as the low altitude at which he was flying left very little margin for error.

The low altitude at which he was flying is also worth noting, since judging by the eyewitness accounts, it was abnormally low. Investigators do not believe that a technical problem forced the pilot to fly so low over Zahara de la Sierra, since he made no emergency calls on the frequency, the airplane was not moving erratically and several kilometers later, the eyewitness on the mountain saw the aircraft flying low without any apparent problems. In addition, there were fields available to the pilot in the area where he could have safely made an emergency landing. And if a technical problem does occur (especially an engine problem), the last thing the pilot would want to do is climb at 300 m/min (about 985 ft/min), beyond the aircraft's safe climbing capability, directly toward a valley wall, only to clear it by just a few meters. Therefore, it may be concluded that the pilot was deliberately flying at that low altitude.

Investigators were unable to determine if the pilot routinely flew so low (in clear violation of the minimum altitudes specified in Spain's Air Traffic Regulations).

2.4. Possible engine failure on final climb

The aircraft was last seen in the air by an eyewitness who was on the mountain, and who saw the accident aircraft fly very close to him after leaving the reservoir and Montecorto behind, en route to Ronda. The aircraft was flying very low, and he thought it was climbing with the wings level and the engine running.

The difference in elevation between that point and the edge of the valley wall was 340 m. If the aircraft passed that point at an altitude of 50 m, it would have had to climb some 295 m to clear the valley wall some 2.65 km away. Assuming an indicated airspeed of 75 kt and a tailwind of 15 kt, the time to reach the valley wall would have been 57 seconds (practically one minute of flight time).

This would have required a climb rate of about 300 m/min (some 985 ft/min) if flying directly to the valley wall in order to clear the edge by 5 m.

However, the Aircraft Flight Manual states that the climb performance for a weight of 850 kg at 15º C, a pressure altitude of 2000 ft and a clean configuration at a speed of 73 KIAS

is 4.05 m/s, equivalent to 800 ft/min or 243 m/min. This performance would have been insufficient for the aircraft to clear the valley wall.

The pilot started to climb out of the valley too late. This may have been because he overestimated his aircraft's performance or he was unaware of the danger associated with flying so low (and with a tailwind).

He was only able to clear the valley wall by pitching the aircraft up more than usual just before reaching the edge. While he cleared the edge, his IAS would have been very low, very close to the stall speed. He would have performed the climb at maximum engine thrust and a high pitch angle, which would also keep the engine from being properly cooled.

It is not known if the fuel pump was on during the climb, but the up angle must have been considerable, which would hamper the delivery of fuel to the engine if the fuel pump had been off. The condition of the wreckage also made it impossible to determine if the tank that was supplying the engine at that moment ran out of fuel.

In this scenario, any reduction in the power delivered by the engine would have been very dangerous, with the valley wall approaching and very little maneuvering room to either side.

The engine inspection determined that the engine did not seize, and given its condition, it was not possible to ascertain if the engine was starved of fuel or if the magnetos failed to spark. It is likely, however, given the high demand placed on the engine along with the poor maintenance, the high angle of attack (possibly with the fuel pump off) and the low quantity of fuel not approved for the engine, that the engine failed, if only partially, resulting in the aircraft reaching the valley wall with a very low IAS. This potential failure would have occurred in the final seconds of the climb, since if it had occurred earlier, the airplane would not have cleared the valley wall and the pilot would have had the option to attempt an emergency landing in the fields to his right.

This potential engine failure would explain why the aircraft, after barely clearing the valley wall, did not continue flying, at least horizontally; instead, it flew in a downward trajectory during the almost 100 m that separated it from the tree against which it impacted, all the while cutting the 1-2-meter-tall vegetation and unable to regain altitude.

The possibility that the pilot chose the crash site to make an emergency landing can be ruled out, since the fields to his right would have been suitable if the emergency had occurred at the start or middle of the climb.

It would also explain why the damage exhibited by the propeller blades indicated that they were windmilling when the aircraft impacted the tree.

The aircraft impacted the tree at a right bank angle. This may have been because the pilot attempted an evasive maneuver to the right of the tree, or because the aircraft was already at or near its stall speed after the climb, and any bank angle undermined even more the vertical component of the lift force supplied by the wings.

3. CONCLUSIONS

3.1. Findings

- The pilot had a valid flying license and class-2 medical certificate at the time of the accident.

- The flights made using the accident aircraft had not been recorded in the aircraft or engine lob books since 7 January 2015, though they had been recorded in the pilot's flight log.

- The aircraft did not have a valid certificate of airworthiness, as it had expired ten months earlier (February 2015).

- At the time of the accident, the aircraft's maintenance status was not as required by its authority-approved manual. The last annual (or 100-hr) and 50-hr checks had been performed in February 2014.

- The maintenance had been deficient.

- The length of the runway at the aircraft's usual aerodrome was too short for the accident aircraft to operate safely, as it routinely used the entire runway length during takeoffs.

- The pilot routinely flew with little fuel onboard and with no passengers in an effort to minimize weight, and thus the takeoff run.

- On the day of the accident, the aircraft's weight with two persons onboard and the fuel would have been around 850 kg.

- The type of fuel normally used to fill the tanks of the accident aircraft (unleaded 95-octane automotive fuel) was not approved by the engine manufacturer.

- On the day of the accident, the pilot filled the fuel tanks from a 20-l bottle of unleaded, 95-octane automotive fuel. It is not known how much fuel remained in each tank, but given the pilot's habits, it would not have been much. The amount of fuel remaining at the time of the accident was very low.

- The accident flight involved additional weight considerations, by way of a passenger, that departed from the pilot's usual flying conditions.

- The extra weight resulted in fuel consumption that was higher than when the pilot flew by himself. It also hampered the aircraft's performance, especially when climbing.

- The low-altitude flight that was being carried out placed considerable demands on the engine, which was consuming more fuel than in cruise flight with lower power demands.

- The fire that broke out after the impact was small. It did not spread to the surrounding vegetation and it went out by itself.

- The weather was not limiting to the flight as planned.

- From at least Zahara de la Sierra onward, the local wind conditions differed from the general conditions, with winds from the west at around 15 kt.

- The pilot deliberately flew the aircraft at low altitudes.

- The pilot decided too late to climb out of the valley he was flying in.

- The only way the pilot managed to avoid the valley wall was by pitching up the aircraft more than usual before reaching the edge. He cleared the wall with a very low indicated airspeed that was close to the stall speed. During the entire climb he kept the engine at maximum power at a high pitch angle, which impeded proper engine cooling and could have hampered the delivery of fuel to the engine.

- An inspection of the engine revealed that it did not seize.

- There was very likely a power failure (if only partial) during the final part of the climb, which resulted in the aircraft reaching the edge of the valley wall at a very low speed.

- This potential engine failure would explain why the aircraft, after clearing the valley wall at a very low altitude above the ground, did not continue to fly level.

- It would also explain the damage to the propeller, which indicate the blades were windmilling at the moment of impact.

- During the final climb, there was no margin or time to execute an emergency evasive maneuver toward the valley.

- The site of the accident was not suitable for making a planned emergency landing.

3.2. Causes/Contributing factors

The investigation determined that the aircraft's engine was stopped at the time of the accident and ruled out any mechanical reasons for this stoppage. The most probable

cause for the engine having stopped was determined to involve the use of a fuel that is not allowed by the manufacturer. The aircraft was also being flown with very little fuel onboard and the pilot executed an aggressive maneuver that could have kept the fuel from reaching the engine.

Contributing to the accident was the deficient maintenance condition of the engine and flying the aircraft at an altitude above the ground that was lower than required.

4. SAFETY RECOMMENDATIONS

None.