CIAIAC

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

Report
ULM A–003/2017

Accident involving a Tecnam P2002 Sierra aircraft, registration EC-FP6, at the Villaverde aerodrome (Toledo, Spain) on 8 February 2017

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

Report

ULM A-003/2017

Accident involving a Tecnam P2002 Sierra aircraft, registration EC-FP6, at the Villaverde aerodrome (Toledo, Spain) on 8 February 2017

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO
SUBSECRETARÍA
COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

NIPO Papel: 161-17-210-0

NIPO Línea: 161-17-208-2

Depósito legal: M-31258-2017

Maquetación: David García Arcos

Impresión: Centro de Publicaciones

COMISIÓN DE INVESTIGACIÓN DE ACCIDENTES E INCIDENTES DE AVIACIÓN CIVIL

Tel.: +34 91 597 89 63
Fax: +34 91 463 55 35

E-mail: ciaiac@fomento.es
http://www.ciaiac.es

C/ Fruela, 6
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

º	Degrees
AEMET	Spain's National Weather Agency
AESA	Spain's National Aviation Safety Agency
CAMO	Continuing airworthiness maintenance organization
DGAC	Spain's Civil Aviation General Directorate
EASA	European Aviation Safety Agency
FSO	Flight Safety Office
ft	Feet
GPS	Global positioning system
h	Hours
ICAO	International Civil Aviation Organization
kg	Kilograms
kt	Knots
km	Kilometers
l	Liters
LH	left hand
l/h	liter per hour
m	Meters
MAC	Mean aerodynamic chord
METAR	Aerodrome weather report
min	Minutes
MTOW	Maximun take off weight
N	North
No.	Number
RCA	Restricted certificate of airworthiness
RH	right hand
rpm	Revolutions per minute
sec	Seconds
S/N	Serial number
TAF	Aerodrome weather forecast
UTC	Coordinated universal time
W	West

Synopsis

Owner and operator:	Private
Aircraft:	Tecnam P2002 Sierra, registration EC-FP6
Date and time of accident:	Wednesday, 8 February 2017 at 14:30 local time[1]
Site of accident:	Villaverde aerodrome (Toledo, Spain)
Persons onboard:	1 pilot, killed
	1 passenger, killed
Type of flight:	General aviation - private
Phase of flight:	Takeoff – initial climb
Date of approval:	31 May 2017

Summary of accident:

On Wednesday, 8 February 2017, a Tecnam P2002 Sierra ultralight, registration EC-FP6, took off from the Casarrubios del Monte aerodrome (Toledo) with the intention to fly to the Villaverde aerodrome (Toledo) and fly back on that same day. Onboard were two individuals.

According to information provided by eyewitnesses, the aircraft reached the Villaverde aerodrome and landed on runway 09, after which it taxied to the runway 27 threshold, where it remained for a few minutes with the engine running. Neither occupant exited the aircraft. A few minutes later, the aircraft took off from runway 27. It rose some 20 m and then impacted the ground 289 m away from the end of the runway.

The investigation has determined that the accident of aircraft EC-FP6 was likely caused by a loss of control after stalling during a takeoff conducted under excess weight conditions, high winds, with a crosswind component close to the certification limits and on a runway with a positive gradient. The investigation was unable to confirm if the engine failed during the flight. It was possible to confirm that the engine was working during the takeoff and initial climb, but that it was not generating power at the time of impact.

[1] All times in this report are local.

This report contains 6 safety recommendations issued to AESA, ÁLAMO AVIACIÓN and TECNAM. In addition, 9 safety recommendations, regarding ballistic parachutes, and already issued on the CIAIAC report reference ULM A-016/2016, are mentioned in this report.

1. FACTUAL INFORMATION

1.1. History of the flight

On Wednesday, 8 February 2017, a Tecnam P2002 Sierra ultralight, registration EC-FP6, took off from the Casarrubios del Monte aerodrome (Toledo) with the intention to fly to the Villaverde aerodrome (Toledo). Onboard were two individuals: the pilot, who was one of the aircraft's eight owners, and a passenger. They planned to fly into the Villaverde aerodrome, park the aircraft, eat at a nearby restaurant and after eating, return to Casarrubios, where the aircraft was based. The pilot had already conducted this type of flight on previous occasions.

According to information provided by eyewitnesses, the aircraft reached the Villaverde aerodrome and landed on runway 09, after which it taxied to the runway 27 threshold, where it remained for a few minutes with the engine running. Neither occupant exited the aircraft. During that time, the pilot called the restaurant to cancel the reservation because he was "*unable to turn off the aircraft and [he] couldn't leave it there*"[2]. The aircraft took off from runway 27, climbed on the runway heading[3] and then descended at a sharp angle until it impacted the terrain.

After crashing into the ground, a fire broke out that caused the ballistic parachute triggering device to explode. Both aircraft occupants were killed in the accident and the aircraft was destroyed (Figure 1). The position of the aircraft relative to the runway is shown in Figure 2.

[2] Quote taken directly from the person at the restaurant who spoke with the pilot.

[3] Based on the eyewitness statements included in Section 1.17.

Figure 1. Aircraft EC-FP6 after the impact and fire

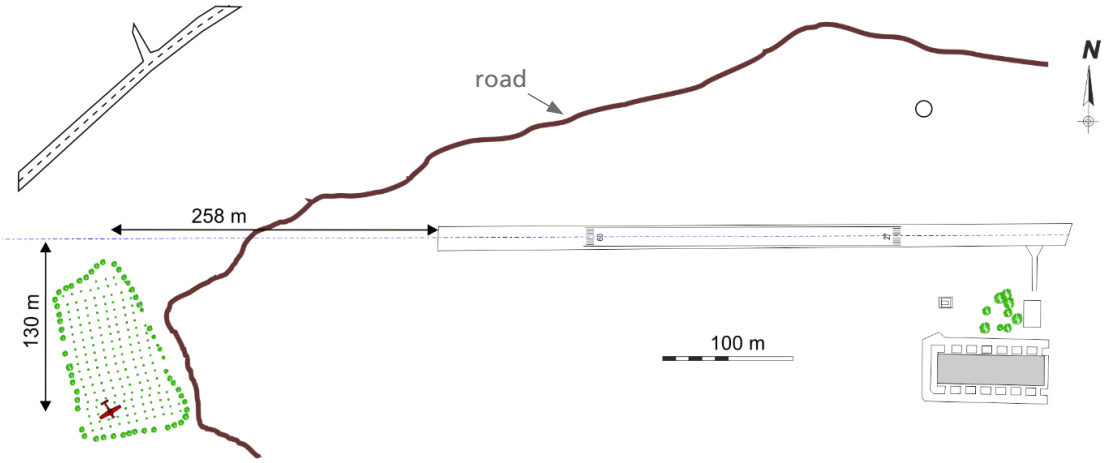

Figure 2. Position of the aircraft relative to the runway

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	1	1	2	
Serious				
Minor				
None				
TOTAL	**1**	**1**	**2**	

1.3. Damage to aircraft

The aircraft was destroyed as a result of the impact and fire.

1.4. Other damage

None.

1.5. Personnel information

The pilot, a 51-year old Spanish national, had been an ultralight pilot since January 2011. After receiving his license, the pilot had renewed it annually until January 2016. From January 2016 until August 2016, his license was expired. He renewed it on 22/08/2016 through the flight school at Casarrubios[4], meaning it was in effect at the time of the accident. His medical certificate had been renewed in April 2016 and was valid at the time of the accident.

In 2011, after obtaining his ultralight pilot license, the pilot, along with seven other individuals he had met in the ultralight pilot license course, purchased aircraft EC-FP6, which he had been flying since. No documentation detailing the exact number of hours was available, but based on estimates from the other owners, the pilot would have had, at most, 200 total flight hours. Investigators were able to confirm the pilot's activity on that aircraft in 2016 (10 flights lasting a total of 12.19 h) and in 2017 (2 flights lasting a total of 1.95 h, one on 28 January and the accident flight in February).

According to information provided by the owners and by the owner of the restaurant, the pilot used to fly from Casarrubios to Villaverde to eat and then fly back. Specifically, he was confirmed to have done this on 28 January at least once in December 2016.

1.6. Aircraft information

The aircraft, a certified ultralight, a Tecnam P2002 Sierra[5], S/N P2002 047, was equipped with a Rotax 912 ULS2 engine, S/N 5650782. It had been built in 2008 by

[4] To renew it, the pilot flew two flights, which included three takeoffs and landings, in a dual-control Tecnam P2002 owned by the school. After these flights, he passed a flight test with an examiner from Spain's National Aviation Safety Agency (AESA).

[5] As shown in the aircraft's documentation, the model was a Tecnam P2002 Sierra. Painted on the aircraft was the Tecnam P2002 Sierra Deluxe logo and the owners stated that it was the "deluxe" model. The flight manuals for the Tecnam P2002 Sierra and the Tecnam P2002 Sierra Deluxe are different.

Aero Empordá. In 2009 it was registered in Spain by its first owner. It had a two-blade propeller and no ballistic parachute. In 2011, the aircraft was sold to a group of eight individuals who had created a sports club[6] and who were listed as the owners of the aircraft. According to the new owners, the aircraft had a three-blade propeller and a ballistic parachute. This change of ownership had been recorded on 07/10/2011 in the aircraft registry. The aircraft was insured and a restricted certificate of airworthiness (RCA) issued in 2009[7].

At the time of the accident, it is estimated[8] that both the aircraft and engine had 965.79 h. The aircraft's maximum fuel capacity was 100 l (divided between two 50-l tanks).

1.6.1. Aircraft maintenance

According to information provided by the owners, they themselves[9] performed the simpler maintenance tasks (oil, spark plug and filter changes). The more complex maintenance tasks were done by a specialized mechanic.

In October 2015, the aircraft made a hard landing at the Casarrubios aerodrome that required making repairs to the aircraft, according to one owner's statement. These repairs were done by a maintenance center, Álamo Aviación[10], which, according to information provided by the center itself, "did not result in any type of work order either at the CAMO[11] or at the 145 maintenance center level due to the private nature of the work". The center reported that the repair affected the following components:

---

[6] These individuals had all taken the ultralight pilot course between late 2010 and early 2011. After receiving their licenses, they decided to purchase an aircraft, forming a sports club in February 2011 and registering it in the Madrid Registry of Sports Entities. There had been different owners since 2011 for different reasons, though some of them, such as the accident pilot, had remained in the group from the start. The club had an internal charter that specified, among other things:

- that each pilot had to be solo certified by an instructor. This certification had to be obtained after a period of inactivity longer than three months.
- the club had a flight log in which pilots had to record the date, hour, pilot's name, problems, run time and fuel added after each flight (these sheets were kept onboard the aircraft, along with the other documentation, and were burned in the fire).

[7] Certificate issued as per the Type Certificate of Airworthiness no. 281-I of Spain's Civil Aviation General Directorate. The certificate of airworthiness was valid for an indefinite period of time.

[8] The sheets from the flight log for January and February 2017 were burned in the accident since they were onboard the aircraft. The previous ones had been removed and yielded information for 2016. Based on these data and on a reconstruction of the flights by the owners in January and February 2017, investigators were able to estimate the number of hours at the time of the accident.

[9] One of the former owners had subscribed to the engine manufacturer's publications.

[10] Part-145 Organization approved by AESA ES 145.151.

[11] Continuing airworthiness maintenance organization.

- Replacement of nose gear and springs in the main gear
- Replacement of engine mount
- Lower engine fairing
- Replacement and adjustment of propeller
- Adjustment of carburetors
- Replacement of clutch and starter motor
- Check and tune up of gearbox
- Change of tires

The work was completed in March 2016, when the aircraft was flown again with 886.82 h. On 07/07/2016, with 913 h (as noted in the work documents provided by the maintenance technician charged with carrying out the more complex tasks), several activities were completed (install oil radiator, tighten rudder cables, tie down carburetor cables and cut the tip off the line entering the fuel filter). After this last task, no other maintenance was done. None of the owners had noticed any problems with the aircraft or the engine.

1.6.2. Aircraft activity

Between March 2016, when the aircraft was returned to service with 886.82 h, and 8 February 2017, it had flown 78 h:

1.7. Meteorological information

The investigation relied on information published by AEMET[12] (METAR[13] and TAF[14] published for the nearest airports, and significant low-level charts) that the pilot might have checked before the flight. Also obtained were wind data recorded by several AEMET stations and a wind farm in the vicinity of the destination aerodrome. Figure 3 shows the location of the stations and wind farm with respect to the accident site.

[12] Spain's National Weather Agency.

[13] Aviation routine weather report.

[14] Aerodrome forecast.

Figure 3. Location of weather stations

1.7.1. AEMET weather information available to the pilot

The closest aviation facilities to the Casarrubios del Monte aerodrome, where the flight originated, are the airports of Cuatro Vientos (30 km northeast) and Getafe (30 km east). The weather information issued for these airports was as follows:

- The METARs from 08:00 until 12:00 showed that in the early morning, the wind was from the west at 20 km/h (11 kt) in Cuatro Vientos and 24 km/h (13 kt), gusting to 42 km/h (23 kt), in Getafe. The wind was calm by 12:00 h.
- The TAFs issued at 10:00 called for variable winds at 9.2 km/h (5 kt) for the period between 10:00 and 19:00, with the following changes by periods:
  - Between 10:00 and 12:00, wind from the north at 18 km/h (10 kt).
  - Between 13:00 and 18:00, with a moderate probability of 40%: wind from the north at 28 km/h (15 kt), gusting to 46 km/h (25 kt).
- The TAFs issued at 12:00, for the period between 13:00 and 22:00, called for wind from the north at 22 km/h (12 kt), with the following changes:
  - Between 13:00 and 18:00, wind from the north at 28 km/h (15 kt), gusting to 46 km/h (25 kt).

The satellite and radar images did not show convective activity, and confirmed that there were few clouds. The weather situation favored the presence of windshear, since the winds on the surface were decoupled from the winds at medium and high

altitudes. This was reflected in the significant low-level weather chart issued at 07:00 (06:00 UTC), which would have been available for the pilot to consult. The area between Casarrubios and Villaverde was in a moderate turbulence zone up to 8000-10000 ft, with the presence of mountain waves.

1.7.2. Wind data from the Cerro de la Oliva wind Farm and from AEMET stations

Northeast of the Villaverde aerodrome at a distance of 6800 m is the Cerro de Oliva Wind Farm, at an elevation of 820 m[15]. The ten-minute data for the wind direction and intensity are shown in the table below. Also shown for each time period are the headwind and crosswind components that an aircraft operating on runway 27 would have experienced:

Time	Sped (km/h)	Direction (º)	Crosswind (from the N, to the right) (km/h)	Headwind (from the W) (km/h)
14:00	26,05	323,6	21	15
14:10	29,74	327,6	25	16
14:20	30,75	321,8	24	19
14:30	29,69	321,4	23	19

The AEMET stations closest to the Villaverde aerodrome, the aircraft's destination, were Mora de Toledo (17 km east at an elevation of 717 m), Toledo (21 km north at an elevation of 515 m) and San Pablo de los Montes (34 km southwest at an elevation of 917 m). The average and maximum wind values recorded by these stations between 14:00 and 14:45 are shown in the table below. Also shown for each time period are the headwind and crosswind components that an aircraft operating on runway 27 would have experienced:

Station	Speed (km/h)	Direction (º)	Crosswind (from the N, to the right) (km/h)	Headwind (from the W) (km/h)
Mora de Toledo	Average: 14	315	10	10
	Maximum: 27	315	19	19
Toledo	Average: 20	360	20	0
	Maximum: 37	360	37	0
San Pablo	Average: 18	360	18	0
	Maximum: 34	360	34	0

[15] The Villaverde aerodrome is at an elevation of 721 m.

1.8. Aids to navigation

Not applicable.

1.9. Communications

The aircraft did not make any emergency calls.

1.10. Aerodrome information

The Villaverde aerodrome (Toledo), at an elevation of 721 m, has a single dirt runway in an east-west, 09/27 orientation. The runway is in an area of compacted earth that is 500 m long by 20 m wide, although the runway proper (between the runway start and end markings) is 245 m long and 14 m wide.

The terrain on which the runway is located is at an angle, such that operations are uphill on runway 27 and downhill on 09.

1.11. Flight recorders

The aircraft had a GARMIN AERA 500 GPS device. It was recovered from the accident site and sent to the recorder laboratory of the French aviation accident investigation authority to be downloaded. Due to the unit's intense exposure to fire, it was impossible to recover any data from it.

1.12. Wreckage and impact information

The aircraft was found in a field with rows of fruit trees planted in a north-south orientation. During its descent, the aircraft did not damage any of the trees, nor were drag marks found on the ground, which indicated that the impact had been vertical. The wreckage was not scattered. The aircraft was in a normal flight position, resting on its lower fuselage, and exhibited impact and fire damage (see Section 1.14). All of the aircraft's structural components were present. Figure 4 shows a diagram with the general layout of the wreckage.

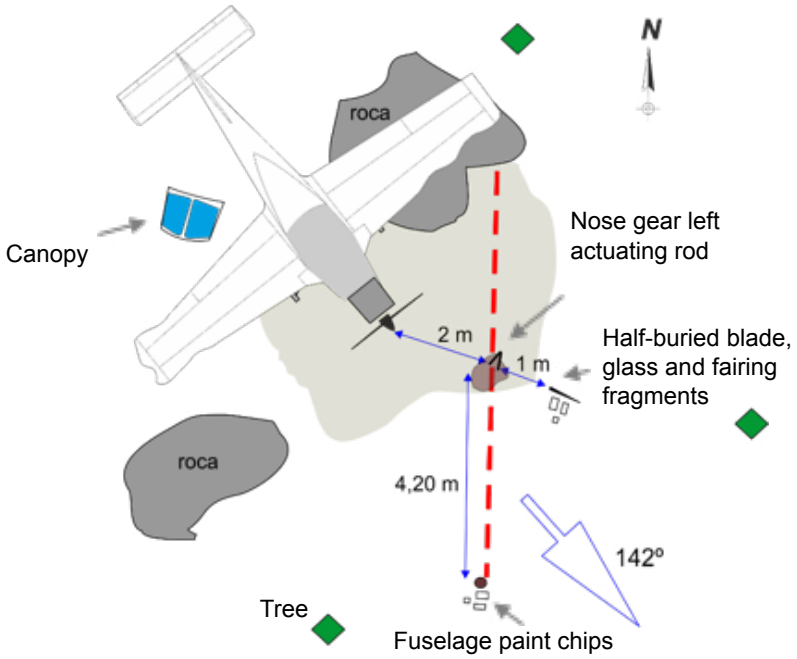

Figure 4. Location of debris

The tail assembly, including the legible registration markings, were not damaged by the impact or the fire. There were minor signs of compression in the longitudinal direction at the junction with the forward fuselage. One mark was identified on the operating rod for the elevator control, produced as it passed through one of the tracks in the forward fuselage, that indicated that at the time of impact, the position of the elevator control was nose up.

All throughout the right wing there were compression marks, from the end of the wing to the root. The first third of the wing was noticeably twisted. The wingtip was broken, and part of the material had detached. The left wing was less damaged than the right wing, and exhibited compression marks located primarily along the leading edge. The wingtip was minimally damaged, and the light was still intact. The left wing was resting on a rock on the ground. Neither wing seemed to have shifted from its installed position. The flaps were confirmed to be retracted.

Figure 5. Left and right wings after the accident

The cockpit and the rest of the front fuselage had been destroyed by the fire. The heat had melted some of the material. None of the equipment from the instrument panel was able to be recovered. The cockpit fuel selector valves were found, which indicated that the right tank was open and the left tank was closed. As for the remaining controls in the cockpit, none were identifiable due to the considerable damage caused by the fire.

The engine had not detached from the rest of the aircraft and was attached to the structure. It did not exhibit significant impact damage, and the exhaust lines rotated fully. It had been affected by the fire. The conclusions drawn from the disassembly and inspection of the engine are provided in Section 1.16.2.

The propeller was attached to the engine. Two of the three blades were attached to the hub and, though burnt, were practically intact over 90% of their surface. The third blade was found half buried three meters forward of the aircraft, along with some glass and a fairing fragment. This blade was not burned. Two meters

Figure 6. Propeller and engine after the accident

forward of the aircraft the nose gear left actuating rod was found half buried. To the right of the location of this rod, 4.2 m away, there was unburned debris from the fuselage on the ground.

The canopy was found next to the leading edge on the right wing, tipped upward. The locks were closed.

1.13. Medical and pathological information

The owner of the aircraft was confirmed to have been sitting in the LH seat and the passenger in the RH seat. There were differences in the complexions of the two occupants, whose weights were estimated at 85 kg for the one seated to the left and 60 kg for the one seated to the right.

1.14. Fire

A fire broke out after the aircraft impacted the ground. After some time, just as several eyewitnesses arrived who tried to help the persons onboard, the ballistic parachute device exploded. It is estimated that the aircraft burned for around 30 minutes between the time of the accident (14:30) until the firefighters arrived at 15:00, at which time there were still active fire sites around the aircraft that were doused with water. The fire's intensity varied throughout the aircraft:

- The fire had severely affected 70% of the aircraft's forward fuselage (engine and cockpit compartment). Only the canopy, which had been ejected, showed no fire damage. The tail assembly (the last 2 m) was intact and the registration markings showed no signs of fire or smoke.
- The right wing exhibited intense signs of fire damage over 40% of its surface in the area closest to the fuselage. The wingtip did not show signs of fire damage.
- The left wing had also been affected by the fire, but to a lesser extent than the right wing. Approximately 25% of the area closest to the fuselage had been exposed to the fire. There were signs of damage from smoke and a lower intensity fire on the leading edge. The paint was still present on the rest of the left wing.

1.15. Survival aspects

After impacting the ground, the aircraft caught fire. The first individuals to arrive the aircraft were the owner of the aerodrome and a worker from a nearby field. Even though the fire had already broken out in the right side of the cockpit, they tried to rescue the person seated in the LH seat, pulling on him but unable to extricate him

because his harness was fastened. The fire was starting to spread to the left side of the cockpit, making it impossible to release the harness. As they were trying to rescue the individual in the LH seat, they saw a small part ejected at high speed toward the rear of the aircraft. This alarmed them and they moved away. A few seconds later, the exposure to the high temperature caused the triggering device for the ballistic parachute to explode.

A review of the emergency services response and activation times confirmed that the first call to the Castilla la Mancha 112 emergency number was placed at 14:31. This call reported that "a small airplane has crashed, that it was flying very low and it is burning". As a result, medical, firefighting, public protection and Civil Guard personnel were dispatched.

1.16. Tests and research

1.16.1. Eyewitness interviews

A total of 17 individuals were interviewed[16], of whom 7 had witnessed the accident from different locations. Most of the information provided by the eyewitnesses is included in the report, as it is deemed of interest to an understanding of the accident. This section contains additional information provided by the eyewitnesses during the investigation.

Aerodrome owner A:

- He confirmed that the pilot flew to the Villaverde aerodrome regularly and did the same thing he planned to do on the day of the accident: travel by airplane, park the airplane at the aerodrome, eat at the restaurant and return to Casarrubios del Monte, which he had last done 15 days earlier.

Aerodrome owner B – located at 1:

- He was entering the aerodrome via the road perpendicular to the runway when he saw an aircraft preparing to take off. He only saw the takeoff and not the previous landing.

Hunter - located at 2:

- He was at the aerodrome bar, with another hunter located at 3.

[16] The interviews of the mechanic and maintenance center personnel are not included since the relevant information from these interviews is contained in Section 1.6.1.

- He saw the aircraft land and take off in the opposite direction from which it had landed. He could see a man and woman in the cockpit.
- It stopped for a while (3-4 min) with the propeller turning. He thought they were going to stop but it took off again. It used up the full length of the runway.
- In his opinion it was going very slowly. It climbed like in two phases, first a little and then some more. Right after this he heard the impact.
- He went to the crash site but there was nothing they could do. They threw themselves to the ground because parts were flying off and then it exploded.
- The wind was from the north-northeast.

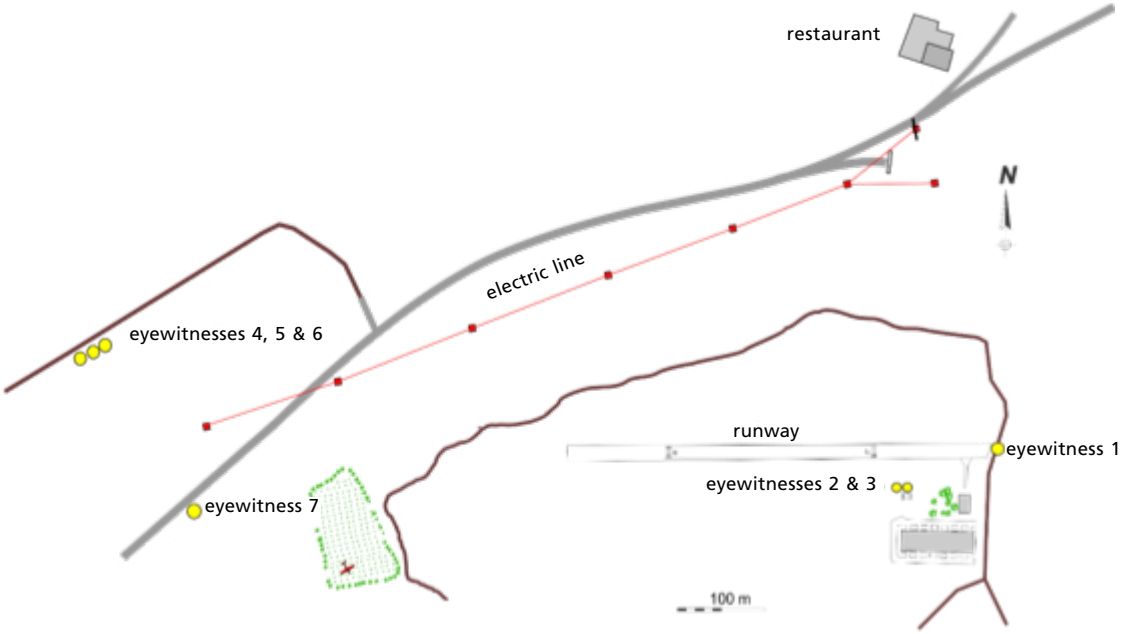

Figure 7. Position of the 7 eyewitnesses who saw the accident

Hunter - located at 3:

- Did not provide any information.

Farm worker - located at 4:

- He was in front of where the airplane fell.
- There were three people, and all three[17] were leaning on the car looking at the aircraft. They were preparing to start work.

[17] Of these three individuals, two of them were interviewed.

- He stated it was 14:30.
- He saw it climb to an altitude no higher than two light posts[18].
- He noticed it bank[19] and pitch[19] down. A fire broke out immediately.
- He went to the accident site and the airplane was already on fire.

Farm worker - located at 5:

- He heard the noise from the airplane. They were used to seeing them take off.
- He saw the left wing dip, then the right, then the left before nose diving to the ground.

Hunter – located at 7:

- It was 14:30 and he was going to the property where the aerodrome is located since it was the last hunting day. He was in a car and saw the aircraft head on.
- He frequently went to the property where the aerodrome is located to hunt and was used to seeing small airplanes take off.
- He noticed that the airplane was not gaining altitude. He saw it bank[19] left and right and then pitch[19] down.
- He went to the aerodrome, entered the bar and asked one of the people there to go with him. By the time they reached the site, the aerodrome owner (whom he knew) and another person were trying to extract the pilot.
- Then suddenly they saw a small piece go flying toward the back, which made them fear the airplane would explode so they backed away from it. A few seconds it exploded.
- The wind was from the north-northwest.

Owner of the restaurant:

- He reported that the accident pilot used to fly in to eat at the restaurant, though he had not done so in a year and a half because the airplane had been broken down, as the pilot himself had told him once. He had flown in three times since October 2015, the last time 15 days prior.

[18] The lamp posts are 13 m tall. This eyewitness was interviewed at the site where he saw the accident, and the altitude was estimated based on a utility pole.

[19] The eyewitness did not use this term.

- He spoke with him by telephone at 11:00, when the pilot made a reservation, and at about 14:00 to cancel the reservation. He stated that the pilot was not nervous, that he was a calm man.

Pilot at Casarrubios del Monte:

- As he was returning to his hangar, he saw the accident aircraft, whose hangar was opposite his.
- The aircraft was stopped with the cockpit closed and the engine running.
- He saw it between 13:00 and 13:30.
- There was a crosswind at Casarrubios but it was not gusting.

Owners[20]:

- They did not know the airplane's weight and were unaware of the load and balance report made after the airplane was manufactured.
- They did not use weight information. They knew two people could fly in the airplane.
- Their fuel policy was to always fly with the tanks full, and in no case less than half full. They never flew with the tanks less than half full.
- They flew with one tank closed.
- They had an agreement not to fly in wind of 20-25 km/h.
- None of the owners had had any problems with the aircraft or with the engine before.

Flight instructor at Casarrubios:

- He had flown this aircraft twice, on 08/01/2017 for 3 h, and on 23/12/2016 for 1 h 34 min, both times to certify a new owner to fly solo.
- He did not notice anything unusual in the aircraft or engine on either flight.

1.16.2. Engine inspection

The aircraft's engine was inspected on 9 March 2017. The components that were able to be inspected, and the findings, are listed below:

[20] Seven of the aircraft's remaining owners and one former owner were interviewed.

- Cylinders: all of the cylinders were completely disassembled. The condition and coloration of the four cylinders (black) indicated they had been working at the lower temperature range. The inside surface on cylinders 1 and 3, located on the right side of the engine (as seen from the pilot's position) exhibited coarseness and were not smooth. This is indicative of having been subjected to high temperatures and sudden cooling. Cylinders 2 and 4 did not exhibit this coarseness.

- Spark plugs: all of the spark plugs were black, indicative of operating at low temperatures, consistent with the color of the cylinders. The lower spark plugs, 2 and 4, had bright deposits along the bottom of the spark plug. The spark plugs in cylinder 1 had carbon deposits, which is considered normal. Of all the spark plugs in the engine, the one at the top of cylinder 1 was short-circuited.

- Fuel pump: it had been consumed completely in the fire. Only the pump shaft could be disassembled, showing no signs of friction, wear or problems rotating.

- Oil filter: despite having been exposed to an intense fire, it was able to be disassembled. Numerous non-metallic particles were found in it.

- Oil pump: it was in good condition, with no signs of friction or seizing and no particles or residue.

- Magnetic screw: there were numerous particles attached to it. Although the date of the last check of this screw could not be confirmed, it is very likely that it was checked when repairs were made to the aircraft, which would have been 90 flight hours before the accident. No particles would be expected after only 90 flight hours, meaning that the number of metallic particles attached to the screw was excessive and indicative of a future engine failure.

- Starter motor and magnetic disc: they were removed from their housings so as to further disassemble the engine. The fire had affected them to such an extent that these components could not be analyzed.

- Propeller gear:

  - The alignment dimple[21] in the friction clutch had shifted from the top casing in the opposite direction from that toward which it should have moved. Figure 8 shows the shift in the clutch casings in the engine on aircraft EC-FP6, and

[21] When the propeller stops instantaneously with the engine under power, the friction clutch absorbs, depending on the case, all or part of the rotational movement produced at the shaft of the gear to avoid cascading the damage to the crankshaft. In other words, the friction clutch acts like a fuse. The clutch is pre-loaded and covered by two casings. When it is assembled, two concentric dimples are made in both casings that align with each other. In the event of an impact with the ground, the lower casing stops with the propeller and the upper casing will tend to continue rotating with the engine, causing one casing to shift with respect to the other (as long as the engine is producing enough power to overcome the pre-load on the clutch). The shift distance is measured in millimeters and stops when the deformed part on the top casing comes into contact with the edge on the lower casing.

in another clutch following a sudden stoppage of the propeller during an impact with the ground and the engine at power. The alignment dimple shifted to the edge of the groove in the lower casing.

- Wear was identified in the propeller attachment half-rings and in two of the three concave pressure washers. The rest of the gearbox assembly did not exhibit signs of breakage or of irregular operation.

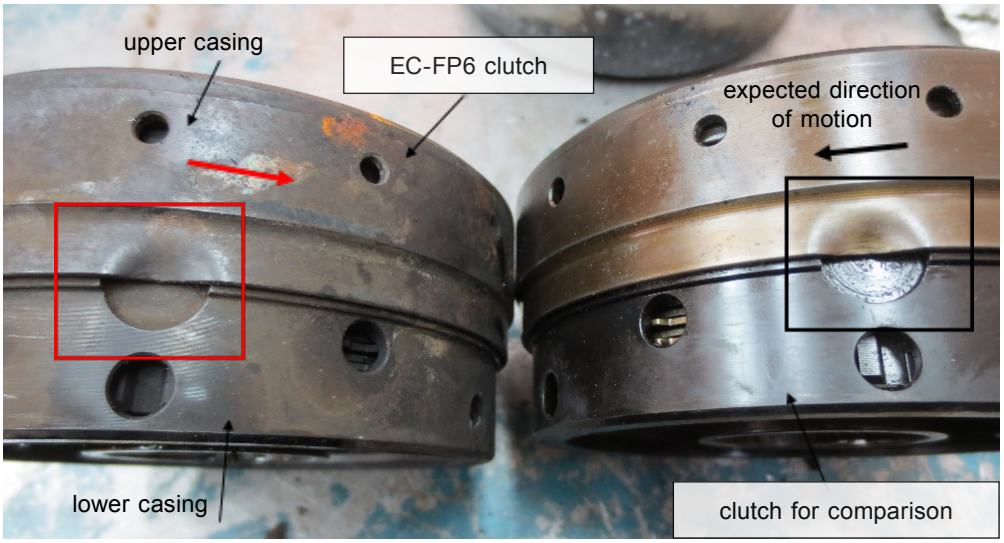

Figure 8. Shift in the opposite direction of the alignment dimple on the clutch

- Crankshaft: the crankshaft support bearing was in good condition. The shaft had seized and was out-of-round at one end.
- Pushrods: the pushrod for exhaust no. 4 had an oval mark on the surface in contact with the cam, which indicated that the rotational motion of the cam was not correct. The remaining pushrods were in good condition.
- Camshaft: the cams on the number 4 cylinder exhibited material wear, particularly the number 4 exhaust cam.

The remaining engine components and accessories had been damaged by the fire and could not be inspected or tested.

1.16.3. DGAC Type Certificate no. 281-I

The type certificate data sheets used as the basis for issuing the RCA for aircraft EC-FP6 contained the following information:

- Weight and balance: between 26.0% and 32.5% of the mean aerodynamic chord.

- Maximum takeoff weight: 450 kg
- Empty weight: 281 kg.
- Propeller: two-blade tractor.

1.16.4. Technical report on the aircraft after its manufacture

As part of the construction process, a technical report was prepared in December 2008 by Aero Empordá (manufacturer), which was presented to AESA in order to register the aircraft. This technical report confirmed that the aircraft had been manufactured with a two-blade propeller and no ballistic parachute. It also included the following information of interest to the investigation:

- A weighing of the aircraft, which relied on distance values from the datum for the Tecnam P2002 Sierra model (which are different from those for the Tecnam P2002 Sierra de Luxe),
- The center of gravity limits were specified between 26% and 32.5% (as in the type certificate but different from those specified in the P2002 Sierra and P2002 Sierra de Luxe flight manuals),
- A dry weight of 314 kg (in excess of the 281-kg weight in the type certificate and the 289-kg weight specified in the P2002 Sierra and P2002 Sierra de Luxe flight manuals),
- A useful weight (fuel, pilot weight, passenger weight and baggage weight) of 136 kg,
- A report from a production flight approved by FSO no. 4, with a total weight of 494 kg (54 kg above the maximum allowed), which resulted in a stall speed of 64 km/h.

The owners were not aware of this information.

1.16.5. Flight manual

The flight manual used by the owners was for a TECNAM P2002 SIERRA DE LUXE (FLIGHT MANUAL Doc. No. 22-13-002-00, edition no. 1, 8 March 2008, revision 0) [22], which provided the following information of interest to the investigation[23]:

[22] Two additional versions of this manual were published, on April 2011 and May 2012. The latter version included a supplement for installing another propeller with variable pitch and also with two blades. No reference was made regarding the possibility of installing a three-bladed propeller.

[23] Only the parts of the procedures of interest to the investigation are included.

- (Section 1) Maximum takeoff weight: 450 kg
- (Section 1) Maximum landing weight: 450 kg
- (Section 1) Empty weight: 289 kg
- (Section 2) CG: center of gravity limits: 20% to 33% of the mean aerodynamic chord.
- (Section 2) Fuel: the engine must be supplied from both tanks during every phase of flight. If there is an imbalance between the tanks, correct it using the fuel levers in the cockpit.
- (Section 2) Crosswind: maximum crosswind component allowed is 15 kt (28 km/h).
- (Section 3) Engine failure immediately after takeoff:
  - Find a suitable place to land safely.
  - The landing must be in the forward direction with small changes in steering that do not exceed 45º left or right.
  - Fuel valves: OFF
  - Flaps: as required
- (Section 4) Engine start: Fuel valves, both ON.
- (Section 4) Before takeoff:
  - Do the check of the ignition system (maximum drop of 300 RPM).
  - Flaps: 15º
- (Section 4) Engine stop:
  - Keep the engine running at 3000 RPM for 2 minutes to lower any residual heat.
  - Electric pump: OFF
  - Disconnect all electrical loads
  - Magnetos: OFF
  - Master: OFF
  - Fuel valves: both OFF.
- (Section 5) The drop in altitude when recovering from a stall with a 30º bank angle is 100 ft.
- (Section 6) The manual does not provide the information necessary to calculate the aircraft's weight and balance. The datum distance values did not match those used to weigh aircraft EC-FP6 after it was manufactured.

1.16.6. Owners' checklists

The owners who purchases the aircraft in 2011 prepared a checklist that they had laminated and carried onboard. The list had two parts, one for normal procedures and another for emergency procedures. The emergency procedures had been taken from the flight manual (identified as "emergency landing", it combined an engine failure during the takeoff run and immediately after takeoff), and they had added the procedure for activating the ballistic parachute. The normal procedures contained most of the information in the manual, although several actions had been modified with respect to the contents of the flight manual:

- The position of the flaps on takeoff: it was left to the pilot's discretion and not at 15º, as instructed in the flight manual.
- Ignition system check: specified a maximum drop of 150 RPM, instead of 300 RPM as in the manual.
- Position of the fuel valves: it stated to operate with one valve closed and the other open, changing the selected tank every 15 minutes.

1.16.7. Refuelings and fuel calculation at the time of the accident

Based on the record of refuelings provided by the Casarrubios aerodrome[24] and the number of hours flown since March 2016, the average consumption of the aircraft was calculated to be 11.73 l/h, with the maximum being 14.8 l/h and the minimum 8.3 l/h. According to the owners, the aircraft consumed 13-14 l/h[25].

The flight activity and last refuelings carried out in January and February were as follows:

- 7 January: two flights were conducted lasting 2 and 1.25 h. After the last flight, the aircraft was refueled with 68 l[26].
- 8 January: a 3-h flight was conducted. The aircraft was refueled with 27 l[27] and then flown for 1.5 h. This is the last time the aircraft was refueled.

[24] The aircraft was based at this aerodrome, and it is there that it was refueled.

[25] The Tecnam P2002 Sierra de Luxe and P2002 Sierra flight manuals specify a consumption in cruise flight of between 13.6 (at 50% of maximum power at takeoff) and 20.4 l/h (at 75% of maximum power at takeoff). The Rotax 912 ULS user's manual specifies a consumption of 27 l/h (at full power at takeoff), 25 l/h (at maximum continuous power) and 18.5 l/h (at 75% of maximum continuous power).

[26] According to the owner who refueled it, he filled it to capacity.

[27] According to the owner who refueled it, he filled it to capacity and checked it visually. This is equivalent to a consumption of 9 l/h.

- 28 January: a 1-h flight was conducted, after which the accident pilot flew to the Villaverde aerodrome with the same plan as on the day of the accident. The flight is estimated to have lasted 1.30 h.

- 8 February: accident flight. The estimated flight time was 0.65 h.

Given that the 27-l refueling of 8 January completely filled the fuel tanks, the amount of fuel onboard the aircraft before taking off from Casarrubios and before taking off from Villaverde was calculated for various consumption rates[28] (8, 12, 14 and 15 l/h):

	consumption (l/h)			
	8	12	14	15
Fuel before taking off from Casarrubios	69,6	54,4	46,8	43
Fuel before taking off from Villaverde	64,4	46,6	37,7	33,25

These figures show that in the least favorable case (15 l/h consumption), the aircraft had 33 l at the time of the accident and 43 l when the pilot started the flight from Casarrubios.

1.16.8. Weight and balance calculation for aircraft EC-FP6

The results from the above table were used to estimate the aircraft's weight and balance under the following eight operating conditions:

- For the flights of 8 February 2017 (without baggage):
  1. prior to takeoff from the Casarrubios aerodrome under maximum fuel consumption conditions (15 l/h).
  2. prior to takeoff from the Casarrubios aerodrome under minimum fuel consumption conditions (8 l/h).
  3. for the accident flight: prior to takeoff from the Villaverde aerodrome under maximum fuel consumption conditions (15 l/h).
  4. for the accident flight: prior to takeoff from the Villaverde aerodrome under minimum fuel consumption conditions (8 l/h).

[28] Assuming the average consumption rates calculated, the maximum and minimum consumption rates and the rate provided by the owners.

- For other typical aircraft configurations (without baggage, with one or two persons onboard and with tanks half full and completely full):

  5. with two 86-kg[29] passengers and maximum fuel load.
  6. with two 86-kg passengers and half fuel load.
  7. with one 86-kg passenger and maximum fuel load.
  8. with one 86-kg passenger and half fuel load.

	Empty aircraft	pilot[30]	copilot[31]	fuel[32]	Total weight (max: 450 kg)	Center of gravity (between 26% and 32.5%)
1	314 kg	85 kg	60 kg	43 l (32,6 kg)	486,68 kg	30,10%
2	314 kg	85 kg	60 kg	69,6 l (52,8 kg)	506,89 kg	29,46%
3	314 kg	85 kg	60 kg	33,25 l (25,2 kg)	479,27 kg	30,34%
4	314 kg	85 kg	60 kg	64,4 l (48,9 kg)	502,94 kg	29,58%
5	314 kg	86 kg	86 kg	100 l (76 kg)	562,00 kg	29,20%
6	314 kg	86 kg	86 kg	50 l (38 kg)	524,00 kg	30,29%
7	314 kg	86 kg	---	100 l (76 kg)	476,00 kg	27,97%
8	314 kg	86 kg	---	50 l (38 kg)	438,00 kg	29,18%

With no baggage and the fuel tanks filled to capacity, the aircraft only has a margin of 60 kg to account for the baggage and the persons onboard, including the pilot. The typical flights carried out by the owners (two persons onboard and fuel tanks full, or at a minimum, half full) represented a 16 to 25% increase in the maximum allowed operating weight for this aircraft.

1.16.9. Weight and balance calculation for the Tecnam P2002 Sierra aircraft

In light of the above information on the excess weight of aircraft EC-FP6, the weight and balance were calculated for a TECNAM P2002 Sierra aircraft with an empty

[29] 86 kg is the weight specified internationally for any person onboard in the European and American certification standards (such as the CS-VLA) when doing weight and balance calculations. Order 14 of November 1988, which lays out the airworthiness requirements for powered ultralight aircraft (ULM), states that the weight "shall not be less than 85 kg".

[30] Assuming an arm of 1.830 m, taken from "Weight and C.G. for ULM. Report 2002/335", provided by Tecnam, since this figure is not included in the flight manual.

[31] Assuming an arm of 1.830 m, taken from "Weight and C.G. for ULM. Report 2002/335", provided by Tecnam.

[32] Assuming a density of 0.760 kg/l and an arm of 1.530 m, taken from "Weight and C.G. for ULM. Report 2002/335", provided by Tecnam.

weight of 281 kg, which is the value given in the datasheets of type certificate number 281-I. The certification data for this aircraft state that it has two seats. With the aircraft fully loaded with fuel, it would only be able to remain below its MTOW of 450 kg if the two occupants combined did not weigh more than 93 kg.

Useful weight of the Tecnam P2002 Sierra aircraft registered in Spain

Due to the low useful weight (weight available for fuel and persons onboard) that aircraft EC-FP6 had (136 kg), and in an effort to evaluate if this was a one-time case, the useful weight of the Tecnam P2002 Sierra aircraft registered in Spain on 1 March 2017 was calculated. Of the 51 aircraft registered in Spain, the average useful weight is 132.9 kg, with high and low values of 169 and 89 kg. This means that for an operation with the tanks full of fuel (76 kg of weight), the average weight available for a pilot, passenger and baggage would be 56.9 kg (with high and low values of 13 and 93 kg).

Application of the calculation criteria for maximum weight in the CS-VLA and CS-23 regulations

Maximum weights are calculated based on the aircraft's certification regulations. In the case of Spain, this regulation is the Order of 14 November 1988, but it does not include a specific criterion for calculating the maximum takeoff weight beyond the legal value defined in the regulation (450 kg for two-seat airplanes or helicopters and 300 kg for single-seat aircraft).

So as to ascertain the criteria for calculating the maximum takeoff weight, the two European regulations were used that would apply to those aircraft in an immediately higher category in terms of weight than ultralights:

- CS-VLA (very light aircraft), applicable to aircraft with a MTOW of up to 750 kg, and
- CS-23, applicable to aircraft with a MTOW of up to 5670 kg.

Both regulations (subpart B-Flight, CS 23.25 and CS-VLA 25, weight limits) specify that the maximum weight shall not be less than the weight calculated in any of the following ways:

Regulation		Maximum weight calculated adding:		
CS-23	2.i	ach occupied seat with a weight of 77 kg[33]	Oil at maximum capacity	Fuel for at least 30 min of flight time at maximum continuous power[34]
	2.i.i	Minimum crew	Oil at maximum capacity	Fuel at maximum capacity[35]
CS-VLA	2.i	Each seat occupied by a person weighing 86 kg	Oil at maximum capacity	Fuel for 1 hour of operation at maximum continuous power[36]
	2.ii	An 86 kg pilot	Oil at maximum capacity	Fuel at maximum capacity

Applying these criteria to the 51 aircraft registered in Spain yields the following results:

- Findings applying criterion in CS-23:
  - Of the 51 aircraft, only 6 (11%) would yield a maximum calculated weight below 450 kg with both calculation methods (2i and 2ii).
  - Of the remaining 45 aircraft, the maximum calculated weight would exceed the 450-kg maximum by an average of 8% (with low and high values of 3% and 17%).
- Findings applying criterion in CS-VLA:
  - Applying criterion 2.i, none of the 51 aircraft registered would have a maximum calculated weight below 450 kg. The average excess weight would be 13% (with low and high values of 5% and 32%).
  - Applying criterion 2.ii, only 6 aircraft (the same that were below the weight applying the criterion in CS-23) would have a maximum calculated weight below 450 kg. The remaining 45 aircraft would have a maximum calculated weight above 450 kg by an average of 8%, with low and high values of 3% and 17%.

[33] In the case of "normal and commuter category aeroplanes". In the case of "utility and acrobatic category aeroplanes" the weight per occupant is 86 kg. .

[34] According to the engine user manual, it would be 12.5 l, equivalent to 9.5 kg.

[35] According to the aircraft manual, it would be 100 l, equivalent to 76 kg.

[36] According to the engine user manual, it would be 25 l, equivalent to 19 kg.

- Findings on the 6 aircraft whose maximum calculated weight would be below 450 kg:
  - These are aircraft whose empty weight is 281 kg (5 aircraft) and 283 kg (1 aircraft).

Manufacturer's report on the weight and balance of the ULM Tecnam P2002 Sierra de Luxe

In May 2014, the aircraft manufacturer prepared a weight and balance report for the TECNAM P2002 Sierra de Luxe. The data used were based on reference values that did not match any of those used in the CS regulations. A standard weight of 70 kg was used for a person (versus 86 kg), and fuel for one and a half hours of flight time (versus one hour or half an hour). The maximum weight was calculated using:

- Empty weight: 281 kg
- Two occupants: 140 kg (two 70-kg individuals)
- Fuel: 29 kg (38 l, fuel for 1:30 h of flight time at maximum continuous power)

1.16.10. Queries made to engine and aircraft manufacturers

The manufacturers of the aircraft and engine were asked several questions pertaining to the hypotheses proposed during the investigation.

One of them involved the runtime possible with the fuel valves closed. Tecnam confirmed that the fuel remaining in the fuel lines (from the tanks to the engine) is approximately 0.5 to 0-75 l. With the gas lever at idle, the engine would stop in 3 minutes, and with it at full power, the engine would stop in 30 seconds.

Rotax was asked about a fault condition included in the ROTAX 912 engine user manual, which, in the chapter on troubleshooting, identifies the following situation:

Engine run — **Engine keeps running with ignition off**

Possible cause	Remedy
Overheating of engine.	Let engine cool down at idling at approx. 2000 rpm.

Rotax was asked about the conditions required for this situation to occur. Rotax replied that this situation is caused by an increase in engine temperature in combination with a mix of fuel and inflammable air. These conditions would lead to

a self-ignition, and therefore to a momentary rotation of the camshaft. Rotax specified that this condition can occur in isolated cases and that if it happens, the camshaft would only rotate a few times. This condition mentioned in the user manual does not mean that the engine keeps turning continuously and indefinitely. Rotax reported that it would revise the cause of this failure in the next edition of the manual.

1.17. Organizational and management information

Not applicable.

1.18. Additional information

Not applicable.

1.19. Useful or effective investigation techniques

Not applicable.

2. ANALYSIS

The analysis of the accident of aircraft EC-FP6 has been arranged into seven sections, which consider the following areas:

- 2.1: Presentation of the findings from the impact based on an analysis of the wreckage.
- 2.2: Reconstruction of the flight undertaken by the aircraft on 8 February 2017 from the time it took off from Casarrubios del Monte, based on statements and reports from emergency services personnel.
- 2.3: Conditions, from an operational standpoint, in which the final take off was flown.
- 2.4: Planning and decision making during the flight.
- 2.5: Study of the engine problem described by the pilot.
- 2.6: Compilation of safety-related aspects identified in this and other investigations conducted by the CIAIAC.
- 2.7: Overweight operations in Tecnam P2002 Sierra aircraft.

2.1. Analysis of the impact

The absence of drag marks and damage to fruit trees in the field where aircraft EC-FP6 fell were a clear indication of a vertical impact. The confinement of the debris to the accident site ruled out the possibility of a structural in-flight failure. The differences in the compression and torsional marks in the right and left wings, the marks on the ground, the parts of the aircraft that penetrated the ground and the extent of the damage to the engine and propeller blades all yield the following conclusions regarding the impact:

- The aircraft had no horizontal translational speed, only vertical speed. The impact was highly vertical.
- The aircraft's orientation in the moments immediately before the impact was approximately 60º.
- Just before it impacted the terrain, the aircraft had considerable pitch and bank angles.
- The initial contact with the ground was made by the right wingtip, causing the wing to bend and the compression marks that affected the entire right wing. This contact left specks of white paint on the ground that were found unburned.

- The next contact occurred almost simultaneously with the leading edge on the left wing, the nose gear (which left the left actuator rod and part of the fairing buried in the ground) and the propeller (which left one of the propellers practically intact and half buried). This contact indicated a pitch attitude that was still considerable. This second contact with the ground resulted in the glass fragments from the canopy and the fuselage fragments found further forward, as shown in Figure 4.
- The aircraft then moved two meters aft, and the tail assembly fell, which left the aircraft level on the ground on a heading of 142°. The canopy, which was closed at the moment of impact, detached from its housing during this shift to the rear.
- Given the damage to the structural parts of the aircraft and to the engine, the impact is not believed to have been a high-energy impact.

As for the aircraft configuration, the following conclusions were drawn:

- The flaps were retracted.
- The aircraft had fuel. This condition was confirmed both the by the calculations done (even assuming maximum consumption, which would be the least favorable condition), as well as by the fact that the aircraft burned for 30 minutes. The aircraft would have had a minimum of 33 l of fuel onboard (33% of the tanks' capacity).
- The fuel valve for the right tank was open.
- It was not possible to determine if, despite the presence of fuel in the aircraft, the correct tank was aligned and how much fuel remained in the two tanks. In other words, it is possible that despite having fuel, it could have been in the tank that was not selected in the cockpit. In this regard, operating with both fuel valves open, as specified in the aircraft flight manual, would have avoided this possibility.
- The elevator control in the moment immediately prior to the impact was in a nose up position.

As concerns the analysis and inspection of the engine and propeller, the following conclusions were drawn:

- Although a disassembly of the engine indicated that it was either stopped or outputting little power, the absence of damage to the three propeller blades indicates that the more likely possibility is that the engine was stopped at the time of impact.
- No operating problem was found to explain, or that could have influenced, the lack of engine power just before the impact.

- The engine had not seized.
- An inspection of the engine suggests (due to the coloration of the spark plugs and cylinders) that it had been run at low cylinder head temperatures which, although within limits, would have degraded the engine's performance. This operating condition should have been detectable by the pilot using the temperature gauge in the cockpit, and would have required leaning the mixture. Even so, this is not believed to have had any effect on the accident.
- The presence of a short-circuited spark plug is also thought to have had no effect on the accident since the remaining spark plugs, including the other one in the same cylinder, were in good working order.
- The metallic particles found in the detector originated in the number 4 exhaust cam and its associated tappet. This was indicative of a future engine problem, probably resulting in a seizure in approximately 500 hours.

2.1.1. Irregular maintenance on the friction clutch

In keeping with the findings on the condition of the engine at the time of the accident, and although it had no effect on the accident, the investigation detected an irregular maintenance practice involving the friction clutch installed in the aircraft.

The friction clutch serves a dual purpose when there is a propeller impact with the engine running. On the one hand, it acts as a fuse link, protecting the crankshaft by absorbing part of the rotational force; and on the other, during maintenance tasks, it indicates if any damage has extended "downstream" into the engine, requiring additional inspections. The friction clutch is thus inspected when the aircraft's propeller has impacted the ground with the engine running. Such was the case in September 2015. The information supplied by the owners and by the maintenance center did not provide any indication as to the nature of the work done on the friction clutch or what condition it was in after the impact, since no supporting documentation was available. The information provided by the maintenance center listed a task involving a "check and tune-up of the gearbox", which contains the friction clutch.

Based on information provided by the Rotax representative in Spain, when the alignment dimple on a friction clutch is found to have shifted after an accident, the clutch is replaced with another one, it is never repaired. In the case of the clutch installed on aircraft EC-FP6, the clutch had been worked on and the alignment dimple (which acts as an indicator) had been forced beyond its normal position, leading to a condition that cannot occur.

Since it was impossible to obtain any kind of documentation on the last repair, investigators were unable to determine what maintenance center worked on the

clutch. The only thing that could be confirmed is that the last maintenance center, Álamo Aviación, inspected the friction clutch, as confirmed in the listing of maintenance tasks. Several situations could have arisen during this check:

- the clutch was not inspected, despite documentation to the contrary, or
- the clutch was inspected and the condition of the friction clutch was not identified, or
- the fault in the clutch was identified and left uncorrected, or
- the fault in the clutch was identified and instead of installing a new one, an effort was made to repair it, causing the shifted alignment marks found after the accident.

At least one of the above situations, or a combination thereof, was involved in the inspection of the aircraft conducted by Álamo Aviación. Since it is impossible to confirm the origin of the work done on the clutch, a generic safety recommendation is issued intended to enhance the training given to the mechanics on the maintenance techniques and practices to be used on the ROTAX engines that are maintained by the Álamo Aviación maintenance center.

2.2. Reconstruction of the flight

The investigation of accidents like the one involving EC-FP6, which do not require any devices to record flight data and whose operations take place in uncontrolled airspace, present difficulties when it comes to reconstructing and confirming information on the flight and the operation. In the case of aircraft EC-FP6, the flight had to be reconstructed based on the accounts of seven eyewitnesses who saw the accident, of the pilot who was at the aerodrome of origin, and on the response times of emergency services personnel. This is because the GPS device, which would have confirmed the flight path, did not yield any information.

Based on the statements, the following sequence of events is likely for the flight of aircraft EC-FP6 on 8 February 2017, the day of the accident:

- At around 11:00, the pilot called the restaurant located across from the Villaverde aerodrome to make a lunch reservation for two people.
- The pilot drove to the Casarrubios del Monte aerodrome in his own car that morning. The aircraft was seen in the hangar area between 13:00 and 13:30 by a pilot who was returning from a flight. This person reported seeing the aircraft stopped, with the propeller turning, and confirmed that there were two persons onboard.
- The aircraft landed on runway 09 at the Villaverde aerodrome.

- After landing, it taxied to the runway 27 threshold and remained there for a few minutes with the engine running without either person exiting the aircraft.
- During the time that the aircraft was stopped, the pilot called the restaurant to cancel the reservation since "*he was unable to stop the aircraft and he could not leave it here*".
- After making the call, the aircraft lined up on the runway and took off from runway 27.
- After rotating, the aircraft climbed to an altitude estimated to have been about 20 m at most.
- The aircraft banked three times in a row in the following sequence: left-right-left.
- After these banking motions, the aircraft pitched down at almost 90° and fell until it impacted the ground at 14:30, after which it caught on fire. This fire would later cause the ballistic parachute mechanism to explode.

Given the 130-m distance between the runway centerline extension and the point where the aircraft crashed, and the eyewitness statements, a left turn after takeoff can be ruled out. Therefore, the aircraft's position relative to the runway was caused by the motion of the aircraft during the initial climb, during the descent or a combination of both.

2.3. Operating conditions

The description of the aircraft's attitude provided by the eyewitnesses (banking, maximum altitude reached with respect to the horizontal distance traveled and high pitch angle) points to the aircraft's lack of speed while climbing after takeoff. This lack of speed is consistent with the problems the aircraft had gaining altitude (it only rose about 20 m according to the estimates conducted), with the loss of effectiveness of the control surfaces (which would explain the successive banking in a situation in which the wind was almost entirely a crosswind) and, finally, the stall of the aircraft.

These conclusions are consistent with the analysis of the impact, which showed that the aircraft had no translational speed, that it descended almost vertically at a considerable pitch angle. In other words, there is agreement between the eyewitness statements and the way in which the aircraft fell.

Of particular note, from an operational standpoint, are two of the conditions in which the aircraft took off: the weather conditions in terms of the wind, and the excess weight of the aircraft.

Operating with a crosswind near the certification limits:

The values shown in Section 1.7.2 for the four stations near the Villaverde aerodrome yield the same conclusions in terms of:

- the wind direction at the aerodrome at the time of the takeoff and accident, which was from the north-northwest, probably from 321°, the direction recorded at the wind farm and consistent with the readings at the Mora de Toledo station. This direction was also confirmed by the fire pattern left on the aircraft wreckage, and which resulted in the tail assembly and the left wing being unaffected by the fire.
- the wind speed could have increased around the time of the takeoff.
- the wind speed values, considering the difference in altitude and distance from the stations with respect to the aerodrome, indicate that the crosswind component was likely very close to the aircraft's certification maximums.

Taking off with a crosswind, especially when it is of considerable intensity, requires the use of additional techniques during takeoff to compensate for the wind's effect on the aircraft. In other words, this condition poses an added complication to the operation for a pilot with little experience and who only flew sporadically.

Overweight operation:

The calculations included in Section 1.16.8 show that the aircraft's weight when it took off from the Villaverde aerodrome was in excess of the certified maximum by between 29 kg (in the case of maximum fuel consumption) and 53 kg (in the case of minimum fuel consumption).

The weight and balance of an aircraft affect the safety and efficiency of the operation. Flying an aircraft with excess weight has a direct effect on the operation. As the analysis of this accident has revealed, overweight operations would have the following, and other, effects: a longer takeoff run is required, it decreases the climb speed, it lowers the climb angle, it restricts the maneuvering room and it increases the stall speed.

2.4. Planning and decision making before and during the flight

Weather conditions during the flight:

The weather forecast for 8 February 2017 (TAFs issued at 10:00 and 12:00 and significant low-level charts) called for the presence of turbulence and a moderate

probability of a crosswind at 28 km/h[37] and gusting to 46 km/h for the area and time period when the flight would take place. This information, which should have been checked by the pilot as part of his flight preparations, must have been unknown to him, since the wind values were high enough to have discouraged the pilot from undertaking the flight. That is to say, the pilot probably did not check the TAF forecasts or the low-level charts for that day to ascertain the weather situation in the area where he would be flying.

The nature of the flight to be performed, with the pilot having already made a reservation that same morning because he wanted to show the passenger the restaurant of which he had spoken to her on numerous occasions (as stated by the restaurant's owner), is believed to have influenced the pilot's decisions during the flight. The pilot had a plan for that day involving another individual who was not related to him and which had also involved traveling to the aerodrome. The natural tendency, especially if there is no information that requires changing the initial plan, as the weather forecast would have in this case, is to continue with the predetermined plan. This is what must have happened on the day of the accident when the pilot took off from Casarrubios del Monte.

Weight and balance calculations for the flight:

As the calculations included in Section 1.16.8 show, the aircraft's weight when it took off from Casarrubios exceeded its maximum certified weight by anywhere from 37 kg (in the case of maximum fuel consumption) to 57 kg (in the case of minimum fuel consumption). It is the pilot's responsibility, as part of the flight preparation and planning activities, to calculate the aircraft's weight and balance. In this case, the pilot did not perform these calculations, and as the conversations with the other owners revealed, neither they nor the accident pilot performed them due to a lack of training and knowledge of the characteristics of the aircraft they flew.

As concerns the weight and balance calculation, as noted in Section 1.16.5, the Flight Manual for the TECNAM P2002 SIERRA DE LUXE contains the following anomalies, which are the focus of a safety recommendation aimed at the aircraft's manufacturer:

- The center of gravity limits are different from those specified in the sheets of DGAC type certificate no. 281-I:
  - Flight manual: CG limits from 20% to 33% of the MAC
  - DGAC type certificate no. 281-I: CG from 26.0% to 32.5% of the MAC.
- It does not have the information needed to do the balance calculation, namely the figures for the distance from the datum. In fact, this information had to be

[37] Maximum crosswind value for which the aircraft is certified.

requested from the manufacturer in order to do the calculations included in this report.

Therefore, while the owners would have been able to do the weight calculation, they would have been unable to calculate the aircraft's balance if they had wanted to. A safety recommendation is issued to the manufacturer to have it complete Section 6 and correct Section 2 in the aircraft flight manual based on the correct information.

Maintenance plan and use of opposite runways:

The wind speed also failed to dissuade the pilot either during the flight or the approach to the Villaverde aerodrome of the need to cancel the flight due to the unsuitable weather conditions, in terms of wind, for flying. The aircraft reached the Villaverde aerodrome as per the preset plan to land and eat at the restaurant. The wind was from 315º, meaning the most suitable runway for landing was 27. The pilot, however, landed on 09 for an unknown reason. Also unknown is his reason for later taking off in the opposite direction, an operation that is regarded as irregular.

Decision to continue flying with an engine problem:

The restaurant owner's statement provided the only information to investigators concerning a possible engine problem. In it, the pilot seemed to describe a problem related to the operation of the engine. The terms he used indicated that:

- the problem involved the engine not stopping, and furthermore that
- the problem had been detected on the ground, logically, when he tried to stop the aircraft to go have lunch. This situation is consistent with the statement from the two eyewitnesses who indicated that the aircraft was stopped at the runway threshold for several minutes and that the propeller continued turning.

Independently of the analysis of the engine failure, which is provided in Section 2.6, the pilot decided not to leave the aircraft at the aerodrome or call a mechanic or another of the owners to request help and ask about the problem that was occurring; instead, he decided to continue flying with an aircraft and engine that was running abnormally. When the engine problem appeared, they were on the ground and he had the possibility of opting not to continue the flight.

The decision to continue the flight could have been influenced by the fact that he was not at his home aerodrome and he had a passenger. The drawbacks from a logistical standpoint of leaving the aircraft at an aerodrome that was not his, calling a mechanic out and finding alternate transport for himself and the passenger to the aerodrome of origin probably weighed more heavily on him than the risks he was taking from a safety standpoint.

The feeling from all of the owners that the engine and aircraft "were running very well" and "had never given them any problems" could also have affected the pilot's decision to continue flying to Casarrubios, and to trust the reliability of the aircraft and engine.

Flight management during takeoff run:

After deciding to return to Casarrubios del Monte instead of staying at the Villaverde aerodrome and looking for an alternate solution to the engine problem, the pilot initiated the takeoff.

The eyewitnesses agree that the aircraft did not make a turn to the left; rather, it maintained a climb attitude on a constant heading in an effort to gain altitude. The final climb condition was the aircraft stalling with a significant crosswind component. The intention to return to Casarrubios at all costs must have been present in the pilot's insistence on gaining altitude and continuing to climb. The eyewitness statements indicate that the aircraft was having problems gaining altitude, and yet the pilot decided to continue the flight and not reject the takeoff.

The fact that the aircraft very likely took off without flaps[38] and climbed to 20 m indicates that at least in that phase of the flight, the engine was running. By the time the aircraft struck the ground, however, the engine was not at power, based on the findings presented in Section 2.1. The damaged condition of the wreckage and the lack of supporting data did not allow investigators to determine happened between those two instances and what caused that difference in the engine's operating condition, whether it was commanded by the pilot or it was due to an engine failure.

Handling of the emergency:

Once the aircraft was airborne, it stalled, as suggested by the eyewitnesses' statements. This was caused either by an engine malfunction or by a problem with the aircraft's operation and configuration, or a combination of both. It is not known if the pilot identified the symptoms of the situation. The way to respond to a stall is to lower the angle of attack in order to gain speed with the airplane as level as possible and apply power if available. In this case, the evidence found indicates that the pilot did not have the airplane configured in order to handle an in-flight emergency. One of the fuel valves was open, which means he also was not following the engine failure procedure, which calls for closing both fuel valves once the landing is assured. The flaps were retracted and it is possible that, due to the short time that elapsed between takeoff and impact, they were retracted for takeoff as well. As

[38] At the moment of impact, the aircraft's flaps were retracted. The short time that elapsed and the low speed reached make it highly unlikely the flaps were deployed for takeoff and then retracted.

described in Section 2.1, the aircraft was not level on impact. Everything thus indicates that the pilot did not properly handle the emergency or the stall which confronted him. The altitude reached, estimated to have been 20 m, was 10 m below the minimum recovery altitude specified in the flight manual. Therefore, even if he had reacted correctly, he would not have had sufficient altitude to recover from the stall.

The airplane's attitude immediately before impact indicated that it crashed with a high pitch and bank angle, inconsistent with a controlled landing attempt. The position of the elevator control indicated that the pilot was commanding the aircraft to pitch up before the impact, which is an instinctive response to an imminent impact with the ground.

2.5. Analysis of the engine problem described by the pilot

The terms used by the pilot to describe the engine problem were opposite those that usually occur in accidents in which the engines stop.

Self-ignition:

The engine's only autonomous mode of operation, meaning the engine remains running even though both the ignition source for the fuel mixture (magnetos) and the fuel supply (fuel valves) are removed, is for a self-ignition condition to arise. This condition, as reported by the manufacturer, could arise but would result in at most a couple of rotations of the cam shaft. Under no conditions would self-ignition allow the engine to run for several minutes at the runway threshold, during a takeoff run and then a climb to 20 m. In other words, the runtime described by the eyewitnesses rules out self-ignition as the source of the engine problem reported by the pilot.

Magnetos:

The procedure for stopping an engine entails, very simply, cutting the ignition source to the mixture (via the magneto switches in the cockpit) and then closing off the supply of fuel to the cylinders (via the fuel valves in the cockpit). Generally, the magnetos are operated first, which by itself would cause the engine to stop, as it would make it impossible for the mixture in the cylinders to combust. If the pilot had carried out this action and the engine did not stop, this would have meant that some part of the ignition system (wiring, magneto, ignition module, etc.) was in bad working order. The operation of the magnetos and the ignition system is verified during the pre-flight checks that should be conducted before any flight and that the pilot should have performed in Casarrubios before starting the flight that day. If he had detected any problems in the operation of the ignition system, he should have canceled the flight. This means that he either did not conduct the pre-flight check, or he did and the ignition system worked correctly, or he detected a problem and flew anyway, which would have been an unsafe action.

Fuel valves:

In any case, even though the magnetos by themselves would have stopped the engine, if there had been a problem with the system, shutting the fuel valves would, as a back-up measure, have stopped the engine. Based on the questions posed to the aircraft manufacturer, and confirmed with several maintenance technicians who work on these aircraft, the engine would stop between 30 seconds (if the throttle lever is placed at maximum power) and 3 minutes (if the throttle lever were at idle) after closing the fuel valves, this being the time required for the fuel remaining in the lines to be combusted.

These times and the description of the times and sequence of events described by the eyewitnesses rule out the possibility that the valves were operated correctly. If he had closed the fuel valves, the time that the aircraft remained stopped on the ground before taking off would have been enough to consume all the fuel remaining in the lines. If not, then upon starting the takeoff run on an upward sloping runway, any fuel remaining would certainly have been used up and the aircraft would not have been able to gain altitude.

Therefore:

- no technical reason was found for the engine not to have stopped. Everything seems to point to pilot error in the performance of the procedure to stop the engine.
- the possibility that the takeoff was carried out with the fuel valves closed is ruled out since upon opening the throttle, the engine would have stopped within 30 seconds, preventing the aircraft from gaining any altitude. Moreover, the flaps were probably not deployed, the takeoff run was uphill, the aircraft was overweight and there was a strong crosswind component.

2.6. Aspects related to ULM safety

The investigation into this accident identified several aspects related to safety, which will be discussed now and that require the issuance of safety recommendations. These aspects were identified not only in this investigation, but are common to other accident investigations involving ULMs conducted by the CIAIAC.

Risk of a ballistic parachute exploding after an accident:

The accident aircraft had a ballistic parachute installed that exploded as a result of the fire that broke out after the accident. This explosion was preceded by the high-speed ejection of the parachute activation lever, which alerted the individuals who were attempting to rescue the aircraft occupants, who then moved away. This

prevented the explosion from seriously injuring these individuals who, unaware of the danger, were attempting to help the occupants.

Considering the lack of information for first responders to an aviation accident, the serious risks to personal safety posed by the explosion of a device of this type, and the fact that this situation has arisen time and again in other accidents investigated by the CIAIAC, this Commission deems it necessary to insist on the safety recommendations pertaining to ballistic parachutes. As a result, the nine safety recommendations issued in the report ULM A-006/2016 (REC 34/17 to REC 42/17, both included), involving ballistic parachutes, are mentioned in this report again. These recommendations span the range of problems related to markings, information, training and awareness of all parties involved, directly or indirectly, in flight activity.

Lack of safety culture and basic training in the ULM community:

The interviews conducted with the aircraft's owners confirmed them to be a group of individuals who were concerned about and interested in "doing things right" and in having all of their procedures "in order". As proof, they had written procedures and checklists that they had laminated and put onboard the aircraft. One of them subscribed to the engine manufacturer's publications and they had implemented an internal set of very sensible guidelines, such as requiring a series of "dual control" flights whenever any of them went a certain length of time without flying or when a new member joined the group, and they had a tacit agreement not to fly if the wind was over a certain speed.

Despite these practices, the investigations into this and other accidents have revealed that there is a large gap in the knowledge of ultralight pilots in terms of some basic safety aspects:

- Ignorance of the aircraft's weight limitations. The owners of this aircraft systematically flew with excess weight. The mere fact that the aircraft had two seats did not mean it could hold two persons under any fuel and baggage weight conditions. In the case of aircraft like the one in this accident, a Tecnam P2002S, the weight margins are particularly slim (see Section 2.7).
- Differences between the procedures used by the pilots and those contained in the flight manual. Differences were found in the accident aircraft involving the operation of the fuel valves, the drop in engine RPMs during the magneto test and the position of the flaps on takeoff.
- Lack of flight planning and preparation. As concerns the meteorology, there is:
  - on the one hand, ignorance of and problems with interpreting significant low-level maps and aerodrome forecasts that would be relevant to this type of flight. It is not sufficient for the weather at the moment of takeoff at the

aerodrome of origin to be good. The pilot has to know what weather to expect in the area he is planning to fly through.

- and on the other hand, the perception that aircraft can "get through anything", even weather, thanks to the avionics equipment onboard.

- Incorrect handling of in-flight emergencies: the attitude with which aircraft impact the ground indicate that they are not under the control of the pilot. Training on basic emergencies, such as dealing with a stall or in-flight engine stoppage, must be thorough and internalized. Pilots should be aware of the need to retrain on these types of maneuvers once their initial training is complete. This is necessary in order to familiarize themselves with how their aircraft behave, and to be ready to react appropriately.

- The decisions made during this accident, from the flight planning to how the emergency was ultimately handled, reveal a lack of safety culture as it pertains to airmanship. Flying mistakes do not offer second chances.

- Failure to apply and adhere to procedures: procedures and checklists are very useful tools that prevent human error. No matter how well a procedure may be memorized, it has to be carried out or reviewed using a checklist. These lists identify mistakes and are particularly useful in situations involving anomalies or a change in routine that result in a normal or standard procedure not being performed (such as the engine failing to stop).

A safety recommendation is issued to AESA pertaining to these aspects to have it conduct education campaigns using the most suitable means for this purpose in ultralight airfields and/or in concert with flight schools. The goal of these campaigns is to make ultralight pilots realize that these factors are present in most ULM accidents, all of which are avoidable.

2.7. Maximum weight and certification of TECNAM P2002 SIERRA aircraft

The operating conditions of aircraft EC-FP6 showed that the owners systematically flew it with excess weight. While it is true that person ultimately responsible for maintaining the aircraft within its weight and balance limits is the pilot flying, aircraft EC-FP6 had, due to its empty weight (289 kg) and its maximum certified legal weight (450 kg), very little margin in terms of useful weight (weight for fuel, pilot, passenger and baggage). The net result is that with the aircraft fully refueled, only 60 kg were available, meaning that:

- Firstly, despite having two seats, this was misleading for users since with the tanks full, this aircraft would only be allowed to operate with one person, and

- Secondly, it allowed for a weight of 60 kg without baggage, which is well below the average weight of an individual (86 kg) for the sole occupant it could accommodate.

These figures were unknown to the owners and in their effort to avoid engine stoppages due to fuel starvation, they always tried to fly with the tanks at full capacity, unaware of the aircraft's weight limitations.

The situation that occurred is not exclusive to aircraft EC-FP6, since as the calculations contained in Section 1.16.9 show, it applies to all TECNAM P2002 SIERRA aircraft registered in Spain on 1 March 2017.

The high empty weight of these aircraft compared to their maximum weight means that of the 51 TECNAM P2002 SIERRA aircraft registered in Spain on 1 March 2017, with the fuel tanks full:

- None of the 52 aircraft would be allowed to fly with two adults onboard, each weighing a standard calculation weight of 86 kg.
- Only six of the aircraft have a weight margin of 93 kg for the pilot, passenger and baggage. This means that one person, the pilot, would be allowed to fly assuming the standard calculation weight of 86 kg, with some left over for baggage. It would still be unable to fly with two persons onboard.
- For the remaining 45 aircraft, the values available for the weight of the pilot, passenger and baggage are well below 86 kg. The most extreme value is 13 kg, for an aircraft whose empty weight is 361 kg.

This information, though it should be familiar to users, is the subject of a safety recommendation for AESA. The recommendation aims to inform users of the weight limitations for passengers and baggage when an aircraft is refueled to maximum capacity, and that depending on the aircraft's empty weight, there are aircraft that cannot be flown with the tanks full or with two passengers.

Review of maximum weight certification criteria

The conclusions drawn about the useful weight call into question if the 450-kg value is truly valid as this aircraft's maximum certification weight. For this reason, the procedures for calculating the maximum weight used in the CS-VLA and CS-23 were utilized (see Section 1.16.9), even if they are not applicable to this aircraft type.

The results of these calculations indicate that of all the TECNAM P2002 SIERRA aircraft registered in Spain, the only ones that would comply with a maximum weight below 450 kg are those whose empty weight is 281 kg, which coincidentally is the weight specified in airworthiness type certificate no. 281-I issued by Spain's Civil

Aviation General Directorate. In other words, when this type certificate was issued, the calculations done with an empty weight of 281 kg complied with the calculations used in the regulations to calculate the maximum weight. The problem is that the aircraft that are subsequently registered have such high empty weights that despite using the same type certificate, it is not viable to certify them to a maximum weight of 450 kg.

Against this background, a safety recommendation is issued to AESA to have it review the certification criteria for TECNAM P2002 SIERRA aircraft within the group of ultralight aircraft with a maximum weight of 450 kg, as it does not seem logical to include it with this group of aircraft. Instead, it should be in a higher aircraft category, such as VLAs.

Review of the type certificate for Tecnam P2002 Sierra De Luxe aircraft

The current situation in Spain involving the Tecnam P2002 Sierra De Luxe is as follows:

- The TECNAM P2002 SIERRA DE LUXE is being certified using the airworthiness type certificate for the Tecnam P2002 SIERRA, which is a different aircraft.
- Type certificate no. 281-I, used to certify the De Luxe model, does not have a specific section for the P2002 SIERRA De Luxe variant.
- The flight manuals for the TECNAM P2002 SIERRA and P2002 SIERRA DE LUXE are different and have basic differences that affect the aircraft's balance and empty weight.
- The aircraft registry in Spain identifies all aircraft as TECNAM P2002 SIERRA, whether they are DE LUXE or not. There is no difference.

In other words, the existence of the TECNAM P2002 SIERRA DE LUXE model is ignored in Spain. To correct this situation, a safety recommendation is issued to AESA to have it issue either a new airworthiness type certificate for the DE LUXE model or to include it within the TECNAM P2002 SIERRA, and thus regularize the situation of these aircraft.

3. CONCLUSIONS

3.1. Findings

General:

- The aircraft had the necessary certificate to make the flight.
- The aircraft had 965 flight hours at the time of the accident.
- The pilot had the licenses necessary to make the flight.
- The pilot had limited and sporadic experience on ultralight aircraft. He had flown 12 hours in the last year. All of his experience was on that aircraft, of which he was a co-owner.
- The pilot was familiar with that day's flight path, as he had flown it several times before, most recently 15 days earlier.

On flights previous to the accident:

- The aircraft had taken off from Casarrubios del Monte with two persons onboard and enough fuel to make the flight.
- The aircraft's weight for the flight was in excess of the maximum allowed takeoff and landing weight.
- The aircraft landed on runway 09 at the Villaverde aerodrome with a crosswind and slight tailwind (wind from direction 321°).
- Shortly after arriving, the aircraft took off from runway 27, in the opposite direction to which it had landed. The wind was from 321°, and the crosswind component was close to the certification limits. The aircraft was overweight when it took off on an upward sloping runway and probably without flaps.
- The aircraft reached an estimated altitude of 20 m over the runway, banked three times and crashed to the ground at a high pitch angle that eyewitnesses described as completely vertical.
- The weather forecast called for winds with a crosswind component that equaled the aircraft's certification maximums, and for turbulence in the area through which the aircraft was going to fly.

On the impact:

- The impact took place at 14:30. It was highly vertical with no translational speed.
- The initial impact occurred at a very pronounced pitch and right bank attitude. The next impact with the ground took place with the left wing and front part of the aircraft. The aircraft then fell back, coming to rest in a normal position on its lower fuselage. The fire pattern detected in the aircraft confirmed the north-northwest wind direction at the time of the accident.
- The aircraft stopped 289 m away from the end of the runway and to its left.
- The engine was not running at the time of impact.
- No internal problems with the operation of the engine were detected that could explain the lack of power on impact.
- There was fuel in the aircraft at the time of impact, and the right fuel tank valve was open. The flaps were retracted.
- It was not possible to confirm if the fuel available in the aircraft was in the tank selected by the pilot.

On the potential problem described by the pilot:

- The problem that the pilot described verbally involved his inability to stop the engine.
- The description of the events and the timeline described by the eyewitnesses rule out self-ignition, taking off with the fuel valves closed and a problem with the ignition system.

3.2. Causes/contributing factors

The accident of aircraft EC-FP6 was likely caused by a loss of control after stalling during a takeoff conducted under excess weight conditions, high winds, with a crosswind component close to the certification limits and on a runway with a positive gradient, probably with the flaps retracted.

The investigation was unable to confirm if the engine failed during the flight. It was possible to confirm that the engine was working during the takeoff and initial climb, but that it was not generating power at the time of impact.

4. SAFETY RECOMMENDATIONS

Although it is not thought to have had an effect on the accident, the investigation identified an irregular maintenance practice involving the friction clutch installed on aircraft EC-FP6. Although it was not possible to confirm which maintenance center worked on the clutch, it was possible to confirm that the last center to have inspected this component after a "hard landing" did not detect the faulty maintenance. As a result, the following safety recommendation is issued:

REC 48/17. It is recommended that the Álamo Aviación maintenance center provide a refresher course to its maintenance technicians on the procedures for inspecting and repairing all of the ROTAX engines that Álamo Aviación repairs.

The CIAIAC has detected in this and other accident investigations involving ultralight aircraft a recurring set of aspects related to the lack of a safety culture and basic safety training as these pertain to the operation of this type of aircraft. The recommendation issued is aimed at having Spain's National Aviation Safety Agency, as part of its duty to ensure aviation safety, carry out awareness and education campaigns at airfields and flight schools on the aspects detected herein using whatever methods it considers most appropriate.

REC 49/17. It is recommended that Spain's National Aviation Safety Agency (AESA) hold education and awareness campaigns at ultralight aircraft airfields and flight schools on the following aspects, which are identified in accidents on a recurring basis:

- Importance of knowing the weight limitations of the aircraft flown by users. The fact that an aircraft has two seats does not mean it is able to carry two individuals and a maximum baggage load with a full tank of fuel. Pilots have to know the aircraft's maximum certified weight and calculate the weight and balance of the aircraft prior to each flight.
- The aircraft flight manuals used must be up to date and the checklists must be based on those manuals.
- It is essential to prepare and plan for the flight that is going to be undertaken. An important aspect is the weather. Pilots have to analyze the weather on the route and the forecasts available for the area through which they are going to fly. Looking at the METAR for the aerodrome of origin at the time of takeoff is not sufficient.
- Pilots have to train on basic emergencies periodically (stall, engine failure, etc.) and learn and recognize the behavior of the aircraft in which they are flying in order to be ready to handle an emergency.
- Decision making, from flight planning to managing in-flight emergencies, is of vital importance. A change in plan, even if it leads to inconveniences, can mean the difference between life and death.

- Procedures and checklists are the most useful tools for identifying human error. They must be used in every phase of flight, especially when unexpected situations arise.

The restrictions that the high empty weight of TECNAM P2002 SIERRA aircraft impose on the useful weight (weight available for fuel, pilot, passenger and baggage) underscore that operating these aircraft has limits, limits that must be made known to the community of users of these aircraft.

REC 50/17. It is recommended that Spain's National Aviation Safety Agency (AESA) inform users of the TECNAM P2002 SIERRA that these aircraft, when fully refueled, cannot be flown with two persons onboard.

The investigation has also identified that the maximum 450-kg weight calculations might be violated by the difference that exists between the empty weight of aircraft that are registered using the 281-kg weight that was specified in type certificate no. 281-I, and the weight initially used to certify these aircraft. As a result:

REC 51/17. It is recommended that Spain's National Aviation Safety Agency (AESA) review the certification criteria for TECNAM P2002 SIERRA aircraft and evaluate if they should remain in the group of ultralight aircraft with a maximum weight of 450 kg.

As concerns the information included in the TECNAM P2002 SIERRA DE LUXE Flight Manual, and specifically the weight and balance calculation, there is a gap in the information needed to calculate the weight and balance and an inconsistency in the center of gravity margin with respect to the information contained in DGAC type certificate number 281-I. So as to correct and complete this information so that users can calculate the weight and balance of their aircraft, the following recommendation is issued:

REC 52/17. It is recommended that the manufacturer, TECNAM, revise and complete the following sections of the TECNAM P2002 SIERRA DE LUXE aircraft's Flight Manual:

- Section 2: correct the center of gravity limits to 26.0% and 32.5%.
- Section 6: include the information needed to enable users to perform a balance calculation, something that is not possible to do with the manual in its current form.

The investigation into this accident has revealed that the existence of the TECNAM P2002 SIERRA DE LUXE model of aircraft was ignored in Spain, and that they were being certified based on the airworthiness type certificate for the TECNAM P2002 SIERRA, which has some significant differences. To address this situation:

REC 53/17. It is recommended that Spain's National Aviation Safety Agency (AESA) issue a type certificate for the TECNAM P2002 SIERRA DE LUXE aircraft that reflects its unique design, performance and operational characteristics.

The CIAIAC investigations into this and other accidents have detected serious safety problems resulting from the explosion of the devices that activate the ballistic parachutes installed on some ULMs. In the CIAIAC's experience, it is very easy for these devices to explode in the event of an accident. This endangers the safety of the individuals onboard and of those who first respond to the scene of an accident. This situation was already identified in CIAIAC report ULM A-016/2016, and resulted in a total of nine safety recommendations (REC 34/17, REC 35/17, REC 36/17, REC 37/17, REC 38/17, REC 39/17, REC 40/17, REC 41/17 and REC 42/17) being issued that spanned a range of problems related to markings, information, training and awareness of all parties involved, directly or indirectly, in flight activity. This report underscores the need to implement safety measures involving ballistic parachutes addressed in these 9 safety recommendations.