CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE ACCIDENTES
E INCIDENTES DE
AVIACIÓN CIVIL

Final report A-019/2008

Accident involving
a PILATUS PC6-B2H4
Turbo-Porter aircraft,
registration EC-JXH,
in Lillo (Toledo),
on 30 May 2008

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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)

Foreword

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

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) nº 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1., 4. and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

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

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

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Abbreviations

00°	Geographical degrees
00 °C	Degrees centigrade
AD	Airworthiness Directive
AEMET	Spain's national weather service
CG	Center of Gravity
cm	Centimeter(s)
CPL(A)	Commercial pilot license
ft	Feet
h	Hour(s)
hPa	Hectopascal(s)
INTA	National Institute for Aerospace Technology
kg	Kilogram(s)
km	Kilometer(s)
kt	Knot
LELT	Lillo (Toledo) aerodrome designator
LECM	Madrid Control Center
m	Meter(s)
m/s	Meter per second
MAC	Mean Aerodynamic Chord
METAR	METeorological Aerodrome Report
N	North
NM	Nautical miles
NE	Northeast
s	Second(s)
SB	Service Bulletin
SE	Southeast
SSW-NE	South-Southwest-Northeast
TAFOR	Terminal Aerodrome Forecast
TOW	Takeoff Weight
UTC	Universal Coordinated Time
VOR	Very High Frequency Omnidirectional Range
W	West
ZFW	Zero Fuel Weight

Synopsis

Owner and operator:	Air Compluto
Aircraft:	PILATUS PC6-B2H4 Turbo-Porter
Date and time of accident:	30 May 2008; 15:45 local time[1]
Site of accident:	Lillo (Toledo)
Persons onboard:	2, fatal (pilot and passenger), 4, passengers injured and 5 passengers uninjured
Type of flight:	General Aviation – Aerial Work – Parachute drop
Date of approval:	21 March 2013

Summary of accident

The airplane had taken off from runway 30 at the Lillo (Toledo) aerodrome for a local parachute drop. Onboard were the pilot and ten sky divers, six of whom consisted of instructor-student pairs doing tandem jumps.

When at an altitude of approximately 14,000 ft and having sounded the acoustic signal indicating two minutes to go before the jump, the airplane was subjected to an instantaneous and sharp negative acceleration that pushed two occupants against the ceiling of the aircraft. As soon as the airplane regained a normal attitude, the left wing fractured and detached.

As a result, the airplane started to fall to the ground. Nine of the parachutists were ejected out and were able to open their parachutes at a sufficient enough altitude to land normally.

The airplane eventually impacted the ground and burst into flames at a site located 4.5 km north of the aerodrome. The fire destroyed the area between the firewall and the aft end of the passenger cabin. The pilot and one parachutist were unable to exit the aircraft and died on impact.

Several components, including the detached wing and its control surfaces, as well as part of the horizontal stabilizer, were thrown off and found between 1.5 km and 2.5 km to the northeast of the main crash site.

[1] All times in this report are local. To obtain UTC, subtract two hours from local time.

The investigation has concluded that as the airplane was turning left to fly the desired heading for conducting the jump, it entered an area of strong storms. As a result, both the wing and the tail were subjected to loads in excess of design loads, which caused several of their components to fracture and the left wing to detach.

It has been concluded that neither those in charge of the aircraft's operation nor the jump supervisors were aware of the severity of the storm located to the north of the aerodrome.

1. FACTUAL INFORMATION

1.1. History of the flight

The airplane, a PILATUS PC-6 Turbo-Porter, operated by Air Compluto, based at the Lillo (Toledo) aerodrome, had been performing parachute drops since the early daylight hours.

Several parachutists arrived at 15:00 h and the airplane took off at around 15:20 h.

Onboard were the pilot, six jump instructors who worked for the Club Deportivo de Paracaidismo (Parachuting Sports Club), three passengers who had never jumped before and another parachutist, a member of the club who was an amateur skydiver. The three passengers were going to do a tandem jump with three of the instructors. The other three instructors were planning to record the three tandem jumps.

The airplane took off from runway 30 and, as reported by the occupants, proceeded to climb normally. However, according to their statements, seconds after the pilot sounded the alarm at 14,000 ft to notify the parachutists that they were within two minutes of the drop area, he announced that he was going to make a turn. It was then that the airplane was subjected to a strong and instantaneous negative acceleration that pushed the occupants against the ceiling of the aircraft.

Figure 1. Photograph of aircraft at crash site

No sooner had they returned to their normal positions when the left wing broke 5.75 m away from the wing tip and detached. This resulted in the right wing rising, inverting the aircraft and causing it to fall while spinning clockwise (as seen from above).

During the fall, the swing doors on the left side of the fuselage, which are always closed, opened. The rotating motion of the airplane about its axis expelled eight of the parachutists via this opening, including the three pairs jumping in tandem. An additional parachutist who was sitting next to the pilot was ejected through the front windshield after his head broke the glass. Neither the pilot nor the remaining parachutist were able to exit the airplane, which crashed to the ground in a crop field located 4.5 km north of the aerodrome. Both of these individuals were killed on impact.

After the impact a fire broke out that destroyed the airplane from station N.º 1 (firewall) to N.º 8 (forward part of the tail cone).

The pilot and one of the instructors were unable to exit the aircraft under their own power, nor were they ejected by the rotation. They were killed on impact and their bodies charred in the subsequent fire.

Four of the occupants suffered various injuries (three serious and one slight) and the other five were uninjured.

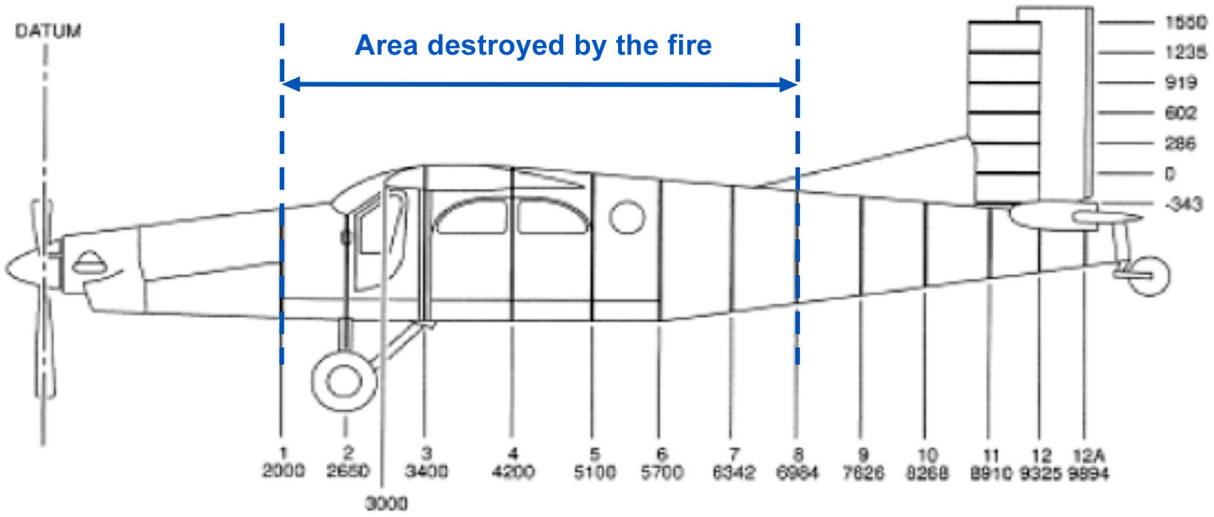


Figure 2. Section destroyed by the fire

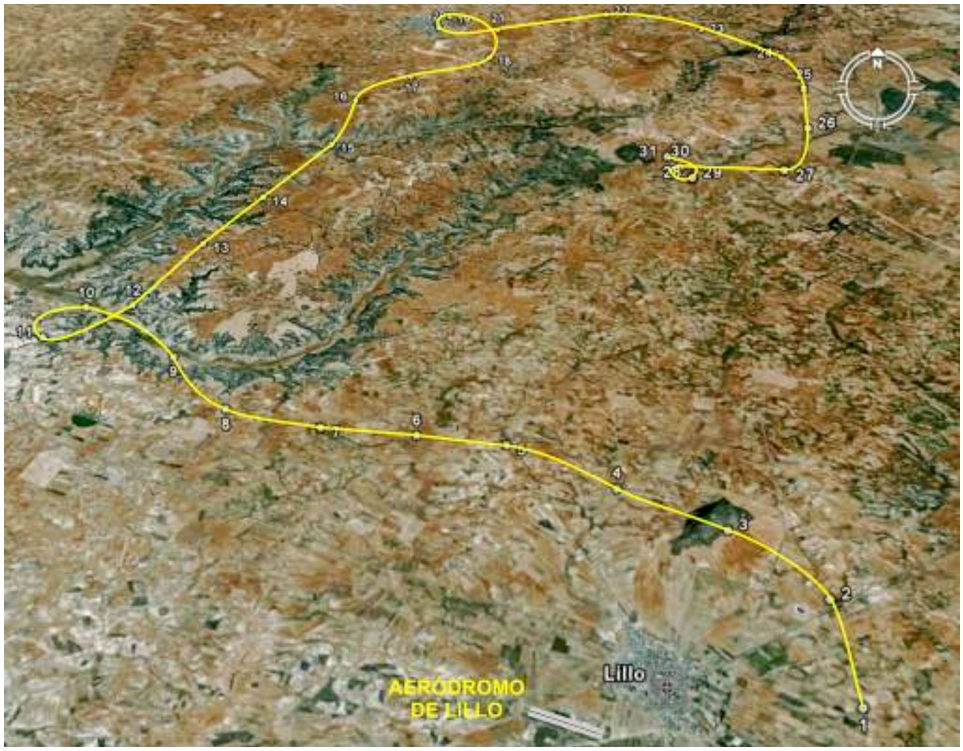


Figure 3. Portion of aircraft trajectory recorded by radar[2]

1.2. Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	1	1	
Serious		3	
Minor		1	Not applicable
None		5	Not applicable
TOTAL	**1**	**10**	

1.3. Damage to aircraft

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

The right wing broke in two places upon impacting the ground. The part closest to the root remained attached to the airplane, along with the inboard flap, and was

[2] Radar trace shown overlaid on image taken from Google Earth.

affected by the fire. The other part, to which the ailerons and the outboard flap were connected, detached and fell to the left of the main wreckage, where it was unaffected by the fire.

The left wing broke up in flight. The part closest to the root remained attached to the fuselage along with the inboard flap and was affected by the fire after impact. The other piece separated in flight and was found 1.5 km northeast of the main wreckage. The outboard flap and the inboard aileron were found separate from the wing, 2 km and 2.5 km away, respectively, also northeast of the main wreckage.

The vertical stabilizer and the rudder were mostly unaffected and remained attached to the airplane. Also attached to these components was a part of the horizontal stabilizer, which was severely damaged.

The horizontal stabilizer, the left elevator and part of the right elevator detached and were found north of the wreckage, in the same area as the remains of the left wing. The engine was not affected by the fire but exhibited significant structural damage. All four blades on the propeller were bent to varying degrees.

1.4. Personnel information

The 38 year old pilot had a Commercial Pilot License (CPL) and a medical certificate, both valid. He had a firefighting rating and a PILATUS PC6 type rating. He had a total experience of 1,100 flight hours, of which 150 had been on the type.

Neither the parachuting instructors nor the remaining passengers had any duties assigned onboard the airplane during the flight.

1.5. Aircraft information

1.5.1. *Aircraft characteristics*

The aircraft was built in 1969 with serial number 700 and had a valid airworthiness certificate. It was equipped with a PRATT & WHITNEY PT6A-34 engine and a HARTZELL HC-D4N-3P/D9511F propeller.

It had a wingspan of 15.87 m and was 10.9 m long and 3.2 m high. Its maximum takeoff weight was 2,800 kg and its maximum landing weight was 2,660 kg.

Since its manufacture, it had belonged to seven different owners and had accumulated 15,833 flight hours and a total of 26,931 landings.

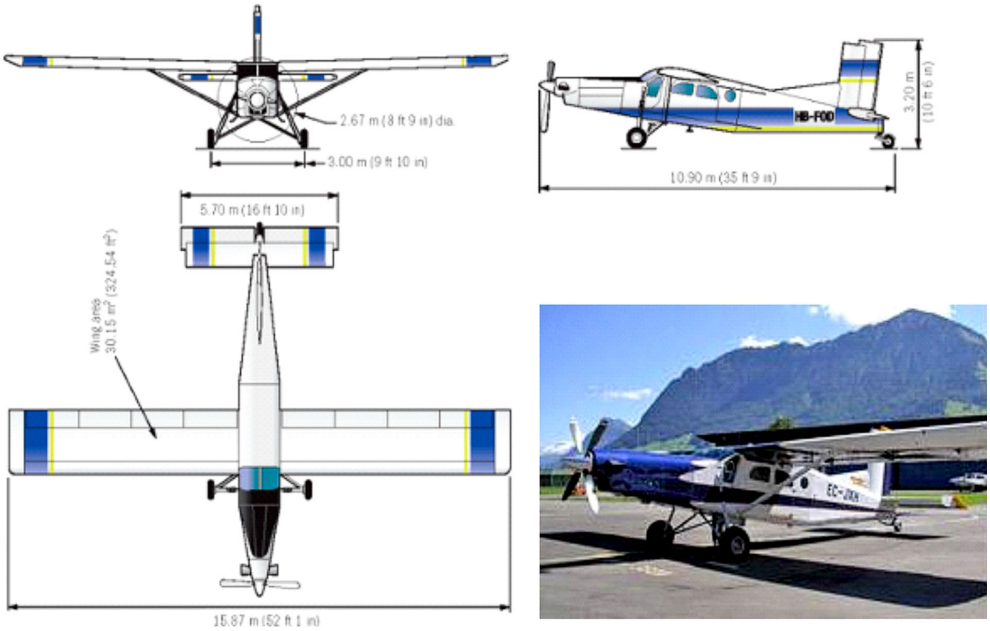


Figure 4. Views of the aircraft

1.5.2. *Maintenance*

The airplane had last been inspected between 15 and 18 April 2008 as part of a 100 h check, with 15,758 h on the airplane. The inspection was conducted by the airplane manufacturer and had revealed no anomalies.

The previous inspection had also been done by the manufacturer's maintenance organization, from 15 to 17 January 2008, with 15,658 h on the airplane, during which the horizontal stabilizer support was replaced due to cracking.

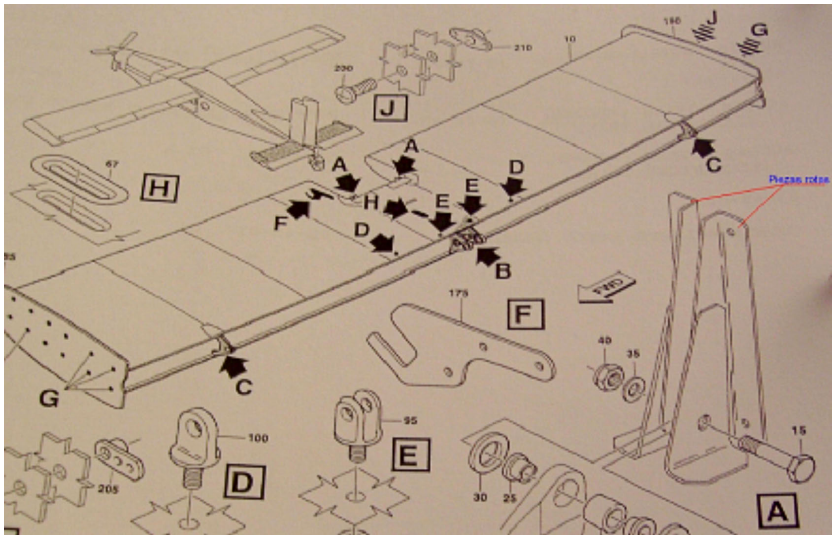


Figure 5. Stabilizer support

The struts had been inspected a few days earlier, on 10 January 2008, in compliance with airworthiness directive AD 2007-0241-E (Service Bulletin SB 57-005) of 30 August 2007, involving the inspection of a ball bearing on the strut bracket.

1.5.3. *Weight and balance*

The weight and balance calculation was made as specified in the Flight Manual using the information provided by the Operator with regard to the weight of the passengers and parachutes, and, after analyzing the flights made and the last refuelings, assuming a fuel amount equivalent to half a tank.

Investigators could not accurately determine whether the airplane's weight and balance had been calculated before the flight. In light of the information obtained, it could not be determined whether this calculation was carried out for each flight.

Figure 6 shows the seating arrangement in the airplane, as reported by the occupants. The passengers are numbered clockwise, starting with the one seated next to the pilot (passenger 1). There was a small bench on the right side of the airplane where passengers 4 and 5 were seated. Passengers 2 and 3 were on the floor. There was a longer bench on the left side where the other five passengers were seated.

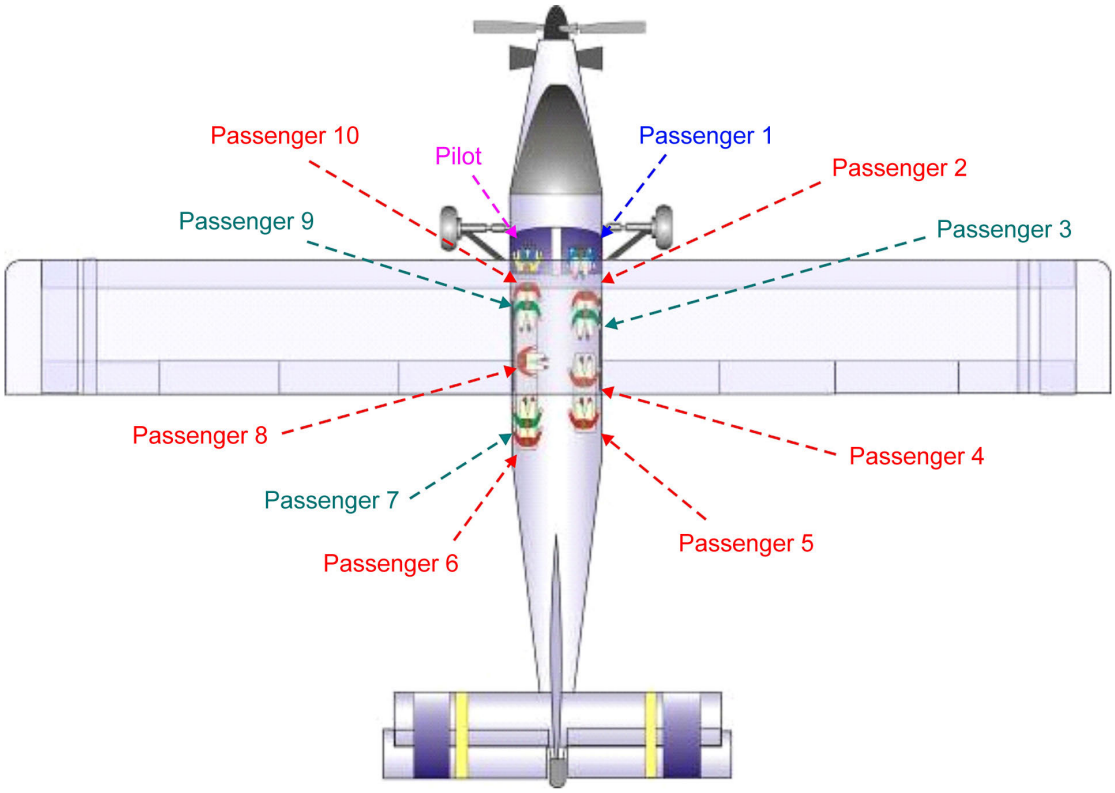


Figure 6. Positions of the occupants

Two different cases were considered for the calculation. In the first, and as shown in the below figure, passengers 4 and 8 were assumed to have the same arm (4.57 m) for the momentum calculation. The same assumption was used for passengers 5, 6 and 7 (5.28 m).

The airplane manufacturer suggested a different calculation based on the same information regarding the occupants' weights, and also on a video recorded by one of the parachutists that showed the inside of the passenger cabin. In its estimate, the arms used to calculate the moments were slightly different. Both estimates are shown in the following table:

Persons & equipment	Weight (kg)		Arm (m)		Moment (kg × m)	
	Case 1	Case 2	Case 1	Case 2	Case 1	Case 2
Empty airplane	1,376.5	1,376.50	3.35	3.35	4,611.27	4,611.27
Pilot + parachute	91.0	91.00	3.05	3.05	277.55	277.05
Passenger 1 + parachute	110.0	110.00	3.05	3.05	335.50	335.50
Passenger 2 + parachute	97.0	97.00	3.85	3.85	373.45	373.45
Passenger 3	68.0	68.00	3.85	4.30	261.80	292.40
Passenger 4 + parachute	68.0	68.00	4.57	4.70	310.76	319.60
Passenger 5 + parachute	110.0	110.00	5.28	5.40	580.80	594.00
Passenger 6 + parachute	100.0	100.00	5.28	5.40	528.00	540.00
Passenger 7	62.0	62.00	5.28	5.00	327.36	310.00
Passenger 8 + parachute	71.0	71.00	4.57	4.70	324.47	333.70
Passenger 9	77.0	77.00	3.85	4.30	296.45	331.10
Passenger 10 + parachute	88.0	88.00	3.85	3.85	338.8	338.80
Oil	13.0	13.00	0.96	0.96	12.48	12.48
Zero fuel weight (ZFW)	**2,331.5**	**2,321.50**			**8,578.69**	**8,649.35**
Fuel	259.2	259.20	3.93	3.93	1,018.70	1,018.70
Takeoff weight (TOW)	**2,590.7**	**2,580.70**			**9,597.39**	**9,668.05**

According to the above table, in the first case the center of gravity would be at 3.7 m (9,597.39 / 2,590.7)[3] from the reference line, that is, 37.08% MAC[4], and therefore within the weight and balance limits (see Figure 7).

[3] CG = TOTAL MOMENT / TAKEOFF WEIGHT = 9,456.13/2,577.7 = 3.66.
[4] MAC: Mean Aerodynamic Chord. The % MAC is calculated using the formula ((CG – 3)/ 1.9) × 100.

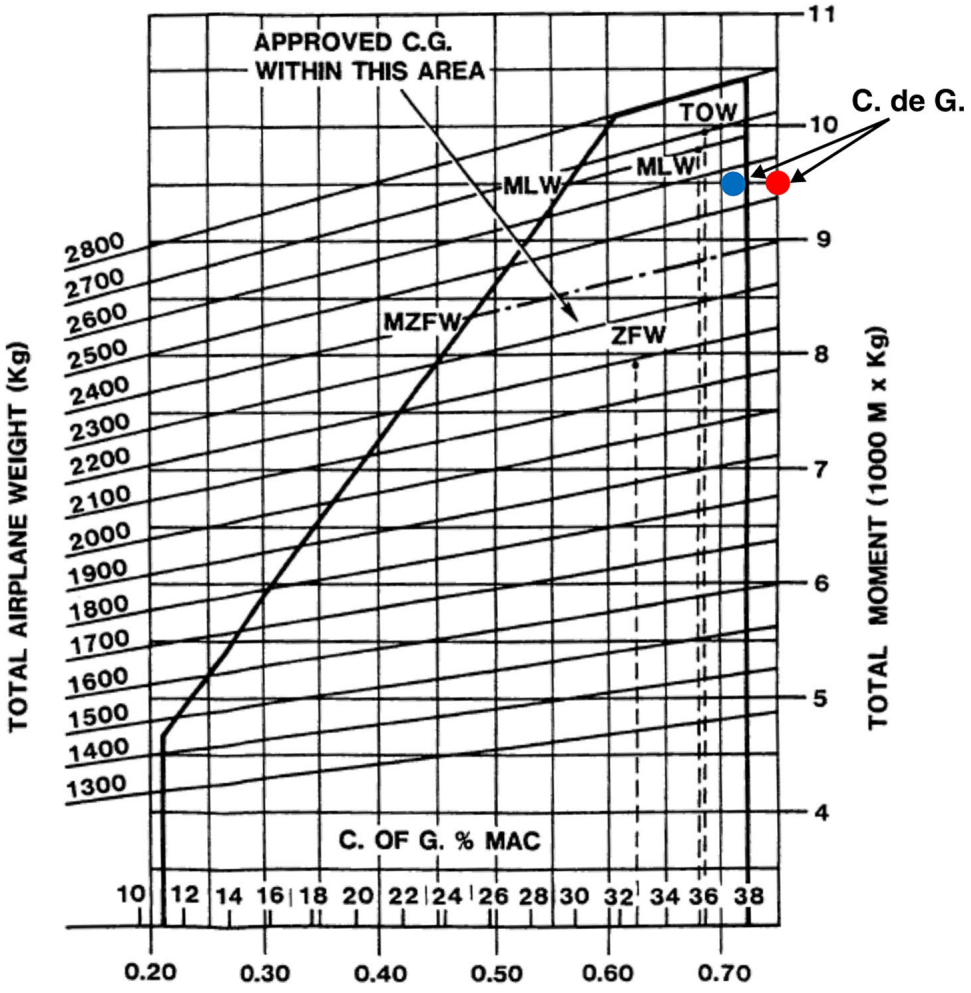


Figure 7. Position of the C.G. in load and balance graph

If we now consider the second load case, the center of gravity would be at 3.74 m (9,668.05/2,580.7) from the reference line, that is, 39.27% MAC, which is outside the limits.

In any event, for the weight and number of passengers on the airplane, small variations in their locations could cause the center of gravity to shift outside the flight envelope.

1.6. Meteorological information

Spain's national weather service (AEMET) reported that on the day of the accident, mid-level weather in the Iberian Peninsula at 15:45 h was dominated by a cold low pressure area centered to the west of Portugal (–20 °C and 500 HPa at an altitude of 5,600 m) that stretched over the entire western peninsula.

The atmosphere was unstable in Avila, Toledo, north of Ciudad Real and south of Madrid with numerous cumulus and stratocumulus clouds. Mixed in were convective-type clouds that were moving from SSW to NE, reaching altitudes in excess of 4,500 m and over 10,000 m in some places.

At coordinates 39º 45' 25.56" N – 3º 18' 23.1" W (site of the accident), the most likely weather at 4,000 m was mostly cloudy skies with cumuliform clouds. Between 15:20 and 15:30 h a storm cell with moderate and increasing convective activity, which was to the SE, started moving over the accident site. The center of this cell, which was moving to the NE, was just east of the accident site by 15:50. At some points along the cell the cloud tops were over 10,000 m high, and over 5,000 m high at the exact location of the accident. No lightning strikes were recorded in the vicinity of the accident site during this time period, although the atmospheric conditions described would be expected to yield moderate to strong updrafts and some precipitation of a convective nature (downpours and storms). The temperature in the area at the time would have been around –10 ºC.

The reflectivity and Eco Top images in figure 8 show, respectively, the type of precipitation in the area at the time of the accident (light) and the altitude of the clouds (between 5 and 10 km).

One of the parachutists was recording during the climb on a camera mounted on his helmet (figure 9). Later, during the fall, the camera turned on inadvertently when he hit his head as he was ejected from the airplane, so part of the fall was recorded. The footage shows the atmospheric situation described above, with abundant clouds (figures 10 and 11).

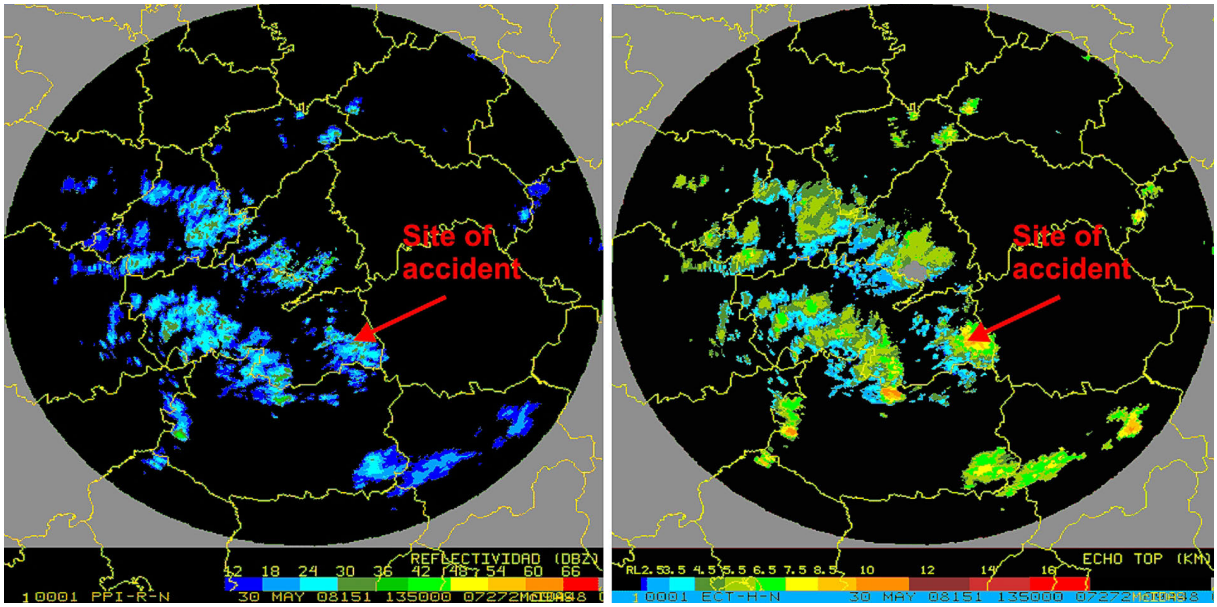


Figure 8. Reflectivity and Eco Top maps for 15:50

Two of the passengers who were making their first tandem jumps reported that during the climb, they could see numerous clouds around them from their respective positions inside the airplane.

Additional accounts were obtained during the investigation from two flight instructors who had left from the Ocaña aerodrome (located 15 NM north of the accident site) at approximately 15:00 h. They were heading south toward the accident area and had to turn back when they noticed a storm ahead of them located near the crash site.

Figure 9. View from inside

Figure 10. Photograph during fall

Figure 11. Photograph during fall

1.7. Communications

The aircraft (EC-JHX) contacted the Madrid Air Control Center (LECM) at 15:38:16 h, with the last exchange taking place at 15:38:25 h. At 15:52:18 h LECM tried to contact the aircraft but received no reply.

1.8. Aerodrome information

The Lillo Aerodrome, designated LELT, is 1 km southwest of the town of Lillo (Toledo) and 10 NM southeast of the Villatobas VOR.

The aerodrome is uncontrolled and has a 750 m long and 18-m wide asphalt runway in a 12-30 orientation. It is at an elevation of 681 m and the coordinates of its reference point are 39º 43′ 2″ N – 3º 19′ 15.9″ W.

1.9. Wreckage and impact information

1.9.1. *Main wreckage*

The airplane fell vertically and impacted in an inverted position at coordinates 39º 45' 25.56" N – 3º 18' 23.1" W, at an elevation of 688 m. Its longitudinal axis was at a 45º angle with respect to magnetic north. There were no drag marks.

A part of the left wing spanning two thirds of its total length was missing. The part of the wing that remained attached to the fuselage was found with the main wreckage. It was joined to the inboard flap, and both components were completely charred. A 1.10-m long section of the strut was still attached.

The right wing broke on impact and a 5.5 m long section of it detached. It was found situated parallel to the airplane's longitudinal axis. The wing segment that remained attached to the fuselage was so severely affected by the fire that only portions of the top surface remained. The fuel cap was in its place and closed. A 1.76 m long part of the strut was still attached, and a 0.47 m long section remained joined to the fuselage. The deformations present indicated that the wing had broken on impact upon striking the ground upside down due to a bending stress from the top surface to the bottom.

The engine was in one piece and without any significant apparent damage, though it had significant structural damage. The propeller was feathered. All four blades were bent to varying degrees, with the tips pointing backward.

The fire had destroyed the section between the firewall (Station 1) and the aft part of the passenger cabin (Station 8). There was continuity and tension in the control surface cables until the last section, in the tail cone, where they had snapped from the force of the impact.

In the tail assembly, the vertical stabilizer and the rudder were in one piece. There was evidence of significant compression damage to the latter. The vertical stabilizer trim tab had not detached and was next to the tail assembly.

Only a part of the heavily damaged right side of the horizontal stabilizer was still attached to the stabilizer assembly, bent over the left side. The rest (the right side and the rest of the left side) was found elsewhere.

The pilot's and copilot's doors, which were always kept closed, were severely affected by the fire.

On the left side of the fuselage were two swinging doors that were closed while airborne. Only the forward door was found.

The sliding door on the right side, which was opened to conduct the jumps, was completely burned in the fire.

The deceased skydiver's emergency parachute had deployed. It was designed to activate automatically upon reaching a descent speed in excess of 35 m/s at an altitude of 225 m.

1.9.2. *Left wing*

The part that detached from the left wing was found alongside the Lillo-Villatobas road, in the segment that is known as the Cerrotraviesa trail, at coordinates 39º 46' 0.18" N – 3º 17' 10.8" W and an elevation of 680 m. It was oriented from east (part near the tip) to west (part near the root), and resting on its top surface. It was 5.75-m long measured along the spar closest to the leading edge. A 0.85-m long segment of the brace was still attached to it. The force of the impact had caused it to bend along its length such that it was convex along the top and concave along the bottom.

The rivets had pulled out of the top skin closest to the root.

There were two dents on the leading edge. The wing tip was torn and a portion of the trailing edge had detached and come to rest in a separate area from the rest of the wing.

The inboard aileron and both flaps were found. The outboard aileron was not found. The inboard aileron, which was only slightly damaged, was the one component that was farthest away from the main airplane wreckage. Specifically, it was found alongside the road that goes from Lillo to Santa Cruz de la Zarza, at coordinates 39º 46' 33.38" N – 3º 17' 17.67" W and an elevation of 692 m. Its fittings were bent.

Figure 12. Left wing

The outboard flap was found on the same road as the wing, at coordinates 39º 46' 6.36" N – 3º 17' 29.58" W and an elevation of 682 m. There were dents at both ends along the leading edge.

The left wing tip and a small part of the tail assembly were found together alongside the La Guardia-Corral de Almaguer road, at coordinates 39º 46' 16.8" N – 3º 17' 30.24" W and an elevation of 690 m.

1.9.3. *Horizontal stabilizer*

Like the left wing, the horizontal stabilizer was also found near the Cerrotraviesa trail, at coordinates 39º 45' 48.66" N – 3º 17' 47.58" W and an elevation of 700 m. It was bent at the center in a U-shape (see Figure 13) and ripped from its fittings at the center. The left side was practically intact. The right side was heavily damaged. It was missing the piece that had remained attached to the main wreckage. A part of the right side of the leading edge was found alongside the La Guardia-Corral de Almaguer road, at coordinates 39º 46' 16.2" N – 3º 17' 26.64" W and an elevation of 690 m.

A fragment from part of the left elevator closest to the tip was found halfway between the left wing and the horizontal stabilizer, also near the Cerrotraviesa trail, at coordinates 39º 45' 53.22" N – 3º 17' 44.7" W and an elevation of 700 m. It had a significant tear with loss of material and there was a heavy impact mark on its top surface.

Figure 13. Horizontal stabilizer

1.10. Medical and pathological information

The pilot and one of the passengers died on impact and their bodies remained in the aircraft wreckage, as a result of which they were charred in the subsequent fire.

The students who were doing tandem jumps were seriously injured and had to be hospitalized. One of them had a spinal injury, another damaged the ligaments in one of his knees, and the third suffered neck and hipbone injuries which required surgery.

One of the instructors was slightly injured and was hospitalized until the next day. The other four instructors and one parachutist who was not working for the Club were uninjured, though they were examined by emergency services personnel who responded to the scene of the accident.

1.11. Fire

After the impact with the ground, a fire broke out that only affected the aircraft, destroying the area from station 1 (firewall) to station 8 (forward part of the tail cone) of the fuselage. Also affected were those portions of the wing that had remained anchored to the structure.

Shortly after the crash, it began to rain, which started to douse the fire. A few minutes later several fire trucks based in Villacañas (Toledo) arrived on the scene and quickly managed to extinguish the fire.

1.12. Survival aspects

All of the jump instructors were wearing both a main and an emergency parachute, which had automatic deployment devices consisting of a control unit that turned on the device and was used to make the necessary adjustments; a processing unit located inside the parachute that monitored the speed and altitude and a cut-off unit, housed in the emergency parachute and independent from the primary system. When this unit activated, it released the emergency parachute when it detected a descent speed in excess of 35 m/s at an approximate altitude of 225 m (750 ft). If released below this altitude, the system was only designed to operate down to approximately 40 m (130 ft), which is equivalent to 4.5 s before impacting the ground.

The students were joined to the instructors via a harness that kept them attached to each other during the jump. Except for the pilot, who was attached to the airplane via his safety harness, none of the jumpers was attached to the airplane.

The pilot was also wearing a parachute that did not deploy because it was not equipped with the safety system that the other occupants' parachutes had. However, it was impossible to determine whether it had failed because it was burned completely in the post-impact fire.

Three of the passengers were jumping in tandem attached to their instructors, and their harnesses worked correctly.

All of the occupants, except for the pilot and passenger 5, left the aircraft as it was falling, though not of their own accord; rather, they were ejected by the airplane's rotation via the opening left by the left-side swing doors, which were originally closed but which opened during the fall. The right-side sliding door through which parachutists are supposed to jump, was closed during the jump and, as reported by passenger no. 2, the instructor in charge of opening it did so some 4 cm after hearing the acoustic alarm sounded two minutes before the jump.

Passenger 1, who was seated facing aft next to the pilot, broke the front windshield with his head and was thrown out of the airplane. He was wearing an altimeter that sent him a signal via headphones and which activated at 1,500 m as soon as he exited the airplane.

Passengers 2 and 3 were jumping in tandem and were seated on the floor in the right side, also facing aft. Passenger 2 stated that the altimeter he was wearing recorded a deployment altitude for his parachute of approximately 3,850 m.

Passenger 4 was seated on the right-side bench facing forward. His task was to video the jump of passengers 2 and 3. He stated that when he opened his parachute in the air, he saw several parachutists around him at a lower altitude.

Passenger 5 was seated at the rear of the right-side bench facing forward. His parachute deployed inside the airplane.

Passengers 6 and 7 formed another tandem team. They were seated at the rear of the left-side bench. Passenger 6, who was the instructor, reported hearing the alarm on his altimeter through his headphones when they were at 6,000 ft inside the airplane, and that once in the air he opened the emergency parachute before it could open by itself. Passenger 8 was also seated on the left-side bench, in the center, between the previous tandem and that made up by passengers 9 and 10. He was facing inward. His task was to video the jump of passengers 9 and 10. His helmet-mounted camera turned on when he hit his head as he was ejected from the airplane, and he taped part of the airplane's fall from the air. He landed some 100 m north of the main wreckage.

Passengers 9 and 10, who comprised the third tandem pair, were seated facing aft in the front part of the left-side bench. Passenger 9 was the instructor. His altimeter output

an acoustic signal at 2,000 m just as they left the airplane. Once the parachute deployed, they landed furthest to the south and away from the wreckage, specifically, to the west of the Lillo-Villatobas road.

Passengers 1 and 4, and the tandems comprised by passengers 2 and 3 and by passengers 6 and 7, all landed in the same area to the south of the main wreckage and east of the Lillo-Villatobas road.

The experience and task during the jump of each passenger is summarized below:

Passenger	Age	Task on jump	Experience
N.º 1	34	None	170 jumps
N.º 2	43	Jump instructor on N.º 1 tandem	Total of 4,900 jumps, 1,200 in tandem as an instructor. Had 400 jumps at the Lillo aerodrome.
N.º 3	36	Student on N.º 1 tandem	None.
N.º 4	29	Camera to record N.º 1 tandem	1,500 jumps. Had been working for the Club for five years.
N.º 5	35	Camera to record N.º 2 tandem	Had been working for the Club for two months.
N.º 6	30	Jump instructor on N.º 2 tandem	Total of 1,180 jumps, 370 in tandem as an instructor. Normally operated out of the Lillo aerodrome.
N.º 7	23	Student on N.º 2 tandem	None.
N.º 8	26	Camera to record N.º 3 tandem	1,600 jumps. Had been working for the Club for three years.
N.º 9	52	Student on N.º 3 tandem	None.
N.º 10	29	Jump instructor on N.º 3 tandem	Total of 2,000 jumps, 400 in tandem as an instructor. Made almost all of his jumps at the Lillo aerodrome.

1.13. Tests and research

During the investigation a macroscopic analysis of the left wing was conducted by an expert in structures and in-service faults. A laboratory microscopic study was not considered necessary, as there were no doubts regarding the cause of the fractures present, namely static overload. The progressive fracture and failure of the material was ruled out.

The wing's spar was broken. This spar consisted of two L-shaped cords and a central metal sheet joining the two.

Both cords and the central core were fractured. Specifically, the upper cord had a 45º bevel fracture on a plane perpendicular to the spar's longitudinal axis. This fracture intersected two attachment holes drilled into the skin of the wing. The lower cord had a flat fracture that extended along two different planes, one parallel to the length of the wing and the other perpendicular to it. The entire spar near the fracture area was bent downward, meaning that the wing detached downward. There were several compression lines in the upper cord of the spar.

The ailerons, like the flaps, were attached to the wing in two places at either end of the ailerons. Looking at these components from the bottom and behind revealed the following fractures:

- Both the outboard and inboard surfaces were bent to the right on the outboard aileron, which had been torn off.
- Both the outboard and inboard surfaces on the inboard aileron were also bent to the right. The outboard surface was half torn off and the inner one completely torn off.
- The outboard side of the outboard flap was bent to the left, and the inboard side was bent to the right.

The left wing had three attachment fittings distributed along its length. These are used to attach the ailerons and flaps. The two ailerons are attached to the outboard fitting. The intermediate fitting supports the inboard aileron and the outboard flap, and the inner fitting supports two flaps. Both the outboard aileron and the inboard flap are also attached to the wing and fuselage by their corresponding fittings.

The outboard fitting was practically intact. The middle one was bent significantly to the left as seen from behind and below, and the inboard one was missing. Since it was located very close to the area where the wing broke, it is fairly likely that it remained attached to the part of the wing that did not detach; however, it was not found in the wreckage, meaning it must have burned completely in the fire.

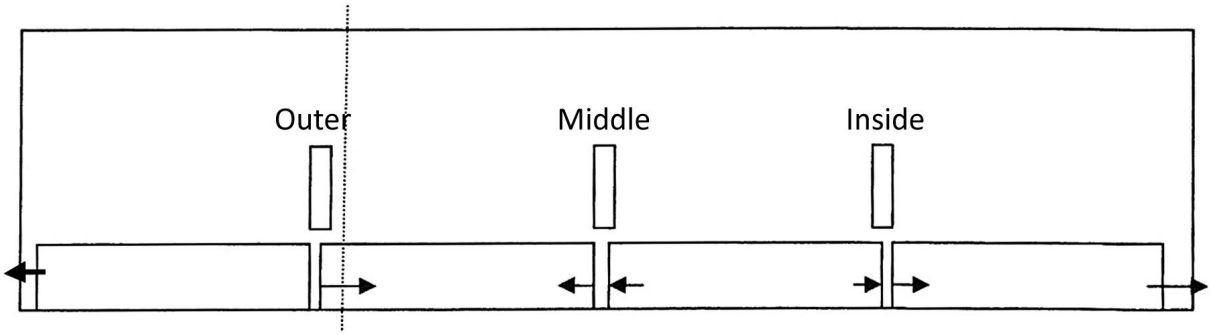


Figure 14. Position of fittings on left wing

The strut on the left wing was broken at approximately its halfway point. When the fracture and the side opposite the fracture were examined, it was noticed that they did not match. Some material was missing, which would confirm the presence of two different fractures in the strut, indicative of both fractures occurring suddenly and violently. Both fractures had a 45º bevel and in all likelihood occurred under compression, which indicates that they were caused by a static overload. The fracture found in the strut fragment that remained attached to the wing had bent under plastic compression, but not due to the fracture process, but very likely as a result of the impact with the ground.

As regards the horizontal stabilizer assembly, it was sent to the structures laboratory of the National Institute for Aerospace Technology (INTA) for analysis. There, over the course of over three years, the bends and fractures exhibited by the structural elements of the horizontal stabilizer were analyzed, including the forward and aft spars, stringers, ribs, metal skin, hinged attachments to the fuselage and the actuator and hinged supports for the elevators.

Also analyzed were the structural elements found in the remains of the left elevator. A characterization study was conducted of the material in the cords of the horizontal stabilizer, which had fractures.

A fractographic study was conducted of the fractures exhibited by the cords of the forward and aft spars, of the fracture of the forward right fitting and of one of the attachment screws on one of the forward spar fittings.

At the conclusion of this study, the INTA determined that the findings of the macrofractographic and microfractographic characterizations indicated that all of the fractures analyzed were ductile in nature and had progressed along their entire lengths due to static overload, there being no progressive fatigue or stress corrosion mechanisms involved in the process.

The study eventually concluded that the fracture and partial disintegration of part of the structure of the left wing and horizontal stabilizer, as well as their subsequent detachment, occurred as a result of a load being placed on these components that at one point exceeded the structural strength specified for the maneuvering envelope.

On 11 December 2012, the INTA issued a report with the material composition and strength of the upper and lower cords on the forward spar, of the upper and lower cords of the aft spar, of the angular support that attaches the forward right fitting to the spar core and of the screw that attaches one of the fittings to the cord on the forward spar. INTA's findings were consistent with those reported by Pilatus involving the composition and hardness of the materials with regard to the design specifications. The origin of these loads was a combination of both aerodynamic and inertial loads,

aggravated by the meteorological conditions present in the area along with the general flight conditions in terms of the aircraft's speed, maneuver, configuration (position of the control surfaces), attitude and weight.

1.14. Organizational and management information

The parachuting operation was organized by the Lillo Skydiving Center, a sports club run under the brand name SKY DIVE LILLO. This center had been active at the aerodrome since September 2000. According to information provided by the organization itself, over 45,000 jumps a year take place there, of which approximately 4,000 are tandem jumps.

Its responsibilities are limited to promoting the sport and safeguarding jumpers during skydiving activities. It is subject to the regulations approved for this purpose by the General Assembly of the federation of which it is a member. The club's responsibilities include informing the pilot of whether the conditions are suitable for skydiving or not and to ensure that the weather conditions are appropriate for landing. During the jumps someone from the Skydiving Center is stationed as a ground controller, whose tasks are as follows:

1. Maintain radio contact with the airplane.
2. Visually verify that there are no other airplanes in the area.
3. Visually verify that there are no flocks of birds in the area.
4. Verify that the wind is within the jump parameters for everyone onboard.
5. Verify that the landing is performed in the proper direction and inform the pilot.
6. Visually verify that all of the parachutes deploy properly.
7. Visually verify that the landings take place in the designated safety areas.
8. Ensure that the equipment is checked before boarding.
9. General check that the boarding is conducted safely and efficiently.
10. Keep people not involved with the activity away from the boarding and landing areas.
11. Ensure that the parachutes are folded after landing.
12. Organize the spotters for the tandem jumps.
13. Establish radio contact with airplanes requesting to land on or cross the field and ensure that the pilot is aware of other aircraft in the area.

The skydiving operation was being conducted by the individuals that ran the skydiving center through a company called AIR COMPLUTO, which had been active at the aerodrome from the same date (2000). The company, however, did not purchase its first aircraft, a PILATUS PC-6B H4, until August 2001, followed by the accident airplane in July 2006 and a CESSNA CARAVAN 208 B in January 2008, which was operational on the day of the accident.

1.15. Additional information

Given the runway's east-west orientation (12-30) and its location south of the town and hangars, and north of a lagoon, the run to drop the skydivers is generally conducted on a heading of 300º, that is, from the town toward the hangars. The jump point is indicated by the pilot.

The trip usually lasts 10 to 15 minutes. Under normal wind conditions, the skydivers exit the airplane in 8 second intervals, approximately. When winds aloft are high, the interval tends to be longer, in proportion to the wind speed (calculated by dividing the wind speed in knots by two).

Before the accident flight, the skydiving center supervisor who was monitoring the jumps from the ground stated that a storm was approaching from the south, which was over Villacañas, 11 km south of the field, and whose cloud base, at an approximate altitude of 1,500 m, he could see. He also stated that it is normal for strong storms to come in from the south in this area. He asked the pilot to do the jump 0.5 NM further north of the usual jump area to ensure that, given the prevailing wind, the skydivers would be able to open their parachutes in an area that would allow them to reach the aerodrome. Six minutes after takeoff he tried to make contact with the pilot but did not receive a reply. Despite this, the pilot called to receive the clearance to give the two-minute warning. There were no further communications.

When the occupants of the airplane were interviewed, two of the passengers making tandem jumps for the first time, as well as one of the instructors and an eyewitness on the ground, stressed in their statements the haste they noted in the actions of the skydiving center supervisors to start the flight due to the storm that was coming in from the south and that was visible over the El Romeral mountains (west of Villacañas).

2. ANALYSIS

During the investigation it was noted that there was no representative of the aircraft's operator at the aerodrome during the flight preparations or takeoff, meaning that the pilot did not have any additional help or information from the company when preparing for the operation. As per the Air Compluto Basic Operations Manual, the pilot was acting as the Operations Supervisor and the Operator did not deem it necessary to have a different supervisor during the flight. It was noted, for example, that the airplane's balance was very close to the allowed limits or even outside said limits, depending on the assumptions used in the calculation. It cannot be stated for certain that the position of the center of gravity did not have a direct effect on the accident.

The pilot apparently started the flight without being aware of the magnitude of the storm that was present north of the aerodrome, exactly over the area where the flight and subsequent jump by the skydivers were to take place.

The supervisor from the club handling the skydiving activity, and who had been at the aerodrome since early in the morning, was also unaware of the existence of this storm.

That neither of these two individuals, who had ample experience with this type of operation and in this area, was aware the complicated weather conditions present north of the aerodrome was undoubtedly due to two facts. First, that neither the operator nor the club conducting the skydiving activity had detailed local weather information (METAR or TAFOR) for the area where the activity was taking place, since the nearest information of this type was for the Cuatro Vientos Aerodrome, which is sufficiently far away that its weather conditions were different from those present at the accident site.

Second, in the area where the accident took place, the cloud base was very high (at an altitude of 4,000 m) and was undoubtedly hard to make out clearly from the aerodrome.

Another factor to consider is that both the pilot and the jump supervisor were focused on starting the flight before another storm to the south came in, which they were perfectly aware of, probably because of the low altitude of its cloud base, which was at approximately 1,500 m and was visible from the aerodrome. Another factor that could have played a role was the possible predisposition of those involved in the operation, and in general of those who work in the area, to be more vigilant for weather phenomena approaching from the south since in their experience, it is these storms that tend to be more severe, as was noted during the investigation.

The fact is that the occupants' statements confirmed the presence of turbulence just prior to the accident, which is consistent with storm conditions and the subsequent convective activity recorded in the images taken during the jump and indicated by the weather information collected after the fact.

The arrangement on the ground of the components that detached in flight is consistent with the statements of several of the airplane's occupants regarding how the accident took place just as the airplane was starting a left turn to line up with the west to east heading used for skydiving operations.

An analysis of the airplane wreckage ruled out a gradual fracture mechanism as well as a material failure. Everything seems to indicate that the fractures of both the left wing and the tail assembly were caused by a static overload resulting from the aircraft's exposure to the turbulence from the violent storm present in the area and from the aerodynamic loads associated with the general flight conditions.

In an effort to improve the investigation of accidents and serious incidents on this type of aircraft when engaged in this type of operation, it would perhaps be beneficial to install a Flight Data Monitoring system.

3. CONCLUSION

3.1. Findings

- The airplane took off from runway 30 at the Lillo Aerodrome. Onboard were the pilot and ten skydivers.
- Three skydivers were making their first jumps, in tandem attached by a harness to an instructor.
- None of the skydivers had any task onboard the airplane.
- The atmosphere in the province of Toledo, north of Ciudad Real and south of Madrid had been unstable throughout the day, with abundant clouds and convective air flows.
- At the time of the accident, there was a storm cell with a cloud base at 4,000 m and vertical cloud formation that was affecting the entire area around the aerodrome, particularly to the north, where the accident took place.
- There was also a storm to the south, but its cloud base was much lower, at around 1,500 m.
- When the aircraft was north of the aerodrome at an approximate altitude of 14,000 ft, the left wing broke and detached.
- The swinging doors on the left side, which were closed, opened during the fall under the effect of the forces to which the aircraft was subjected.
- Nine skydivers were ejected out the gap left by the open doors. Once in the air, they managed to open their parachutes at a sufficient altitude that they were able to reach the ground normally.
- The aircraft crashed to the ground 4.5 km north of the aerodrome and then burst into flames.
- The fire destroyed the portion of the aircraft between the firewall and the aft section of the passenger cabin.
- The pilot and one of the skydivers were unable to exit the aircraft and perished on impact. Their bodies were burned by the fire.
- A part of the left wing, its control surfaces and part of the horizontal stabilizer detached and were found some 1.5 to 2.5 km northeast of the main wreckage site.
- The macroscopic analysis of the fractures found on the left wing concluded that they had been caused by a static overload. Progressive fracture mechanisms and material failure were ruled out.
- The analysis of the horizontal stabilizer revealed that the fractures found on it occurred as a result of a load being placed on it that at one point exceeded the structural strength specified for the maneuvering envelope.

3.2. Cause

The accident took place as the aircraft was entering an area of strong turbulence inside a storm. The aircraft was turning left to align with the heading used for the parachuting

run, and as a result of the turn both the wing and the tail were subjected to loads in excess of design loads. This caused several of their components to fracture, resulting in the detachment of the left wing and the horizontal stabilizer.

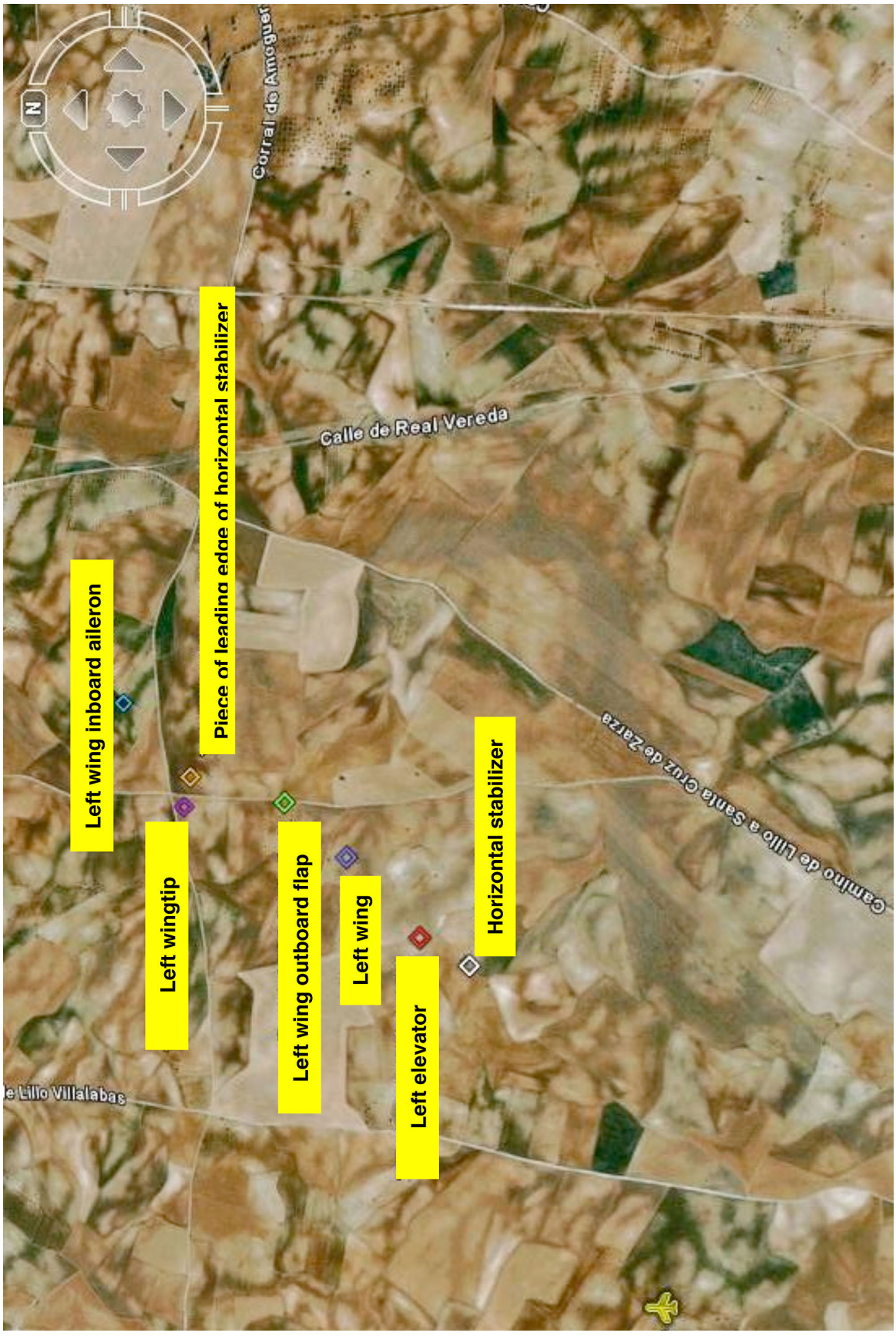
Contributing significantly to the accident is the fact that neither the company that operated the aircraft nor the jump supervisors were aware of the violent storm present to the north of the aerodrome, exactly over the area where the flight and the skydiving activity were going to take place.

4. SAFETY RECOMMENDATIONS

RECOMMENDATION 08/13. It is recommended that the International Civil Aviation Organization establish as an essential requirement for skydiving operations that the aircraft utilized for this activity have onboard a flight data recorder capable of logging at least the basic parameters of the aircraft's operation.

APPENDIX

APPENDIX A
Layout of debris field


Left wing inboard aileron
Piece of leading edge of horizontal stabilizer
Left wingtip
Left wing outboard flap
Left wing
Left elevator
Horizontal stabilizer
Calle de Real Vereda
Camino de Lillo a Santa Cruz de Zarza
Corral de Amoguer
e Lillo Villalabas
N