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INVESTIGATION REPORT

Accident to the Pilatus – PC-12 - 47E registered LX-JFD

on 30 March 2020
on approach to Nice-Côte-d'Azur airport (Alpes-Maritimes)

Time	Around 15:23[1]
Operator	Jetfly Aviation S.A.
Type of flight	Own-account transport
Persons on board	Pilot, co-pilot and passenger
Consequences and damage	Aircraft substantially damaged

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in October 2021. As accurate as the translation may be, the original text in French is the work of reference.

[1] Except where otherwise indicated, the times in this report are in local time.

In-flight lightning strike, structural damage observed on ground

1 - HISTORY OF THE FLIGHT

Note: the following information is principally based on the flight recorder LDR1000 data, the crew reports, the radio-communication recordings and the radar data.

The pilot-in-command carried out a flight departing from Paris-le-Bourget airport (Seine-Saint-Denis) bound for Nice-Côte d'Azur. The purpose of this flight was to transport a passenger, co-owner of the aeroplane. The aeroplane is one of a fleet of forty PC-12s, operated by Jetfly Aviation, exclusively for the co-owners. In accordance with the provisions for non-commercial operations in the operator's flight manual, the pilot-in-command was assisted by a second pilot, who the operator calls the co-pilot[2]. She accompanied the pilot-in-command in order to help her with certain tasks, in particular with respect to the safety of the aircraft and its occupants.

[2] The Pilatus PC-12 is certified to be flown with a flight crew of at least one pilot.

The crew indicated that during the descent in IMC (without external visual references) towards Nice, they encountered turbulence and icing but the conditions did not seem worrying to them.

At 15:11 (see Figure 1, point ❶), the crew asked the Nice controller if they could change heading as required for avoidance purposes[3]. The controller replied that they could change heading at their discretion.

[3] The crew used the weather radar and the stormscope to avoid storm cells.

At 15:13, the crew reported that they had the ground in sight at FL 100 and continued the visual descent.

At 15:15, they indicated that they were at FL 100 again and that they had lost sight of the ground. They requested a radar vector to continue the approach. The controller gave a heading of 140° and the crew replied that they were going to follow a heading of 110° for avoidance purposes. The controller added that he would vector them to overhead the Nice airport for a visual approach.

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At 15:22 (see Figure 1, point ❷), the crew descended to FL 060 and changed their heading by 30° to the right for a heading of 160° for avoidance purposes.

At 15:23 (see Figure 1, point ❸), the crew told the controller that they were in good conditions. When descending through FL 60 and at this point in calmer conditions, there being no turbulence, they saw a brief flash of lightning and heard a loud bang. The crew reported that a few seconds later they were outside the clouds. The propeller and engine parameters remained normal and there was no evidence to suggest that the aircraft's operation was impaired. Nevertheless, the crew decided to land at Nice as quickly as possible.

At 15:24, the crew reported to the controller that the plane had just been struck by lightning, asked for the most direct heading possible and added that they had encountered good conditions for visual manoeuvring. At the controller's request, the crew confirmed that they had sight of the ground, that they had encountered good conditions and that they were taking a direct heading to the airport.

The crew indicated that they did not feel any abnormal vibrations up to the end of the flight.

The Rescue and Fire Fighting services were on standby and present at the plane's arrival.

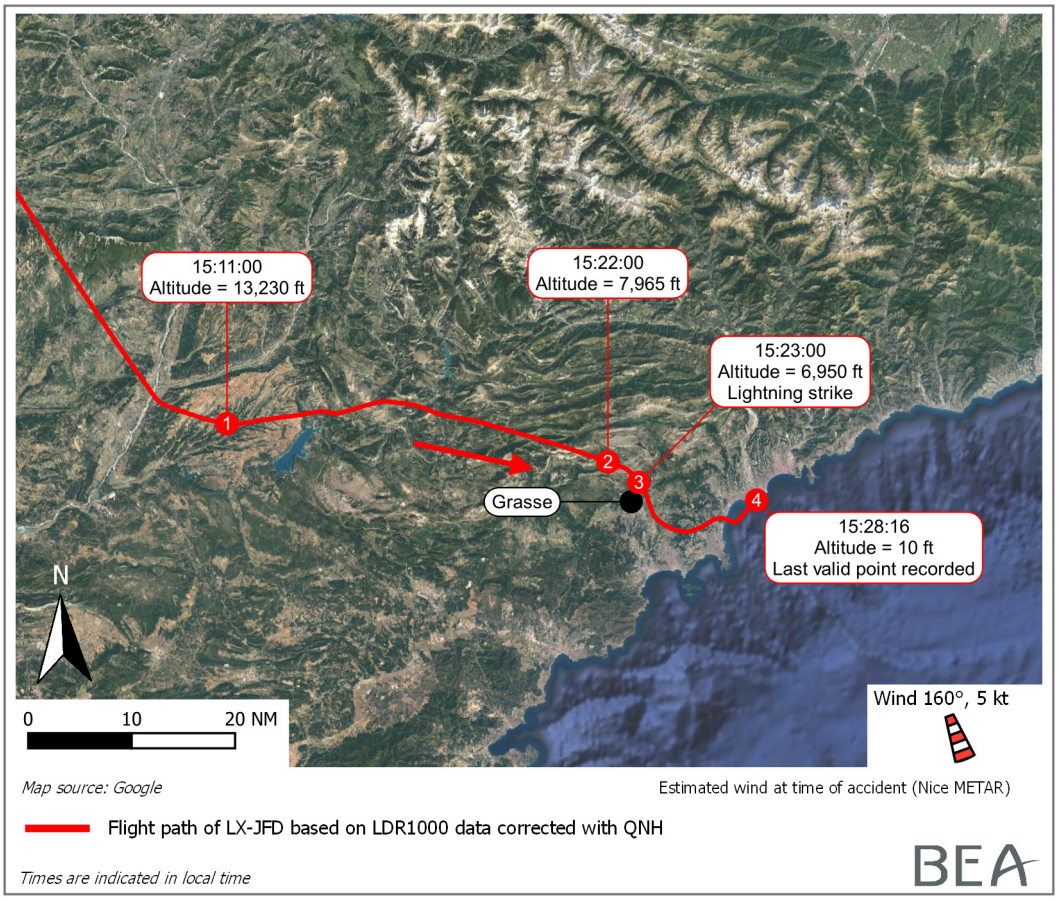


Figure 1: LX-JFD's flight path

After the flight, the crew inspected the aeroplane and noticed lightning damage on the propeller and rear section of the fuselage.

2 - ORGANIZATION OF THE INVESTIGATION

The day of the occurrence, the operator notified the in-flight lightning strike to the French air navigation service provider (DSNA) and the Directorate of Civil Aviation of the Grand Duchy of Luxembourg (DAC). The BEA was not informed of it.

A few days later, while inspecting the aircraft, the maintenance personnel observed damage on the left wing unrelated to the in-flight lightning strike. On 04 June 2020, the operator informed the DAC that structural damage had been found on the left wing.

On 29 June 2020, the DAC informed the Luxembourg Administration for Technical Investigations (AET) of the lightning strike and damage on the left wing. The AET immediately contacted the BEA which started to collect information from the aircraft operator and manufacturer in order to decide on the appropriateness of opening a safety investigation.

On 9 July 2020, given the initial elements collected, the BEA decided to open a safety investigation. The Luxembourg investigation authority (state of the operator), the Swiss investigation authority (state of manufacture) and the United States investigation authority (state of propeller manufacture) appointed their accredited representatives and technical advisers (on behalf of respectively the operator and DAC, the aircraft manufacturer and the propeller manufacturer).

3 - ADDITIONAL INFORMATION

3.1 Crew licences and experience

3.1.1 Captain

The 30-year-old pilot-in-command held an aeroplane Commercial Pilot License (CPL (A)) issued in September 2013 with the following ratings:

- multi-engine piston (MEP);
- instrument rating/multi-engine (IR/ME);
- Pilatus PC12 class;
- aerobatic flight;
- flight instructor (aeroplane) (FI (A)).

She had logged 429 flight hours on type as pilot-in-command of which 27 hours in the previous 30 days.

3.1.2 Co-pilot

The 31-year-old co-pilot held an aeroplane Commercial Pilot License (CPL (A)) issued in October 2011 with the following ratings:

- multi-engine piston (MEP);
- instrument rating/multi-engine (IR/ME);
- Pilatus PC12 class;
- night rating (aeroplane),
- flight instructor (aeroplane) (FI (A)).

She had logged 600 flight hours on type of which 27 hours in the previous 30 days.

3.2 Aircraft, engine and propeller information

Aircraft
Manufacturer: Pilatus Aircraft Ltd.
Model: PC12-47E.
Serial Number: 1787.
Time since new: 1,243 h 35 min.
Number of landings since new: 1134.

Engine
Manufacturer: Pratt & Whitney Canada.
Model: PT6A-67P.
Serial Number: RY0859.
Time since new: 1,243 h 35 min.
Number of cycles since new: 1130.

Propeller
Manufacturer: Hartzell
Model: HC-E5A-3A.
Serial Number: SA593.
It is a variable-pitch propeller with five composite blades.
Time since new: 1,243 h 35 min.

3.3 In-flight lightning strike information

The aeroplane was equipped with a weather radar and a stormscope.

It was also equipped with a Lightweight Data Recorder, an LDR1000. The analysis of the recorded data did not reveal the in-flight lightning strike.

3.3.1 Damage resulting from in-flight lightning strike

Propeller
One of the propeller blades was damaged by the lightning (see Figure 2).

The main damage was located in the trailing edge area of the blade. This area is composed of foam and approximately 1 mm-thick carbon fabric ply. This area is not considered as structural. The blade was not repairable.

Source: Jetfly Inspection Report

Figure 2: Damage observed on a propeller blade

The propeller manufacturer had never previously observed this type of damage in operation due to an in-flight lightning strike. In its experience, the damage occurs near the blade tips and several blades are generally affected. The particular nature of this damage could correspond to an exit point rather than an entry point, i.e. the lightning travelling through the aircraft airframe towards the blade and not from the air towards the blade. The severity of this lightning strike is similar to what can be observed in the laboratory during the propeller certification and corresponds to relatively high energy. The propeller manufacturer considered that the damaged blade was still structurally solid in the spar area and that the propeller could continue to operate without failure or rupture.

After replacing the blade, the propeller was overhauled and then reinstalled on the aircraft.

Engine

The complete inspection of the engine showed that the main damage observed was related to the lightning strike, in particular:

- The presence of residual magnetism in the propeller shaft, the second stage planet gear carrier, the power turbine shaft, the gas generator case, the compressor rotor, and the starter generator drive pad.
- Arcing and spots of melted material on the roller bearings, gearbox housing, propeller governor drive shaft, propeller governor bevel gear shaft, planet gear carrier, starter/generator drive cover and drive support roller bearing and the accessory gearbox housing.
- Rubbing on compressor turbine blade tips.
- Erosion and impact damage on the compressor blades.
- Mechanical damage on a gear shaft tooth.
- Scores and nicks/gouges on oil scavenge pump housing.

The damage observed did not jeopardize the airworthiness of the engine.

After replacing the damaged parts, the engine was reinstalled on the aircraft. The starters/generators were also checked and then reinstalled.

Airframe

The right ventral fin was damaged by the lightning (see Figure 3).

Source: Jetfly Inspection Report

Figure 3: Damage observed on right ventral fin

After repair, the ventral fin was reinstalled on the aircraft.

Avionics
The stall protection system (stick pusher) and stormscope computers were damaged. The other onboard systems operated normally.

3.3.2 Meteorological information

Meteorological information available before the flight
Before carrying out the flight, the crew had the weather information contained in the flight file at their disposal:

- The METARs and TAFs of the aerodromes on the planned route and in particular at Nice.

The meteorological conditions at Nice at 11:30 were the following: wind from 110° at 5 kt, visibility greater than 10 km, clouds 3 to 4 octas at 1,100 ft, 1 to 2 octas at 3,300 ft (Cumulus Congestus), 3 to 4 octas at 10,000 ft, 5 to 7 octas at 23,000 ft, temperature 15 °C, dewpoint temperature 11 °C, QNH 1,013 hPa, no significant change forecast in the two hours following the report.

The Nice weather forecasts made at 10:00 were the following:

- For the period 11:00 to 17:00, wind from 100° at 7 kt, visibility greater than 10 km, clouds 3 to 4 octas at 1,000 ft, 5 to 7 octas at 4,000 ft.
- Temporary fluctuations lasting less than an hour and covering less than half of the period from 12:00 to 20:00: 3 to 4 octas at 2,000 ft (Cumulus Congestus).
- Temporary fluctuations lasting less than an hour and covering less than half of the period from 14:00 to 19:00: 1 to 2 octas at 3,000 ft (Cumulo Nimbus).

- A significant weather chart covering the route, valid at 14:00 and a vertical cross-section forecast made at 08:00 based on the London WAFC forecast. During the descent to Nice, turbulence and moderate icing conditions were forecast below FL 140.

General situation in south-east France
The day of the lightning, the weather was very unsettled, there were clouds at all levels with embedded cumulonimbus giving rise to thunderstorms, except on the coast.

The turbulence was moderate to high close to the storm systems.

15:30 Nice METAR
The meteorological conditions at Nice were the following: wind from 160° at 5 kt, visibility greater than 10 km, cloud cover 3 to 4 octas at 1,100 ft, 1 to 2 octas at 3,300 ft (TCU), 3 to 4 octas at 10,000 ft, 5 to 7 octas at 23,000 ft, temperature +15 °C, dewpoint temperature +11 °C, QNH 1,012 hPa.

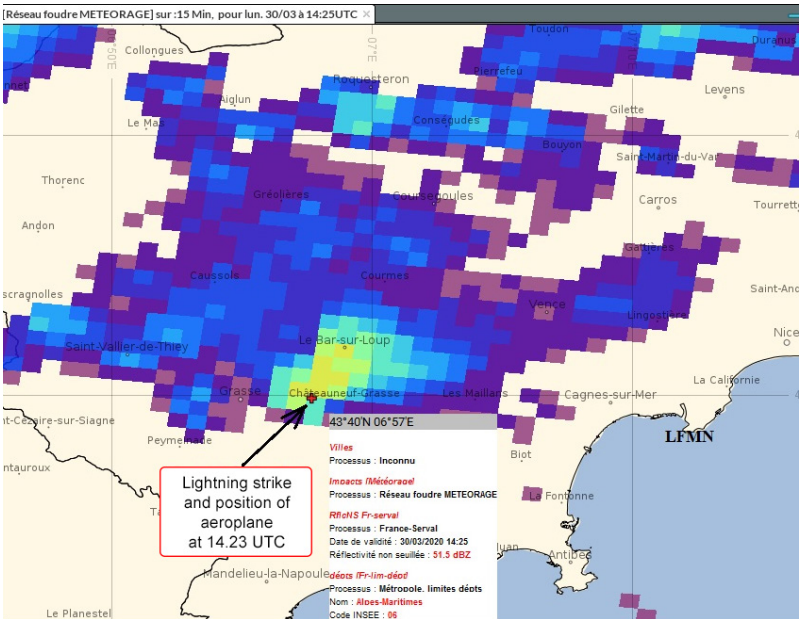
Lightning strikes between 15:10 and 15:25 (see Figure 4)
Only one lightning strike close to the plane's flight path was recorded by Météo-France. It is shown by a red cross close to the district of Grasse (Alpes-Maritimes).

The discharge current recorded was very high (147.7 kA). By comparison, the discharge current of the other strikes recorded in the same period was less than 20 kA. Impacts of more than 100 kA are among the most powerful recorded and are rare.

Given the distribution of the lightning recorded in the same period, it is probable that the presence of the aeroplane participated in triggering the electric discharge phenomenon.

Analysis of 15:25 precipitation radar image (see Figure 4)
The image shows a calculated reflectivity in the area of the heaviest precipitations (yellow pixels) which suggests hail. Generally speaking, turbulence is strong under, in and around such Cumulonimbus. However, the accuracy of the (Météo-France) weather radar means that it is not possible to have more information about the strength of small-scale turbulence.

At 15:23, the position of the lightning strike (red cross on Figure 4) was consistent with that of the plane.



Source: Météo-France

Figure 4: Radar image of precipitations at 15:25

3.4 Structural damage observed on ground information

3.4.1 Description of structural damage

The damage observed by the maintenance personnel consisted of deformations of the left wing skin, at the leading edge and under the wing (see Figures 5 and 6).

Figure 5: Deformations observed on left wing leading edge

Figure 6: Deformations observed on lower surface of left wing

The aircraft was examined at Pilatus Maintenance at Stans in Switzerland. Only the left wing was damaged.

Signs of major structural damage were observed on the skin of the left wing in the form of diagonal folds/creases in several places. The arm of the outboard flap mechanism was permanently deformed.

Symmetry and alignment measurements of the airframe structure did not reveal significant deformation. The inspection of the wing attachment points and the geometry of its attachment points to the fuselage did not reveal any permanent deformation.

According to the aircraft manufacturer, the damage found could be the consequence of a hard landing.

However, certain types of damage which could indicate a hard landing were not present:

- No deformation on upper surface of wings.
- The whole of the landing gear well was free of flaking, cracks and paint marks.
- The left main landing gear and shock-absorber were in good external condition. There were no marks on the up stop. Their disassembly showed no damage.
- There was no damage on the attachment points of the left main landing gear.
- The left wheel and tire were in good condition.

The observations made on the aircraft seem to support the hypothesis of high loads in flight rather than a hard landing.

The left wing and certain parts of the trailing edge flap had to be replaced to return the aircraft to service.

3.4.2 History of maintenance operations

A major maintenance inspection was carried out on the PC12 LX-JFD from 5 to 16 November 2019. The aircraft had logged 997 flight hours and 938 landings since being delivered new. The operations carried out grouped those of the 300-hour, 300-hour/12-month, 600-hour, 600-hour/12-month and 1,200-hour/12-month inspections.

In particular, the surface condition of the wings along with the control arms and housings of the trailing edge flaps were checked. No damage was observed.

3.4.3 Aircraft log book

The examination of the aircraft's log book since the last inspection in November 2019 did not show any event likely to have caused structural damage.

3.4.4 Analysis of flight data recordings

The analysis of the ACMS[4] data since the maintenance inspection in November 2019 did not bring to light any element indicating a hard landing or acceleration likely to have caused structural damage in flight.

[4] Aircraft Condition Monitoring System. Developed for maintenance purposes, it records the engine trends, overspeeds and load factor exceedances on the three axes.

The sampling frequency of the data recording means that it cannot be affirmed that there was, or was not a hard landing. The ACMS system is not designed to detect "hard" landings which must be reported by the pilot.

The data recorded in the LDR1000 was analysed. It corresponded to the last six flights carried out by LX-JFD which included the flight of 30 March 2020 in which the aircraft was struck by lightning. On 24 March 2020, the aircraft had landed at Denham aerodrome in Great Britain with a high calculated vertical speed. However, the load factors, speeds and bank values recorded do not show any situation which could have resulted in a structural overload of the wing during these last six flights.

3.4.5 Detection of structural overloads

A hard landing is not exclusively characterized by the exceedance of a vertical acceleration maximum limit. It depends on other parameters such as the vertical speed, airspeed, aircraft attitude and bank angle, roll and pitch rate, weight and balance of the aeroplane and the quantity of fuel in the wings. Consequently, a hard landing detection system does not exist on the PC12. Its detection is principally based on the pilot's impression and on the observation of damage or deformation on the landing gear or the outer skin of the wings and fuselage during a pre-flight inspection and maintenance operations.

The geometry of the aeroplane (cockpit forward of the main landing gear), the quality of the soft trims and the pilots' experience influence the impression of abnormal accelerations permitting the characterization of structural overloads.

Load factor operational limits are defined for in-flight operations. They are recorded and detected by the ACMS. The position of the accelerometers and their sampling frequency do not permit, however, the measurement of local accelerations which characterize high aerodynamic loads which may be caused by rough manoeuvres.

4 - CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation. They are not intended to apportion blame or liability.

Scenario

In descent to Nice airport, the crew tried to avoid storm cells by using the aeroplane's weather radar. They encountered icing conditions and moderate turbulence. Shortly before coming out of the clouds and when the flight conditions were becoming calmer, the aeroplane was struck by lightning. Given the distribution of the lightning recorded in the same period, it is probable that the presence of the aeroplane participated in triggering the electric discharge phenomenon. The strength of the discharge current was very high and caused damage to the propeller that the manufacturer had never seen previously in operating conditions. Its structure was not compromised however.

A few days later, during the aircraft inspection, other structural damage not related to the lightning strike was found on the left wing. The wing had to be replaced.

The investigation showed that this structural damage had occurred between 16 November 2019, date at which the aircraft was released from the last maintenance operation and 30 March 2020, the lightning strike flight. This damage was probably caused by an in-flight overload of the wing even if a hard landing cannot be totally excluded. It was not possible to precisely determine or date the occurrence which caused it. The conditions of the last flight were favourable to high loads being applied to the structure. However, the load factors, speeds and bank values recorded do not show any situation which could have resulted in a structural overload of the wing during these last six flights.

Contributing factors

Assuming that the structural damage occurred before the lightning flight, the following elements might have contributed to its late detection:

- The difficulty of visually detecting wing deformations during the pre-flight inspection.
- The specifications of the Aircraft Condition and Monitoring System (ACMS) which do not permit the characterization of a hard landing or rough manoeuvre.
- The difficulty for pilots to characterize the severity of an abnormal acceleration based on just an impression, whether in flight or on landing.

Safety lessons

The characterization of an in-flight or on-ground structure overload is principally based on the crew's impression. Consequently, it is possible that this type of occurrence does not lead to a report being made and the airworthiness of the aircraft being checked.

In these conditions, a careful pre-flight inspection is of particular importance. Indeed, it is the last safety barrier to prevent a flight with a structurally damaged aircraft from being carried out. In particular, folds in the wing and fuselage skin and moving parts of the wings, and deformations of the flight controls are signs that must alert the pilot and lead to him/her asking a member of the maintenance personnel for his/her opinion.