BEA
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SAFETY INVESTIGATION REPORT

Accident to the ISSOIRE AVIATION - APM30 registered F-HHOP on Sunday, 2 August 2020 at Arras-Roclincourt (Pas-de-Calais)

Time	At 12:53[1]
Operator	Aéro-club Les Ailes Arrageoises
Type of flight	Local
Persons on board	Pilot
Consequences and damage	Pilot fatally injured, aeroplane destroyed
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.	

Rupture of left flap control, loss of control during approach, collision with ground

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on radar data, data recorded in the APIBOX system on board the aeroplane, statements and telephone message recordings on the instructor's telephone.

The pilot, unaccompanied, took off at 11:50 from runway 22 of Arras-Roclincourt aerodrome for a local flight towards the coast on a route that he was used to taking.

On his return, the pilot flew overhead Arras-Roclincourt aerodrome (see **Figure 1**, point 1) and after turning for a reconnaissance, he headed towards the downwind leg of the aerodrome circuit for runway 22 (point 2). At 12:51, the pilot started the descent. At 12:53, the aeroplane collided with the ground on the axis of the runway and came to a stop in a field of tall corn.

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

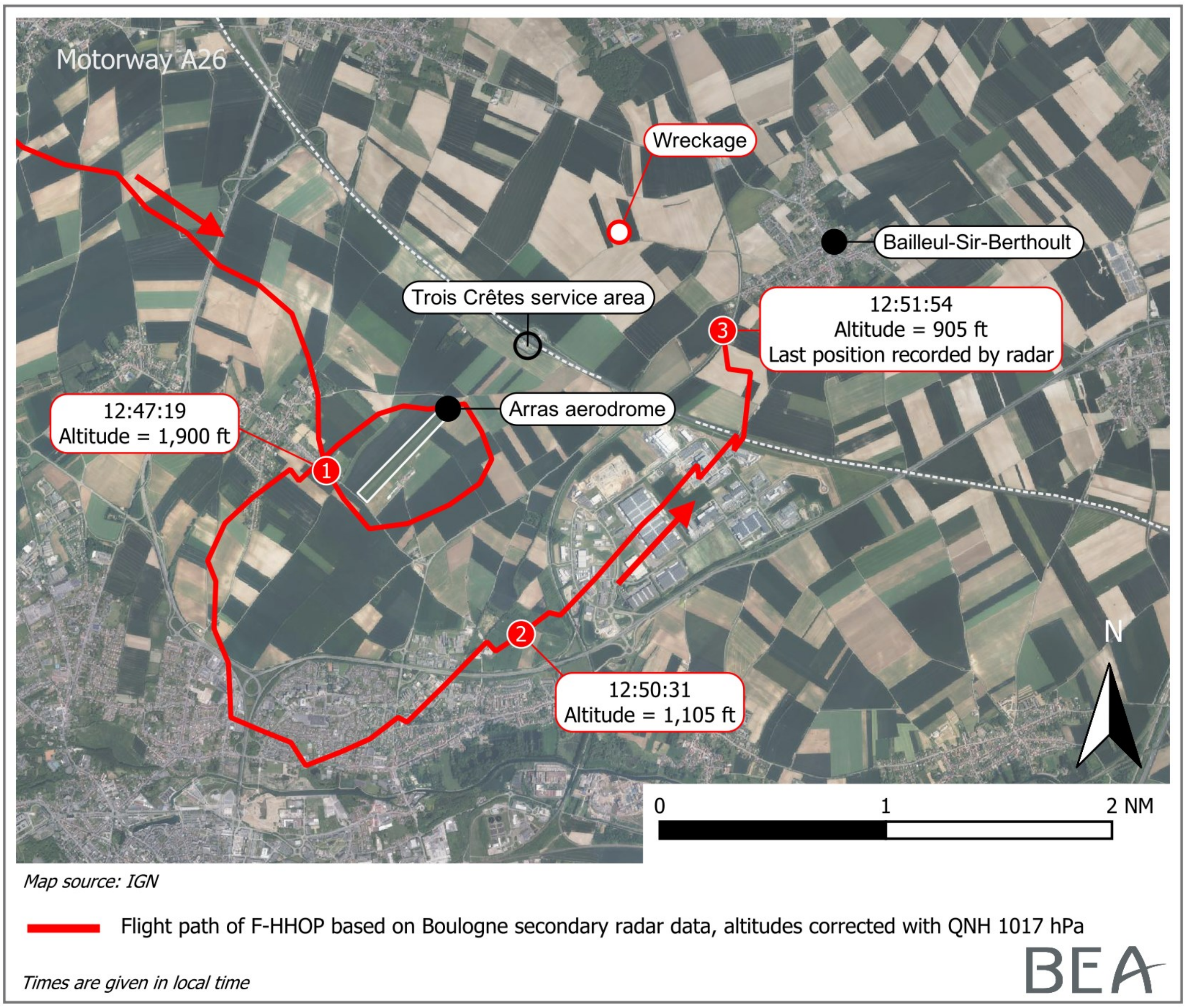

Figure 1: end of flight path of F-HHOP

2 ADDITIONAL INFORMATION

2.1 Site and wreckage information

The accident site was on the axis of runway 22, around two kilometres before the runway threshold. The wreckage was situated in the middle of a field of corn, the crop was about two metres high. It was visible neither from the closest road nor from the track leading to the field (see **Figure 2**).

Figure 2: wreckage in corn field (source: BEA)

A first impact mark was located around 50 m north-east of the position of the main wreckage. The observation of the site and wreckage found that the aeroplane's left wing had struck the ground and then torn off (see **Figure 3**). The energy at the time of the collision with the ground was moderate.

Figure 3: views of wreckage from initial impact point (on left), and left wing found between the first point of impact and the main wreckage (on right) (source: BEA)

Forward of the wings, the aeroplane was destroyed. From the wing roots to the tail plane, the fuselage was in a relatively good condition. The canopy was missing.

The flap control on the instrument panel was set to 25° (landing position) which was consistent with the position of the right flap.

The screw which fastened the left flap actuating rod to the flap itself had failed (see **Figure 6**, item 41). One end of this screw was still in place in the flap attachment (see **Figure** *4*), the other end was found on the site between the area of the first impact and the position of the wreckage. The conical washer (see **Figure 6**, item 40) was not found. Detailed information about the results of the laboratory examination of the ruptured screw are given in paragraph 2.2.3.

Figure 4: left flap arm and end of rod attaching screw in position in bore hole (source: BEA)

Except for the left flap control, the flight controls were either continuous or had failed as a result of the impact.

The examination of the wreckage did not find any other element which could explain the loss of control.

The emergency locator transmitter (ELT) and the antenna were found attached to their respective mounts in the aeroplane. However, the connector connecting the ELT to the antenna was found broken (see **Figure 5**).

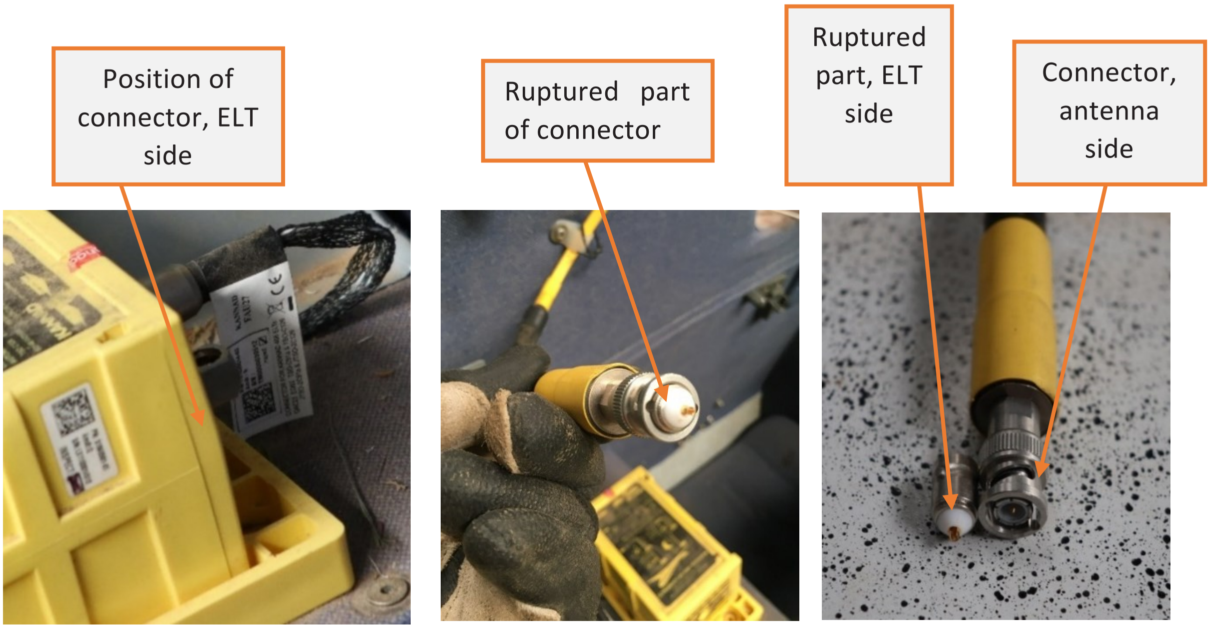

Figure 5: ruptured elbow connector between the ELT and the antenna (source: BEA)

The ELT was found active: the switches on the ELT and on the instrument panel were set to "ARMED". The red light on the ELT was flashing and the intermittent aural signal was active indicating that the ELT was emitting. As the antenna was disconnected from the ELT, no search and rescue (SAR) service received the signal emitted by the ELT.

2.2 Aeroplane information and additional examinations

2.2.1 General information

The APM30 is the three-seat version of the two-seat APM20 (two forward seats and one rear seat) built by Issoire Aviation. It shares with the APM20, the same composite structure and the same equipment. It is equipped with a 100-hp Rotax 912S engine and complies with the European Aviation Safety Agency (EASA) CS-VLA[2] certification requirements.

Access to the rear seat on the APM30 is preferably from the right, with a footprint symbolising this access (see **Figure 10**).

In 2023, there were 35 APM20s/30s in operation (20 APM20s and 15 APM30s).

2.2.2 Wing flap system

The flap selector (see **Figure 6**, item 1) has three positions: 0, 12.5° (take-off) and 25° (landing). The flaps are controlled by a multi-function unit which actions the electrical control actuator (item 3) and are mechanically interconnected by a system of metal rods and composite bellcranks as described in **Figure 6** below.

[2] *Very Light Aircraft*.

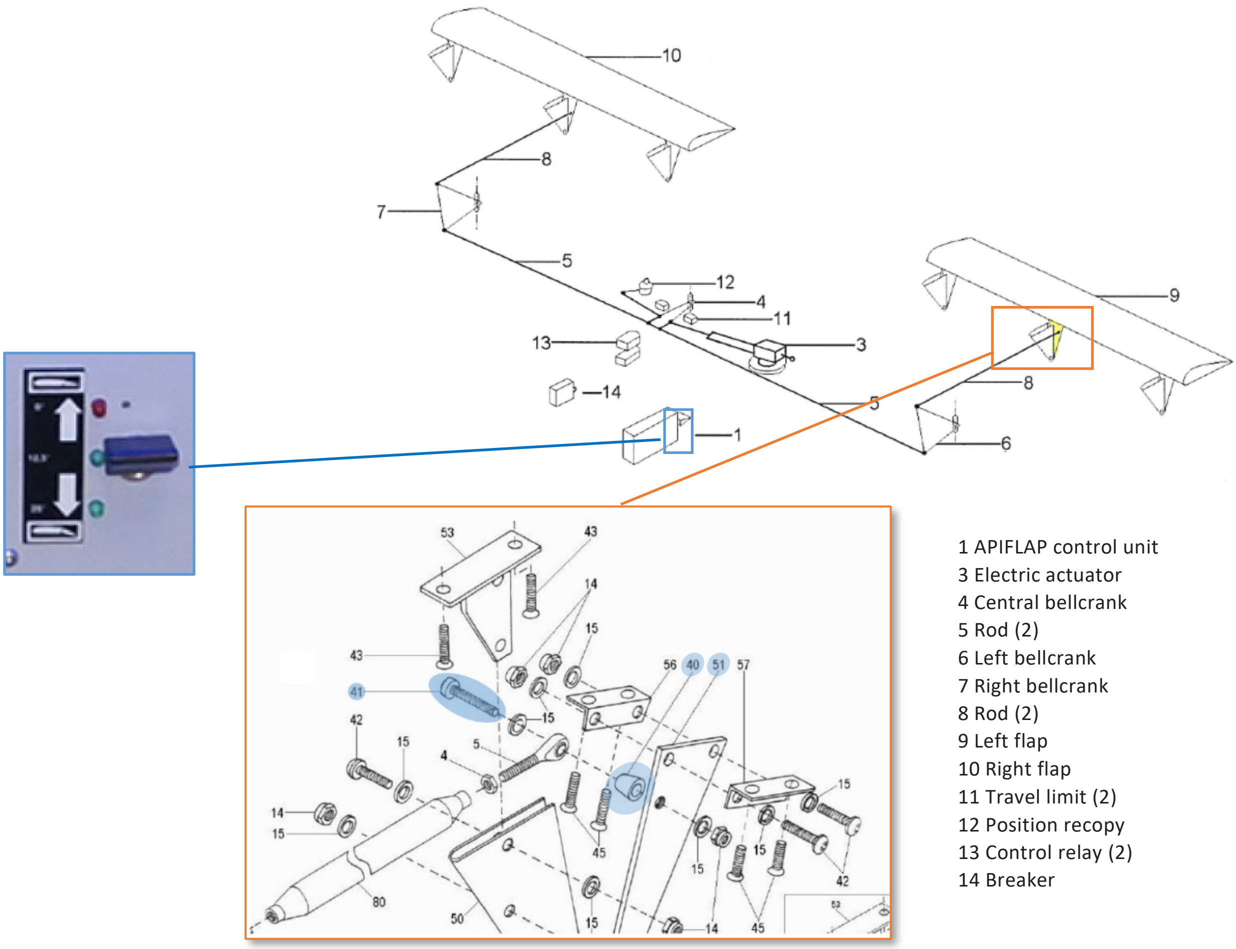

Figure 6: diagram of wing flap actuating mechanism on the APM30 (source: Issoire Aviation, annotated by the BEA)

There are three lights (one amber and two green) on the instrument panel, on the left side of the control, indicating the position of the flaps or a possible malfunction. These lights are based on the position of the flap electric motor (item 12). The aeroplane flight manual specifies that the flashing of the upper amber light indicates a fault. The aeroplane manufacturer indicated that the amber light is designed to flash if there is a difference between the position of the instrument panel control and the position of the flap electric motor and not if there is an anomaly in the flap control system downstream of the electric motor.

If a flap is no longer connected to its control, the aeroplane is likely to experience aerodynamic asymmetry (lift, drag and induced effects) which could compromise its controllability.

The CS-VLA certification specification does not require it to be shown that the aeroplane can still be piloted in the event of asymmetric extension of the flaps.

Issoire Aviation indicated that it had nevertheless determined by means of aerodynamic calculations[3], that a maximum flap asymmetry could be countered by moving the roll control by 80% of its travel in the opposite direction.

[3] These calculations were not checked by the BEA.

Furthermore, the CS-VLA does not impose a specific risks analysis method with respect to malfunctions or failures. It solely specifies that, "*The equipment, systems, and installations must be designed to minimise hazards to the aeroplane in the event of a probable malfunction or failure*" (CS-VLA 1309). It was for the manufacturer to determine if a malfunction or failure had to be covered by an abnormal or emergency procedure. This is not the case for the asymmetric extension of the flaps on the APM30, as for most light aircraft complying with CS23[4] and very light aircraft CS-VLA. Furthermore, the aeroplane did not have a system for monitoring and blocking the asymmetric extension of the flaps as is the case for aircraft complying with CS25[5] for example.

2.2.3 Examination of flap screws

The left flap arm (see **Figure 6**, item 51) and the screw attaching it to the control rod (item 41) were removed for detailed examination in the BEA laboratory. The equivalent system on the right side of the aircraft was also removed (see **Figure 7**).

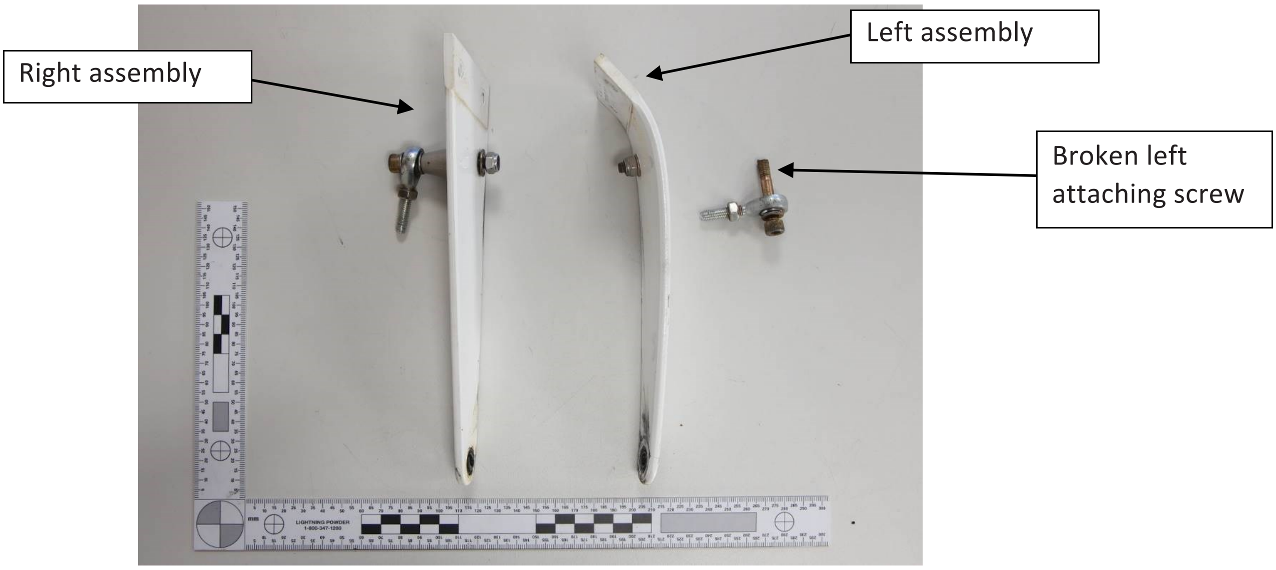

Figure 7: examined flap arms of F-HHOP (source: BEA)

The left attaching screw had failed in the root of the thread, 35 mm below the screw head. There was no visible deformation of the screw along its length. The material used, its microstructure and its hardness complied with the expected requirements for a screw of this type[6].

All of the characteristics observed during the visual examination (see **Figure 8)** and under the scanning electron microscope (SEM) indicate that the screw had failed as a result of a fatigue cracking process under alternating bending loads.

A multitude of micro-cracks had begun in the root of the thread, joining to form ratchet marks and eventually forming two main cracks, diametrically opposed. They continued to propagate until the remaining stressed section of the screw was no longer sufficient to withstand the in-service loads, leading to its complete failure (matt and grainy area characteristic of a sudden overload failure).

[4] Certification Specifications for Normal, Utility, Aerobatic and Commuter Aeroplanes.
[5] Certification Specifications for Large Aeroplanes.
[6] The screw head had a mark corresponding to class 8.8 of standard NF EN ISO 898-1.

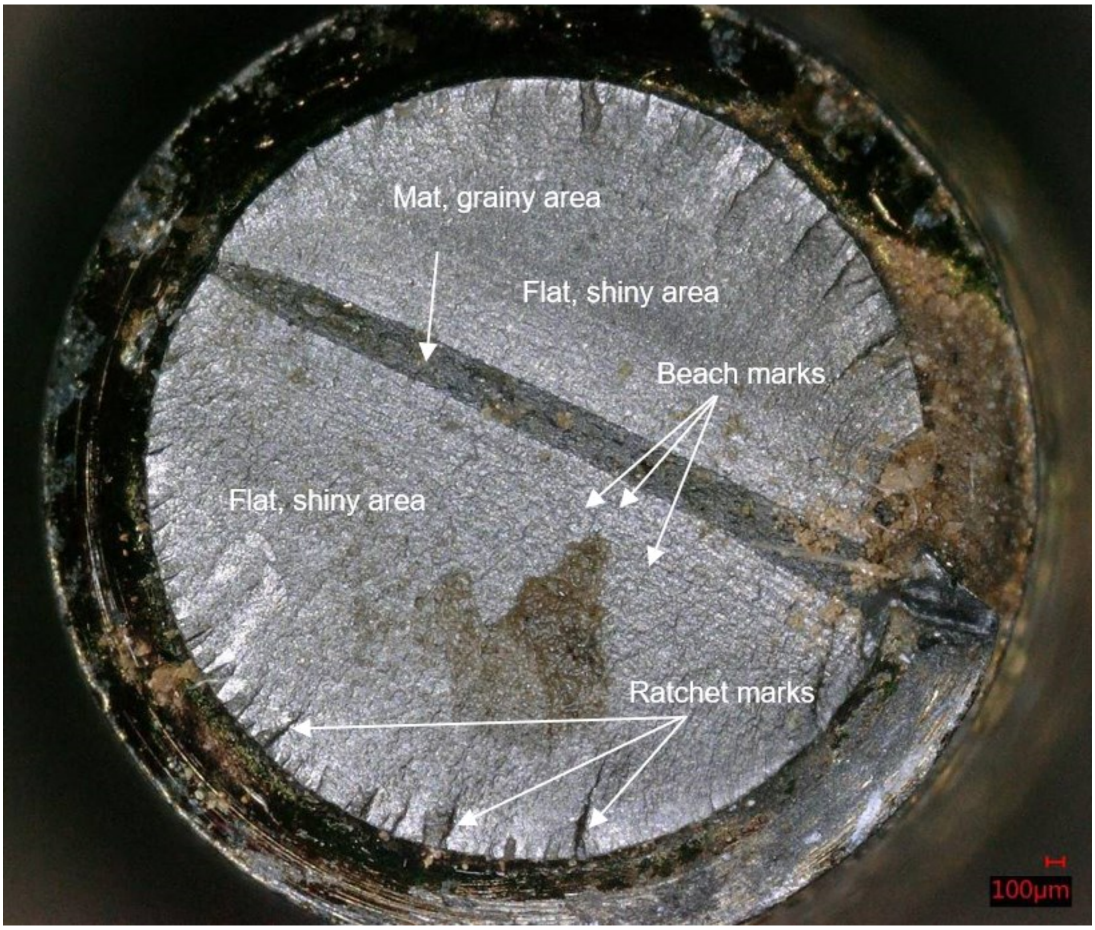

Figure 8: fracture face of broken left attaching screw (source: BEA)

The right screw was examined for comparison purposes. Although visually intact, micro-cracks were observed under the SEM in the root of the thread, over around ten millimetres, in a comparable area to where the failure had occurred in the left screw.

Attaching screws (right and left) from another APM30 belonging to another flying club were examined by the BEA after they had been removed for replacement in the scope of a routine maintenance operation. Examined under the SEM, these screws also had micro-cracks in the root of the thread.

Two new screws provided by Issoire Aviation were examined for comparison. These screws did not have micro-cracks in the root of the thread.

Note: fatigue cracks start after a period of accumulating and storing energy. In general, this incubation period represents 50 to 90% of the service life of an equipment item, during which damage is not visible. When the stored energy reaches a certain threshold, this leads to one or more incipient micro-cracks. The propagation of these cracks is the last step in the fatigue process before the final failure. They also create stress concentrations, generally increasing the speed of their propagation. Conserving a suitable torque tightness can help delay the onset of fatigue.

The right and left arms of F-HHOP were also examined (see **Figure 9**). A deformation of the left arm was observed, characteristic of abnormally high loads probably following the separation of the left wing when the aircraft collided with the ground. After removing the screwed assemblies, it was observed that the conical washer had only left a mark in one sector on the left arm (blue arrow) whereas the mark on the right side was clearer with a more homogeneous circumference (red arrow). The asymmetric mark on the left arm corresponded to the direction of application of the bending forces of the screw/conical washer assembly. This finding was consistent with incorrect tightening of the screwed assembly, leading to the introduction of abnormally high bending forces within the left attaching screw.

<u>Note</u>: a tightness fault is a condition which can result from the application of an inappropriate method or tightening torque or from the loosening of the assembly over time.

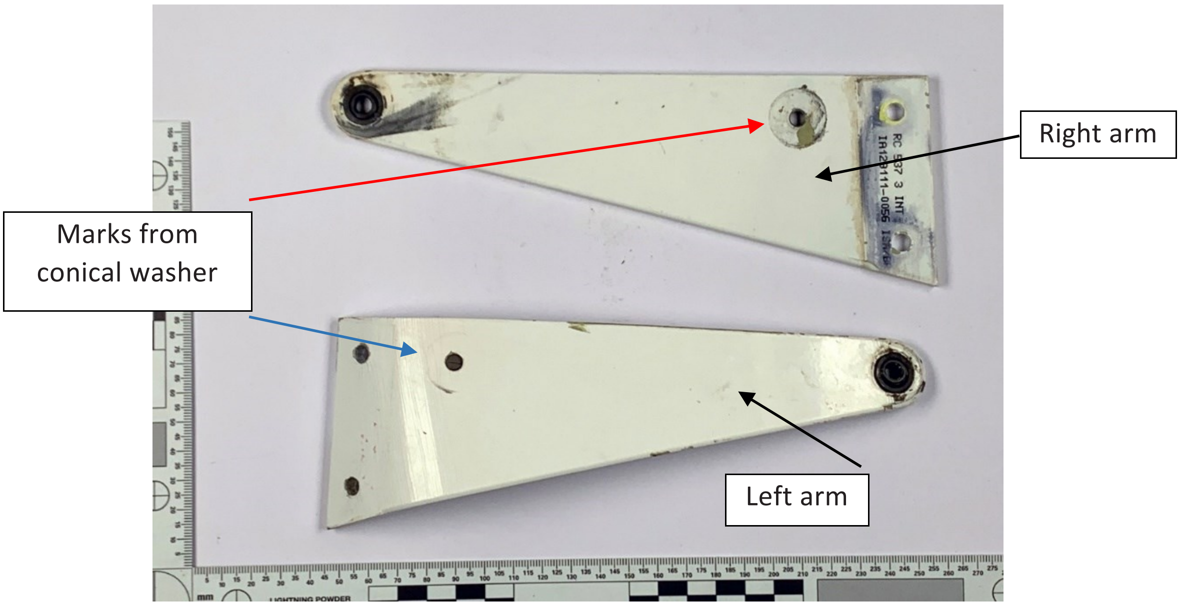

Figure 9: right and left arms of F-HHOP (source: BEA)

The screws examined from the second APM30 were received at the BEA already disassembled. The arms were not examined.

2.2.4 Emergency locator transmitter (ELT)

- Description of ELT assembly

The ELT installed in F-HHOP was a Kannad 406 AF Compact. It was fixed on a mount attached to the aeroplane structure (ledge on left side of rear passenger seat). The ELT was connected via an elbow connector to an interior antenna Kannad ANT 100 fixed to the rear of the pilot's seat. The Kannad 406 AF Compact models were not equipped with a built-in GPS antenna. According to the serial numbers of the APM30s, the ELT antenna was fixed in different ways to the back of the pilot's seat.

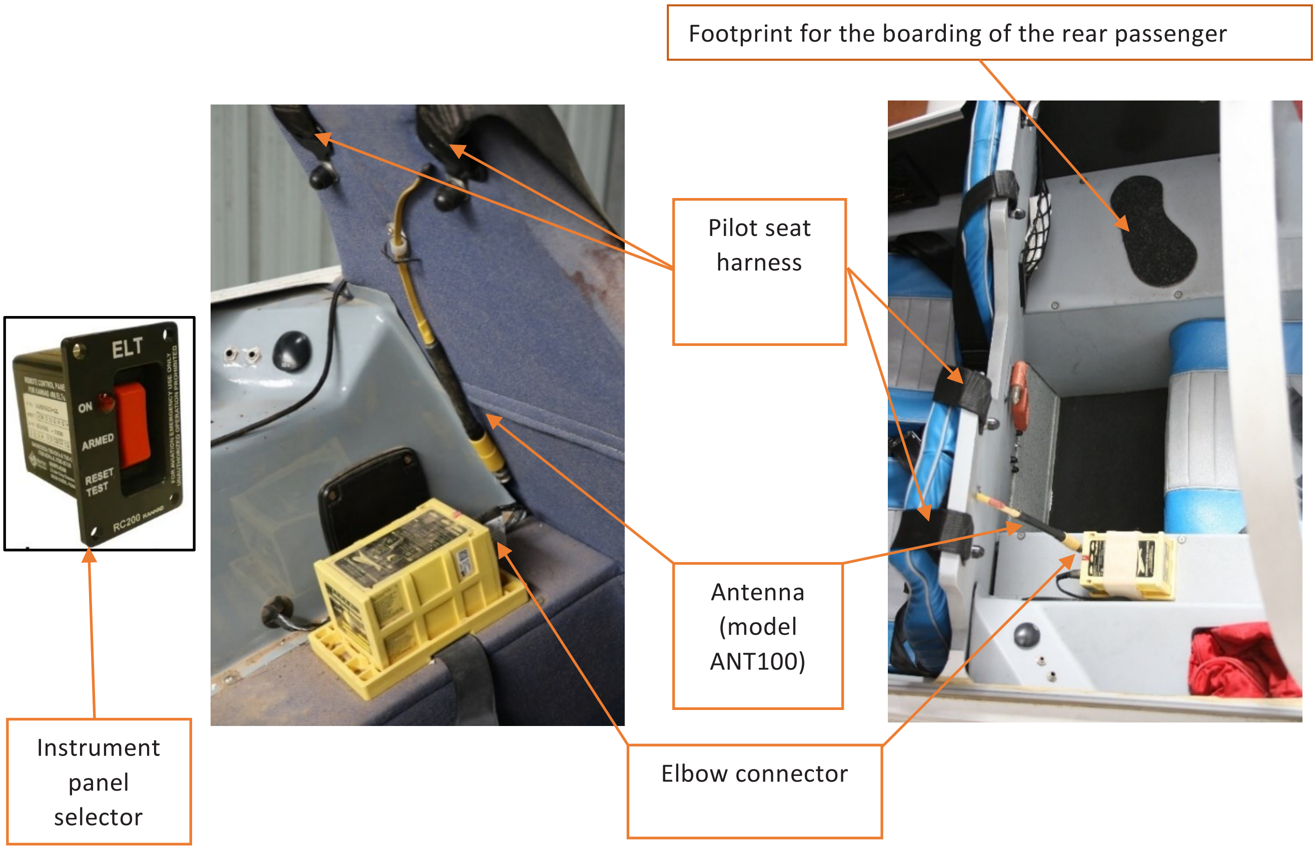

Figure 10: installation of ELT in F-HHOP (source: BEA)

Figure 11: installation of ELT in another APM30 (source: Aéroclub Brocard-Étampes)

- Certification of ELT installation

The ELT model was changed on the APMs in 2008 following the obligation to carry an ELT emitting on the 121.5 and 406 Mhz frequencies. Issoire Aviation filed a modification file[7] with EASA covering, among other aspects, the replacement of the ELT. The file indicated the ELT model to be installed (Kannad 406 AF Compact) without specifying the antenna model used or how it was fixed in the cabin.

Furthermore, it could be understood from the diagram in the appendix of the file (see **Figure 12**) that this was an approved external antenna model and that the antenna was joined to the ELT and not attached to the back of the pilot's seat. This modification file was approved by EASA on 21 July 2008 by a “Minor change approval” referenced EASA.A.C10413.

[7] Modification file No FM 22-08 dated 9 July 2008.

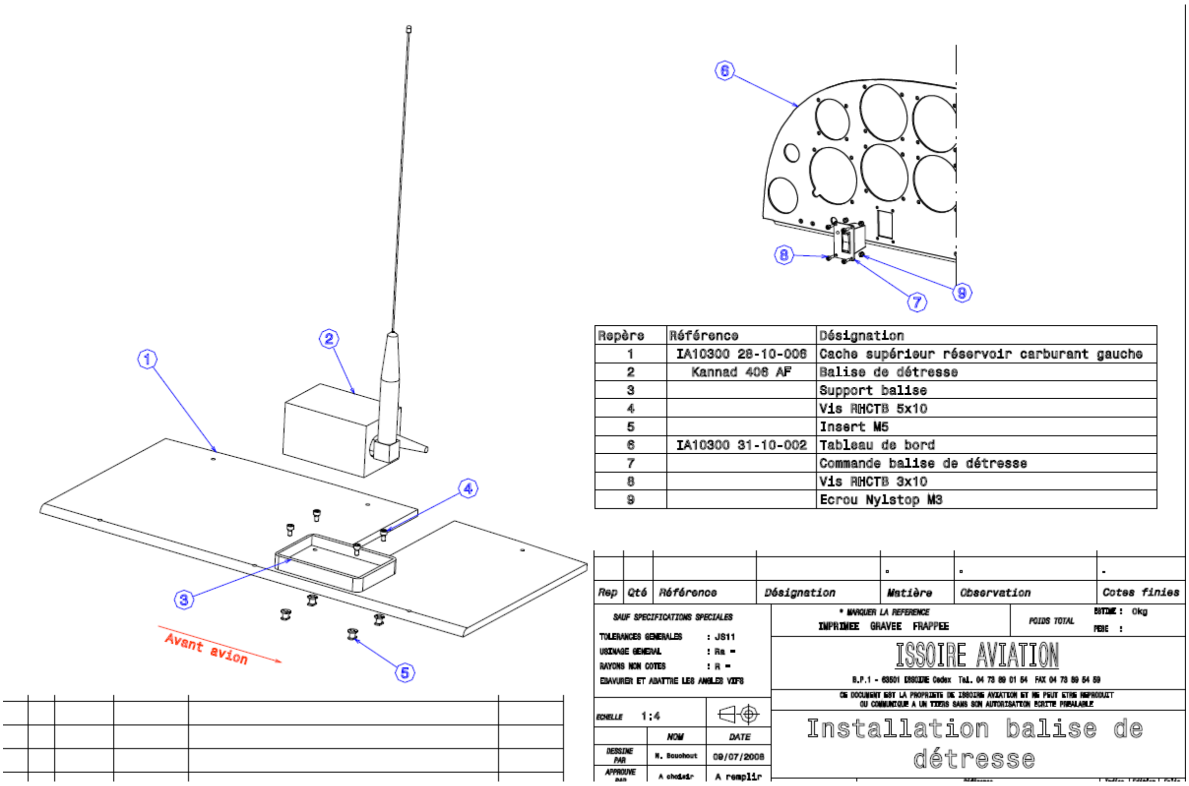

Figure 12: diagram in the ELT modification file
(source: Issoire Aviation)

The ELT manufacturer's installation and operation manual[8] listed the five antennas compatible with the 406 AF Compact ELT. These were external antennas to the aeroplane airframe. The antenna model ANT100 was, however, listed with a note indicating that it was an auxiliary antenna designed to be used as a portable equipment item after an aircraft accident. The antenna was not approved and its use as an auxiliary antenna was subject to an approval by the competent authorities.

The manufacturer of the ELT indicated that given the specificity of installing ANT100 as the main antenna inside the aircraft airframe, it should have been contacted by the manufacturer of the aircraft for an advice request and that this should have been the subject of a substantiation file for EASA, in order to demonstrate that this installation offers the same operation and radiation guarantees as the recommended installation[9]. Issoire Aviation transmitted an ELT test sheet for a test carried out on 6 June 2008 to the BEA. This document specifies neither the test result, nor the standards in force nor the comparison with the radiation of an external antenna. The ELT manufacturer indicated that it had not been consulted by Issoire Aviation about this aspect.

Furthermore, the EUROCAE ED-62B standard updated in December 2018 indicated that the ELT installation manual must specify that an external antenna may be placed inside the aircraft

[8] Kannad DOC08038D document ref. 0145599D published on 10 June 2008, amended by Revision 3 of 5 May 2010.

[9] Kannad indicated that the radiation tests carried out by the ELT manufacturer were based on the simulation of an external antenna placed on a metal aeroplane. No simulation was carried out with the antenna placed inside a composite aeroplane fuselage, this being the responsibility of the aeroplane manufacturers.

fuselage, provided that the transmission power transmitted by the antenna (EIRP[10]) is not reduced by more than 0.2 dB in the 406.0 to 406.1 MHz frequency range (paragraph 6.2.11.2.1). This indication is present in the Kannad ELT installation manuals for ELT's complying with standard ED-62B, i.e. post December 2018.

- Statements from managers of other flying clubs operating APM30s

The BEA contacted other flying clubs operating APM30s. Those contacted indicated that the way the ELT was installed could sometimes interfere with the movements of passengers getting into the rear seat or possible luggage placed on the rear seat. In addition, in certain cases, one of the shoulder straps of the pilot seat harness may wind itself around the antenna when it is unfastened (see **Figure 10**). These situations are likely to pull on the antenna and on the connector, and may lead to the latter breaking or being disconnected from the assembly.

A manager of one of the flying clubs contacted by the BEA indicated he had observed by chance, during a maintenance inspection, that an internal conductor of an antenna connector on an APM30 was ruptured, without knowing for how long the aeroplane had been flying with a broken connector. A manager of another flying club explained that when he took possession of a previously-owned APM30, he noticed that the ELT antenna connector was disconnected without the seller being able to indicate either the cause of this disconnection or for how long it had been disconnected.

- ELT test

A self-test function exists on the ELT. The ELT operation manual recommends that the pilot or maintenance personnel check that the antenna is correctly connected and carry out a self-test from the instrument panel once a month. It is specified that the ELT self-test should not be done more than once a week in order not to discharge the ELT's internal battery.

The aeroplane flight manual requires that the ELT is tested before each flight (paragraph 4.5 normal procedures).

The self-test is carried out by temporarily setting the three-position selector on the instrument panel to TEST and then letting it return to the ARMED middle position (see **Figure 10**)[11].

For the Kannad AF Compact model installed in F-HHOP, this test only concerns the ELT and does not detect the disconnection of the antenna. Furthermore, the ELT manufacturer indicated that given the small distance between the ELT and the aeroplane's radio receiver, it would be possible to hear the brief distress signal on 121.5 Mhz emitted during the test, even if the antenna was disconnected from the ELT.

Later models of the ELT marketed by Kannad have an additional 406 Mhz back-up antenna built into the ELT. During the self-test on these models, the reflected power on the antenna connector will be detected as incorrect and the test will send an error code if the antenna is disconnected.

[10] Equivalent Isotropically Radiated Power.
[11] Video describing the ELT test sequence.

2.3 Aeroplane maintenance

Bénifontaine Aéro carried out the maintenance work on F-HHOP, based on the maintenance programme recommended by the manufacturer.

A visual inspection of the flap screws (41) on the APM30 was specified in the 2,000-hour/6-year inspections. This inspection included disassembling the flaps and screws. The manufacturer did not require the replacement of the screws at this time. As indicated in paragraph 2.2.3, the cracks observed on the screws (41) examined by the BEA would not be visible during such an operation.

The last 2,000-hour/6-year inspection was carried out on 27 August 2018, after a total of 1,571 flight hours. The mechanic who carried out this work indicated that at that time, the flaps were removed and inspected in accordance with the manufacturer's maintenance manual. He explained that he had complied with the method and torque values recommended by the manufacturer. The maintenance workshop transmitted to the BEA, the APM30 inspection protocol sheet mentioning that this task had been carried out. The mechanic indicated that at that time, the ball joints, end fittings and screws (41) had also been replaced. Issoire Aviation transmitted to the BEA, a sales slip addressed to the maintenance workshop including these latter items.

The last inspection was a 100-hour (200-hour engine) inspection carried out on 10 July 2020. At the time, the aeroplane had logged a flight time of 2,171 h. No inspection of the screws (41) was specified in this task.

On the day of the accident, the aeroplane had logged 635 flight hours since the flap screws had been replaced during the 2018 inspection.

The maintenance manual did not specify any particular maintenance action on the ELT. Only the battery was to be replaced at regular intervals.

2.4 Analysis of ATC and Apibox data

The aeroplane was equipped with a light Apibox recorder. The accident flight data was downloaded and analysed at the BEA[12].

A reduction in speed and engine power can be seen in the data during the descent after the reconnaissance turn over the aerodrome. The downwind leg was carried out at 12:49 at an altitude of 1,100 ft, with an engine rating close to 3,500 rpm and a mean indicated airspeed of 72 kt.

At the time of the presumed loss of control, the indicated airspeed increased by around 20 kt to reach 95 kt before decreasing again. The engine rating was reduced to 1,850 rpm before increasing again. A vertical acceleration of 2.3 g was recorded, probably on the first impact with the ground. The recording stopped at 12:53.

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[12] The Apibox was not connected to a GNSS computer or to certain on-board instruments. The position and attitudes of the aeroplane and the time were not recorded. For this reason, the Apibox data and the radar data was synchronised by comparing altitudes.

2.5 Meteorological information

According to the French met office, Météo-France, the region was under a fairly inactive rear of a depression. The forecast wind on the 14:00 wind chart was a westerly wind of 10 kt at 2,000 ft. The wind observed was a westerly wind of around 10 kt. A few occasional strong gusts (25 to 30 kt) were recorded on the Arras automatic (non-aeronautic) weather station during the period of the accident. Visibility was greater than 10 km with few clouds.

2.6 Pilot information

The 58-year-old pilot held an aeroplane private pilot licence (PPL(A)) obtained on 3 February 2015 following training carried out entirely with Les Ailes Arrageoises flying club.

The flying club's flight time record showed that he had a total experience of 110 flight hours mainly on the APM30 (F-HHOP), including 7 flight hours in the previous three months.

The pilot's main instructor stated that the flying club followed the training programme proposed by the national instructor pilots association (ANPI) and that the pilot's training had included flap failure exercises. However, he specified that asymmetric flap extension had not been covered during the training, as it was not explicitly included in the programme. Nevertheless, the instructor indicated that he asked his students to avoid extending the flaps in a turn, without going into more detail about the risk of an asymmetric extension.

2.7 Management of asymmetric flap extension

Acceptable Means of Compliance AMC1.FCL.210 PPL(A) of Part FCL of European regulation No 1178/2011 known as "Aircrew"[13] indicates that during PPL(A) training, emergency drills including aeroplane systems failures (exercise 1b – (C)) must be included. For most light aircraft, such as the APM30, asymmetric flap extension is not covered by an emergency procedure.

In France, training organisations can either design their own training programme and have it approved by the French civil aviation safety directorate (DSAC), or, if they wish, use pre-approved programmes, such as those provided by the French aeronautical federation (FFA) or the ANPI. The training programmes submitted to the DSAC by the FFA and the ANPI both include flap extension failure and landing without flaps exercises. However, there is no explicit provision concerning the management of an asymmetric flap extension.

It is very probable that pilots have little awareness of the risk of an asymmetric flap extension.

2.8 Survival aspects

2.8.1 Sequence of rescue operations for F-HHOP

Based on the statements from the instructor, members of the flying club and rescue workers, as well as recordings of voice messages and certain telephone communications between the SAMU (French emergency medical service) and the other rescue services, the BEA has retraced the chronology of the SAR operations for F-HHOP, which can be broken down as follows:

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[13] Commission regulation of 3 November 2011 laying down technical requirements and administrative procedures related to civil aviation aircrew (Version in force on the day of the accident).

- 12:53: time of the accident estimated by the BEA;
- between 13:19 and 13:25, the pilot called his former instructor by telephone three times, but was unable to reach him. He left two voice messages, the first stating that he had crashed near the aerodrome and the second that he had sight of the two slag heaps at Lens;
- at 13:20, the pilot notified the local fire brigade of the accident by dialling 18 from his mobile phone;
- at 13:29, the pilot managed to contact the instructor by phone and explained that it was as if he had gone into a spin on final, that he was in a cornfield and repeated that he had the Lens slag heaps in sight. A team from the flying club, consisting of the instructor and other members, set off by car to try to locate him by road, without success, as the aeroplane was completely hidden by the high corn crop;
- at 13:35, a member of the flying club in the car dialled 112 from his mobile phone and, after waiting several minutes, was put through to the Pas-de-Calais SAMU (emergency medical service in Pas-de-Calais). He initially asked to be put in touch with the ARO[14] or the *Gendarmerie de l'Air*[15]. The SAMU began questioning him and he informed them that an aeroplane had crashed near Arras-Roclincourt on final for runway 22 and that they had had the pilot on the telephone, who was injured and conscious.
  During this conversation with the member of the flying club, which lasted several minutes, the on-duty supervisor of the Pas-de-Calais SAMU coordinated the intervention of the other emergency services (fire brigade, CODIS[16], National Gendarmerie) and organised a group communication with the member of the flying club and the fire brigade. The member of the flying club told the fire brigade that they were still looking for the crashed aeroplane, which was probably situated before the motorway, i.e. near Bailleul-Sir-Berthoult[17], and that they were going to use another aircraft to locate it.
  The member of the flying club told the fire brigade that in parallel, they were on the telephone with the pilot, and then, at the fire brigade's request, gave them the pilot's number. The fire brigade asked him to hang up with the pilot so that they could call the latter directly;
- at the same time, the instructor who was in the same car, called Lille-Lesquin control tower by telephone to inform them of the accident. Lille control tower recorded the occurrence and informed him that they had not picked up an ELT signal;
- the fire brigade contacted the pilot of F-HHOP on his mobile phone. He answered the call, but was unable to specify his location in relation to the information previously transmitted (on final 22 at Roclincourt, in a cornfield, with two Lens slag heaps in sight). The fire brigade sent him a text message to force the transmission of the exact position. To do this, the pilot had to click on the link in the text message. No position was received by the emergency services and then the pilot stopped responding;

[14] Information and flight support regional office.

[15] Unit of the French Gendarmerie which protects the Air bases of the French Air and Space Force and investigates aviation accidents and incidents when a military aircraft is involved.

[16] Centre Opérationnel Départemental d'Incendie et de Secours (Departmental fire and rescue operations centre).

[17] Bailleul-Sir-Berthoult is a district on the north side of the A26 motorway and close to the actual accident site. Arras aerodrome is situated on the south side of the motorway.

- at 13:39, the SAMU on-duty supervisor called the SDIS[18] alert processing centre. The latter was not aware of the accident. The on-duty supervisor then sent out a SMUR (mobile emergency and resuscitation service) ground team equipped with a 4x4 vehicle. The latter was directed to the Trois Crêtes service area, located on the south side of the A26 motorway, pending a more precise location of the crashed aircraft;
- the SAMU on-duty supervisor called in the Pas-de-Calais SAMU helicopter[19], which took off from Arras University Hospital at 13:49 to help locate the precise site of the accident;
- at 13:56, the helicopter pilot saw a shape in a cornfield, north of the A26 motorway, but did not immediately recognise it as an aeroplane. He decreased his flight altitude for a further check and then recognised the aeroplane. The pilot climbed again and flew off to collect the ground team from the Trois Crêtes service area to the south of the motorway. Unable to land at the accident site because of the high corn crop, he landed with the medical team a hundred metres further along, by the side of the road. The rescue team reached the wreckage on foot and arrived beside the pilot in F-HHOP at around 14:05. He was unconscious, with the telephone in his hand.

No official aeronautical alert phase (ALERFA) or distress phase (DETRESFA) was activated.

2.8.2 Medical and pathological information for pilot of F-HHOP

At 14:05, when the SAMU arrived at the site, the paramedics observed that the pilot was in a coma and had multiple traumas. Resuscitation was initiated and death was pronounced after 25 min. No autopsy was carried out.

2.8.3 Resources and operation of ARCC Lyon in the event of an air accident

General responsibility for SAR operations in the event of an aircraft accident lies with the French Air and Space Force, via the Aeronautical Rescue Coordination Centre (ARCC Lyon) for the management of airborne resources and general coordination, and with the Prefect for the management of ground rescue operations.

The ARCC Lyon situated at the top of Mont Verdun is the coordination and rescue centre for mainland France. It can call on military or civilian airborne resources, such as those of the civil defence, the gendarmerie, the border police, the SAMU, the fire brigade or the French navy. The ARCC Lyon's missions and resources have been detailed in a previous BEA report[20]. A free, national aviation emergency number (191) is available 24/7 to alert the ARCC Lyon of an air accident or suspected accident. The ARCC Lyon is responsible for clarifying the situation, determining the probable accident area and coordinating the emergency response.

[18] Service Départemental d'Incendie et de Secours (Departmental fire and rescue service).

[19] The pilot of the SAMU helicopter indicated that he was not trained in the specific nature of SAR operations in the event of an aircraft accident.

[20] Accident to the Schempp Hirth-Ventus 2B registered F-CIJT on 19 August 2020 at Saint-André-les-Alpes (see paragraph 2.8.1).

Since 2018, the ARCC Lyon organises aeronautical information days to inform local stakeholders (SIDPC[21], gendarmerie, SDIS, fire brigade, DMD[22], ADRASEC[23]) about SAR aspects and good practices. The ARCC Lyon organised 13 of these days between 2018 and 2020 on its Mont Verdun premises; no stakeholders from the Pas-de-Calais department attended these days. Since 2022, the aeronautical information days are organised off the premises in order to more easily reach SAR stakeholders in departments at a distance from Lyon. Services from the Pas-de-Calais department attended the aeronautical information day held in Lille on 6 June 2023.

Figure 13: ARCC Lyon operations room (source: French Air and Space Force)

In the case of the accident to F-HHOP, the absence of a signal received from the ELT or of a telephone call to 191, whether by the pilot, the members of the flying club, air traffic control or the SAMU, meant that neither the ARCC Lyon nor the SATER plan of the Pas-de-Calais Prefecture could be activated.

3 CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation.

Scenario

Before landing on runway 22 of Arras aerodrome, the screw of the left flap control on F-HHOP failed in fatigue. The pilot had set the flaps to the landing position (25°). It is probable that the green light of the flap selection unit was lit in the 25° position. It is also probable that the amber light remained off as it is designed to indicate a malfunction upstream from the flap screws. The pilot therefore had no information on the instrument panel indicating the incorrect position of the left flap. The failure of the screw led to an aerodynamic asymmetry and the induced effects, which could have led to a loss of control. The pilot did not understand what had happened, and

[21] *Service Interministériel de Défense et de Protection Civile* (Inter-ministerial Civil Defence and Protection Service).

[22] *Délégation Militaire Départementale* (Departmental Military Delegation).

[23] *Association Départementale des RAdioamateurs au service de la SEcurité Civile* (Departmental Association of Amateur Radio Operators Serving Civil Defence). These associations which answer to the civil defence are the sole structures approved to be trained and equipped to provide terrestrial radiolocation of signals emitted by portable or aeronautical SARSAT ELTs and to guide rescue teams.

was not able to avoid the collision with the ground at 12:53. The wreckage was situated in a field planted with tall corn, making it invisible from the ground.

The emergency locator transmitter (ELT) was effectively activated on impact. However, the distress signal was not emitted due to the connector linking the ELT to the interior antenna, fixed to the back of the pilot's seat, having ruptured. This meant that the associated search procedures were not launched. While it is probable that the accidental rupture of the connector was prior to the accident flight, the BEA cannot rule out the possibility that the connector ruptured on impact with the ground.

Despite numerous telephone exchanges between the pilot and his former instructor, and between members of the flying club and the local rescue services (Pas-de-Calais SAMU called on 112, fire brigade called on 18), neither the members of the flying club who were looking for him nor the SMUR emergency responder team who had positioned themselves on the south side of the motorway, nor the fire brigade who had tried to retrieve the position of the pilot's telephone, were able to accurately locate the accident. It was the Pas-de-Calais SAMU helicopter pilot who identified the accident site north of the motorway from 13:56 and then transferred the SMUR medical team who reached the pilot at 14:05, i.e. around 1 h 15 min after the accident.

The pilot was found unconscious and then declared dead.

Contributing factors

The following factors may have contributed to the in-flight loss of control and the collision with the ground:

- the amplitude of the aerodynamic effects created by the asymmetry between the right flap set to 25° and the left flap in a retracted or intermediate position due to the failure of the control screw;
- the difficulty for the pilot to detect and understand the situation;
- the low height at which the asymmetry probably appeared leaving little time for the pilot to react, if this was possible.

The following factors may have contributed to slowing down the launching of adapted search operations and the accurate location of the pilot and wreckage:

- the rupture of the connector linking the antenna and the ELT with the result that no signal was transmitted by the ELT;
- no telephone call being made to the 191 telephone number dedicated to aviation emergency situations by the various parties involved.

Safety lessons

Aviation emergency number (191)
The temptation to cross-check information before contacting the ARCC Lyon, or to start improvised ground only searches may cause delays in the dispatch and intervention of the appropriate rescue resources. This has already been illustrated by the accident to the glider registered F-CIJT (see paragraph 2.8.3).

From a landline or mobile phone, 191 is the free number, available 24/7, for handling aviation emergency calls (regardless of whether an aircraft accident is certain or not).

The ARCC Lyon has the methods and procedures to deploy the most effective means of locating and responding to an aircraft accident, even on the outskirts of an aerodrome. By calling 191, the ARCC Lyon can launch SAR operations for the occupants of aircraft that have been or may be involved in an accident.

The continuing efforts to promote the emergency number 191 by both the ARCC Lyon with respect to all stakeholders and units involved in potential search operations, and by the DGAC and the federations with respect to pilots and flying clubs is likely to make the use of this number more systematic.

Raising pilot awareness of flight control malfunctions
A malfunction in the flap control system can lead to asymmetric extension of the flaps. The consequent effects, particularly those linked to differences in lift and drag, are likely to alter or even compromise the aeroplane's controllability.

These effects and the resulting level of controllability are difficult to assess and can differ significantly from one type of aeroplane to another. They are not necessarily assessed by the manufacturers.

Generally speaking, this type of malfunction is dealt with first and foremost from the point of view of airworthiness. It is considered as a condition compromising safety and the probability of it occurring must be reduced to a minimum. Based on this logic, manufacturers of light (CS-23 and equivalent) or very light (CS-VLA and equivalent) aircraft generally do not design dedicated emergency procedures.

The investigation found that many pilots do not consider the possibility of an asymmetric flap extension and/or are unaware of its consequences.

Practical in-flight training is hampered by the limited realism of a simulated situation and the absence of the recovery manoeuvre recommended by the manufacturer. Improvising such an in-flight simulation could directly compromise safety.

Furthermore, most light aircraft simulators do not have reliable models to reproduce this type of situation. Practical training could, in certain respects, have counter-productive consequences ("negative training").

However, pilots could probably benefit from being made aware of this possibility by their instructors during their initial and recurrent training. The flight phases during which a malfunction of this nature is most likely to occur are generally characterised by low speed and height. If the aircraft remains partially controllable, rapid understanding and reaction are required to avoid an accident. The DSAC or the federations could propose summaries for instructors to support and provide a scope for this awareness-raising. This type of initiative could be extended to most malfunctions affecting aerodynamic flight controls, for which pilots have no corresponding procedures or training.

4 SAFETY MEASURES TAKEN SINCE THE OCCURRENCE

Safety measures taken by the manufacturer

- Airworthiness Directive (AD) concerning the flap screws

Following the BEA's examinations of the flap screw, EASA issued an emergency AD dated 9 May 2023. This AD, with immediate effect upon its publication, refers to Issoire Aviation Service Bulletin (SB) No 63 issued at the same date and concerns all APM aeroplanes. The AD specifies that it is issued on a temporary basis and that actions may be requested in subsequent ADs.

The SB asks all APM operators to check screw play[24] and to change the screws within the next 50 flight hours and no later than 30 July 2023. At the time of writing this report, Issoire Aviation had received the former screws, the results of the analyses are not known.

[24] Issoire Aviation determined that play may show a possible tightness fault.

5 RECOMMENDATIONS

Note: in accordance with the provisions of Article 17.3 of Regulation No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation in no case creates a presumption of fault or liability in an accident, serious incident or incident. The recipients of safety recommendations shall report to the safety investigation authority which issued them, on the measures taken or being studied for their implementation, as provided for in Article 18 of the aforementioned regulation.

5.1 Examination of screws (41) and analysis of results

The scanning electron microscope (SEM) analyses of screw (41) on the left side of F-HHOP, carried out at the BEA, found that it had failed as a result of a fatigue cracking process under alternating bending loads. The failure of this screw is liable to result in the asymmetric extension of the flaps, the aerodynamic effects of which might compromise the controllability of the aeroplane. The asymmetric marks left by the conical washers on the left arm are consistent with a tightness fault of the screwed assembly without it being possible to determine the exact cause of this. A tightness fault can contribute to the development of a fatigue cracking process.

The SEM examinations of other screws (41) carried out by the BEA (right flap of F-HHOP and screws from two flaps of a second APM30) found micro-cracks in the root of the thread, invisible to the naked eye, in a comparable area to the failure area of the left screw of F-HHOP. The propagation of these cracks is the last step in the fatigue process before the final failure. No mark characteristic of a tightness fault was found on the arm of the right flap of F-HHOP. The arms of the second APM30 were not examined.

The final failure of the screw occurs when the aerodynamic stresses on the flap increase and the remaining stressed section of the screw is no longer sufficient to withstand the in-service loads, as may be the case when the flaps are operated by the pilot, for example during the approach or after take-off. The surprise effect which might result from this type of failure and the low height at which it might occur leave pilots little time to analyse the situation and attempt to regain control of the aeroplane.

The observation of a fatigue cracking process on each of the four screws examined by the BEA and the potentially catastrophic consequences of the failure that may result from this, as materialised by the accident to F-HHOP, call into question the level of airworthiness of the fleet made up of some thirty aeroplanes.

An AD was issued by EASA on 9 May 2023, referring to the mandatory Service Bulletin No 63 issued by Issoire Aviation on the same day. These documents mention a possible condition compromising safety. Operators are required to check screws (41) for play and replace them on all APM20s and APM30s in operation. The replaced screws must be sent to Issoire Aviation. It is specified in the AD that it has been issued on a temporary basis and that other subsequent ADs may be issued in order to implement other actions if necessary.

At the time of writing this report, neither the nature of the examinations carried out by Issoire Aviation nor their results, are known to EASA. No additional AD is planned at this stage.

Consequently, the BEA recommends that:

- **whereas the left flap screw (41) on F-HHOP failed following a fatigue cracking process;**
- **whereas the three other APM30 flap screws (41) examined by the BEA had micro-cracks, invisible to the naked eye, testifying to a fatigue cracking process;**
- **whereas it has not been shown that the check for play of screws (41) is sufficient for preventing the fatigue cracking process from starting;**
- **whereas the failure of screw (41) can result in the asymmetric extension of the flaps and compromise the controllability of the aeroplane;**
- **whereas this situation is likely to occur at low height, leaving the pilot little time to recover the control of the aeroplane;**
- **whereas the AD published in May 2023 was an urgent, temporary measure and the ensuing results are not yet known by EASA;**
- **whereas it has not been shown that simply replacing the screws with identical screws, as recommended by the AD published in May 2023, means that the risk of a new failure during the service life of the aeroplane will be avoided;**

  EASA ensure that Issoire Aviation carry out the relevant examinations of the collected screws, and analyses of the results in order to determine whether or not the risk of failure persists, and impose new preventive measures if these prove necessary. [Recommendation FRAN-2024-004].

5.2 Installation of emergency locator transmitter (ELT)

The investigation found that the connector linking the ELT to the antenna was ruptured on F-HHOP. The connector was probably damaged before the accident flight when a passenger took the rear seat or on positioning an object on the seat or from a harness shoulder strap, although it is not possible to rule out the possibility of the connector having ruptured on impact.

The nominal operation of the ELT and the correct transmission of the distress signal are fundamental to the satisfactory launch and coordination of search and rescue operations, even when the accident site is close to an aerodrome or the departure base of the rescue teams.

The rupture of the ELT-antenna connector which prevented the distress signal from being transmitted correctly, could probably have been avoided by protecting the ELT and its accessories.

At the time of writing this report, Issoire Aviation indicated that it had explored various installations providing effective protection of the ELT. It specified that it was also studying the possibility of using another ELT model which had a self-test which detects an antenna connection fault.

Consequently, the BEA recommends that:

- **whereas the correct transmission of the ELT is an essential component for quickly launching appropriate search and rescue resources in the event of pilot incapacitation, as defined in national and departmental plans;**

- **whereas the physical protection of the ELT, its antenna and its cables and connectors is essential in order to preserve the chances of correct transmission by the ELT in the event of an accident;**
- **whereas it is probable that the connector linking the F-HHOP ELT to its antenna was torn off prior to the accident flight, on the ground, by the movement of a person or object in the rear or from a harness shoulder strap (although it is not possible to rule out the possibility of the rupture having occurred during the impact of the accident) which meant that there was no correct transmission of the ELT signal;**
- **whereas the information collected by the BEA during the investigation indicated that ruptures of the ELT-antenna connector have been detected by other operators of APMs;**
- **whereas the ELT's built-in test does not make it possible to detect a disconnection of the antenna on the Kannad AF Compact models,**

EASA ensure that Issoire Aviation develop a robust solution for the installation of an ELT and its accessories on board APMs and that this solution is also implemented on the aeroplanes already in service.
[Recommendation FRAN-2024-005].

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.