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INVESTIGATION REPORT

Accident to the AEROS SKYRANGER registered 13LZ

on 7 May 2019
at Saint-Antonin-sur-Bayon (Bouches-du-Rhône)

Time	Around 16:15[1]
Operator	Aéroclub NOSTRADAMUS
Type of flight	Cross-country
Persons on board	Pilot
Consequences and damage	Pilot fatally injured, microlight destroyed

This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in April 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.

Collision with the terrain

1 - HISTORY OF THE FLIGHT

Note: the following information is principally based on statements and on a video taken by a witness, as well as on radio communication recordings.

At around 16:05, several witnesses standing at the foot of Sainte-Victoire mountain (position A Figure 1) and on the peak (positions B and C Figure 1) saw the microlight make several out-and-back flights between the south face of the mountain and the village of Saint-Antonin-sur-Bayon (Bouches-du-Rhône). These witnesses stated that the microlight had each time flown along the face from west to east on a path practically parallel to the terrain, at an altitude below that of the peak, before heading southwards at Croix de Provence. During the final turnaround, a witness in the village of Saint-Antonin-sur-Bayon (position D Figure 1) saw the microlight fly at an altitude lower than that of the previous flights then turn northwards in the direction of Croix de Provence (point 1 Figure 1). All of the witnesses stated that the microlight had remained on a straight path, at a constant altitude and that they had not heard a variation in engine rating. Approximately 200 metres from the face (point 2 Figure 1), the microlight banked left then continued to fly in a straight line for around 50 metres. The wings slowly returned to the horizontal position, then the microlight collided with Sainte-Victoire mountain, around 20 metres from the top of the rocky face, to the west of "*Brèche des Moines*" viewpoint. The microlight caught fire and fell to the foot of the face.

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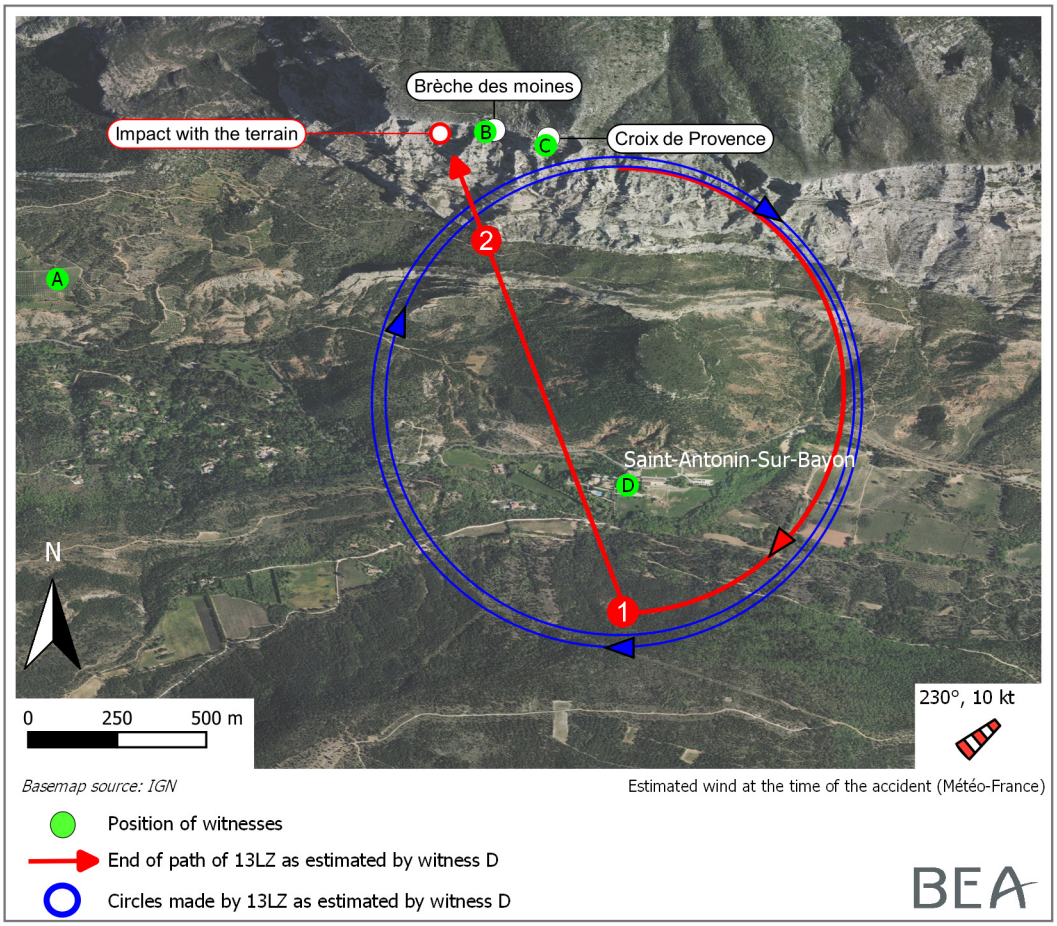


Source: BEA

Figure 1: Estimated path of the microlight according to a witness on the ground

2 - ADDITIONAL INFORMATION

2.1 Pilot information

2.1.1 Experience

The 61-year-old pilot held a fixed wing microlight licence issued in 1996 and a private pilot licence (aeroplane) issued in 1988. He had logged 150 flight hours in an aeroplane. It was not possible to determine the total number of flight hours logged by the pilot in a microlight between 1996 and 2017. In April 2017, he had started a refresher course in dual flight at the ULM Aviation Services flying school based at Aix-Les Milles aerodrome[(2)]. In August 2018, he had joined the Aéroclub Nostradamus and had been signed off to fly the SKYRANGER on 3 September 2018.

Since April 2017, according to his log book, he had logged 56 hours in a microlight, 18 hours of which on type and two-and-a-half hours of which in the previous three months, all on type.

[(2)] According to an instructor at this school, the pilot had not flown for a number of years.

2.1.2 Medical and pathological information

The pilot's wife specified that he had not been undergoing any medical treatment or been suffering from any illness. Blood samples taken from the pilot did not reveal any substance likely to have impaired his faculties. The autopsy carried out on the pilot did not reveal any element likely to explain the accident.

2.2 Meteorological information

The meteorological conditions estimated by Météo-France at the location at the time of the accident were as follows: 230° wind of 10 kt, visibility of more than 10 kilometres, broken clouds at 5,700 m. Several paragliders who witnessed the accident reported a southwesterly wind of 8 kt (15 km/h) gusting up to around 11 kt (20 km/h) at the time of the accident. The analysis of the meteorological conditions brought to light no element likely to have contributed to the accident.

2.3 Statements

The chief-pilot of the Aéroclub Nostradamus said that he had crossed paths with the pilot at the aerodrome between 15:00 and16:00. The pilot was going to the hangar to take the microlight out and told the chief-pilot that he wanted to fly, but had not specified either the destination or the purpose of the flight. The chief-pilot also stated that the week preceding the accident, he had made a 40-minute dual handling flight in 13LZ with another student-pilot and that all had gone smoothly.

2.4 Telecommunications and radar data

The microlight was equipped with a mode S transponder that was not detected by the radars. Due to damage associated with the collision and the fire, it was not possible to determine whether the transponder was switched on or off. Primary radar data was retrieved, but it was not possible to associate any path with the microlight's flight with certainty. Reconstruction of the path of the microlight was therefore not possible. From take-off up to Sainte-Victoire mountain, the pilot did not make radio contact with any air traffic organisation and probably flew outside of controlled air spaces. He was then in uncontrolled air space (class G), near the controlled area of Aix-Les-Milles (class D CTR).

Between 16:16:20 and 16:17:05, he sent a total of five radio messages over the Aix-Les-Milles control tower frequency. The pilot's first message reported control problems. The controller responded but the pilot's next message indicated that he had not heard the response. Forty-five seconds lapsed between the pilot's first message and the collision with the terrain. In his next four messages, the pilot seemed to be agitated, worried and on edge.

2.5 Examination of the wreckage and the accident site

The wreckage was found at an altitude of 830 m, in a scree on the south slope of the mountain. Positioned 25 m below the peak, at the foot of the rocky face rising 855 m above the wreckage (see Figure 2), it was lying flat on the slope facing towards the mountain face. The microlight was completely burned except for all of the metal structures and some of the tailplane covering. The instrument panel was destroyed. The pilot's seat-belt buckle was found locked. The airframe parachute flare went off after collision with the ground[3].

[3] The microlight was equipped with an airframe parachute. The grip to deploy the parachute's flare was located between the seats. This was destroyed by the fire. According to the chief-pilot of the flying club, there was no safety pin.

Source: BEA

Figure 2: General view of the site and the wreckage

2.6 Examination of the flight control cables

2.6.1 Elevator

The elevator control was continuous. The visual observation on site revealed no damage to the cables and no further examination was performed.

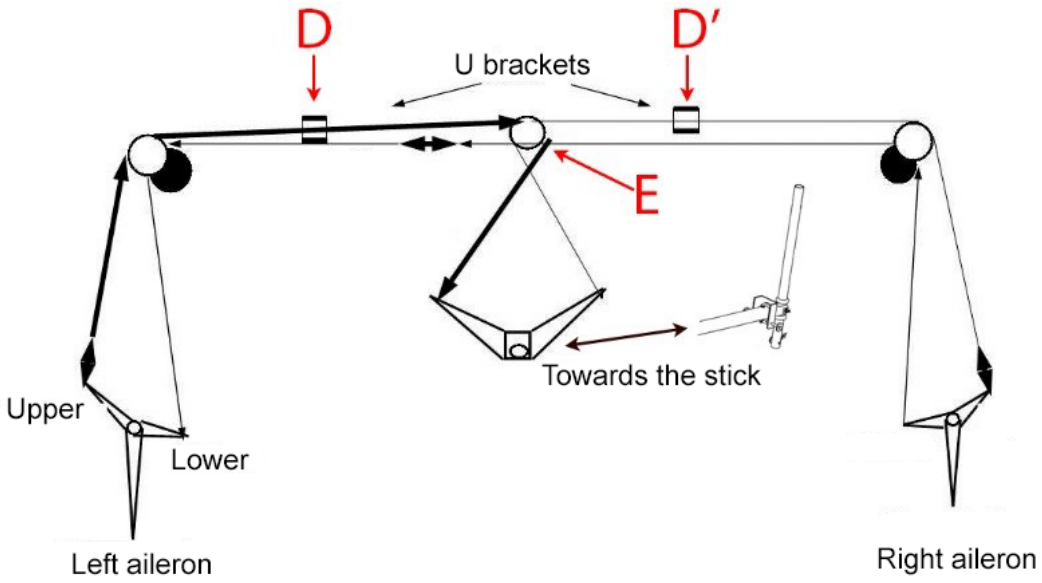
2.6.2 Aileron

The examination of the aileron control cables[4] and their comparison with those of another Skyranger revealed:

- A breakage of all of the strands of the upper cable linked to the right aileron (zone E) located in line with the pulleys orienting the vertical cables to the wings (see Figure 3) and the presence of some wires with a morphology of fracture surfaces indicating friction wear (SEM[5] examination). However, it was not possible to determine if cable breakage had occurred before or during the accident.
- The presence of broken wires on both upper cables (zones D and D') at the U-brackets of each wing (see Figures 3 and 4). Nevertheless, this damage probably did not impact the manoeuvrability of the aileron control.

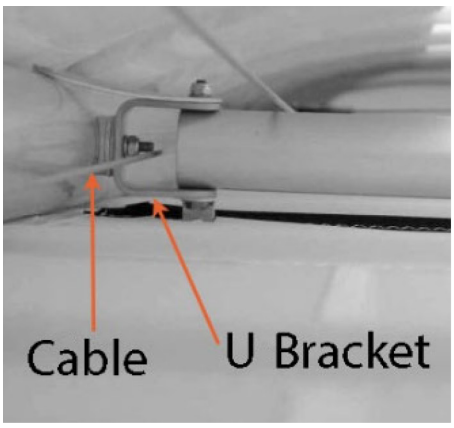
[4] Assembly of strands, themselves comprising metal wires.

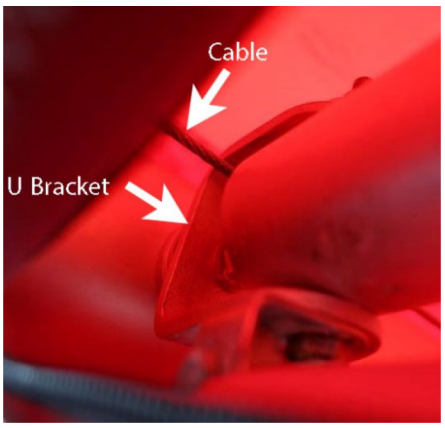
[5] Scanning electron microscope.



Source: Skyranger Assembly Manual version MM SK 0508 and BEA annotations

Figure 3: Functional diagram of the aileron control and areas of damage





Source: Skyranger UK built issue 4 and BEA annotation

(a) Routing of a cable as illustrated in the assembly manual of a Skyranger

(b) Routing of a cable on another Skyranger microlight

Figure 4: Illustration of a cable passing through a U-bracket on the SKYRANGER

2.6.3 Rudder

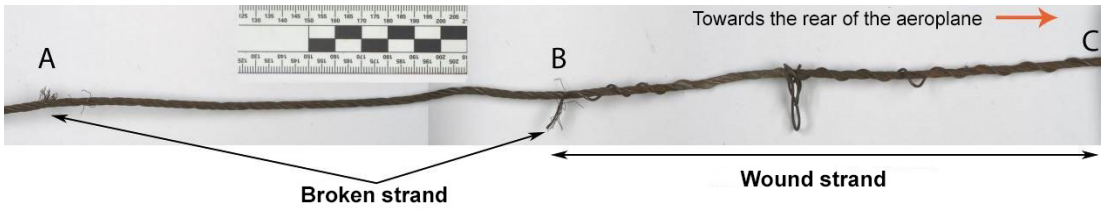
Two cables form the link between the rudder pedals and bellcranks. They also pass through two pulleys located between the seats (see Figure 7).

The microlight's rudder control was continuous at the time of the accident. Nevertheless, the cables were damaged in several places.

The visual examination of the LH cable on site showed that a section of the cable had a broken strand[6] which had wound around the cable over 20 centimetres (see Figure 5). The SEM examination of the broken strand showed that the fracture surfaces of some wires presented a morphology characteristic of friction wear. These observations indicate that the strand had probably broken before the impact with the ground, the breakage of just one strand at impact being highly unlikely.

[6] Configuration of the cable: 7 strands of 19 wires.

The laboratory examination of the RH cable using the rag method showed the presence of multiple broken wires at a position equivalent to position B on the LH cable (see Figure 6).



Source: BEA

Figure 5: Damaged section of the LH cable of the rudder control

Source: BEA

Figure 6: Position B of the RH cable with presence of broken wires upstream of pulleys, pedal in neutral
(cable bent using a vice in the laboratory to provide a better view of the broken wires)

Due to the condition of the wreckage, it was not possible to locate on site the positions of the damage observed on the rudder cables directly on the microlight involved in the accident. These were determined by comparison with another AEROS SKYRANGER[7] of the same type as 13LZ[8].

Therefore, with the rudder pedal in neutral[9]:

- position A corresponds to an area of possible contact with a tube of the structure located under the seat;
- position B corresponds to a position just upstream of the pulleys;
- position C corresponds to a position downstream of the pulleys.

The presence or absence of a protection[10] between the metal tube of the airframe structure and the cable in position A was unable to be checked on the microlight involved in the accident due to the consequences of the fire. The pulleys were completely destroyed and it was not possible to examine them.

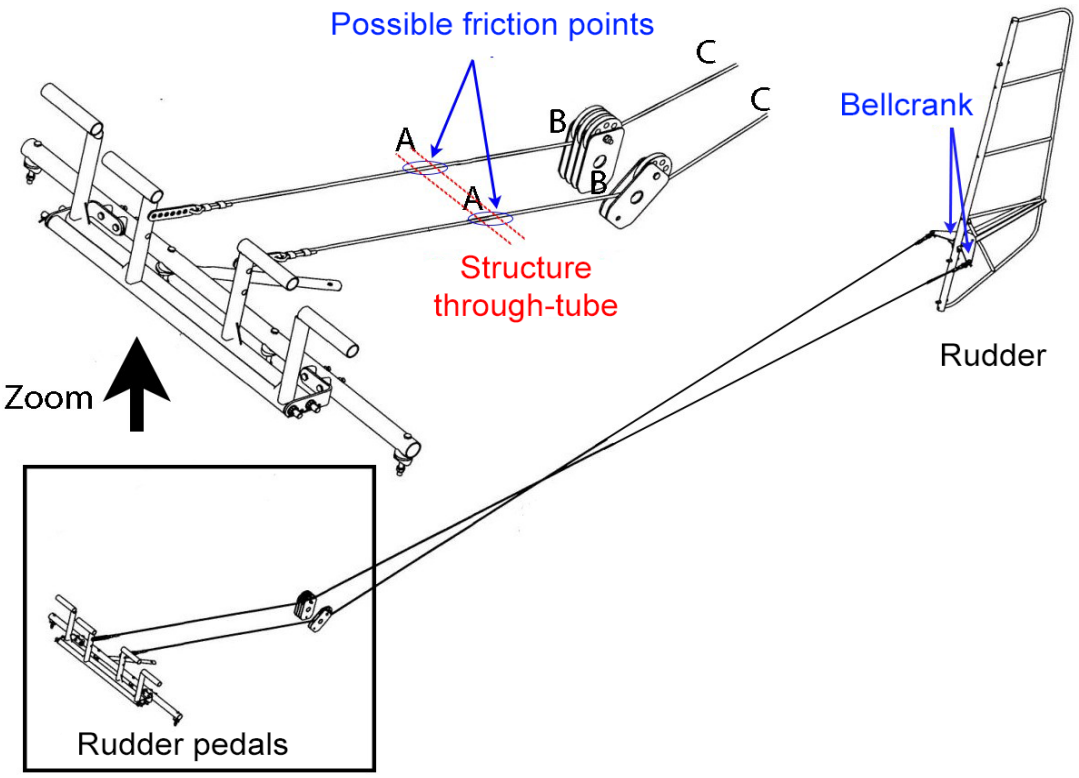
Taking into account the possible deflection of the cables, positions B of the RH and LH cables as well as a part of the winding of the LH cable are sections that pass through the pulleys.

[7] Commissioned in 2000.

[8] Identification code B203SF01024 Revision 1 identical to that of 13LZ.

[9] Note that the cable deflection is around 8 cm.

[10] To assemble the rudder control, the SKYRANGER assembly manual version 03/95 recommends protecting the cables against friction by bonding or fixing a PVC sheet between the cable and the metal parts (idem for aileron cables).



Source: Assembly Manual MM SK 0508 and BEA annotations

Figure 7: Functional diagram of the rudder control and positions of damage

To summarise, the examination of the rudder control cables:

- Revealed on the RH cable the presence of broken wires using the rag method on the section of the cable that passes through the pulley.
- Showed that a strand on the LH cable was probably broken before the impact with the mountain face. The winding of the strand around its cable may have restricted or even prevented the passing of the cable through the pulley. As the pulleys were unable to be examined, any blockage of the cable was unable to be confirmed.

2.7 Analysis of the video recorded on the mobile phone of a witness

A video taken by a witness who was standing on the rock balcony of the Croix de Provence priory (position B Figure 1) was retrieved. This video shows that, ten seconds before the impact, the microlight was banked left by around 30° with a pitch attitude close to horizontal. The flaps were retracted. It was heading at around 150 km/h[(11)] towards the face of the mountain at an altitude below that of the peak. The wings then slowly returned to horizontal when, one second later, the microlight hit the rock face.

The spectral analysis of the video soundtrack indicated that the engine was at full throttle and that there was no variation in power during the 10 seconds of flight recorded on the video up to the time of impact. No significant movement of the microlight around the yaw axis and no modification of the position of the rudder were visible in the video images. However, due to the image quality, it was not possible to establish whether the ailerons were moving or still.

(11) The microlight user manual specifies a VNO (maximum structural cruising speed) of 125 km/h and a VNE (never exceed speed) of 165 km/h.

2.8 Microlight information

2.8.1 Microlight's maintenance log

The microlight was assembled by the Aéroclub Nostradamus using a kit built in series, purchased in 1998.

In the identification card request file sent to the DSAC in November 2007 following the declaration of a major modification (replacement of the Rotax 582 engine with a 912UL engine), the Aéroclub NOSTRADAMUS had listed the maintenance manual MESK-01-1999 and the user manual MUSK 1-1999.

This maintenance manual recommends the checking of flight control cables during the 25-hour inspection or every three months, as well as turning of the pulleys by a quarter of a turn, always in the same direction, to prevent wear of the pulleys in the same pulley section. The manual also asks for the flight control cables to be checked at each 100-hour inspection or annually. This check must focus in particular on the rudder and aileron cables in line with where they pass through the pulleys, in the clamps, the connecting parts or near the passing places close to the structure. All damaged cables must be replaced. During the 1,000-hour or five-year inspection, the microlight must be fully disassembled to check the structural parts not accessible during the checks performed to date. During this inspection, the flight control cables and the pulleys must be replaced if necessary or as a precautionary measure (without exceeding 2,000 hours).

The flying club's maintenance log[12] indicated a 2,000-hour inspection performed in April 2014 (at 2,655 flight hours) then during the summer of 2014, a replacement of the covering and replacement of the elevator and rudder cables. There was no mention of the aileron cables being replaced. However, the chief-pilot thinks that the aileron cables were replaced during the first covering replacement in September 2008 (at 1,035 hours). The last maintenance inspection of the microlight was performed in December 2018, at 3,400 hours. It was not possible to determine the number of hours logged by the microlight since then.

[12] The maintenance log (and the hours counter) was started in 2007, when the microlight's engine was replaced. There is no record of maintenance work carried out on the microlight before 2007.

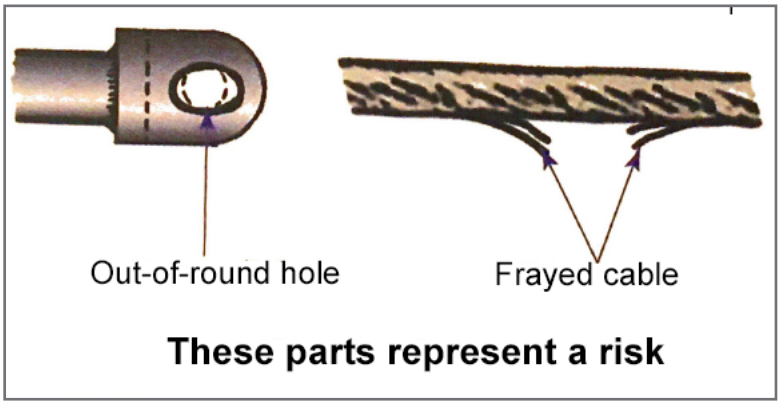
The chief-pilot maintained the microlight's airframe and updated its maintenance log. He had not completed any aeronautical mechanic's training except for an engine training course organised by the French Microlight Federation (FFPLUM). He explained that he followed no framework and that replacements were not based on the number of flight hours of the microlight. He stated that he had never used the maintenance manual provided by the manufacturer of the microlight. Each time the covering was replaced, the wing was completely disassembled, a visual check of the cables was made and, if one of them appeared shiny or worn, a rag test was carried out. However, he stated that he did not replace the cables as long as they slid correctly through the pulleys, even though the rag sometimes snagged on them. During the 2,000-hour inspection, he had disassembled and visually inspected the cables, then checked them using a rag. The aileron cables did not appear to be worn. He thought that the 25-hour and 100-hour inspections were only engine inspections recommended by ROTAX and made no 100-hour inspection of the airframe.

He remembers observing that between the pedals and the pulleys located between the seats, the rudder control cables touched the engine mount tube that ran underneath the seats and he had observed that the tube was a little shiny where the rudder cables routed along it. He remembers that the cables had been supplied with a protection sheath. These sheaths were not found in the wreckage following the fire.

2.8.2 Best practices to maintain an aircraft of simple/conventional design

A microlight is characterised by a simple design principle and maintenance[13]. This maintenance is normally entrusted to the holder of the identification card, who may contact the manufacturer or a professional if this operation exceeds their level of competence.

The Microlight Pilot Manual[14] states that maintenance is carried out during use of the aeroplane by observing the condition of different components and operating anomalies; and also during periodic inspections, through the inspection, adjustment or replacement of certain components. It also specifies that the manufacturer generally provides a summary of the different inspection operations and their frequency after a certain number of operating hours or every year for example. It is essential that a schedule is drawn up detailing each component to be inspected, the frequency of the inspections and the mandatory replacement of deteriorated or highly stressed parts. If an anomaly (see Figure 8) is observed during an operating phase (assembly, disassembly, flight, etc.), it is essential to remedy this anomaly without delay as safety can be compromised if a detail that appears insignificant is ignored.



Source: Microlight pilot's manual (BEA translation)

Figure 8: Examples of anomalies

[13] See instruction of 24 June 2019 pertaining to the microlight which repeals that of 21 February 2012.

[14] Published by Éditions Cépaduès, 14th edition 2019.

[15] https://www.faa.gov/documentlibrary/media/advisory_circular/ac_43.13-1b_w-chg1.pdf

The Advisory Circular AC 43.13 1B[15] of the Federal Aviation Administration (FAA) provides best maintenance practices for aeroplanes of conventional design. Chapter 7-149 of this circular covers, in particular, the inspection of cables. It specifies that control cables must be checked at each annual inspection or every 100 flight hours. Any cable with a broken wire in a critical fatigue area (e.g. passing through pulleys or in fairleads) must be replaced. This circular also describes the inspection method that consists in running a rag over the area to be inspected to see if it snags on broken wires. The text insists on the importance of the visual examination, which must be able to detect broken wires inside the cable, when the rag inspection is not sufficient. An examination with a magnifying glass and/or the bending of the cable may be necessary to visually detect the presence of broken wires when this is suspected.

Considering these best maintenance practices, the presence of broken wires is a sufficient warning indicator that must necessitate the immediate replacement of the cable unless the manufacturer specifically recommends otherwise.

2.8.3 Blockage or loss of a flight control linkage

The SKYRANGER microlight user manual states that, in the event of a blockage or loss of a flight control linkage, it is still possible to control the microlight. In particular, it recommends:

- In the event of the loss of the elevator, the use of the engine's power, flaps or the elevator trim to maintain control of the microlight, and the performance of an emergency landing.
- In the event of loss of the aileron, the use of the pedal or the grasping of one of the cables at the top of the cabin to see if an action remains possible.
- In the event of loss of rudder, the limitation of aileron deflection (to prevent entering a spin at high angles of incidence).

It also states that the SKYRANGER microlight is much more responsive on the yaw axis than on the roll axis and that it is therefore advisable to use the pedals in conjunction to avoid any relative impression of lack of aileron response.

3 - 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

The pilot made wide circular out-and-back flights between Sainte-Victoire mountain and the village of Saint-Antonin-sur-Bayon, at an altitude below that of the peak of the mountain. When the microlight was south of the village of Saint-Antonin-sur-Bayon, it suddenly headed towards Sainte-Victoire mountain. The reason for this change of path could not be explained. The pilot reported control problems over the Aix-Les-Milles control tower frequency. It was not possible to determine if this message was sent before or after the path change.

It is possible that the rupture in flight of a strand on one of the rudder cables restricted the rudder control by hampering the passage of a cable at a pulley. The rudder control has a major role in the coordination with the roll axis. As a result, this may have had consequences on the manoeuvrability of the microlight. The video filmed by a witness shows the microlight in straight flight during the last 10 seconds of its flight, with a slow variation in roll to the right, heading straight towards the mountain face with the engine at full throttle.

The investigation was unable to determine why the pilot did not apply a nose-up action to clear the terrain or did not activate the airframe parachute when the control problems he reported occurred.

Contributing factor

The absence of the check of the condition of the cables during the 25-hour and 100-hour inspections did not enable to operator to be aware of the extent of damage to one of the two rudder cables.

Safety lessons

Periodic check of the microlight's primary flight control cables

The primary flight control cables of an aeroplane are essential flight safety components. Their periodic inspection is therefore required applying a suitable method and periodicity.

Damage observed to a metal cable may sometimes seem insignificant, but its consequences can be major. It is therefore essential to apply the recommendations of the manufacturer in this matter to the letter.

Use of the airframe parachute in the case of the blockage of the flight control linkages

The blockage of the flight control linkages, as well as their restriction or their failure, constitutes an emergency situation when this occurs in flight. It is therefore important to know what to do in such a situation.

The different ways to behave in flight if the flight control linkages block are rarely indicated in the flight manuals and are not taught in instruction. An article written in the "*Aviation Safety*" magazine and published on 18 December 2012 deals with this subject[16].

[16] https://www.aviationsafetymagazine.com/features/flight-control-failures/

When the flight control linkages block and there is a risk of loss of control or collision with an obstacle or terrain, the deployment of the airframe parachute is an alternative way to minimise the consequences of the accident. The French Microlight Federation published several flight safety bulletins[17] [18] [19] on the use of airframe parachutes.

[17] https://ffplum.fr/images/BSV/2015/newsletter_securite_mars_2015.pdf

[18] https://ffplum.fr/images/BSV/2017/bsv_juillet_2017.pdf

[19] https://ffplum.fr/images/BSV/2017/bsv-40-septembre-2017.pdf