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COMISIÓN DE
INVESTIGACIÓN
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E INCIDENTES DE
AVIACIÓN CIVIL

Report
ULM A-013/2016

Accident involving an Evektor EV-97 Eurostar aircraft, registration EC-KTF, in San Ignacio del Viar (Seville, Spain) on 20 May 2016

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO

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Foreword

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

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

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

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

Contents

Abbreviations

00:00	Hours and minutes (length of time)
00º	Geometric degrees / Magnetic heading
AEMET	National Weather Agency
AESA	National Aviation Safety Agency
AGL	Above ground level
cm	Centimeters
dd/mm/yyyy	Day, month and year (date)
ft	Feet
FI	Flight instructor
HP	Horsepower
IAS	Indicated airspeed
Kg	Kilograms
Km	Kilometers
Km/h	Kilometers per hour
LETJ	Trebujena aerodrome ICAO code (Cádiz, Spain)
m	Meters
Min	Minutes
Mm	Millimeters
NE	North East
rpm	Revolutions per minute
SB	Service Bulletin
SW	Southwest
ULM	Powered ultralight aircraft
W	West

Synopsis

Owner and operator:	Private
Aircraft	Evektor EV-97 Eurostar; registration EC-KTF
Date and time of accident:	20 May 2016 at 20:15[1]
Site of accident:	San Ignacio del Viar (Seville, Spain)
Persons onboard:	1 pilot, slightly injured
Type of flight	General aviation - private
Phase of flight	En-route- climb to cruising altitude
Date of approval:	27 September 2017

Summary of the event:

The ultralight aircraft took off from the Alcalá del Río aerodrome (Seville) en route to the aerodrome of Trebujena (Cadiz) at approximately 20:10. According to the pilot's statement, the cockpit canopy opened unexpectedly while at an altitude of about 700-750 ft (600-650 ft above ground level).

The pilot was unable to close the canopy without releasing the flight controls. The open canopy caused a great instability in the elevator and control stick, making it very difficult for the pilot to control the aircraft.

In the end, the pilot was unable to keep the aircraft from striking a high-voltage power line, which caused the aircraft to fall and impact the ground, resulting in significant damage to it.

The pilot sustained minor injuries.

The investigation has determined that the accident was caused by the diminished control of the aircraft due to the involuntary opening of the canopy, resulting from an unauthorized modification to the locking mechanism on the canopy, which caused the aircraft to impact a high-voltage power line.

1 All times in this report are local.

The pilot did not activate the parachute system installed in the aircraft because the thought the aircraft was too close to the ground. The emergency procedure for the canopy opening in flight did not reference the parachute system.

Two safety recommendations are issued to the aircraft manufacturer to study the influence of an open canopy on the effectiveness of the aircraft's parachute system and to improve the emergency procedure for the canopy opening in flight.

1. FACTUAL INFORMATION

1.1. History of the flight

Aircraft EC-KTF landed at the Alcalá del Río aerodrome at about 12:30 on 20 May 2016, after taking off from the Trebujena aerodrome. Only the pilot was onboard.

At 14:20 that same day, the pilot conducted a training flight on the aircraft belonging to the Ilipa Magna flight school as part of the refresher seminar to renew his FI-ULM (ULM flight instructor) rating. The flight lasted 36 minutes and was uneventful.

At 18:00, the pilot conducted another training flight lasting 42 minutes, which was also uneventful.

After a 30-minute break, the pilot began to prepare ULM EC-KTF for the return flight to Trebujena. After doing the pre-flight inspection and refueling, he took off from runway 24 at approximately 20:10.

Shortly after takeoff, with the aircraft at an altitude of 700-750 ft (600-650 ft AGL) and a speed of 120 km/h, as per the pilot's statement, the cockpit canopy opened which destabilized the aircraft significantly and made it difficult to control.

The pilot was unable to close the canopy and he was only able to partly control the aircraft. As a result, the ULM ended up striking a high-voltage power line, and as a consequence of this, impacting the ground.

The aircraft sustained heavy damage. The pilot received minor injuries.

1.2. Injuries to persons

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal				
Serious				
Minor	1		1	Not applicable
None				Not applicable
TOTAL	1		1	

1.3. Damage to aircraft

There was significant damage to both wings, the front of the fuselage, the rudder, propeller, engine mount and front landing gear. All of the damage was caused by the impact with the ground.

1.4. Other damage

Not applicable.

1.5. Personnel information

The pilot, a 50-year old Spanish national, had a ULM pilot license issued by Spain's National Aviation Safety Agency on 22 October 2009. His fixed-wing multi-axis rating was valid until 31 December 2017.

He had a class-2 medical exam that was valid until 8 April 2017.

Total hours: approximately 800

Hours on the type: approximately 100

Total hours in the previous 30 days: 15.6

Hours in the model in the 30 previous days: 10.4

On the day of the accident, the pilot had flown about 2 hours.

In the week following the accident, the pilot took the exam to renew his ULM instructor rating, which he passed.

1.6. Aircraft information

The Evektor EV-97 Eurostar is an ultralight monoplane with low wings and a fixed tricycle landing gear. It has two seats side by side and a maximum takeoff mass of 450 kg.

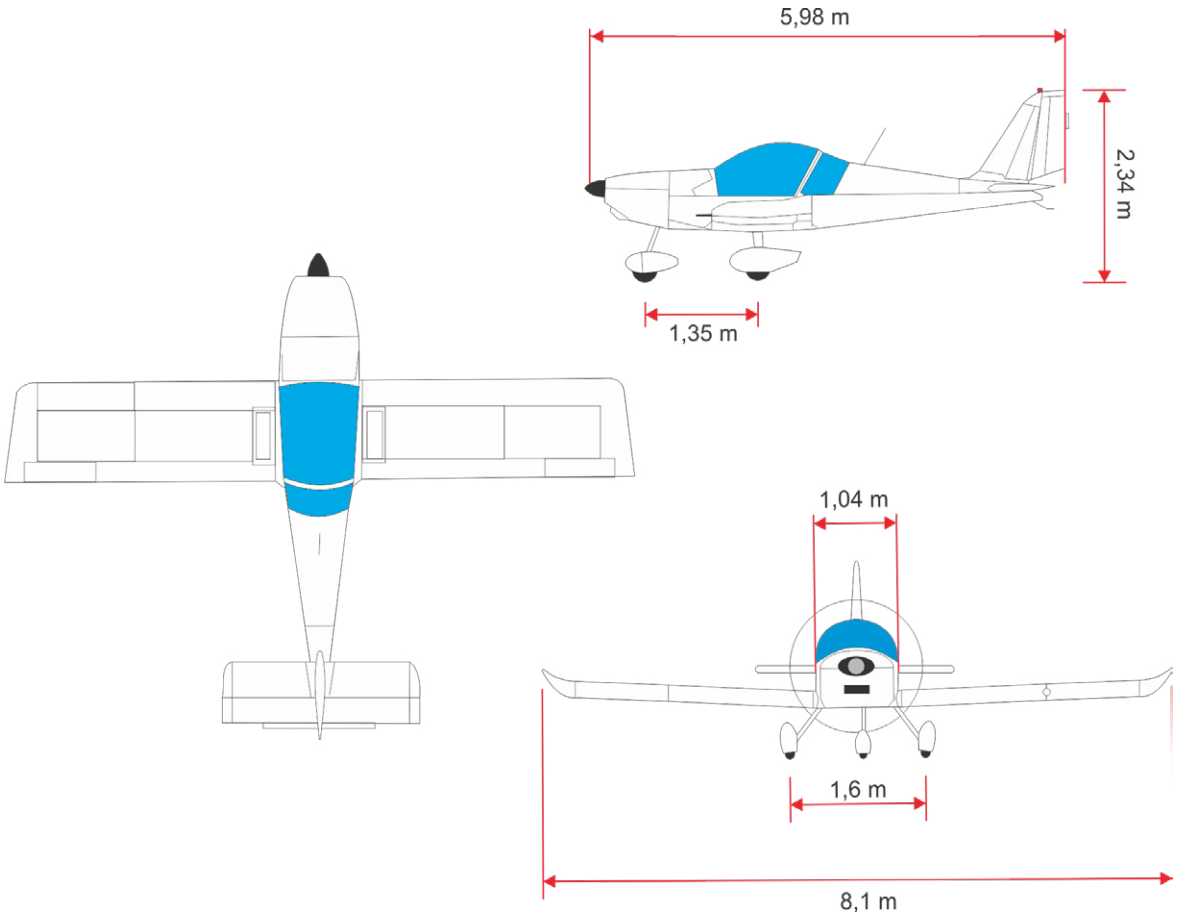

Figure 1. Dimensions of the aircraft

Aircraft EC-KTF was built in 2007, with serial number 2007 3003. It was equipped with a 100-HP Rotax 912 ULS engine, serial number 5648629, which was also manufactured in 2007. At the time of the accident, both the aircraft and engine had a total of 570 h.

The Registration Certificate in effect at the time of the accident was issued by AESA on 17 March 2015, the Special Restricted Certificate of Airworthiness was also issued by AESA, on 10 March 2010.

The aircraft had a maintenance program that was approved by the Civil Aviation General Directorate on 11 November 2008. This program required, among others, a 100-hour/annual inspection of the aircraft.

The last 100-hour/annual inspection was carried out on 21 August 2015, with 532 hours on the aircraft. This inspection involved checks of the airframe, as well as an inspection of the engine and a flight test. This inspection was carried out by Mantenimiento Alisur.

1.7. Meteorological information

According to the information provided by the National Weather Agency, AEMET does not have weather data for the location where the accident occurred. It does, however, have a primary station located at the Seville Airport, some 16 km away from the accident site. In light of the data from this station, and the satellite and radar images and adverse weather warnings, the most likely conditions at the accident site were as follows:

- Wind: from the SW, around 230º, at a speed of about 24 km/h, gusting to 35 km/h.
- Visibility: no clouds and good visibility on the surface.
- There was no precipitation or adverse weather warnings.

1.8. Aids to navigation

Not applicable. The flight took place under visual flight rules.

1.9. Communications

The pilot reported leaving the circuit but did not make any communication related to the emergency.

1.10. Aerodrome information

The aircraft took off from the Alcalá del Río aerodrome in the province of Seville.

According to information provided by the aerodrome operator, it is at an elevation of 44 m (144 ft) and it has one 510-m long, 35-m wide compacted dirt runway in a 06/24 orientation.

The aerodrome's location in relation to the accident site is detailed in Section 1.12.

1.11 Flight recorders

The aircraft did not have flight recorders, as they were not required for the aircraft type.

1.12. Wreckage and impact information

The aircraft impacted the ground 1600 m away from the end of the runway in use, as shown in Figure 2. The area is easily accessible and near a road that leads to the town of San Ignacio del Viar. The terrain was made of soft soil and had wheat planted on it.

There was an outline on the wheat field that showed the final position of the aircraft, which was a short distance away, approximately 48 meters, from a power line.

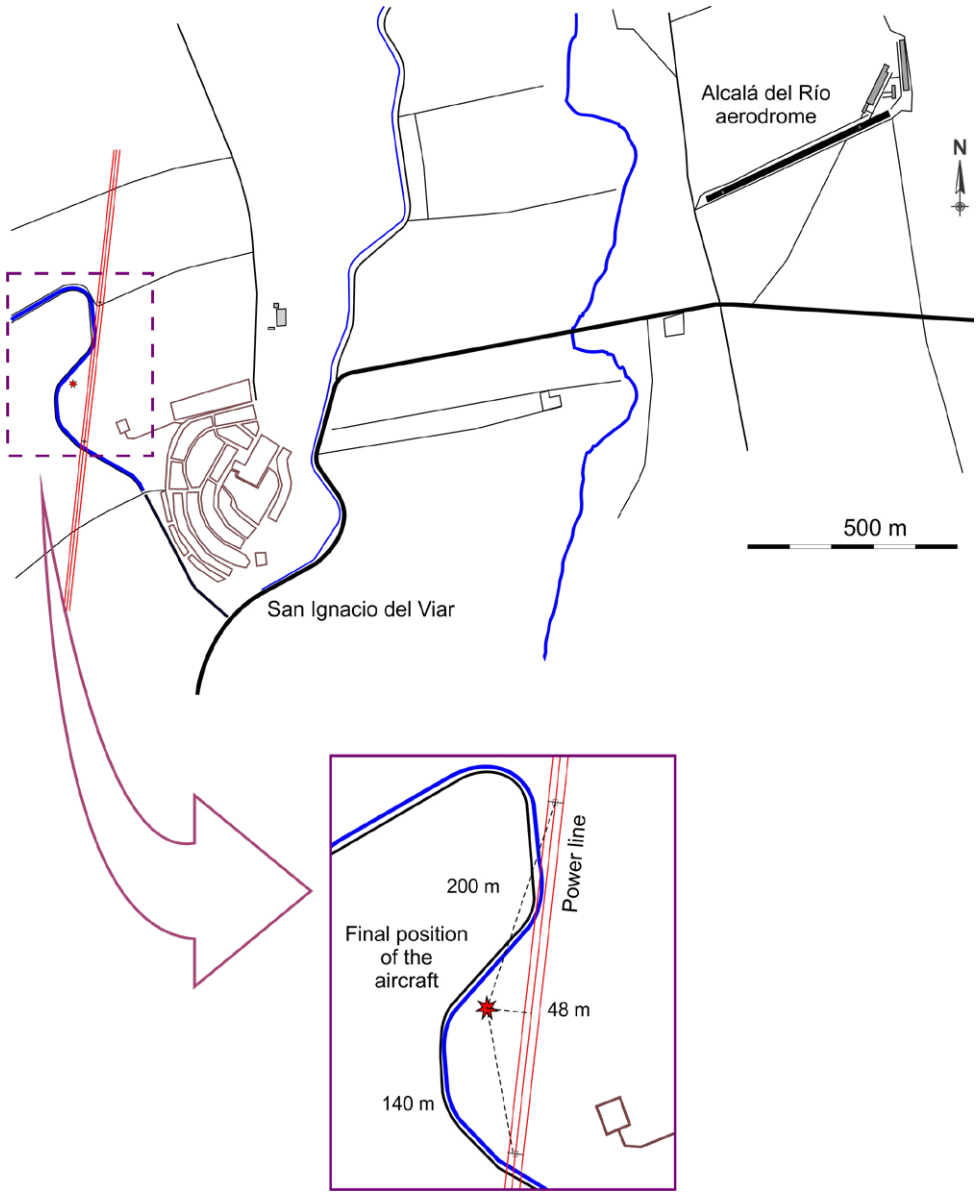

Figure 2. Location of accident site

There were no displacement marks left on the ground by the aircraft.

The measurements of the poles or the characteristics of the power line are not exactly known, since the utility that owns them did not respond to the CIAIAC's request for information, but it is estimated that the power line is approximately 32 m off the ground.

1.13. Medical and pathological information

The pilot had bruising caused by the restraining action of the harness during the impact. He also had a bruise on his head and a dislocation in the leg and another in the foot, due to the accident.

1.14. Fire

There was no fire.

1.15. Survival aspects

Both aircraft seats were outfitted with a lap belt and harness, which was attached to the aft wall. The lap belts and harnesses were in perfect condition. The pilot's harness absorbed the energy of the impact and restrained him properly, contributing to his survival.

1.16. Tests and research

1.16.1. Inspection of the aircraft

With the exception of the propeller blades, no aircraft parts detached due to the accident. So as to transport the aircraft to a hangar at the Alcalá del Río aerodrome, the two wings were removed. The aircraft was inspected at said hangar.

The switches in the cockpit were operated by the individuals who aided the pilot, meaning the positions of these switches at the time of the accident are not known.

The right wing exhibited compression damage on the outboard half of the leading edge. This damage started at the outer edge and continued in the direction of the wing root. There was also compression damage on the trailing edge, close to the root.

The left wing had compression damage and fractures on the leading edge, close to the root. The rest of the wing was undamaged.

Figure 3. Right wing

Figure 4. Left wing

The front part of the aircraft's fuselage was bent upward and to the left, as seen from the cockpit.

The aircraft's canopy was broken and deformed.

The main landing gear was not muddy and it did not exhibit any marks or apparent damage. The metal bar on the front landing gear showed signs of having scraped a metallic element. There were also marks on the top front of the fairing (see Figure 5). There was no dirt in the fairing, but there were wheat stalks.

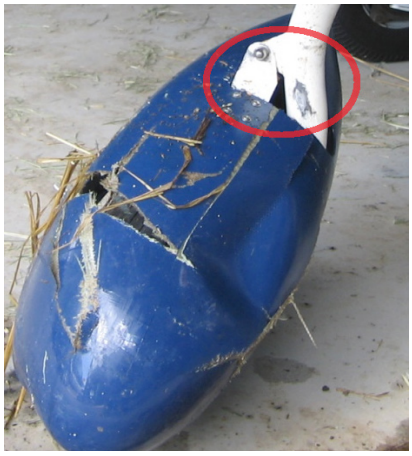

Figure 5. Marks on front gear

The rudder exhibited compression damage and its top part was bent to the left where the position light is located.

No apparent defects were found in the fuel system and both engine carburetors had fuel when they were disassembled.

There was continuity in the flight controls, except for at the points where the wings were detached.

The engine cowling exhibited various fractures, particularly on the left side of the aircraft. The engine mount had been damaged and deformed by the impact. Various engine accessories were also damaged. No defects were found in the engine that could have affected the accident.

The propeller cone was completely destroyed. The three blades were broken at the root, in the hub, and there was mud at the front of the hub. As for the wood fibers in the fractures, none were found to exhibit signs of twisting, which would have indicated the sudden stoppage of the engine, but there were fibers that had been crushed toward the root of the blade. The blades did not exhibit marks compatible with having struck the power line, or severe damage from impacting the ground, only minor drag marks. These marks were practically parallel to the direction of rotation (but without quite being concentric) in blade A, and at approximately a 45° angle from the direction of rotation in blade B. There were no marks on blade C.

Figure 6. Propeller blades

Figure 7. Propeller hub

1.16.2. Emergency parachute

Aircraft EC-KTF was equipped with a Magnum 501 pyrotechnic parachute. This optional equipment is installed at the front of the fuselage, between the firewall and instrument panel.

This system can be activated by means of a lever located at the bottom center of the dashboard, identified with a sign that reads "RESCUE SYSTEM PULL IN EMERGENCY". The sign also shows an image of the aircraft hanging from a parachute.

According to the documentation of the parachute manufacturer, in critical situations the rescue system must be activated as soon as possible, since the airplane loses altitude quickly as its downward speed increases. The system should be activated no lower than 200 m AGL, but the success of a low-altitude recovery will depend on the airplane's horizontal and vertical speeds at the moment of activation. The manufacturer states that there have been documented rescues from altitudes as low as 80 m[2].

2 Source: "Ballistic rescue parachute systems series Magnum. Installation and user's manual", stratos 07.

The lever for actuating the parachute was broken and the parachute was partially deployed. There was continuity in the system but the rocket was damaged, possibly due to the impact with the terrain.

1.16.3. Canopy locking mechanism

The aircraft has a teardrop-shaped canopy made of organic glass bolted to a steel structure. The canopy is attached at the front of the fuselage at two points so that it can be tilted forward. To make it easy to operate, the weight of the canopy is counterbalanced by two gas struts that allow opening it without effort.

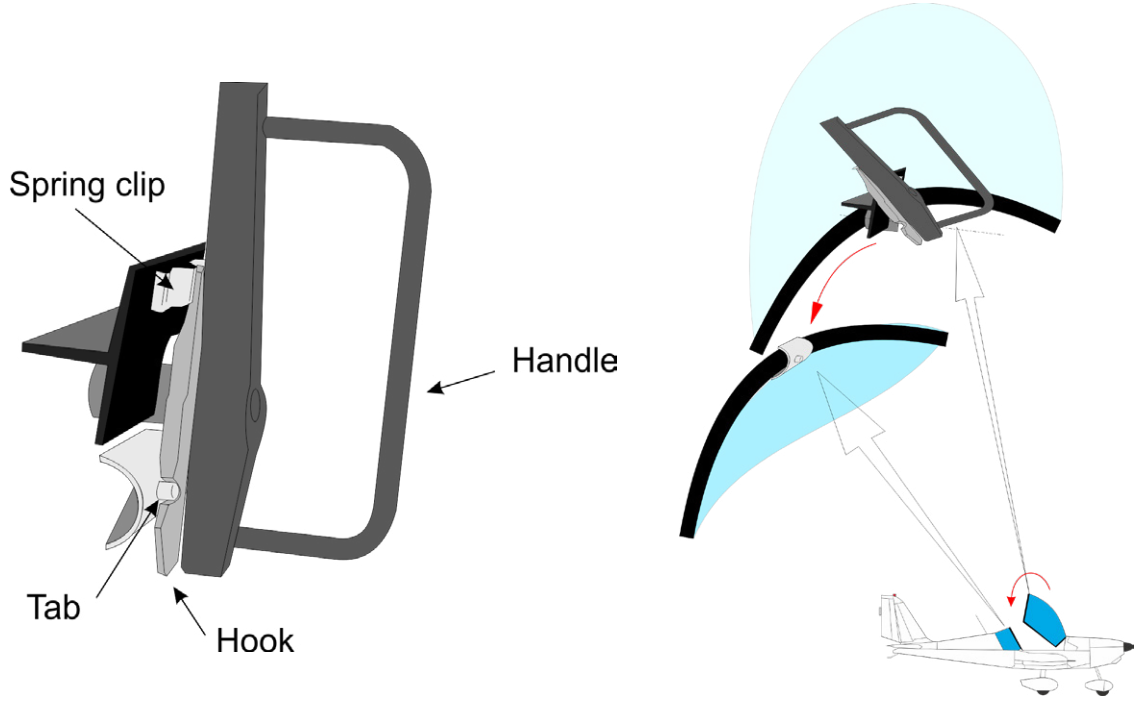

Figure 8. Parts and location of the canopy locking mechanism

At the rear of the canopy is the locking mechanism, as shown in Figure 8. It consists of a handle with a hook that locks into a small tab at the rear of the cockpit. The handle is secured with a spring clip system that keeps it from opening accidentally. To lock and unlock the system, some force must be applied when turning the handle (Figure 9).

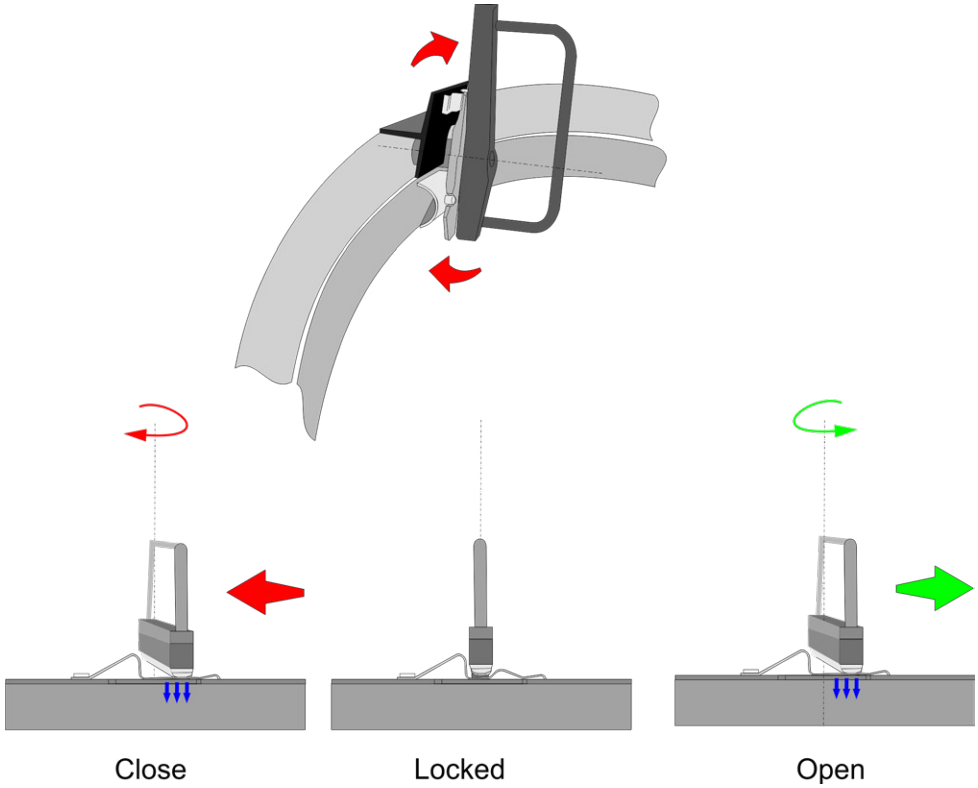

Figure 9. Operation of the canopy locking mechanism

During the accident investigation, the locking mechanism was fully disassembled and inspected. The hook had been filed down, which had reduced its thickness (Figure 10). This modification was only noticeable if the part was disassembled, since it was riveted to the structure. The aircraft manufacturer was asked about this, and it stated that it had not authorized the modification carried out on the locking system. The manufacturer explained that, as in other cases, the canopy had opened due to improper maintenance, since the hook had been filed down so the canopy could close easier. It stated that an overly gentle motion to open and close the canopy should be a warning sign, since in these conditions the possibility exists that the system will open accidentally.

Figure 10. Modification to the canopy locking mechanism

1.16.3.1. Manufacturer service bulletins

In April 2012, Evektor-Aerotechnik issued service bulletin EV97-018a, classified by the manufacturer as mandatory and applicable to all EV-97 Eurostar aircraft. The bulletin requires incorporating the emergency procedure for the canopy opening in-flight into the aircraft flight manual (included in the appendix to this report). This procedure explains that if the canopy opens in flight for any reason, this will induce vibrations in the horizontal tail unit[3] and the control stick, affecting the pilot's ability to control the aircraft. The SB indicates the procedure to follow in such a situation.

1. Tightly grip the control stick to reduce vibrations of the horizontal tail unit due to wake behind opened canopy.
2. Keep cool.

WARNING

The priority is to maintain aeroplane controllability.

Attempts to close the canopy are secondary.

3. Adjust engine power for horizontal flight at speed of 100-110 km/h.
4. Trim the aeroplane.
5. Close the canopy if possible (enough time, sufficient altitude, experienced crew) by pulling the canopy side frame down. The vibrations of the horizontal tail unit will diminish after closing the canopy and the aeroplane will be better controllable. It will be probably impossible to fully close and lock the canopy because of temporary deformations due to air loads.
6. If the situation does not allow canopy closing, then the whole attention should be paid to maintenance of aeroplane controllability.
7. Choose area or airfield suitable for emergency landing.
8. Carefully perform landing manoeuver:
9. Set wing flaps to Landing I (30°) position, throttle as needed, trim the aeroplane.

CAUTION

At a solo flight, if the pilot is holding by his/her one hand the canopy pulled down and controls the aeroplane by other hand, it is necessary to momentarily grip the control stick between the knees and use free hand to extend the flaps, pull the throttle and adjust trim. Then immediately grip the control stick.

3 The horizontal tail unit comprises the horizontal stabilizer and the elevator.

10. Perform landing.
11. Inspection of the canopy condition, its attachment, lock system is necessary to be done after the flight. Also inspection of the condition and attachment of the horizontal tail unit and control system.

In November 2015, Evektor-Aerotechnik issued service bulletin EV97-033a, classified by the manufacturer as mandatory and applicable to all Eurostar and Sportstar aircraft with a metal frame around the canopy. The reason for the bulletin stated that as a consequence of not following procedures, in certain circumstances the lock in the cockpit could be released in flight, causing the canopy to open. The SB states to install a mechanical catch on the canopy frame to act as an additional securing element and prevent the canopy from opening even if its locking mechanism failed (it would only open a few centimeters). The material is provided by the manufacturer at the owner's request, the latter being responsible for the associated costs.

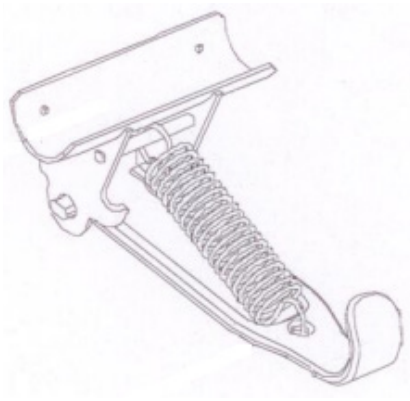

Figure 11. Canopy catch

Figure 11 shows the catch. The SB also includes various pages to replace in the pilot's operating handbook, one of which modifies the Before Takeoff checklist by replacing the line "Cockpit closed" by "Cockpit locked and secured by the catch".

The owner had requested a quote for this catch three months before the accident, but it had not been installed on aircraft EC-KTF.

1.16.4. Pilot's statement

The pilot stated that he left the Trebujena aerodrome (LETJ) in the morning and was flying another aircraft for several hours to renew his ULM instructor rating.

He filled the tank in Ilipa Magna to return to Trebujena. He did the pre-flight check and found no discrepancies. When he took off from runway 24, he verified that everything was correct (pressures, temperatures, magnetos, etc.). The engine was at 5000 RPM and he was climbing at 120 km/h.

The pilot stated that he was at an altitude of 700 to 750 ft (600-650 ft AGL) when he heard a noise and felt a pressure change in the cockpit, "it was like hearing the wind." Then the aircraft carried out a very abrupt nose- down manoeuvre. He noticed he had no elevator control, so he continued flying in a straight line without turning. The airplane had a strong nose-down tendency, but it was oscillating up and down. He had to pull hard on the stick. It felt like an open cockpit. He saw an open strip and felt the air.

He thinks that the canopy shadowed the elevator, because he was unable to control it. He tried to fly the airplane and turned to close the canopy with one hand, but he was unable to. In order to reach it, he would have had to let go of the aircraft's control stick, but he thought it best to try to control the aircraft. So he put the engine at idle and tried to control the rudder. He did not want to roll for fear of stalling. He saw the power lines and since the airplane would not climb, he decided to go underneath. He felt the airplane touch the wires, after which the airplane fell, striking the ground and flipping forward. He thought the propeller might have touched the cable.

The accident took place at approximately 20:15 local time. He was helped out of the airplane by a man who was walking in the area. The canopy broke and he got out through the hole in the canopy.

He said that he had bruises from the harness and lap belt and strong pain on his left foot and leg, due to a dislocation.

He explained that he did not activate the parachute because he thought he was not high enough for it to deploy.

The pilot said he had not changed or altered the canopy locking system, nor did he know it had been altered, though he thought the closing action seemed very gentle. He said he had purchased the aircraft three or four years earlier.

When asked if he himself stopped the engine, he replied that he pulled very hard on the throttle lever intending to place it in idle, and that he may have stopped it but could not recall. He also thought it might have been stopped by the propeller rubbing the cable.

He thought the "canopy opening in flight" emergency procedure published by the manufacturer was not useful and that it did not reflect the real situation like the one he had lived flying alone. He did not consider the fact that there were vibrations (the emergency procedure only spoke of vibrations) to be significant. On the contrary, he considered decisive the attitude of the plane due to the fact that the opening of the canopy caused shade in the air flow in the elevator, horizontal stabilizer and part of the vertical. He explained that this caused the plane nose to fall immediately and uncontrolled with a very rapid loss of altitude.

The pilot described as "agonising" the aircraft's lack of response in these circumstances and considered it significant that an emergency landing was assumed in point 7 of the procedure.

1.16.5. Statement from eyewitness at aerodrome

The eyewitness was at the runway 24 holding point when aircraft EC-KTF took off at approximately 20:10.

As he was lining up in the runway, he saw EC-KTF descending on an unusual way, losing it from sight behind a hill. He took off and saw the aircraft on the ground.

The pilot of aircraft EC-KTF was taking a refresher seminar to renew his FI-ULM rating at Ilipa Magna. He had flown two training flights with him that day, one in the morning lasting 36 minutes, and another in the afternoon lasting 42 minutes. Both flights had been problem-free. He was taking his exam the following week.

The eyewitness heard the pilot of EC-KTF report leaving the circuit, but he did not make any emergency communication.

1.16.6. Report from aerodrome manager

A transcript of the accident report written by the aerodrome manager is provided below:

> "The pilot arrived at the airfield at about 12:30 that same day, flying in from the Trebujena aerodrome (LETJ) in aircraft EC-KTF, a flight that lasted 34 minutes. The pilot's physical condition was normal.
>
> At 14:20 that same day, the pilot performed a training flight in the aircraft of the Aero Ilipa Magna school as part of the refresher seminar to renew his FI-ULM rating. The flight lasted 36 minutes, during which the pilot acted as the instructor and the school instructor played the role of the student pilot, as required by the authorization for the aforementioned seminar. The flight was completely normal. At about 15:15, the instructor and pilot ate a light lunch together at the La Cochera bar in the town of Alcalá del Río.
>
> After eating lunch, both returned to the airfield to do another dual-control flight, which started at 18:00 local time and lasted 42 minutes. This flight was also completely normal, like the previous one.
>
> After a 30-minute break, the pilot started preparing ULM EC-KTF for the return flight. This preparation involved taking on 20 liters of fuel and a complete pre-flight check, which did not reveal anything out of the ordinary.
>
> At about 20:00 local time, the pilot started up the ULM and after allowing it

to warm up and checking the cockpit, he took off from the runway 24 threshold. After reporting leaving the traffic circuit via W (approximate heading of 230º), the pilot stated that when he was about one kilometer away from the runway at an altitude of around 800 feet, he felt a large pressure drop in the cockpit, accompanied by a loss of elevator control, resulting in a steep dive. Faced with this situation, the pilot decided to lower the engine RPM to the minimum to minimize the descent rate and attempt to regain control of the ULM. During this maneuver, the ULM struck a high-voltage power line located some 2 km away from the runway 24 extension, still on an approximate heading of 230º. After this impact, the ULM crashed to the ground, impacting nose first and flipping over, coming to rest in an upside down position.

After a few minutes the pilot was able to release his lap belt and exit the aircraft with help from an individual who was near the accident site. The pilot had minor injuries and was fully conscious.

The takeoff and sharp descent were observed by the instructor and a student at the school, who were lining up for takeoff on runway 24 after the pilot of the accident aircraft reported leaving the circuit. On seeing the strange maneuver, he took off in search of the ULM, which had dropped below the horizon. They found it in the position described earlier, after which they reported the situation to the airfield so that rescue operations could commence as soon as possible.

After reaching the site, some 10 minutes later, the local police from Alcalá del Río was already on the scene and had taken charge of the situation."

1.17. Organizational and management information

Not applicable.

1.18. Additional information

1.18.1. Accident involving an EV-97 Eurostar aircraft, registration OH-U430, in Jämijärvy (Finland) on 30 June 2010[4]

Summary

A Eurostar EV-97 aircraft on a visual flight crashed to the ground shortly after takeoff and was completely destroyed. Both the pilot of the aircraft and the passenger were killed.

Shortly after takeoff the aircraft's canopy opened. The aircraft fell to the ground in an almost horizontal position less than a minute after takeoff, just over one kilometer west of the aerodrome.

The canopy likely opened due to a strong and gusty wind and to the canopy's locking mechanism. The aerodynamic forces created by the gusts cause momentary changes to the aircraft's structure and, according to the manufacturer, the original locking mechanism is not sufficient under these circumstances. The manufacturer tried to improve the reliability of the locking system by publishing a bulletin with instructions for changing out the new parts in the locking system to keep the canopy from opening during temporary structural changes. The parts in the airplane's canopy locking system had been replaced, but one part that contributed significantly to the system's reliability had not been changed. The factor contributing most to this was that the instructions published in the bulletin for assembling the alteration parts delivered were inadequate. Another reason for not changing the part was the aircraft owners' expectation that the changed parts increased enough the locking system's reliability.

The cause of the accident was the loss of aircraft control after the canopy opened during flight. An open canopy disturbs air flow, which causes strong vibrations in the horizontal stabilizer, elevator and control stick, resulting in a considerable nose-down effect. The fact that the pilot probably tried to close the canopy, and in doing so would have neglected to monitor the flight parameters, contributed to the loss of control of the aircraft.

The canopy and its locking mechanism

There are two different cockpit and canopy widths on EV-97 ultralights. The most

4 Source: "B2/2010L Ultralight Aircraft accident at Jämijärvi on 30 June 2010", Finnish Safety Investigation Authority.

common cockpit width is 104 cm (outside width) and the wider model is 113 cm across. The wider model can be transparent at the top or it can have a reinforced metal sheet running lengthwise along the center. Unlike the more common cockpit, the lower frame of the wider canopy has guide pins that align the holes in the lower rail of the canopy. The wider one is flatter in its top part than the one with the regular width. In all models, the wider canopy is hinged at the front left and right such that it opens forward. It is kept open by gas struts on either side. At the rear of the canopy is a locking handle with a hook that locks behind a small pin at the rear of the cockpit. There are minor differences in the locking mechanisms of the two aircraft despite the width of the canopy.

The owners of the aircraft thought that the canopy locking mechanism was not reliable. The problem was the attachment between the outer handle and the inside of the canopy, which was loose. The increasing amount of play was considered a risk because the spindle of the exterior handle could break at the hinge. To solve this problem, the aircraft's owners had contacted the importer of the aircraft, who supplied them with the parts needed for the modification, but which the owners carried out incorrectly. The reason for the confusion was that the instructions in the manufacturer's bulletin, EV-97-009A, involving the modification, did not match the parts that were supplied for the work.

Once the modification was done, the owners' concerns over the locking system dissipated, though in reality the problem of the accidental opening of the canopy had not been resolved.

Manufacturer's service bulletin

On 3 January 2006, the manufacturer, Evektor-Aerotechnik, published service bulletin number EV-97-009a, on the wide canopy locking mechanisms and classified by the manufacturer as mandatory. The reason for publishing this bulletin was reports of repeated involuntary canopy openings in flight. The manufacturer thought the most likely cause for this was the improper design of the locking mechanism, which was not considered adequate for all air loads that could affect the canopy during flight. Because of this, the bulletin provided instructions for modifying the locking mechanism, the parts of which were supplied by the manufacturer.

Opening of the canopy in flight

The Safety Investigation Authority asked the manufacturer, Evektor-Aerotechnik, about the possible factors related to the opening of the canopy in flight, the behavior of an open canopy and its possible effects.

The behavior of an open canopy was investigated on the wide-canopy aircraft model on the ground. With the engine at 3850 RPM, the canopy was opened at the rear from a few centimeters to 20 cm. In the takeoff acceleration simulation, the canopy was opened up to 40 cm. Also investigated was the behavior of an open canopy on the ground with the narrow-canopy model[5] , which was opened at the rear some 30 cm with the engine at over 3500 RPM.

According to the manufacturer, in flight, the tear-shaped canopy is affected by a lifting force, that is, lift is created by suction. This force is normally stronger than the drag force pushing the canopy down. This means that a canopy hinged at the front edge and not locked (at its rear edge) tends to lift at the rear edge. If the canopy is not closed and locked correctly, the locking handle can open, which would open the canopy due to vibrations during flight.

The manufacturer carried out several test flights with a wide-canopy airplane in 2004 to study the effects of an open canopy on the aircraft's flight characteristics. The test flights showed that despite the open canopy, the ability to control and maneuver the airplane remained acceptable.

Gliding with the engine at idle and the flaps retracted at an IAS of 100-120 km/h, the canopy opened 55-57 cm, measured from the rear edge to the fixed frame of the canopy at its highest points. Climbing at maximum power at an IAS of 100-120 km/h, the canopy opened 37-30 cm.

Moreover, when the canopy is open, it widens some 10 to 20 mm on either side, making it that much more difficult to close in flight. Lowering the speed also reduces the widening effect.

The disrupted air flow caused by an open canopy leads to vibrations in the horizontal stabilizer and elevator, as much as +/- 50-70 mm at the end of the elevator. The vibration is stronger at full power, and is felt in the control stick, as well.

According to the manufacturer, attempting to close the canopy in a solo flight may require additional effort and skill from the pilot to control the situation, an effort that could have a negative effect on flight safety. The problem with closing the canopy is that it expands in flight, and the rear moves forward. In order to close the canopy, the locking handle must be held in the OPEN position while at the same time the canopy frame is pushed to the rear in order to be able to correctly close and lock the mechanism.

5 Aircraft EC-KTF is the narrow-canopy model.

Other incidents involving opening the EV-97 Eurostar canopy in flight in Finland

The Finnish Accident Investigation Authority received reports of other cases involving canopies opening accidentally in flight. These incidents had occurred with both canopy models and, based on the information received, had taken place in gusty weather and/or negative acceleration conditions.

1.18.2. Accident involving an EV-97 Eurostar aircraft, registration HB-WAV, on Lake Neuchâtel, in the municipality of Auvernier (Switzerland) on 29 July 2006[6]

On 29 July 2006, the pilot, who was flying alone, took off in an EV-97 aircraft, registration HB-WAV, from runway 05 at the Neuchâtel aerodrome. The pilot explained that, shortly after flaps retraction and power reduction, suddenly the aircraft showed a strong tendency to drop its nose. He tried to compensate it by pulling hard on the stick, then opened the throttle. The rate of descent was reduced but he couldn't stabilized the airplane and it continued falling down.

The airplane impacted the surface of Lake Neuchâtel and quickly sank. Despite being seriously injured, the pilot was able to exit the aircraft under his own power.

The accident was caused when the pilot lost control of the aircraft due to the sudden opening of the canopy, which had not been properly locked. The canopy opened shortly after takeoff, after the flaps had been retracted. This phenomenon could be explained by the changing vibrations and increased speed that take place after retracting the flaps.

1.19. Useful or effective investigation techniques

Not applicable.

6 Source: "Final report no. 2004 by the Aircraft Accident Investigation Bureau concerning the accident to the Ecolight, Eurostar EV 97 aircraft, registration HB-WAV on 29 July 2006 on Lake Neuchâtel 900 m off the port, in the municipality of Auvernier/NE, 5 km south-west of Neuchâtel."

2. ANALYSIS

2.1. Weather conditions

There was good visibility in the area, so the possibility that the pilot impacted the cable because poor visibility prevented him from seeing it sooner is ruled out.

AEMET estimated that the wind in the area was around 24 km/h and gusting to 35 km/h. But these estimates were made using measurements taken at a station 16 km away from the accident, and neither the accident pilot nor the pilot who took off after him encountered strong wind gusts, so it is likely that the wind in the accident area was a little lighter.

2.2. Impact sequence

The right wing exhibited compression damage on the outboard half of the leading edge. This damage started at the outer edge and continued in the direction of the wing root, while the left wing only had compression damage on the leading edge, close to the root.

The front part of the aircraft's fuselage was bent upward and to the left, as seen from the cockpit. This was due to the impact between the ground and the right side of the nose, though the impact was mostly frontal.

The damage to the right leading edge, combined with the deformation of the fuselage and the engine mount to the left, suggest that the propeller hub impacted the ground a few moments after the right wing.

Given the minimal damage exhibited by the blades, including the absence of cable marks, the possibility that they impacted the power lines is ruled out. The breaks in the blades did not exhibit fibers with signs of a rotational component, which would have indicated the sudden stoppage of the propeller. They were, however, crushed inward by the almost vertical impact of the nose against the ground. This suggests that the blades did not break in flight, but rather when the nose impacted the ground.

The short distance between the power line and the impact site on the ground is not sufficient for a sudden change in engine performance, meaning that when the airplane struck the cable, the engine was stopped or running at very low RPMs. Investigators were unable to identify any engine failures, though fuel starvation can be ruled out as there was fuel in the carburetors. In his statement the pilot said that he pulled back very quickly on the throttle lever, and that he may have stopped the engine.

The marks found on the front landing gear were caused by impacting the power line, which slid along the fairing to the bar. The aircraft must have then rotated about its axis to untangle itself from the power line, since it fell a short distance away from the line, which was at an approximate height of 32 meters.

The damage to the top of the rudder was minor and caused by a low impact energy after the aircraft flipped forward.

An analysis of the aircraft wreckage indicates that the impact sequence was as follows:

1. The front landing gear impacted the power line, which almost completely stopped the aircraft in the air as it rotated forward. It then fell practically vertically, with its longitudinal axis almost perpendicular to the ground.
2. The outside leading edge of the right wing impacted the ground. The aircraft hit the ground slightly tilted to the right (left yaw).
3. The nose of the aircraft impacted next, with the propeller blades breaking as the hub dug into the ground and the aircraft flipped forward.
4. The top part of the tail impacted next, with the aircraft ending up inverted on the ground.

2.3. Opening of the canopy in flight

According to the pilot's and eyewitnesses' statements, the aircraft took off and climbed out without problems and the pilot reported leaving the circuit.

Then, while climbing at a speed of 120 km/h and at an altitude of 700 to 750 ft, according to the pilot statement, the canopy opened and suffered a loss of the elevator control.

According to the manufacturer, during flight the tear-shaped canopy is affected by a lifting force, meaning that lift is created by suction. Normally this force is stronger than the drag force pushing the canopy downward. This means that a canopy hinged at the front and unlocked (at the rear) will tend to lift at the rear. If the canopy is not closed and locked correctly, the locking handle can turn and the canopy will open due to vibrations during the flight.

Based on a study conducted by the Finnish Accident Investigation Authority on incidents involving an open canopy, the opening occurred in gusty and/or negative acceleration conditions. At the time of this accident there were probably gusts, but nothing out of the ordinary. The gusts may have induced small vibrations that could have helped to open the canopy, but the extent of their influence is difficult to

gauge. What probably contributed more were the changes to the vibrations in the aircraft produced by the change in the aircraft's attitude and by the increased speed after transitioning from the takeoff to the initial climb.

2.3.1. Effects of an open canopy during flight

Based on the information gathered on canopies opening in flight, the disrupted air flow caused by an open canopy leads to strong vibrations in the horizontal stabilizer and elevator, as well as to a strong nose-down pitch.

The vibration that is transmitted to the control stick, the significant nose-down effect and the air flow in the cockpit can, when they occur suddenly, have a significant adverse effect on the pilot's performance. Moreover, when the canopy is open, it widens by about 10 to 20 mm to either side, making it that much more difficult to close it in flight.

The pilot's attention tends to focus easily on the canopy and its behavior, which could lead the pilot to neglect the control of the aircraft.

Not being aware that the canopy can open accidentally can make the situation very difficult to handle. This is why the manufacturer issued SB EV97-018a, which instructed recipients to amend the flight manual for all EV-97 models to include the emergency procedure for the canopy opening in flight.

This procedure warns that the priority is to maintain control of the aircraft, and that trying to close the canopy is secondary. In fact, it states that "It will be probably impossible to fully close and lock the canopy because of temporary deformations due to air loads." The manufacturer thus recognized the enormous problems a lone pilot would have closing the canopy. The procedure recommends that a pilot flying solo hold the canopy down with one hand and the control stick with the other. It might even be necessary to momentarily hold the control stick between the knees and use the free hand to operate the flaps and throttle and adjust the trim. The situation for a pilot flying solo is complicated, even adhering to the manufacturer's procedure.

In the case at hand, the pilot explained that this procedure did not describe the real situation and that it had not been of much help. According to him, it is not possible in such a situation to fly the aircraft with one hand while holding the canopy with the other, due to the strong nose down effect generated in the aircraft.

The pilot of another accident on the same model of aircraft, also due to the opening of the canopy, explained that suddenly the aircraft showed a strong tendency to

drop the nose. He tried to compensate it by pulling hard on the stick but he couldn't stabilized the airplane and it continued falling down.

The emergency procedure does not contemplate this strong nose-down effect that both pilots experienced and which significantly degraded aircraft control: it only mentions vibrations.

After performing several test flights in 2004 to study the effects of an opened canopy on the flight characteristics of the aircraft, the manufacturer described the control capability and handling of the aircraft as acceptable. However, according to the testimonies of pilots who experienced this experience, there are difficulties associated with the control of the aircraft that make it difficult to make an emergency landing safely. It is considered that these circumstances should be warned in the emergency procedure.

The manufacturer's procedure makes no mention of the parachute system, even though it is offered as an option on the aircraft that can avoid an accident in the event of a loss of control.

It is possible that the open canopy on the aircraft could interfere with the effectiveness of the parachute, depending on its location. That it why the manufacturer should study this situation and, based on the results, amend the emergency procedure, whether the use of the parachute is advisable or not. A safety recommendation is issued in this regard.

2.4. Canopy locking mechanism

In January 2006, the manufacturer, Evektor-Aerotechnik, published service bulletin number EV-97-009a, on the wide canopy locking mechanisms and classified by the manufacturer as mandatory. The reason for publishing this bulletin was reports of repeated involuntary canopy openings in flight. This bulletin was not applicable to aircraft EC-KTF, which had the narrow, or standard, canopy. When the manufacturer was asked about this, it assured there were no indications of any problems with this type of mechanism.

When the canopy locking mechanism on aircraft EC-KTF was disassembled, it was noted that the hook attached to the handle had been thinned. The hook had been filed down and this caused the spring clip to offer less resistance, opening and closing easily.

The actual pilot/owner stated that he had not altered the locking mechanism, nor did he know it. He hadn't noticed the reduced width of the part, since it was only

evident if the mechanism was completely disassembled. He did say, however, that it seemed to close very easily, but he never thought anything of it.

The manufacturer confirmed that this tapering constituted an unauthorized modification of the locking system. It also underscored the importance of having owners ask the manufacturer about any anomaly in the aircraft, since an overly soft locking mechanism is indicative of inadequate maintenance, and in such cases the manufacturer can help identify the root cause of the problem.

The unauthorized modification of the locking mechanism means that the aircraft was not airworthy at the time of the accident.

In November 2015, Evektor-Aerotechnik issued service bulletin EV97-033a, classified by the manufacturer as mandatory and applicable to all Eurostar and Sportstar aircraft with a metal canopy frame, like on EC-KTF. The reason for the bulletin stated that as a consequence of not following procedures, in certain circumstances the locking mechanism in the cockpit could be released in flight, causing the canopy to open. The SB states to install a mechanical catch on the canopy frame to act as an additional securing element and prevent the canopy from opening even if its locking mechanism failed. It would only open a few centimeters. The SB also includes various pages to replace in the aircraft flight manual, one of them involving a modification to the Before Takeoff checklist that entails replacing the line "Cockpit locked" with "Cockpit locked and secured by the catch".

This catch, which would have kept the canopy from opening more than a few centimeters, instead of the 55 to 57 cm that the manufacturer's study found when gliding with the engine at idle, had not been installed on aircraft EC-KTF. This would have minimized disruptions to the air flow and the vibrations in the elevator, which would have made the aircraft much more controllable than in the accident scenario, thus reducing the likelihood of its occurrence.

2.5. Pilot's actions

On this aircraft, once the pilot's seatbelt is fastened, it is not easy to access the handle to close the canopy, which is on the rear canopy frame. Moreover, when the canopy is open, it widens at either side, which makes it that much more difficult to close in flight. The pilot's focus tends to shift toward the canopy and its behavior, and away from controlling the aircraft.

The pilot explained that he turned to try to close the canopy with one hand but was unable to. He said that in order to reach it, he would have had to remove both hands from the controls. He thus decided to ignore the canopy and focus on

controlling the airplane. He did not want to roll for fear of stalling and being unable to recover the airplane, given its reduced maneuverability.

Even though the pilot saw the power line, the scant maneuverability of the aircraft, combined with its vertical oscillations, prevented him from avoiding it, and the front gear ended up impacting it.

The pilot's decision not to let go of the controls to close the canopy was correct, since if he had released them, he would have lost all control of the aircraft. In this case the pilot was quite experienced on the aircraft type and had flown it recently. A week after the accident the pilot took the exam to renew his ULM instructor rating, which he passed. This shows that he was more skilled than the average ULM pilot, and even so he could not get the aircraft to maneuver in a way that was acceptable.

The pilot did not actuate the parachute system installed in the aircraft because he thought he was too low and the parachute would not deploy. The emergency procedure for the canopy opening in flight did not make reference to the parachute system.

In the test flights conducted by the manufacturer with the canopy open, the ability to control and handle the airplane was considered acceptable despite the vibrations of the elevator and control stick. But these tests are normally conducted by an expert test pilot who would not be caught off guard by the opening of the canopy in flight, since he knew it would happen ahead of time. This would allow him to be ready and more calm than if it had happened unexpectedly.

In other events in which unexpectedly the canopy opened in flight and the pilot was unable to close it, the pilots did not complete a normal approach and landing due to the difficulty in maneuvering the airplane and to the type of situation facing them. For a pilot to suddenly find himself unable to maneuver the aircraft, with a loud noise and air flowing inside the cockpit while close to the ground, leaves very little margin for analyzing the situation. Therefore, in an effort to avoid this dangerous situation, owners of this aircraft type should install the canopy catch described by the manufacturer in SB EV97-033a.

3. CONCLUSIONS

3.1. Findings

1. The pilot had a valid and in force license and medical certificate.
2. The pilot had ample experience and expertise in flying ULMs.
3. The weather conditions were not limiting for the flight, though wind gusts may have played a role in opening the canopy.
4. The pilot did not make any emergency communication.
5. The aircraft had a Registration Certificate issued by the National Aviation Safety Agency on 17 March 2015.
6. The aircraft had a Special Restricted Certificate of Airworthiness issued by the National Aviation Safety Agency on 10 March 2010.
7. The last 100-hour/annual inspection was carried out on 21 August 2015, with 532 hours on the aircraft.
8. No defects were found in the aircraft's propulsion system or in the flight controls that could have affected the accident.
9. After taking off, the aircraft's canopy opened. The pilot was unable to close it.
10. The pilot lost much of his control over the aircraft and as a result was not able to avoid impacting a power line.
11. The front landing gear became entangled in the power line, stopping the aircraft, which fell to the ground a short distance away.
12. No aircraft components detached in flight.
13. The pilot's lap belt and harness withstood the energy of the impact and restrained him correctly, contributing to his survival.
14. An open canopy in flight induces strong vibrations in both the horizontal stabilizer and in the elevator due to the disrupted air flow. This has a significant nose-down effect on the aircraft.
15. The vibration in the elevator that is transmitted to the control stick, along with the nose-down effect produced in the aircraft and the bothersome air flow in the cockpit, can have a detrimental effect on the pilot's performance.
16. The pilot did not activate the parachute that was installed in the aircraft.
17. The aircraft manufacturer had issued a service bulletin detailing an emergency procedure in the event that the canopy opened while in flight. This procedure did not consider the use of the parachute system.
18. There have been various incidents and accidents involving this aircraft model and the opening of the canopy in flight.
19. The aircraft did not have the canopy catch mechanism specified in service

bulletin EV97-033a, issued by the aircraft manufacturer.

20. Owners of this aircraft type should install the canopy catch that the manufacturer describes in SB EV97-033a.

3.2. Causes/Contributing factors

The accident was caused by the reduced control of the aircraft, resulting from the involuntary opening of the canopy as a consequence of an unauthorized modification to its locking mechanism, which led to the aircraft impacting a high-voltage power line.

4. SAFETY RECOMMENDATIONS

The aircraft manufacturer published an emergency procedure for the canopy opening in flight, but said procedure makes no mention of the parachute system, even though it is an optional system that in event of a loss of aircraft control can prevent an accident.

It is possible that the open canopy on the aircraft could interfere with the effectiveness of the parachute, depending on its location. That it why the manufacturer should study this situation and, based on the results, amend the emergency procedure, since, whether the use of the parachute is advisable or not, this should be specified in the procedure so pilots know exactly what actions to take if they find themselves in such a situation.

Moreover, the emergency procedure is not thought to be viable for a pilot flying solo and does not describe sufficiently the difficult situation he faces. A more detailed and realistic emergency procedure helps the pilot to be more prepared and responsive to the situation. As a result, it is considered that the manufacturer should improve this procedure.

REC. 69/17. It is recommended that Evektor-Aerotechnik study and improve the emergency procedure for the canopy opening in flight described in SB EV97-018a.

REC. 70/17. It is recommended that Evektor-Aerotechnik conduct a study on the effect that an open canopy has on the deployment of the parachute rescue system installed on Evektor EV-97 aircraft, and that it use the results of the study to determine whether or not to recommend using the parachute in the emergency procedure for the canopy opening in flight described in SB EV97-018a.

APPENDIX

Emergency procedure for the canopy opening in flight

FLIGHT MANUAL **EV-97 EuroStar**

EMERGENCY PROCEDURES

3. A Canopy opening in fight

WARNING

Always make sure before flight, that the canopy is properly and fully closed and secured!

If the canopy would open in flight from any reasons, then wake behind opened canopy will cause vibrations of the horizontal tail unit and consequently of the control sticks which affect aeroplane controllability.

Follow the procedure hereinafter to solve such situation:

1. **Tightly grip the control stick** to reduce vibrations of the horizontal tail unit due to wake behind opened canopy.
2. Keep cool.

WARNING

The priority is to maintain aeroplane controllability.

Attempts to close the canopy are secondary.

3. Adjust engine power for horizontal flight at speed of 100-110 km/h
4. Trim the aeroplane.
5. Close the canopy if possible (enough time, sufficient altitude, experienced crew) by pulling the canopy side fram down.
   The vibrations of the horizontal tail unit will diminish after closing the canopy and the aeroplane will be better controllable. It will be probably impossible to fully close and lock the canopy because of temporary deformations due to air loads.
6. If the situation does not allow canopy closing, then the whole attention should be paid to maintenance of aeroplane controllability.
7. Choose area or airfield suitable for emergency landing.
8. Carefully perform landing manoeuver:
9. Set wing flaps to Landing I (30°) position, throttle as needed, trim the aeroplane:

CAUTION

At a solo flight, if the pilot is holding by his/her one hand the canopy pulled down and controls the aeroplane by other hand, it is necessary to momentarily grip the control stick between the knees and use free hand to extend the flaps, pull the throttle and adjust trim. Then immediately grip the control stick.

10. Perform landing
11. Inspection of the canopy condition, its attachment, lock system is necessary to be done after the fligh. Also inspection of the condition and attachment of the horizontal tail unit and control system.

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