Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

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# Safety Investigation Report


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Final

# ACCIDENT
# AIR COPTER A3C-T
# IN MATAGNE-LA-PETITE
# ON 8 JUNE 2018

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## FOREWORD

This report is a technical document that reflects the views of the investigation team on the circumstances that led to the incident.

In accordance with Annex 13 of the Convention on International Civil Aviation and EU Regulation 996/2010, it is not the purpose of aircraft accident investigation to apportion blame or liability. The sole objective of the investigation and the Final Report is the determination of the causes, and to define recommendations in order to prevent future accidents and incidents.

In particular, Article 17-3 of Regulation (EU) 996/2010 stipulates that the safety recommendations made in this report do not constitute any suspicion of guilt or responsibility in the accident.

The investigation was conducted by the AAIU(Be) with the support of the Belgian Defence Air Safety Directorate.

Note:

About the time: For the purpose of this report, time will be indicated in UTC, unless otherwise specified.

## SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| ’ | Minute |
| “ | Second |
| AAIU(Be) | Air Accident Investigation Unit (Belgium) |
| AIP | Aeronautical Information Publication |
| AMSL | Above mean sea level |
| AR | Arrêté Royal (French for Royal Decree) |
| ATC | Air Traffic Control |
| BCAA | Belgian Civil Aviation Authority |
| CAT | Category |
| CAVOK | Ceiling and Visibility OK |
| E | East |
| EASA | European Aviation Safety Agency |
| EU | European Union |
| FDR | Flight Data Recorder |
| FH | Flight hour |
| FREQ | Frequency |
| ft | Foot (Feet) |
| GND | Ground |
| Hz | Hertz |
| ICAO | International Civil Aviation Organisation |
| KB | Koninklijk Besluit (Dutch for Royal Decree) |
| Kt | Knot(s) |
| LDG | Landing |
| LH | Left hand |
| LT | Local Time |
| m | Metre(s) |
| METAR | Aviation routine weather report (in aeronautical meteorological code) |
| MHZ | MHz |
| N | North |
| NE | North-east |
| NOSIG | No significant change (used in trend-type landing forecasts) |
| PSN | Position |
| QFE | Barometric pressure of the aerodrome. |
| QNH | Pressure setting to indicate elevation above mean sea level |
| RH | Right hand |
| RWY | Runway |
| UTC | Universal Time Coordinated |
| VFR | Visual Flight Rules |

## TERMINOLOGY USED IN THIS REPORT

**Safety factor:** an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence.

**Contributing safety factor:** a safety factor that, had it not occurred or existed at the time of an occurrence, then either:
(a) the occurrence would probably not have occurred; or
(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or
(c) another contributing safety factor would probably not have occurred or existed.

**Other safety factor:** a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

**Safety issue:** a safety factor that
(a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and
(b) is a characteristic of an organization or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

**Safety action:** the steps taken or proposed to be taken by a person, organization or agency on its own initiative in response to a safety issue.

**Safety recommendation:** a proposal by the accident investigation authority in response to a safety issue and based on information derived from the investigation, made with the intention of preventing accidents or incidents. When AAIU(Be) issues a safety recommendation to a person, organization, agency or Regulatory Authority, the person, organization, agency or Regulatory Authority concerned must provide a written response within 90 days. That response must indicate whether the recommendation is accepted, or must state any reasons for not accepting part or all of the recommendation, and must detail any proposed safety action to bring the recommendation into effect.

**Safety message:** an awareness which brings to attention the existence of a safety factor and the lessons learned. AAIU(Be) can distribute a safety message to a community (of pilots, instructors, examiners, ATC officers), an organization or an industry sector for it to consider a safety factor and take action where it believes it appropriate. There is no requirement for a formal response to a safety message, although AAIU(Be) will publish any response it receives.

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## SYNOPSIS

| | | | |
|---|---|---|---|
| **Classification:** | Accident | **Type of operation:** | Ultralight - Local |
| **Level of investigation:** | Standard investigation | **Phase:** | Initial climb |
| **Date and time:** | Friday 8 June 2018<br>Exact time unknown | **Operator:** | Private |
| **Location:** | In a wood, south of EBMG airfield<br>N50° 5' 59.8" E004° 38' 29.37" | **Persons on board:** | 1 |
| **Aircraft:** | Gyrocopter Air Copter A3C-T | **Aircraft damage:** | None |
| **Occurrence category:** | Loss of control – In-flight (LOC-I) | **Injuries:** | 1 fatality |


### Abstract

The owner of the gyrocopter went to Matagne-la-Petite airfield (EBMG) with the intention to perform a flight. There was nobody present at the airfield at the time. The pilot took-off without notifying anyone of his intentions. After the gyrocopter and the pilot were reported missing, the police started to search for the aircraft. The wreckage was found the day after the accident at 600 metres from the airfield. The pilot was found deceased.


### Cause

The accident was caused by a loss of control in flight. The direct cause of this loss of control could not be determined. It could have been due to excessive vibrations or the consequence of either insufficient handling following an engine failure or incapacitation of the pilot.

### Possible contributing factors

To a loss of control:

- Excessive play in the flight control linkages, resulting in an imprecise roll and pitch control.
- The play in the flight controls could have made possible an amplification of the vibrations generated by the damaged propeller and the rotor blades.
- Poor workmanship in the performance of engine maintenance and inadequate monitoring of the engine performance leading to a possible engine failure

To a medical issue:

- The age of the pilot.
- The absence of a recurrent aeromedical examination.

# 1 FACTUAL INFORMATION.

## 1.1 History of the event.

On Friday 08 June 2018, the owner of the gyrocopter went to Matagne-la-Petite airfield (EBMG) and took-off without letting someone know of his intentions. The airfield was closed and there was nobody present. There was no witness of the take-off, the flight and/or the accident itself.

The chronology of the event was reconstructed as much as possible based on indirect testimonies and on the analysis of the engine Turbocharger Control Unit (TCU).

After the pilot arrived at the airfield, he put his gyrocopter out of the hangar and ran the engine for about 17 minutes before taking off. From the recording of the TCU it can be deducted that the accident occurred very shortly after take-off.

At 13:00 UTC, pilots coming to EBMG noticed the door of the hangar open and the parked car of the pilot. In the evening, his wife, worried of not seeing her husband coming back, contacted the airfield. As it became obvious that the gyrocopter was missing, the persons present at the airfield called the police. The mobile phone system was interrogated and indicated a position in the vicinity of the airfield. A search was initiated by the police, including an aerial search with a helicopter. This initial search was unsuccessful.

Finally, the wreckage was found the next morning, Saturday 09 June at 04:50 UTC at 600 metres southwest of EBMG, in a wooden area. The gyrocopter crashed after a steep descent into the woods. The pilot was found deceased.

## 1.2 Injuries to persons.

| Injuries | Crew | Passenger | Others | Total |
|---|---|---|---|---|
| Fatal | 1 | 0 | 0 | 1 |
| Serious | 0 | 0 | 0 | 0 |
| Minor | 0 | 0 | 0 | 0 |
| Total | 1 | 0 | 0 | 1 |

## 1.3 Damage to aircraft.

Aircraft is totally destroyed.

## 1.4 Other damage.

Slight damage to trees and limited pollution of the soil.

## 1.5 Pilot information

| | | | |
|---|---|---|---|
| **Age and nationality** | 81 years - Belgian | **Medical:** | Unknown |
| **License:** | ULM license (Issued by DGAC France) | **Injuries:** | Fatally injured |
| **Ratings:** | Multi-axes (August 2008) Gyrocopter (July 2009) Radio (April 2009) | **Restraint used:** | Lap belt + dual shoulder belts. |
| **Flight experience:** | Unknown, as no record was available. | | |
| **Medical:** | There is no formal requirement for a recurrent medical examination for ULM pilots in France. No medical certificate was available. | | |

The pilot owned first an ultralight aeroplane and later bought the gyrocopter. Both aircraft were parked in a hangar at EBMG airfield.

The pilot learned to fly his own gyrocopter when he bought it in 2011. After a rapid and intensive training, the pilot was formally qualified to fly alone. Reportedly, the short training period was much owed to the pilot's limited time availability and the qualification would have been given upon an informal condition that he would further self-train following a specific training schedule that the instructor prepared for him. However, the gyrocopter manufacturer stated that the conversion from aeroplane to gyrocopter involves the acquisition of new specific conditioned reflexes and this usually requires some time, even more so for older students (the pilot was aged 74 at the time).

Pilots of EBMG airfield stated that the owner regularly flew with his ultralight aeroplane. However, he was prohibited to fly with this gyrocopter from EBMG airfield. Therefore, according to the airfield's commander, when the pilot wanted to fly the gyrocopter, he installed it on a trailer and transported it by road to another airfield located in France. However, retrospectively, there was a suspicion that the pilot sometime took off and landed at EBMG when the airfield was closed, without any witness.

Additionally, owing to the effect of growing age, the pilot was recommended for several months by his peers and by the airfield commander to not fly with a passenger anymore. Eventually, the pilot decided several months before the accident to sell both his aircraft.

## 1.6 Aircraft information.

The AIR COPTER A3C-T is a non-certified ultralight gyrocopter, designed and produced by the company AIR COPTER located at Lherm, Haute-Garonne, France. About 25 gyrocopters of the A3C family were manufactured.

It features a hinged rotor with its 2 opposite blades mounted in a hub bar in such a way that if one blade flaps up, the other has to flap down.

This gyrocopter has a two-seat side-by-side configuration enclosed cockpit with a windshield and tricycle landing gear.

**General characteristics**

- Crew: one
- Capacity: one passenger
- Empty weight: 250 kg
- Gross weight: 450 kg
- Fuel capacity: 34 litres
- Rotor blade profile: NACA 8H12
- Disk Span (Dia.): 8.40 m
- Propellers: 3-bladed composite
- Powerplant: 1 × Rotax 914 four cylinder, liquid and air-cooled, turbocharged, four stroke aircraft engine, 86 kW (115 hp)

**Performance**

- Maximum speed: 170 km/h
- Cruise speed: 140 km/h
- Climb speed: 90 km/h
- Rate of climb: 4 m/s (780 ft/min)

**The accident gyrocopter**

No record of the maintenance and no logbook was available to allow for proper evaluation of the history of the aircraft. The gyrocopter was on sale for a few months and was described on a website as having about 185 hours total flight time.

The following documents were collected from different sources:

- DGAC computer generated description of aircraft dated 08 February 2007
- DGAC 'Fiche d'identification ULM' dated 17 April 2008
- Bill of sale of the gyrocopter to the pilot involved in the accident dated 5 July 2011
- DGAC 'Carte d'identification ULM' issued to the accident pilot on 16 December 2015
- DGAC acknowledgment of receipt of the document "Déclaration d'aptitude au vol", last issued on 22 February 2018

As the gyrocopter isn't certified or registered following ICAO standards, the flight authorization delivered by DGAC is restricted to flights in the French airspace. A specific validation by the concerned aviation authority is required to fly over a foreign territory.
The Belgian Civil Aviation Authority (BCAA) stated that their records show no request for validation of the French flight authorization having been submitted for this aircraft.

The gyrocopter was equipped with a ROTAX 914UL engine with serial number 4419068.
The propeller initially installed by Air Copter was a 3-blade DUC Windspool. However, the propeller found installed on the gyrocopter after the accident was a ARPLAST 5-blade propeller, obviously installed later by the owner[1] and whose installation was not approved by the gyrocopter manufacturer.

[1] Reportedly, this propeller originated from the other ULM owned by the pilot.

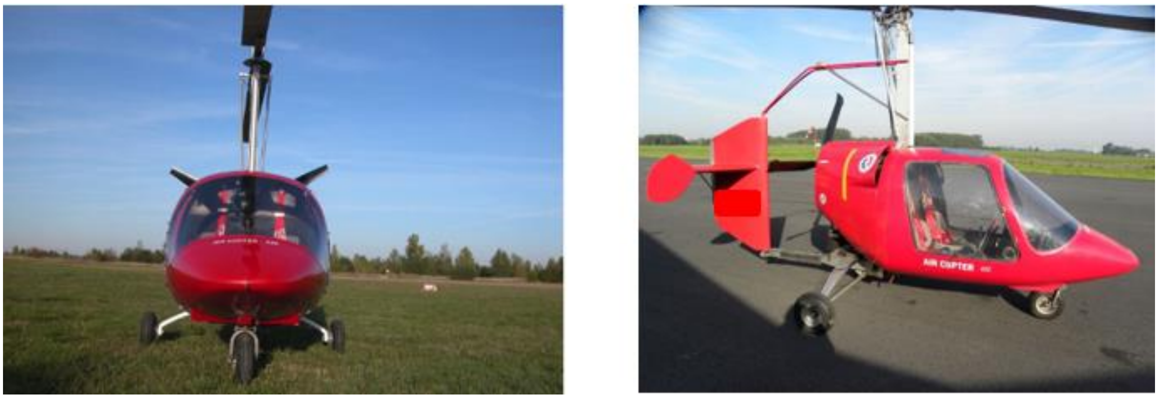


Figure 1: the accident gyrocopter.

The owner carried out himself the maintenance of both his gyrocopter and his ultralight aeroplane.

According to the gyrocopter manufacturer, the winglets located at both sides of the horizontal stabilizer are not original. These winglets are made of wood and fabric. Actually, when installed by the gyrocopter manufacturer, winglets are made of a composite construction and have a different shape.

## 1.7 Meteorological conditions.

| | | | |
|---|---|---|---|
| Source: | Charleroi Airport | Clouds: | Scattered at 1200 ft |
| Time: | 10:50 UTC | Visibility | 4000m (Hazy) |
| Distance from site: | 42 km North of EBMG | QNH: | 1016 hPa |
| Wind direction: | 350° (Variable) | Temperature: | 21°C |
| Wind speed: | 05 kt | Dew point: | 16°C |

| | | | |
|---|---|---|---|
| Source: | Florennes Air Base | Clouds: | Few at 1000 ft<br>Scattered at 1500 ft<br>Broken at 5000 ft |
| Time: | 11:55 UTC | Visibility | 4000m BR (Mist) |
| Distance from site: | 15km North of EBMG | QNH: | 1015 hPa |
| Wind direction: | 010° (Variable) | Temperature: | 20°C |
| Wind speed: | 08 kt | Dew point: | 17°C |

As can be deducted from the above tables, the wind at the approximate time of the accident was a gentle breeze (between 05 kt and 08 kt) and variable predominately from North direction.

## 1.8 Aids to navigation

As the gyrocopter was not equipped with a transponder, it could only be detected by a primary radar, without any possibility of identification. The primary radar imagery from Florennes air base was analysed to visualize the flight of the gyrocopter.

Within the expected time frame and location of the accident, only 2 radar return signals were detected at 11:05:48 UTC and 11:06:12 UTC. The signals were located north of the EBMG airfield and moved southwards before disappearing.

## 1.9 Communication.

There is no record of communication between the gyrocopter and any other station.

## 1.10 Aerodrome information.

EBMG Doische/Matagne-la-Petite airfield is located in the Walloon Region at about 14 km south of Florennes air base and south-east of the city of Philippeville. Coordinates are 50°061'7''N – 004°38'17''E and elevation is 787 ft (240 m).
The airfield is dedicated to ultralight aircraft (ULM/DPM). It is equipped with a 260-meter-long 33-meter-wide bi-directional 06/24 grass runway with a right-hand circuit for runway 24 with a circuit height of 750 ft AGL. The use of the aerodrome is subject to prior permission from the operator.

## 1.11 Flight recorders.

There was no flight recorder installed, nor was it required. However, the engine Rotax 914 is equipped with a Turbocharger Control Unit (TCU) to control the boost pressure. This TCU records the different engine data in three subparts.

- <u>Subpart 1: Recordings of exceedances</u>:
  The highest value of any exceedance of three parameters (see right column below), occurring within a one-minute time interval, is recorded in the event-logger provided the exceedance lasts more than one second.
  A maximum of 100 exceedances are recorded in a ring buffer. When the event-logger is full, it will automatically overwrite the oldest records.

| Channel | Parameter | Unit | Alert thresholds |
|---|---|---|---|
| 1 | Speed | rpm | 5900 rpm |
| 2 | Load – Throttle position | % | / |
| 3 | Air pressure | hPa | / |
| 4 | Airbox pressure | hPa | 1450 hPa |
| 5 | Airbox temperature | °C | 90°C |
| 6 | Servo position | % | / |
| 7 | Reserved | / | / |
| 8 | Boost time | seconds | / |

- Subpart 2: Engine data of the last 20 minutes of engine operation:
  The value of seven different parameters (see above) are stored and saved each minute regardless if an alert threshold was exceeded or not. The recorded “Boost Time”, starts running from a pressure of 1250 hPa. After 20 recordings, the system automatically overwrites the oldest records.

- Subpart 3: Lifetime data:
  The largest exceedance of speed, airbox pressure and airbox temperature having occurred since the engine went into service is recorded, along with the engine total operating time when these exceedances occurred. The TCU also shows the total number of exceedances of the concerned channel and the cumulated time of exceedances for each channel.
  Additionally, it shows the total time of boost operation (Boost time – More than 1250 hPa) in hours, minutes and the ratio (percentage) of boost time compared to the total operating time of the engine.

The TCU of the engine was downloaded by BEA (Bureau d’Enquête et d’Analyse – France). The results of the download are shown in the appendices of this report.

A total of 100 exceedances are recorded in the TCU from 99h47 to 184h04 engine time. The exceedances are distributed as follows: 36 over-boost, 63 overspeed and 55 airbox too high temperature, but some recordings show a dual exceedance (Example over-boost and excessive airbox temperature at the same time).
Given the significant number of exceedances (more than one per hour), the engine manufacturer was consulted for an opinion regarding these exceedances.

The manufacturer stated:

*This great number of exceedances (“Alarm records”) is not normal. Any such exceedance may be caused by a serious condition such as the inappropriate installation or operation of the engine. These conditions must not be ignored and appropriate actions must be taken even at the first occurrence. All exceedances cause the illumination of a warning light in the cockpit and must be understood as an early warning sign for a potential engine failure.*

## 1.12 Wreckage and impact information.

### Crash site findings

The wreckage is located at about 600 metres south-east of EBMG, in a wooden area. The gyrocopter crashed after a steep descent into a wood.

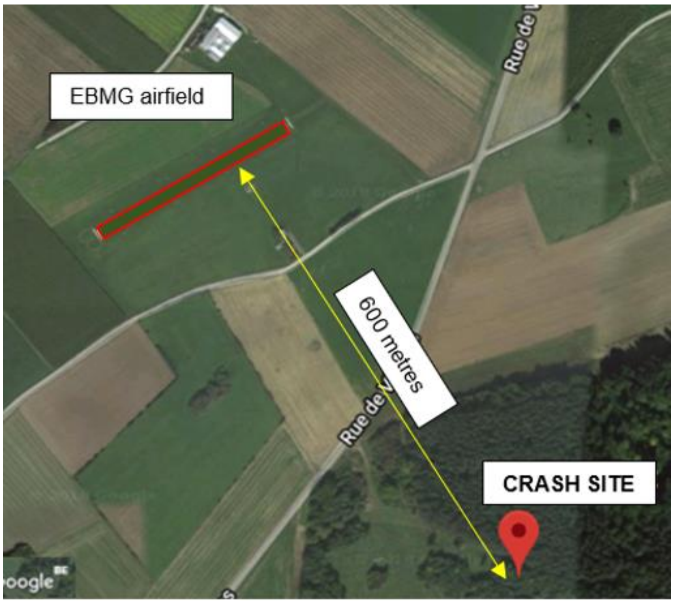



Figure 2: Aerial view showing the position of the crash site in relation to EBMG airfield.

Damage to the surrounding trees indicates that the gyrocopter flew southwards and had a rather low forward ground speed at impact.
All the parts that separated from the wreckage were found in the close vicinity of the cabin and show signs of rupture at the final impact. However, the winglet of the left-side horizontal stabilizer and the left side horizontal stabilizer were found a little further, at about 5 to 7 meters north of the main wreckage, suggesting that they separated just before the final impact.
The left side of the cockpit, where the pilot was sitting, was totally destroyed by the collision of the gyrocopter with a tree.

Figure 3: The left side of the cabin was completely destroyed.

Figure 4: Scattered tail parts in relation to the belly of the cabin.

From the 5 blades of the propeller, 2 blades completely separated from the hub, 1 partially separated (1/3 remained attached to the hub) and 2 non-adjacent blades remained attached to the hub, one of which showing some damage. All the separated, or partially separated blades were retrieved very close to the main wreckage. One of them was even retrieved under the main wreckage.

**Detailed inspection of the wreckage**

Both rotor blades are bent upwards at the root but the curvature changes to the opposite direction about at the half-span of the blades, featuring a S shape.
Traces of red paint, similar to the paint of the airframe, are present on the leading edge and on both the lower and upper surfaces of the rotor blades at a position compatible with an impact with the left vertical winglet and the leading edge of the left horizontal stabilizer.

Figure 5: One rotor blade (with the hub bar still attached) featuring a S shape

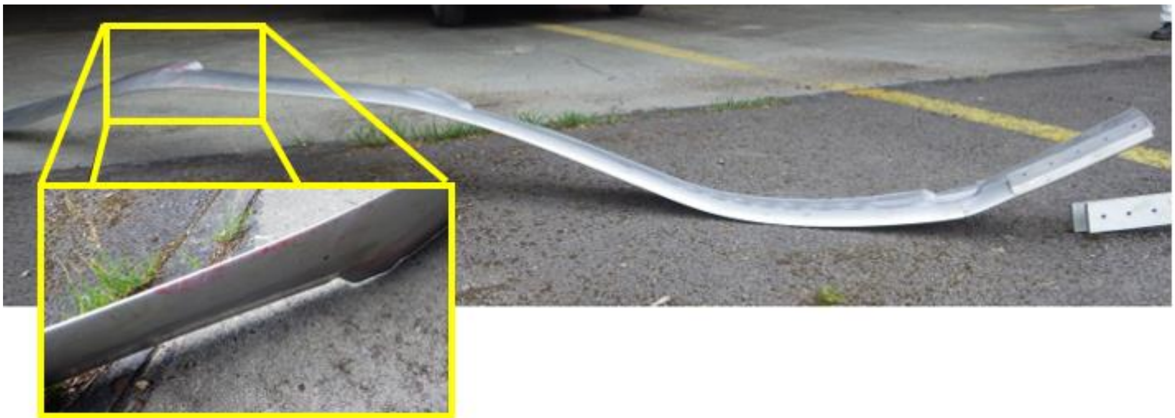


Figure 6: Second rotor blade also featuring a S shape deformation and red traces of contact with aircraft's tail section.

Both mechanical stops of the hub bar are bent downwards obviously resulting from impact(s) with the rotor hub bar. This hub bar, consisting of 2 parallel strong aluminium plates fixed on a tower block, showed deformations compatible with impacts with the stops installed in the hub. As can be seen in Figure 7, the hub bar and the blades were removed from the rotor hub for the transportation of the wreckage.


Figure 7: Both mechanical stops of the hub are bent downwards.

Figure 8: Bent hub bar.

Reconstruction of the tail section shows damage compatible with an impact of the rotor blades with the left-side vertical winglet and with the leading edge of the left-side horizontal stabilizer.

Figure 9: Reconstruction of the tail section.

Figure 10: Damage compatible with rotor blade impacts.

The flight control linkage of the rotor (pitch and roll) and the rudder cables were verified and flight control continuity was confirmed.

However, significant play was detected at the ends of the pitch and roll rods located between the stick frame and the control horn. The resulting play in the left-to-right direction (roll) at the control handle was determined to be approximately 4 cm. The same evaluation of the play in the front-to-rear direction (pitch) could not be performed because one bearing was damaged, likely due to the impact.

Verification of the tightening of the nuts and bolts located at the end of each rod revealed that they could be easily tightened with an angle between 45° and 90° under a very moderate torque. Retorquing resulted in a significant reduction of the play at each rod end assembly. After retightening, the play in the left-to-right direction (roll) at the control handle was dramatically reduced from about 4 cm to 4 mm in the left-to-right direction (roll).

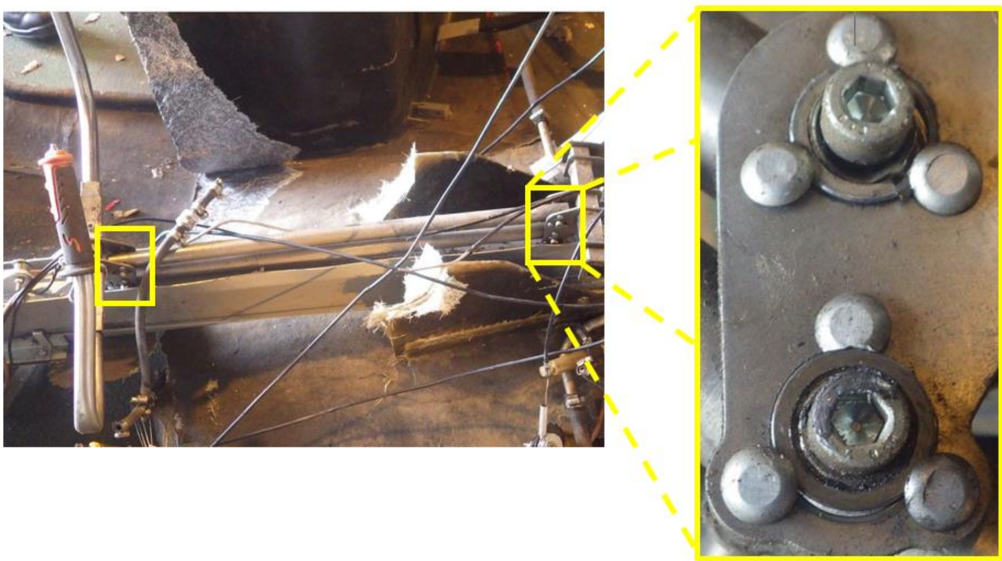


Figure 11: Bolts (4 ) assembling the roll and pitch rods were found insufficiently torqued.

Beside the installation of a propeller without the approval of the manufacturer and the significant play in the flight control linkage, the inspection of the airframe revealed numerous technical anomalies and/or indications of inadequate workmanship in the performance of maintenance. In particular:

- Bad welding (showing cracking, lack of fusion, spatter and undercutting) of a support for a non-genuine rotor brake pad.
- Bad arc welding of 4 non-genuine steel blocks on the pre-rotator gear plate for the magnetic rotor speed sensor.
- Inadequate soldering of a wire inside the plastic housing of an electrical connector of the engine ignition.

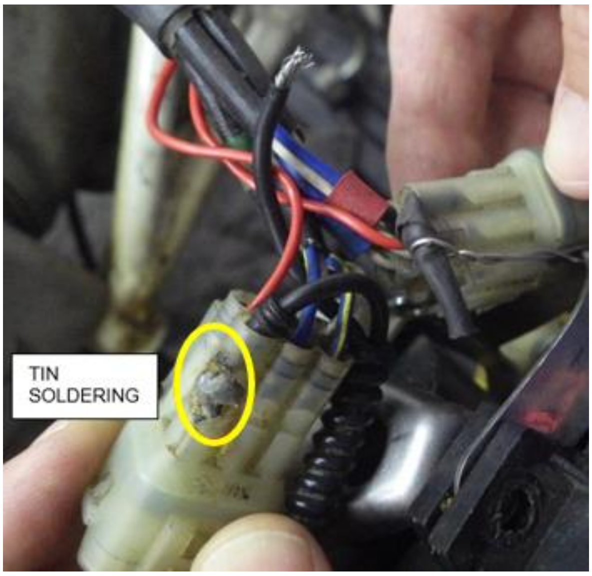



Figure 12: Inadequate soldering of a wire.

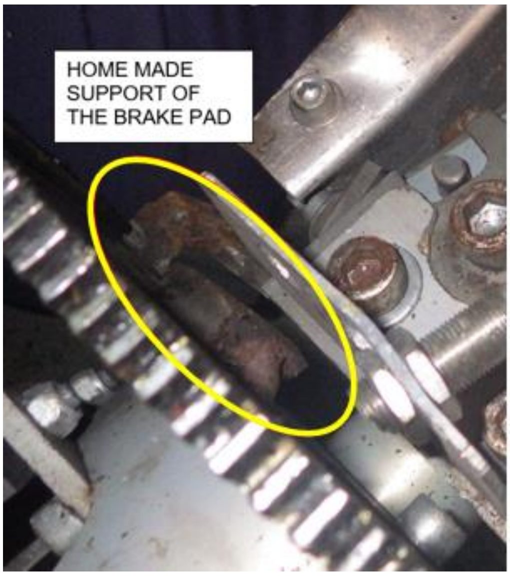
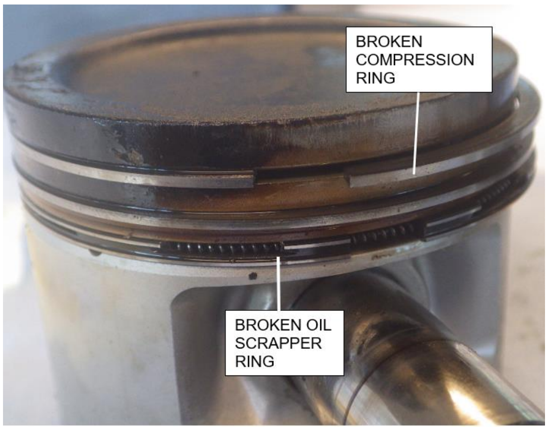



Figure 13: Bad welding of a support for a non-genuine rotor brake pad.

**Engine inspection**

Both carburettors, although severely damaged, were inspected for contamination and other defaults. Although no anomaly was found, the inspection could not fully exclude the presence of anomalies, given the extensive damage to the carburettor.
The fuel filters were inspected and found slightly contaminated but not to such an extent to disrupt the fuel feed of the engine.
The ignition system could not be tested due to the damage.
Removal and inspection of the folded paper element of the oil filter revealed a contamination, although moderate, by small metallic particles.



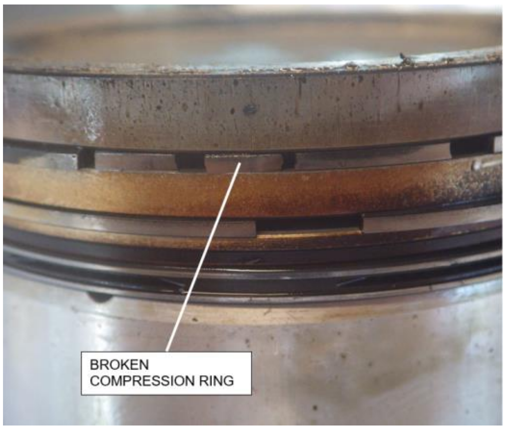




Figure 14: Pictures of damaged ring installed on 2 different pistons

The removal of the cylinder heads and the cylinders revealed that the compression ring of one piston was fractured in 5 pieces and the compression ring and oil scrapper ring of another piston were also fractured (compression ring: into 2 pieces, oil scrapper: numerous pieces). In spite of the visible damage to the piston rings, the concerned cylinders were easy to remove. There was no indication of piston seizure both onto the cylinder walls and the pistons. The assembly of the connecting rods didn't show any play and they were free to rotate. The crankshaft could be turned freely without sticking.

Propeller inspection

Beyond the damage caused to the propeller by the accident, the contact surface of the propeller hub with the spacer showed evidence of severe fretting. The fretting had been caused by an inadequate installation of the propeller onto its spacer, using too long bolts. As the end of the bolts came into contact with the driving pulley of the pre rotator, the clamping force between the spacer and the propeller was insufficient to avoid a relative movement between them.

Figure 15: propeller hub damaged by severe fretting

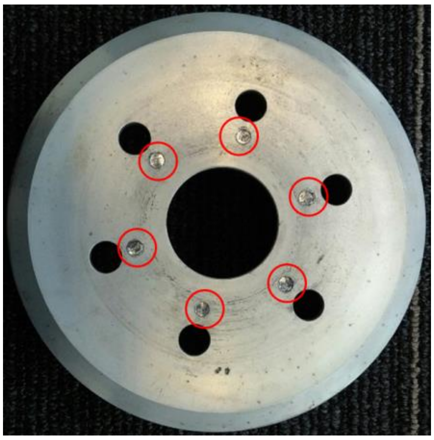


Figure 16: pre rotator pulley showing bolts end contact damage

## 1.13 Medical and pathological information.

The dead body of the pilot showed several severe open wounds with very little blood loss.

The verbal request from AAIU(BE) for an autopsy of the deceased pilot in accordance with the co-operation protocol with Justice (Openbaar Ministerie - Ministère Public) was not accepted by the Prosecutor in charge.

## 1.14 Fire.

Although the fuel tanks were punctured during the crash, there was no fire.

## 1.15 Survival aspects.

The left front side of the cabin, where the pilot was seated, was entirely destroyed by the impact with a tree, leaving the pilot no chance of survival although his safety belt was fastened.

The gyrocopter was equipped with a 4-point safety belt (lap belt + shoulder harness) where the shoulder harness was attached to the rear wall of the cabin. The lap belt and the harness properly withstood the deceleration but the attachment point to the cabin failed at impact.

## 1.16 Tests and research.

Not applicable

## 1.17 Additional information.

Belgian regulation regarding the health check process of pilots, cabin crew and air traffic controllers (Royal Decree 12 July 2013[2]) requires that all ultralight pilots pass regularly a class medical examination. For pilots having the age of 40 years and older this happens every 24 months. This medical examination requirement goes together with the ultralight pilot licences delivered by the Belgian aviation authority.

However, this Belgian regulation does not apply to pilots who get a licence delivered by a foreign aviation authority, even if they regularly fly above Belgian territory.

Due to the absence of European harmonisation in the area of ultralight aircraft and ultralight pilot licences, each EU member state has its own rules in this matter, involving, amongst others, that not all EU aviation authorities require a recurrent aeromedical examination for ultralight pilots.

[2] 12 JUILLET 2013. - Arrêté royal organisant la vérification des conditions d'aptitude physique et mentale des membres d'équipage de conduite et de cabine des aéronefs civils, ainsi que des contrôleurs de la circulation aérienne. 12 JULI 2013. - Koninklijk besluit tot regeling van de organisatie van de controle van de voorwaarden inzake lichamelijke en geestelijke geschiktheid van de leden van het stuurpersoneel van burgerlijke luchtvaartuigen, van cabinebemanning en van luchtverkeersleiders.

# 2 ANALYSIS.

## 2.1 The flight

Examination of the last recordings of the Turbo Control Unit reveals that just before the accident, the engine ran for at least 17 minutes, between 185h07 and 185h24 (Engine time), at a constant ambient pressure of 990 hPa.

Based on the QNH of Florennes Air Base (1015 hPa) and the elevation of the airfield (+/- 787 ft), the air pressure recorded by the TCU (990 hPa) does approximately correspond to the calculated QFE (989hPa) at EBMG airfield at the time of the accident. This means that the engine ran on the ground for at least 17 minutes before take-off.

Moreover, the TCU did not record a lower ambient pressure at the end of the 17 minutes of the engine run and it only records the engine data every minute, indicating that the accident occurred within the first minute following take-off.

As the wind came predominantly from the north, the gyrocopter very likely took off on runway 06. Assuming (see above) the accident occurred shortly after take-off, the gyrocopter would have made a right turn toward the south while climbing. Note that the aerodrome circuit is on the left side for runway 06. The accident site is located at 600 metres from the runway. Comparing this with the still-air distance of 1500 m when travelled at a 90 km/h climb speed, this would indicate that the accident occurred within 1 minute after take-off.

This scenario is also compatible with the direction of the damage found to the trees around the crash site.

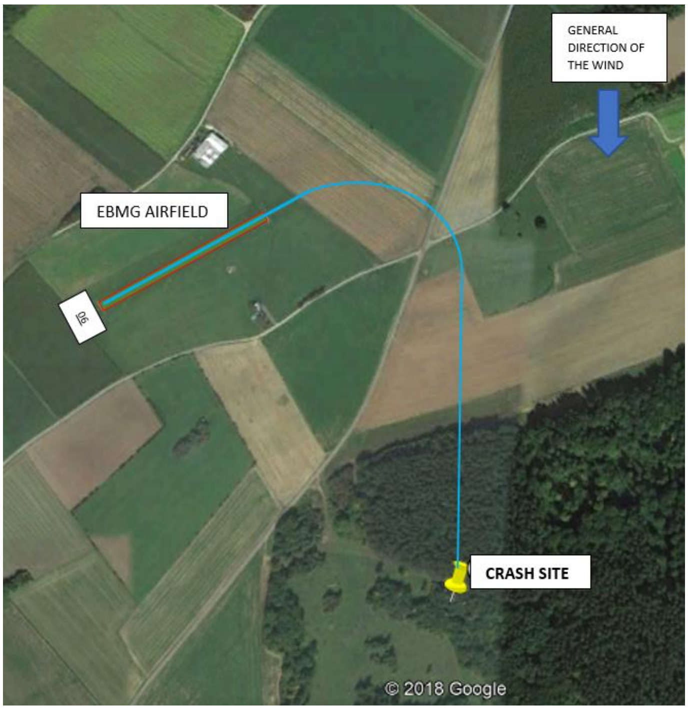



Figure 17: Probable flight path.

## 2.2 Possible causes of the accident

As there was nobody to witness the accident and as there is no substantive evidence of structural failure or engine stoppage, the precise sequence of events and the cause of the accident could not be established with a sufficient degree of certainty.

However, the cause of the accident is likely to be found in one (or a combination) of the following factors:

- Operational:

The downward bending of the mechanical stops of the hub bar and the indications of rotor blades impact with the left horizontal stabilizer and winglet could be evidence of main rotor blade flapping. The investigation could not determine whether the findings are symptoms of a flapping phenomenon during flight, or were resulting from the first contacts of the blades with the top of the trees, just before the final impact.

The element supporting the hypothesis of rotor blade flapping in flight are as follows:

- The location of the crash site is compatible with an altitude where the pilot could have levelled off. This is a phase of the flight known to be prone to rotor blade flapping if the stick is quickly pushed too much forward when levelling off. This manoeuvre will reduce the lift and the load factor causing a reduction of the rotor blade coning. In this case, the rotor blades will flap down and, under the influence of the Coriolis effect, the rotor speed will drop, which is conducive to rotor blade flapping.
- The significant play detected at the ends of the pitch and roll rods located between the stick frame and the control horn makes it difficult to apply small and adequate control inputs for a comfortable and precise way of piloting.
- The gyrocopter flying south was submitted to a tail wind which can be an aggravating factor in case of an inadequate handling of the pitch control (abrupt forward pressure on the stick).

However, the separated left horizontal stabilizer and winglet were found rather close of the main wreckage, which tends to indicate damage resulting from contact with the top of the trees.

- Technical:

Damage to the propeller blades seem to be consistent with the engine not producing power at impact. As not all the blades separated and the separated ones were found very close to the engine, it is suspected that the engine was working at low RPM or was stopped at impact. The blades could have failed either under the deceleration forces generated by the impact or when they were hit by the tail surfaces that also separated from the airframe at impact. As described in chapter 1.12, the contact surface of the propeller hub with its spacer showed evidence of severe fretting. As the propeller spacer didn't show similar fretting damage, it is obvious that the damage originated from a previous incident. The owner performed a limited repair, consisting of the replacement of the spacer, the installation of 6 bushings inside the ovalized holes of the hub, the installation of 3 centering pins in the spacer and the drilling of corresponding blind holes in the hub.
The contact surface of the hub showed a significant and unequal loss of material. This anomaly would prevent an acceptable blade run-out of the installed propeller. In case of an

excessive blade run-out, the correct adjustment of the blades angle can be difficult or even impossible to achieve in practice. This correct adjustment is of paramount importance to avoid mechanical and aerodynamical unbalance. An unbalanced propeller has the potential to cause vibrations that combined with those of the rotor blades could result in more severe vibrations. The gyrocopter manufacturer stated that combination of different sources of vibrations can shake the entire gyrocopter to such an extent that it can affect its controllability with the potential to cause a loss of control.
The significant play found at the ends of the pitch and roll rods located between the stick frame and the control horn could also have been a contributing factor for a possible loss of control of the gyrocopter. The rotor blades could enter into resonance with the vibrations produced by the propeller and result in rotor blade flapping.
The engine could have stopped operating because of the significant shocks and vertical accelerations caused by the vibrations of the rotating parts and/or the rotor blade flapping, moving up and down the fuel contained in the float chamber of the carburettors.

The damage found on the piston rings (compression ring of 2 different pistons and 1 oil scrapper ring of one of them) reduced the performance of the engine, increased the oil temperature and caused an excessive oil consumption. However, as no indication of a piston seizure was found, these conditions did not cause the engine to stop operating. There is probably a link between the great number of alarms recorded by the TCU and the damage found to the piston rings. This damage suggests that the engine suffered from the repetitive over-boost and over temperature events. As stated by the manufacturer, each alarm triggers a warning sign to the pilot (cockpit indication). In this case, appropriate corrective action needs to be taken without delay. The damage found indicate the situation existed for some time.

Given the impact damage to the carburettors, it was impossible to fully exclude the presence of a possible fuel feed anomaly. As for the ignition system, the damage sustained by the entire fuel system did not allow to test it and to positively confirm the absence of anomaly.

The various technical anomalies found reveal that the maintenance of the gyrocopter was not adequately performed. It is therefore not excluded that there were other undetected anomalies that could have caused an engine failure.

- Medical/fitness:

The pilot was 81 years of age and intended to sell his aircraft. The airfield commander and fellow pilots recommended the pilot to avoid flying with a passenger owing to the effect of growing age.
The medical assessment of the physical fitness of the pilot, as required by the Belgian ULM regulation (ULM pilots of 40 years and older are required to pass an aeromedical examination every 24 months), is not applicable for French-registered ULM operated in Belgium.
The verbal request for an autopsy of the deceased pilot from AAIU(BE) was not accepted by the Prosecutor in charge. The investigation could not confirm, nor invalidate the possibility that a medical condition of the pilot would have caused the accident.

# 3 CONCLUSIONS.

## 3.1 Findings

- The gyrocopter had a valid ‘Carte d’identification’ and ‘Fiche d’identification’ delivered by the French aviation authority (DGAC).
- No validation of the French flight authorization had ever been submitted to the Belgian CAA to fly over Belgian territory. Flying in Belgian airspace was therefore illegal.
- The pilot was qualified and licensed by the French aviation authority (DGAC) for piloting ultralight aeroplanes and ultralight gyrocopters above French territory. However there are indications that the license was issued on condition that that the pilot followed a specific training schedule that the instructor prepared for him. This maybe indicates that he should not have been issued a license until further training was satisfactory completed.
- In Belgium, ULM pilots aged 40 and older are required to pass an aeromedical examination every 24 months (every 5 years before the age of 40). By contrast, no similar aeromedical examination is required in France for ultralight pilots.
- The pilot took off from EBMG airfield when the airfield was closed, in the absence of any witness. Nobody witnessed the accident.
- The accident occurred very soon after take-off at about 600 metres from the airfield.
- The inspection of the wreckage revealed several obvious technical anomalies at the airframe as well as at the engine and the propeller. Alarms of the engine Turbo Charger Unit are indications of a possible inappropriate installation or operation of the engine that should have been immediately corrected. All this shows that the maintenance carried out by the pilot was not adequate.
- The propeller hub was found with noticeable surface damage resulting from an earlier problem. The hub was obviously repaired after the event, but the contact surface remained uneven. A significant play was also present in the flight controls. The combination of both anomalies could have generated unwanted vibrations.
- The pilot had never been authorized to operate his gyrocopter from and to EBMG airfield.

## 3.2 Cause

The accident was caused by a loss of control in flight. The direct cause of this loss of control could not be determined. It could have been due to excessive vibrations or the consequence of either insufficient handling following an engine failure or incapacitation of the pilot.

## 3.3 Possible contributing factors

To a loss of control:

- Excessive play in the flight control linkages, resulting in an imprecise roll and pitch control.
- The play in the flight controls could have made possible an amplification of the vibrations generated by the damaged propeller and the rotor blades.
- Poor workmanship in the performance of engine maintenance and inadequate monitoring of the engine performance leading to a possible engine failure

To a medical issue:

- The age of the pilot.
- The absence of a recurrent aeromedical examination.

# 4 SAFETY ACTIONS AND RECOMMENDATIONS.

## 4.1 Safety issue: The absence of a recurrent aeromedical examination for pilots holding an ultralight licence delivered by some foreign aviation authorities.

The Belgian regulation regarding the medical condition of pilots, cabin crew and air traffic controllers (Royal Decree of 12 July 2013) requires that all ultralight pilots pass a class 4 medical examination every 5 years or as from the age of 40, every 2 years.

The purpose of this requirement is to detect a possible risk of incapacitation in flight, along with possible health degradation and any other possible degradation of the pilot performance such as impaired vision or hearing or even cognitive problems, for the benefit of safety.

Due to the absence of European harmonization in the area of ultralight aircraft and ultralight pilot licences, each EU member state has its own rules in this matter and not all EU countries require a recurrent aeromedical examination by aeromedical examiners for ultralight pilots. The absence of a recurrent aeromedical examination is a missed opportunity to detect on time a possible medical issue.

The Belgian domestic rules in this matter apply for citizens holding a Belgian ULM licence. However, currently a pilot holding an ULM Licence issued by a foreign country who regularly flies inside the Belgian airspace does not have to comply with the Belgian regulation regarding the medical condition.

In France, the requirement of a recurrent medical fitness check may be complied with through a self-examination and declaration by the pilot. The correctness of the self-examination and declaration is essentially the responsibility of the pilot him(her)self. This investigation and several others show that this system allows some ULM pilots having a poor medical condition to go undetected.

In Belgium, the overall ULM fleet is made of an important portion of French-registered ULM aircraft being owned and operated by Belgian nationals. The intent of the Belgian regulation to mitigate the “medical” risk of pilots flying in Belgium by recurrent medical examination by aeromedical examiners is therefore not met and may lead some individuals, not conscious of safety implications, to shift from a Belgian to a foreign ULM pilot licence that is more convenient for them. Therefore:

**Safety recommendation BE-2019-0005:**
It is recommended that the Belgian Civil Aviation Authority (BCAA) couples the permission (either temporary or permanent) to fly over Belgian territory to a foreign registered aircraft without a Certificate of Airworthiness i.a.w. ICAO Annex 8 (such as ultralight aircraft) to all license holders who will fly with that aircraft (thus not only the owner) and requires those license holders to have a valid medical certificate that is at least equal to the one required for pilots flying such a Belgian registered aircraft.

Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

AAIU-2018-06-08-01

# 5 Appendices

## 5.1 TCU Alarm Records

=============== ALARM RECORDS (1 Minute Maxima) ===============

| Mode/Time | | Ch. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| I | 99:57 | 5535 | 14 | 1009 | 1500 | 36 | 77 | - | 18 |
| I | 100:04 | 6039 | 13 | 984 | 339 | 50 | 86 | - | 0 |
| I | 100:06 | 6027 | 13 | 981 | 340 | 52 | 87 | - | 0 |
| I | 100:07 | 6050 | 13 | 982 | 590 | 63 | 94 | - | 0 |
| I | 100:17 | 5513 | 14 | 1010 | 1500 | 33 | 79 | - | 10 |
| I | 100:18 | 5493 | 14 | 1010 | 1500 | 32 | 74 | - | 15 |
| I | 100:19 | 5466 | 14 | 1010 | 1500 | 34 | 79 | - | 3 |
| I | 100:23 | 5547 | 14 | 1010 | 1500 | 30 | 76 | - | 6 |
| I | 100:24 | 5425 | 14 | 1010 | 1500 | 30 | 76 | - | 16 |
| O | 100:25 | 5425 | 14 | 1010 | 1500 | 27 | 75 | - | 3 |
| I | 100:27 | 5671 | 16 | 1010 | 1500 | 38 | 79 | - | 6 |
| I | 100:28 | 5740 | 14 | 1010 | 1500 | 43 | 81 | - | 8 |
| I | 100:29 | 5737 | 14 | 1010 | 1500 | 41 | 78 | - | 3 |
| O | 100:29 | 5680 | 14 | 1010 | 1500 | 37 | 80 | - | 3 |
| I | 100:42 | 5541 | 14 | 1010 | 1500 | 51 | 84 | - | 7 |
| I | 101:05 | 5342 | 14 | 1010 | 1500 | 27 | 71 | - | 6 |
| I | 101:06 | 5293 | 14 | 1008 | 1500 | 57 | 88 | - | 13 |
| I | 101:19 | 4752 | 14 | 1012 | 1500 | 20 | 66 | - | 13 |
| I | 101:05 | 5342 | 14 | 1010 | 1500 | 27 | 71 | - | 6 |
| I | 101:06 | 5293 | 14 | 1008 | 1500 | 57 | 88 | - | 13 |
| I | 101:19 | 4752 | 14 | 1012 | 1500 | 20 | 66 | - | 13 |
| I | 101:20 | 4701 | 14 | 1012 | 1500 | 23 | 73 | - | 29 |
| I | 101:21 | 5144 | 14 | 1012 | 1500 | 31 | 76 | - | 12 |
| I | 101:47 | 4833 | 14 | 974 | 1500 | 21 | 70 | - | 20 |
| I | 101:48 | 4834 | 14 | 974 | 1500 | 23 | 72 | - | 5 |
| I | 101:49 | 4796 | 14 | 974 | 1500 | 23 | 72 | - | 13 |
| I | 101:50 | 4884 | 14 | 974 | 1500 | 25 | 74 | - | 18 |
| I | 101:51 | 4710 | 14 | 974 | 1500 | 29 | 75 | - | 13 |
| I | 101:54 | 4879 | 14 | 974 | 1500 | 35 | 79 | - | 8 |
| I | 102:02 | 4820 | 14 | 974 | 1500 | 28 | 75 | - | 20 |
| I | 102:04 | 4824 | 14 | 974 | 1500 | 31 | 79 | - | 7 |
| I | 102:05 | 4870 | 14 | 974 | 1500 | 29 | 77 | - | 4 |
| I | 102:07 | 4885 | 14 | 974 | 1500 | 29 | 77 | - | 8 |
| I | 102:12 | 5017 | 15 | 982 | 1500 | 22 | 72 | - | 6 |
| I | 102:41 | 5210 | 14 | 1007 | 1500 | 25 | 71 | - | 8 |
| I | 102:42 | 5097 | 14 | 1007 | 1500 | 28 | 71 | - | 8 |
| I | 103:37 | 5759 | 13 | 1004 | 374 | 90 | 100 | - | 0 |
| I | 103:38 | 5455 | 13 | 1004 | 473 | 96 | 100 | - | 0 |
| I | 103:39 | 2794 | 13 | 1004 | 574 | 91 | 100 | - | 0 |
| I | 103:44 | 4989 | 13 | 1004 | 525 | 90 | 100 | - | 0 |
| I | 104:24 | 5207 | 13 | 996 | 1500 | 70 | 96 | - | 7 |
| I | 105:09 | 5038 | 14 | 998 | 366 | 90 | 100 | - | 0 |
| I | 105:31 | 5211 | 14 | 1004 | 1500 | 38 | 79 | - | 16 |
| I | 105:52 | 4709 | 19 | 1005 | 1500 | 26 | 76 | - | 13 |
| I | 149:48 | 5922 | 110 | 1003 | 1338 | 42 | 89 | - | 5 |
| I | 154:03 | 5912 | 111 | 1007 | 1387 | 35 | 100 | - | 14 |
| I | 154:04 | 5924 | 111 | 999 | 1383 | 38 | 89 | - | 4 |
| I | 155:21 | 5913 | 110 | 1006 | 1379 | 40 | 89 | - | 15 |
| I | 170:09 | 5916 | 111 | 996 | 1387 | 41 | 100 | - | 16 |
| I | 170:20 | 5941 | 111 | 995 | 1392 | 46 | 94 | - | 28 |
| I | 170:24 | 5923 | 93 | 979 | 1176 | 46 | 76 | - | 0 |
| I | 170:29 | 5929 | 110 | 995 | 1379 | 52 | 94 | - | 26 |
| I | 171:31 | 5917 | 110 | 992 | 1389 | 37 | 90 | - | 16 |
| I | 171:34 | 5940 | 110 | 992 | 1392 | 39 | 90 | - | 25 |
| I | 172:01 | 5915 | 110 | 967 | 1340 | 44 | 92 | - | 10 |
| I | 172:17 | 5955 | 110 | 967 | 1360 | 46 | 92 | - | 20 |
| I | 172:29 | 5931 | 110 | 965 | 1321 | 43 | 90 | - | 11 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| I | 172:35 | 5936 | 110 | 963 | 1338 | 54 | 91 | – | 34 |
| I | 172:38 | 5951 | 110 | 966 | 1402 | 49 | 100 | – | 15 |
| I | 172:39 | 5953 | 110 | 965 | 1359 | 53 | 103 | – | 9 |
| I | 172:40 | 5923 | 102 | 966 | 1233 | 45 | 102 | – | 0 |
| I | 172:44 | 5922 | 110 | 965 | 1344 | 51 | 91 | – | 20 |
| I | 172:59 | 5925 | 110 | 966 | 1355 | 48 | 92 | – | 20 |
| I | 173:22 | 5912 | 111 | 982 | 1391 | 44 | 100 | – | 10 |
| I | 174:41 | 5913 | 110 | 981 | 1350 | 45 | 91 | – | 3 |
| I | 174:42 | 5912 | 110 | 989 | 1339 | 43 | 102 | – | 8 |
| I | 175:05 | 5946 | 111 | 976 | 1383 | 52 | 96 | – | 24 |
| I | 175:13 | 5948 | 95 | 937 | 1187 | 56 | 83 | – | 0 |
| I | 175:14 | 5906 | 95 | 928 | 1184 | 56 | 82 | – | 0 |
| I | 175:52 | 5919 | 110 | 989 | 1361 | 36 | 104 | – | 7 |
| I | 175:53 | 5919 | 111 | 992 | 1394 | 41 | 103 | – | 13 |
| I | 176:11 | 5929 | 110 | 992 | 1389 | 45 | 93 | – | 26 |
| I | 176:12 | 5921 | 110 | 979 | 1376 | 47 | 90 | – | 5 |
| I | 176:41 | 5928 | 111 | 978 | 1391 | 51 | 93 | – | 13 |
| I | 177:43 | 5905 | 110 | 983 | 1375 | 56 | 100 | – | 25 |
| I | 177:45 | 5911 | 110 | 983 | 1407 | 59 | 102 | – | 16 |
| I | 177:47 | 5935 | 111 | 983 | 1408 | 63 | 103 | – | 25 |
| I | 177:56 | 5918 | 110 | 983 | 1420 | 63 | 104 | – | 21 |
| I | 178:03 | 5912 | 110 | 982 | 1352 | 51 | 92 | – | 14 |
| I | 178:03 | 5912 | 110 | 982 | 1352 | 51 | 92 | – | 14 |
| I | 178:04 | 5910 | 111 | 983 | 1409 | 58 | 104 | – | 17 |
| I | 178:06 | 5906 | 111 | 983 | 1403 | 54 | 104 | – | 11 |
| I | 178:09 | 5917 | 111 | 983 | 1415 | 59 | 104 | – | 16 |
| I | 178:21 | 5922 | 111 | 982 | 1394 | 48 | 96 | – | 17 |
| I | 178:26 | 5916 | 110 | 983 | 1399 | 55 | 100 | – | 20 |
| I | 178:27 | 5929 | 110 | 977 | 1387 | 59 | 94 | – | 17 |
| I | 179:41 | 5931 | 110 | 990 | 1380 | 51 | 93 | – | 6 |
| I | 179:52 | 5917 | 110 | 1000 | 1391 | 45 | 100 | – | 11 |
| I | 180:40 | 5909 | 111 | 989 | 1389 | 42 | 100 | – | 15 |
| I | 180:50 | 5910 | 110 | 989 | 1352 | 54 | 102 | – | 25 |
| I | 180:51 | 5912 | 111 | 989 | 1426 | 58 | 105 | – | 25 |
| I | 180:52 | 5929 | 109 | 978 | 1327 | 59 | 97 | – | 2 |
| I | 180:54 | 5971 | 110 | 989 | 1355 | 55 | 102 | – | 39 |
| I | 180:55 | 5965 | 110 | 988 | 1337 | 56 | 105 | – | 16 |
| I | 180:56 | 5910 | 109 | 989 | 1320 | 54 | 101 | – | 25 |
| I | 181:03 | 5917 | 81 | 984 | 1130 | 52 | 101 | – | 0 |
| I | 181:19 | 5920 | 111 | 990 | 1389 | 49 | 94 | – | 4 |
| I | 182:29 | 5947 | 110 | 990 | 1396 | 60 | 96 | – | 16 |
| I | 182:30 | 5912 | 86 | 986 | 1151 | 60 | 80 | – | 0 |
| I | 183:11 | 5908 | 110 | 989 | 1345 | 68 | 94 | – | 32 |
| I | 183:22 | 5926 | 86 | 974 | 1159 | 60 | 80 | – | 0 |
| I | 183:24 | 5932 | 109 | 969 | 1262 | 67 | 89 | – | 0 |
| I | 183:52 | 5913 | 110 | 995 | 1383 | 49 | 94 | – | 13 |
| I | 184:04 | 5908 | 111 | 995 | 1436 | 69 | 99 | – | 47 |
| Mode/Time | Ch. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

END

### 5.2 TCU Last 20 minutes of operating time records

| Mode/Time | | Ch. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| I | 185:07 | 2347 | 8 | 990 | 983 | 36 | 100 | – | 0 |
| I | 185:08 | 3913 | 29 | 990 | 999 | 35 | 101 | – | 0 |
| I | 185:09 | 1603 | 1 | 990 | 977 | 34 | 100 | – | 0 |
| I | 185:10 | 1602 | 1 | 990 | 976 | 35 | 100 | – | 0 |
| I | 185:11 | 1597 | 1 | 990 | 976 | 35 | 100 | – | 0 |
| O | 185:11 | 2792 | 13 | 990 | 976 | 20 | 104 | – | 0 |
| I | 185:12 | 3277 | 28 | 990 | 981 | 21 | 102 | – | 0 |
| I | 185:13 | 1931 | 3 | 990 | 975 | 22 | 100 | – | 0 |
| O | 185:13 | 1931 | 3 | 990 | 975 | 22 | 100 | – | 0 |
| I | 185:14 | 3091 | 14 | 990 | 977 | 23 | 104 | – | 0 |
| I | 185:15 | 3845 | 29 | 990 | 981 | 23 | 103 | – | 0 |
| I | 185:16 | 1088 | 0 | 990 | 975 | 25 | 100 | – | 0 |
| I | 185:17 | 1375 | 1 | 990 | 976 | 26 | 100 | – | 0 |
| O | 185:18 | 2330 | 5 | 990 | 976 | 26 | 100 | – | 0 |
| I | 185:19 | 3115 | 18 | 990 | 980 | 27 | 102 | – | 0 |
| I | 185:20 | 5470 | 111 | 990 | 1316 | 36 | 100 | – | 3 |
| I | 185:21 | 5725 | 111 | 989 | 1395 | 60 | 104 | – | 42 |
| I | 185:22 | 3089 | 10 | 990 | 988 | 54 | 100 | – | 0 |
| I | 185:23 | 3492 | 32 | 990 | 990 | 43 | 101 | – | 0 |
| I | 185:24 | 5717 | 111 | 990 | 1398 | 68 | 96 | – | 44 |

### 5.3 TCU Lifetime Data

======================== LIFETIME DATA ==========================

| Channel | [Unit] | Maximum | Oper.time | Alerts | Alerttime |
|---|---|---|---|---|---|
| SPEED | [rpm ] | 6050 | 100:07 | 111 | 0:10:51 |
| AIRBOX_PRESS. | [mbar] | 1580 | 56:54 | 342 | 0:51:29 |
| AIRBOX_TEMP. | [°C ] | 96 | 77:56 | 104 | 1:54:00 |
| BOOST | [%/h ] | 77.2 | 74:42 | xxxxxx | xxxxxxxxx |
| BOOSTTIME | [h:mm]: | 13:03 | (= 7.0% of Op.hours) | | |

Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

AAIU-2018-06-08-01

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