Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

Air Accident Investigation Unit (Belgium)
City Atrium
Rue du Progrès 56
1210 Brussels

Safety Investigation Report

ACCIDENT
B&F TECHNIK, MODEL FK12 COMET
AT AVERNAS
ON 18 OCTOBER 2015

Ref.:
AAIU-2015-AII-12

Issue date:
05 January 2017

Status:
Final

TABLE OF CONTENTS

FOREWORD

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

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 the EU 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). The report was compiled by Henri Metillon and was published under the authority of the Chief Investigator L. Blendeman.

Note:

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

SYMBOLS AND ABBREVIATIONS

’	Minute
°C	Degrees centigrade
AAIU(Be)	Air Accident Investigation Unit (Belgium)
BCAA	Belgian Civil Aviation Authority
CAVOK	Ceiling and Visibility OK
E	East
EBAV	Avernas ultralight airfield
FH	Flight hour(s)
F-NI	Fire/smoke (non-impact)
LH	Left hand
m	Metre(s)
MSN	Manufacture’s serial Number
MTOW	Maximum Take-off Weight
N	North
O/H	Overhaul
PIC	Pilot in Command
PFM	Pilot’s Flight Manual
PPL	Private Pilot Licence
QNH	Pressure setting to indicate elevation above mean sea level
RH	Right hand
RPM	Revolutions per Minute
RWY	Runway
SEP	Single Engine Piston rating
SN	Serial Number
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 organisation 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, organisation 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.

SYNOPSIS

Date and time:	18 October 2015 at 11:05 UTC
Aircraft:	B&F Technik, model FK12 Comet, SN: 057
Accident location:	In a field near EBAV airfield, Avernas-le-Bauduin, Belgium 50°42'23"N, 5°03'54"E
Aircraft owner:	The pilot was the owner
Type of flight:	Local
Phase of flight:	Cruise
Persons on board:	One, the owner
Injuries:	One fatal

Abstract:
The aeroplane took off for a second flight of the day from EBAV airfield at 10:50. A few minutes later, the aeroplane was seen on fire and returning to the airfield by witnesses. The aeroplane flew over the airfield and crashed in a neighbouring field, 250m from the airfield's hangars. The aeroplane flipped over upon impact and the wreckage burned completely. The pilot died in the wreckage.

Occurrence type: F-NI: Fire/smoke (non-impact)

Cause(s):
The cause of the accident is an uncontained in-flight fire in the engine compartment that the pilot was unable to extinguish.
The root cause of the fire could not be determined with certainty.
However, two scenarios were considered plausible:

- The fire could have originated from a failed exhaust pipe, sending hot gases into the engine compartment.
- Based on the analysis of the recent maintenance operations, the fire may have originated from a fuel leak at the fuel line connection of RH carburettor, recently removed and reinstalled.

Contributing safety factors:

- Maintenance performed without the support of qualified personnel and/or not verified by a qualified person.
- Old weld repair of the exhaust performed by a non-professional person, increasing the risk of subsequent exhaust cracks.
- Installation of heat resistant tape around the exhaust pipes preventing quick detection of damage, unless it is regularly removed for inspection.
- No regular actuation and/or test of the fuel shut off valve, causing a possible stuck fuel shut off valve to remain undetected.
- No specific emergency procedure available in the flight manual for in-flight engine fire and no check list available covering amongst others the possible emergency situations.

1 Factual Information

1.1 History of the flight

The pilot, owner of the FK12 Comet ULM aeroplane, arrived at the EBAV airfield on Sunday 18 October 2015 at around 07.00. He prepared his aeroplane for flight. The aeroplane took off for a first flight on that day at 08:45 for a 50 minute local flight. Witnesses spoke with the pilot after this flight, and heard no comment regarding the aeroplane's condition.

The aeroplane took off for a second flight at 10:50. The aeroplane was seen returning to the airfield at 11:04 by witnesses who reported that it was on fire at the front side of the fuselage or at the engine compartment. Another witness also stated that he saw the aeroplane coming back to the airfield with the left landing gear wheel on fire. One witness stated that the engine made an abnormal noise. No particular comment was made about the emission of smoke (colour, type and appearance, etc.).

The aeroplane flew over the airfield, turned to the left and suddenly pitched down and crashed in a neighbouring field 200m from the airfield's barracks.

Airfield personnel rushed to the rescue of the aeroplane with fire extinguishers. During the firefighting operation, a sudden additional flame arose from the fire and delivered a noise similar to fireworks.

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
None	0	0	0	0
Total	1	0	0	1

1.3. Damage to aircraft.

The aircraft was totally destroyed.

1.4. Other damage.

There was some minor impact damage to the surface of the cultivated field. The ground was contaminated by some fuel and engine oil and above all fire residues.

1.5. Personnel information.

Pilot:

Sex:	Male
Age:	63 years old
Nationality:	Belgian
License:	Ultralight Aircraft Flight Authorization issued in Belgium, first on 8 October 1985, last on 23 March 2014. The Flight Authorization was valid until 25 March 2016.

Medical certificate:	Class 4 medical certificate valid until 14 April 2016.
Experience:	Wide experience flying ultralight aircraft. Total experience was around 1000 FH. Average flight hours during the last 5 years: 45 FH/Year. On type: around 280 FH.

1.6. Aircraft information.

Airframe:

- Manufacturer: B&F Technik
- Type: FK12 Comet
- Serial number: 57
- Built year: 2003
- Registration: Belgian registered
- Certificate of registration: N°6605 issued by BCAA on 10 September 2008.
- Permit to fly: ARCA ref N-1999-604 issued by BCAA on 17 Sept 2008.
- Type authorization: 2003-85 Issue 1 – 16/06/2003
- Aeroplane total time: Unknown.

Engine:

- Manufacturer: BRP - Rotax
- Type: 912 UL 80 hp
- Total flight hours: Unknown
- Serial number: 440 63 68

Aeroplane history

In 2003, the major components of the aeroplane were delivered to the first owner, a French citizen, likely as part of a fast-build kit. The first owner handled the assembly of the aeroplane, installed a 100 HP Rotax 912 ULS engine and flew with the aeroplane up to 2008.

In 2008, the aeroplane was sold to the pilot involved in the accident. It was flown to Belgium where significant maintenance was performed to the propulsion system. Amongst others, the original 100 HP engine was replaced by a new Rotax 912 UL engine, in a type delivering 80 HP.

Engine exhaust

Reportedly, the exhaust system was not part of the original kit causing the first owner to manufacture a specific exhaust system.

The second owner decided to replace the original “home-made” exhaust assembly by a new one. As the exhaust was not available in a ready-to-use version, it was delivered as a kit by B&F. The different components were adjusted to the engine by the owner helped by friends and were thereafter welded by a qualified welder.

Fuel system

The aeroplane was equipped with a 58 litres fuel tank (2 litres unusable) located inside of the fuselage below the front instrument panel.

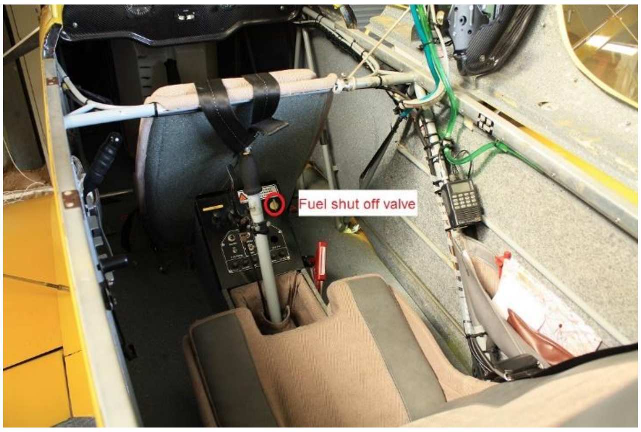

Figure 1: view of the shut off valve control knob

It was also equipped with a fuel shut off valve accessible to the pilot sitting on the aft seat, which is the seat that must be occupied when flying solo.

Reportedly, this shut off valve was always left in the open position. It was never closed after the flight, which is not obligated by the flight manual, and was practically never changed position to test its operation or tightness.

Options
An optional emergency parachute (Ballistic Recovery System/ BRS-5) was installed in the accident aeroplane.

Flight Manual
The aeroplane was provided with an Aeroplane Manual however it could not be retrieved.

For the purpose of the investigation, the Aeroplane Manual for FK 12 S2 Comet, available at the manufacturer recommended “FK service center” web site was used.

The flight manual chapter 3.11 “Emergency procedures – Stall recovery” clearly prohibits some aerobatic manoeuvres that could cause carburettor fuel leaks and possible engine fire.

Stalls (especially with power on), spins and all maneuvers with zero or negative g-load must be avoided under all circumstances, these maneuvers may cause a fire, especially when using ROTAX engines with carburetors.

Figure 2: extract of the flight manual regarding possible carburettors fuel leak

Check list
No indication was found showing the existence of a check list that the pilot used as a quick and easy information source instead of the flight manual for the pre-flight inspection, the different phases of the flight and in case of emergency.

General:

The B&F FK12 Comet is a single-engine ultralight biplane designed in Germany and manufactured by "FK Lightplanes". The FK12 first flew in 1999 and is approved in Germany as ultralight according BfU 95[1].

The aeroplane is equipped with single bay (one interplane strut each side) wings of equal span, significant stagger and swept at about 14°. The two seats are in tandem. It can be flown from either seats, the pilot in command occupies the aft seat. Vertical and horizontal tail surfaces are trapezoidal, with a swept fin. The Comet has a metal tube fuselage structure, using steel at the front and aluminium further aft.

A conventional undercarriage with spring cantilever legs is mounted on the lower fuselage longerons. It is covered with a mixture of composites and fibreglass laminates. The Comet is powered by different versions of Rotax horizontally-opposed four cylinder engines.

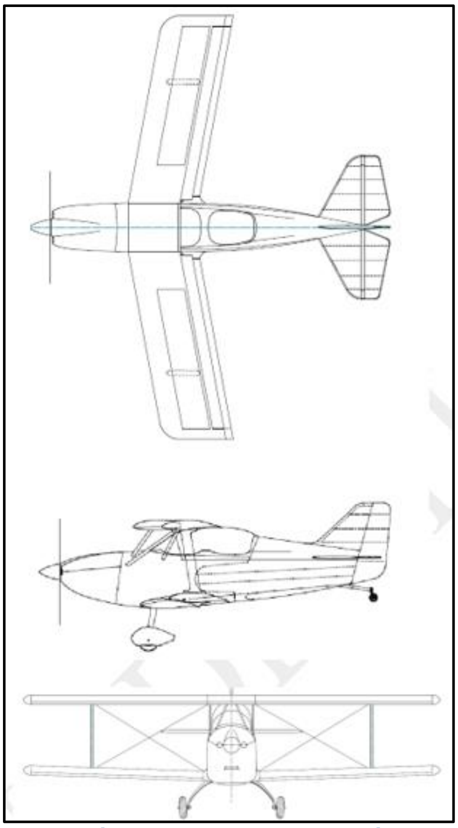

Figure 3: FK12 Comet 3-view

1.7. Meteorological conditions.

There are no meteorological observations made at the airfield itself. The meteorological observations around the time of the crash made in EBLG were:

- Wind direction variable between 320° and 050° and wind speed between 1kts and 4kts
- Few clouds at 250ft and broken at 4200ft.
- Visibility: more than 10km
- Temperature: 9°C and dew point: 5°C.
- QNH: 1019hPa.

1.8. Aids to navigation.

The aeroplane was not equipped with a GPS when the accident occurred. The owner sometimes used a portable GPS when he intended to perform a navigation flight.
As the aeroplane was not equipped with a transponder, the only available radar recording corresponding to the FK12 originates from the primary radars of Belgocontrol. The 69 second radar image shows the aeroplane flying west of the airfield in a counter clockwise turn conducted at an undetermined height. The last recorded flight direction and position at 11:05:18 does not match with the direction of the impact, suggesting that the radar image does not show the last part of the flight. Another possibility could be that the radar image shows another aeroplane.

[1] BfU 95 is the technical standard applicable to ultralight aeroplanes in Germany

Communication.

No radio communication reported and recorded during the flight.

1.9. Aerodrome information.

The EBAV Avernas ULM airfield is located 1.5 km north northwest of Avernas-le-Bauduin. The geographical coordinates of the airfield are N 50' 42' 24'' – E 5° 04' 05''.

The use of the airfield is subject to prior permission from the operator (PPR), the ultralight flying club "Aéro Club de Hesbaye".

The airfield features two bi-directional grass runways arranged in line and separated from each other by a small perpendicular country road. The runways are oriented 50° / 230° (RWY: 05/23). The runway located north of the airfield was temporarily closed and was used as a taxiway to join the southern runway after crossing the country road.

Northern runway (temporarily closed) dimensions: 235 x 30m.
Southern runway dimensions: 260 X 30m.
Elevation: 394 feet.
Take-off and landing pattern: LH when taking-off and landing on the runway 05. A RH circuit is prescribed for take-off and landing on runway 23.

When the accident occurred the runway 05 was in use.

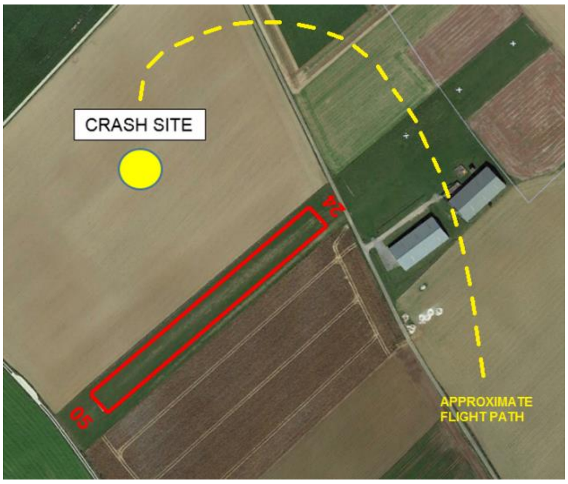

Figure 4: Approximate flight path and the crash site position.

1.10. Flight recorders.

No flight recorder was installed, nor was it required.

1.11. Wreckage and impact information.

<u>On the crash site examination</u>
The aircraft crashed on a cultivated field, to the west of the EBAV airfield.

The impact and the wreckage distribution show that the aeroplane was heading south when it impacted the ground. The first impact area was located at 3 m from the final resting place. The wreckage was lying upside down, almost completely consumed except the metallic parts and other small parts scattered some distance from the fire.

Small debris originating from the engine cowling and the canopy were distributed up to 48 meters in front of the main wreckage with respect to the impact direction. Pieces of transparent plastic found on the ground, out of reach of the smoke produced by the post impact fire, showed smoke deposit on both internal and external sides.

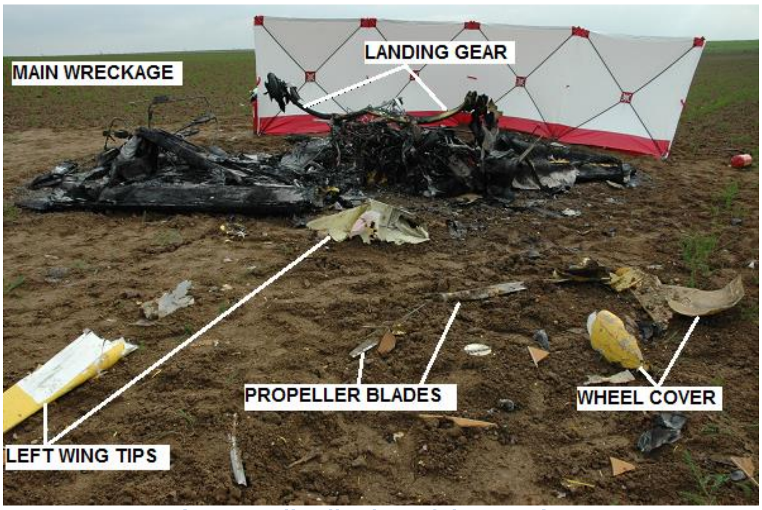

Figure 5: distribution of the wreckage

Further examination of the engine compartment

Exhaust system

The wreckage was carefully examined paying particular attention to the engine compartment. The exhaust system was removed, reconstructed and the different components were identified based on the cylinder numbering by the engine manufacturer. (Cylinder 1: right fwd. Cylinder 2: left fwd. Cylinder 3: right rear. Cylinder 4: left rear).

Figure 6: pipe wrapped with a heat resistant tape

The exhaust pipes were surrounded by a thermal protection which consisted in a special heat resistant tape coiled around the pipes.
Some part of the protection suffered obvious mechanical damage during the ground collision and some lengths of the pipes were found unprotected.
It could not be determined if the protection was present on the whole length and in good condition before the crash.

Each cylinder had its own exhaust tube system, made of 2 pipes slid into each other by a ball and cone connection allowing a small relative rotation between them. All cylinder individual pipe assemblies were routed to and ended in a common exhaust muffler.

The following particularities were found:

- Cylinder 1: minor deformation
- Cylinder 2: pipe torn open near the cylinder head fixture
- Cylinder 3: Straight pipe recently repaired and found in good condition. The bent pipe is deformed at the ball and cone connection and 2 big holes are observed in the middle of the curve.
- Cylinder 4: The straight pipe, equivalent to these recently repaired at the cylinder 3, is deformed and separated into three parts.

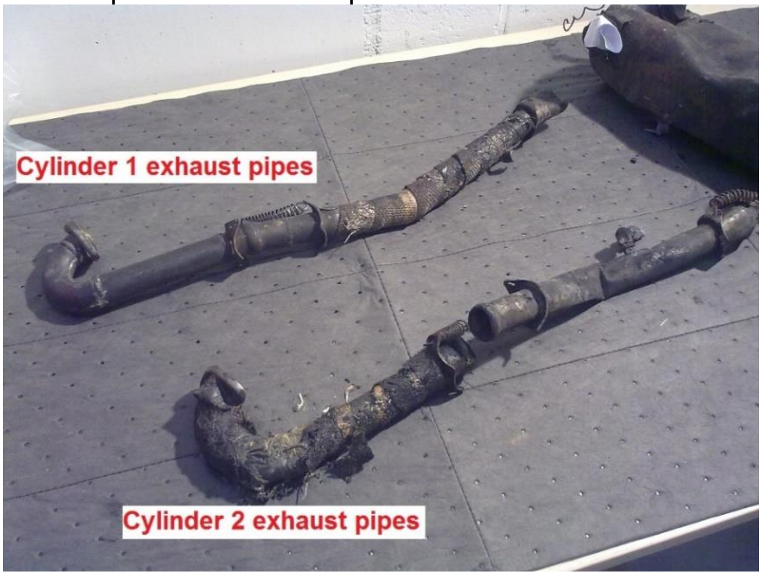

Figure 7: cylinder N°1 and N°2 exhaust pipes

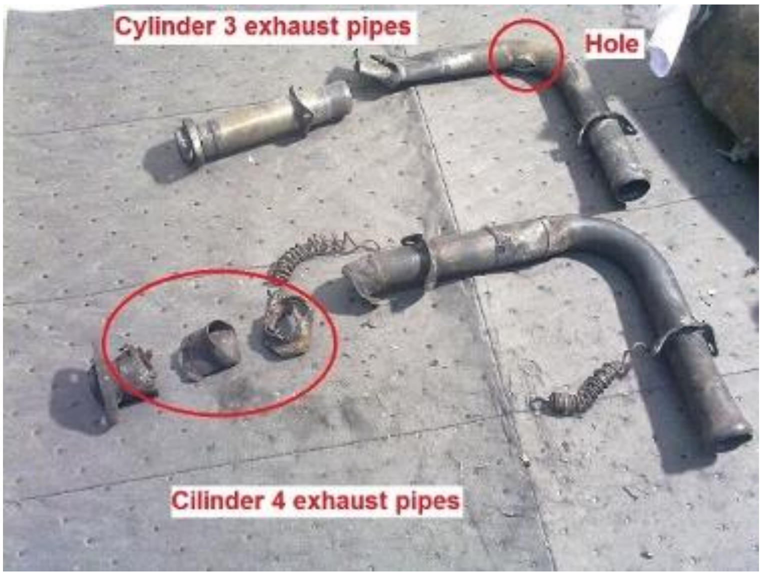

Figure 8: cylinder N°3 and N°4 exhaust pipes

Figure 9: cylinder N°3 recently repaired straight pipe

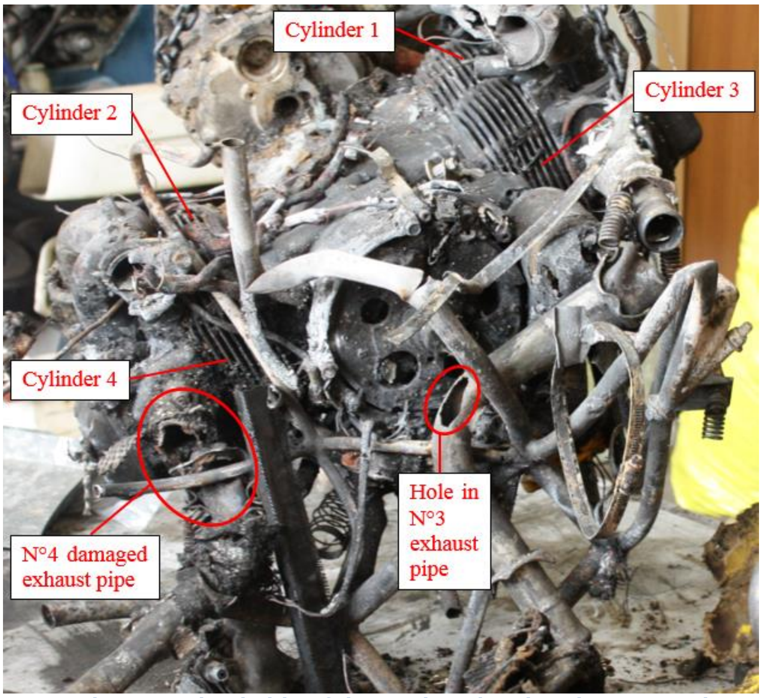

Figure 10: backside of the engine showing damage to the rear exhaust pipes


Figure 11: detail of holes in the N°3 exhaust pipe

Fuel system

The fuel system suffered extensive fire damage, going so far that most fuel rubber lines had completely disappeared and carburettors and intake pipes were partially molten.

Reconstruction of engine cowlings

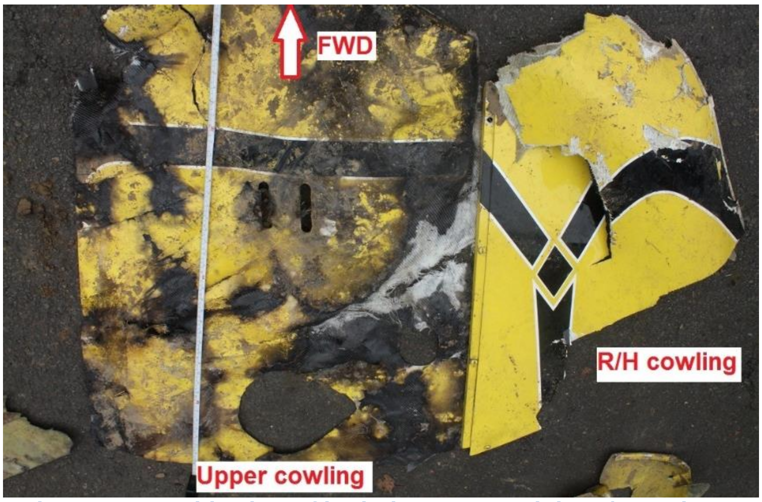

Figure 12: outside view of both the upper and the R/H engine cowlings

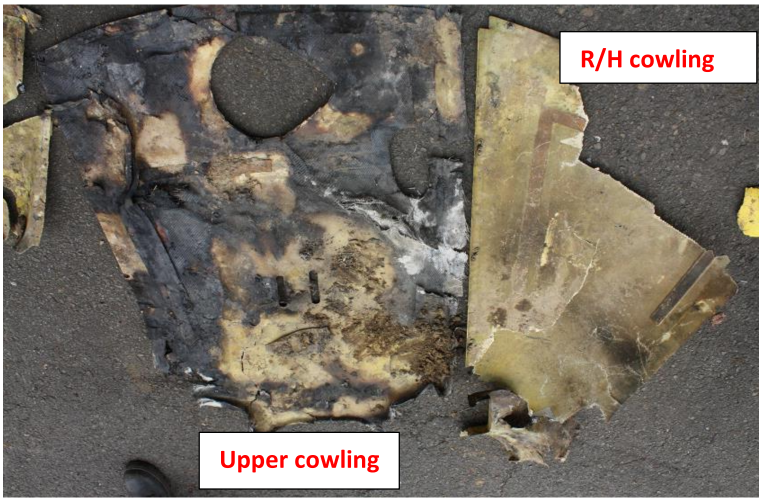

Figure 13: inside view of both the upper and the R/H engine cowlings


Figure 14: air intake of the water cooler located below the lower engine cowling

The upper and the right side engine cowlings had been retrieved as well as the lower part of the ducting used to route the ram air through the water cooler.

When looking for shaped traces of smoke/fire, no obvious sign of in-flight fire inside and outside these cowlings was found. All burning signs found indicated a stationary fire.

The lower and the left side cowling disappeared in the fire.

1.12. Medical and pathological information.

No autopsy or blood sampling was performed.

1.13. Fire.

Fire was extensive, and started during flight.

1.14. Survival aspects.

Notwithstanding the pilot wore the safety belts and shoulder harnesses, the impact and subsequent fire were considered not survivable.

1.15. Tests and research.

The perforations in the N°3 bent exhaust pipe had been analysed by the laboratory of the Royal Military Academy (“Department of Civil & Materials Engineering”) in order to determine the cause of the perforations and to possibly establish a relationship between the exhaust pipe damage and the post-crash firing of the BRS rocket trapped in the wreckage.

1.16. Additional information

Another fellow pilot who regularly flew with the aeroplane stated that the pilot of the accident flight told him that he only used the electrical fuel pump during take-off.
Nevertheless, the fellow pilot noticed several times that the electrical fuel pump switch had been left in the ON position after the last flight.
He concluded that by distraction, the pilot regularly flew with the electrical fuel pump operating from the beginning up to the end of the flight.
Note: the flight manual instructs using the electrical fuel pump only during take-off and landing and in case of engine failure.

2 Analysis

2.1 In-flight fire

Some pieces of transparent plastic coming from the canopy showed smoke contaminations on both internal and external surfaces.
The smoke residues on external surfaces of the canopy show that the canopy was surrounded by smoke in flight. As the smoke flow could only have been directed rearward by the airspeed there is no doubt about the fact that the fire originated from a place forward of the canopy, namely from the engine compartment. The contamination on the inside of the canopy plastic demonstrates that smoke entered inside the fuselage in flight likely through the ventilating system and/or through the non-air tight fire wall and/or even maybe through holes caused by the fire in the front fabric of the fuselage.

The in-flight fire could have resulted from four possible origins: an electrical short circuit, a fuel leak, an oil leak or an exhaust pipe failure.

The wreckage was extensively damaged to such an extent that most evidence had disappeared. The carburettors and the aluminium intake pipes were partially molten as well as the fuel tank. The other fuel system components were also damaged to such an extent that their pre fire condition could not be determined. The electrical wires and components were also found so fire damaged that no information could be drawn.

<u>Engine oil leak</u>
A fire caused by an engine oil leak could be disregarded because no oil trace was found on the remains of the engine cowling and no heavy blue smoke had been reported by witnesses.

<u>Electrical short circuit</u>
No indication was found showing that an anomaly could have occurred in the electrical circuit. Although impossible to be excluded, the hypothesis of an electrical fire had been considered as being unlikely.

<u>Fuel leak in the engine compartment</u>
A fuel leak at the carburettors is adequately identified in the flight manual as a possible cause of fuel leak when performing zero or negative G-load manoeuvres.

According to fellow pilots, the accident pilot was never seen or never reported performing intentional zero or negative G-load manoeuvres. Therefore, it can be concluded that a leak at the carburettors, caused by zero or negative G-load, may be discarded.

For many years, the owner performed the maintenance of his aeroplane with the support of an experienced friend. In fact, he was not sufficiently qualified to perform alone all maintenance tasks. They performed together every autumn a deep and careful maintenance of the aeroplane. Amongst others, every second year all fuel lines and the associated clamps were systematically renewed. However, the support of his friend stopped 3 or 4 years before the accident resulting in less thorough maintenance and periodic replacement of the fuel lines was no longer done. Over the years, the risk of fuel leakage increased with the effects of ageing on components in addition to less thorough inspections.

An in-flight fuel leak in the engine compartment theoretically can only occur downstream of the mechanical fuel pump i.e. between the pump and the carburettors. It can also occur anywhere in the engine compartment when the electrical fuel pump is operating, typically during take-off.

Normally, the pilot had only to activate the electrical fuel pump during the engine checks and during take-off. However, reportedly, he forgot from time to time to switch off this pump after take-off, meaning that a fuel leak at any fuel line submitted to the pressure of the electrical fuel pump cannot be excluded at any stage of the flight.

Another hypothesis could be that the feeding line of the right side carburettor, that had been removed and replaced a short time before the accident to facilitate the repair of N°3 cylinder straight exhaust pipe, had not been properly refitted or was damaged, causing pressurized fuel to escape partially from the hose and to vaporize close to the exhaust pipe.

An engine exhaust failure

Two weeks before the accident, the owner removed N°3 cylinder straight exhaust pipe (right rear cylinder) for repair. He asked assistance from a professional welder to overhaul this exhaust pipe. Based on the interview with the welder, the damaged pipe was separated into several pieces and the material was in such bad condition that a local repair was not possible. Therefore, they cut the damaged section and welded a new one onto the ends that were still in good condition. The spring support was also reused and welded onto the new section of the pipe. This exhaust pipe was recovered in the wreckage, showing that the repair had been properly performed and it did not suffer much from the accident.

Reconstruction of the remains of the N°4 straight exhaust pipe (showing a design which is similar to the above mentioned pipe N°3) showed it was separated into 3 parts at the springs support plate. Although a part of this pipe suffered deformation due to the accident, close examination of the ruptures determined that the exhaust pipe was already in very bad condition before the accident. The ruptured areas showed multiple old poor weld repairs and material degradation precisely at the place where the pipe separated into 3 parts. Close examination of these remains concluded that it was possibly already separated before the aeroplane hit the ground.

Therefore, it is possible that hot exhaust gases escaping from the separated exhaust pipe had set the left carburettor feeding line or the left side engine cowling on fire. Taking into account that the fuel pump capacity is significantly higher than the fuel consumption, it is not excluded that although the presence of a leak at the feeding line, the carburettor fuel supply remained sufficient to operate the engine.

Figure 15: remains of the cylinder N°4 straight exhaust pipe

The hypothesis of an exhaust system failure is also supported by a witness statement saying that he heard the engine emitting an abnormal noise when flying back to the airfield. Another witness also stated that he saw the aeroplane coming back to the airfield with the left landing gear wheel on fire which, from the place where the witness was located, could have been confused with a fire located at the left engine cowling or at left front fuselage side. Additionally, the left engine cowling entirely disappeared in the fire while the other cowlings, recovered in the wreckage, are significantly less damaged and show only static fire damage, without airflow oriented smoke traces.

2.2 Flight manual emergency procedures in case of fire and smoke

Chapter 3 of the Flight Manual “Emergency Procedures” had been reviewed about the procedure to be applied in case of fire and/or smoke. The Flight Manual states the following:

3.9. Engine / Carburetor Fire

fuel selector……….. ……………………………………………………….OFF
throttle……………………………………………………………………...full open
if required:
starter………………………………………………………………………engage

3.10. Fire and Smoke (Elecric)

all electrical systems ………………………………………………………OFF
landing…………as soon as possible, if required perform emergency landing
rescue system ……………activation only, if immediate landing not possible

Figure 16: extract of the flight manual

The instructions found in the flight manual in case of Engine/Carburettor Fire (& 3.9.) seem to be applicable in case of engine/carburettor fire when the aeroplane is on the ground, in other words when starting the engine. This is a deduction from the fact that this instruction states that the starter must be engaged “If required”, i.e. when the fire arises during an attempt at engine starting and the engine had failed to start.

There is no explicit instruction covering the case of an in-flight engine fire as:

- What to do when the electrical fuel pump is operating.
- What to do with the cabin heating and ventilation system.
- What about the use of the rescue system?

2.3 Post-accident firing of the BRS rocket trapped in the wreckage

At the beginning of the investigation, it was suspected that the perforations found in the curve of N°3 bent exhaust pipe could have been the cause of the inflight fire.

However, another assumption was that the pipe had been perforated after the impact by the firing of the BRS rocket, trapped in the wreckage and located close to the tube. According to witness accounts, the rocket could have been fired by the extremely high temperature of the post-accident fire.

In order to establish the facts, the pipe and the remains of the rocket had been inspected by a laboratory of the Royal Military Academy ("Department of Civil & Materials Engineering").

The investigation of the laboratory determined that the perforation clearly shows proof of fusion caused by an external heat source. The laboratory stated that the observed element (contaminants) on the perforation surfaces can be probably linked to the heat source that caused the melting of the tube. Comparison of the contaminants on the exhaust tube with the residue from the burned rocket shows the presence of similar elements (magnesium, silicon, aluminium and phosphor).

In summary, it is very likely that the perforations found on this exhaust tube were caused by a flame coming out the BRS rocket.

2.4 Forced landing

Witnesses stated that the engine was still running when the pilot flew back to the airfield, indicating that the engine fuel supply was still effective. Therefore, there is no doubt that the shut off valve was still in the open position.

There are three possible explanations why the shut off valve wasn't closed. Either it was a deliberate decision, or the pilot simply didn't think about it, or it was technically impossible.

A possible explanation for the pilot's decision to not shut off the fuel valve could be that he first heard that something was going wrong with the exhaust and decided to fly back to the airfield. At that moment, the aeroplane was maybe not yet on fire, or the fire was not yet visible, meaning that from the pilot's point of view there was no absolute priority to shut off the fuel and perform an emergency off field landing. In this hypothesis, it is only when flying close to the airfield that the pilot realised that the aeroplane was on fire, leading him to opt for a power on emergency landing at the airfield.

Another possibility could be that the pilot didn't succeed to stop the fire because the fuel shut off valve was stuck. The possibility of a frozen fuel shut off valve is an established risk because the pilot almost never handled this valve, causing it after a while to possibly become very hard to move by hand. When realizing he was not able to activate the valve, the pilot could have thought that he had more chance to be rescued after an emergency landing at the airfield.

3 Conclusions.

3.1 Findings

- The pilot was duly qualified and licenced for piloting ultralight aeroplanes. He had a wide experience flying ultralight aeroplanes, including on the accident aeroplane that was his property since September 2008.
- The aeroplane was in an airworthy condition which means properly type accepted, registered and covered by a valid permit to fly.
- The weather conditions were acceptable for a local flight implying good visibility and light wind.
- This day, the aeroplane first performed an uneventful local flight. After this flight, the pilot did not mention any problem.
- The aeroplane caught on fire in flight during the second flight of the day. The pilot tried to fly back to the airfield, in the vicinity of which the accident occurred.
- The airframe was totally destroyed by the violence of the impact and by the extensive post impact fire.
- No specific guidance in the flight manual was found about the procedure to be applied in case of in-flight engine fire.
- Examination of the remains of the exhaust system found that most pipes were wrapped in a heat resistant tape which the installation was not original and/or not approved by the aeroplane designer/manufacturer.
- Two weeks before the accident, the cylinder N°3 exhaust pipe had been removed, properly repaired by a qualified welder and reinstalled by the owner. Removal of the right side carburettor and its associated fuel line was necessary to gain access to this exhaust pipe.
- The N°4 cylinder exhaust pipe was determined to be in very bad condition before the crash, to the extent that the possibility exists that it failed in flight.
- The poor condition of the N°4 exhaust and the lack of extensive maintenance entry in the aeroplane log book tends to show that the quality of the maintenance was insufficient.

3.2 Causes.

The cause of the accident is an uncontained in-flight fire in the engine compartment that the pilot was unable to extinguish.
The root cause of the fire could not be determined with certainty. However, two scenarios were considered plausible:

- The fire could have originated from a failed exhaust pipe, sending hot gases into the engine compartment.
- Based on the analysis of the recent maintenance operations, the fire may have originated from a fuel leak at the fuel line connection of RH carburettor, recently removed and reinstalled.

Contributing safety factors:
Starting from the above hypothesis about the root cause of the accident and the few findings made during the examination of the wreckage, the following possible contributing factors have been identified:

- Maintenance performed without the support of qualified personnel and/or not verified by a qualified person.
- Old faulty workmanship on the exhaust weld repair (N°4 exhaust pipe), increasing the risk of subsequent exhaust cracks.
- Installation of heat resistant tape around the exhaust pipes preventing an adequate visual inspection (unless it is regularly removed for inspection) resulting in non-detection of damage.
- No regular actuation and/or test of the fuel shut off valve, causing a possible stuck fuel shut off valve to remain undetected.
- No specific emergency procedure available in the flight manual for in-flight engine fire and no check list available covering amongst others the possible emergency situations.

4 Safety actions and recommendations.

4.1 Safety issue: Inadequate modification and/or inappropriate maintenance of the exhaust system.

Some ultralight owner and ultralight maintenance organization have altered the exhaust system by wrapping heat resistant tape around the exhaust pipes. The purpose of this modification would be to minimise the heat radiation and conduction inside the engine compartment in order to reduce the risk of fuel vapour lock in the fuel system and heat damage to the engine cowlings.
However, the main disadvantage of this modification is to increase the risk of overheating of the exhaust pipe, causing possible premature heat deformation and cracks. This can also increase the risk of corrosion damage if the heat resistant tape retains some moisture. Additionally, the wrapping prevents the pipes being visually inspected. However, these disadvantages can be mitigated by regular removal of the tape and thorough inspection of the entire exhaust system. Therefore:

Recommendation BE-2017-0001:
It is recommended that the Belgian Ultralight Federation provides some warnings about the wrapping of the exhaust pipe with heat resistant tape, in particular if it is not originally installed and/or recommended by the aeroplane manufacturer.

4.2 Safety issue: Possible undetected stuck or internally leaking fuel shut off valve

During the investigation it was found that the fuel shut off valve of ultralight aeroplanes is rarely actuated and tested, unless the shut off valve is combined with a fuel tank selector valve. The lack of regular test has the potential for an undetected stuck fuel shut off valve situation to develop and also the potential for keeping in service an undetected internally leaking valve. Both types of deficiencies could make it impossible to interrupt an impending engine fire caused by a fuel leak in the engine compartment. Therefore:

Recommendation BE-2017-0002: It is recommended that the Belgian Ultralight Federation promotes regular actuation and test of the fuel shut off valve.

4.3 Safety issue: No specific emergency procedure in the flight manual in case of in-flight engine fire.

The instructions found in the flight manual in case of Engine/Carburettor Fire (& 3.9.) seem to be essentially applicable in case of engine/carburettor fire i.e. for an aeroplane standing on the ground. There is no explicit instruction covering the case of an in-flight engine fire as:

- What to do when the electrical fuel pump is operating.
- What to do with the cabin heating and ventilation system.
- What about the use of the rescue system in case of in-flight fire?

Therefore:

Recommendation BE-2017-0003: It is recommended that the aeroplane manufacturer improves chapter 3 of the Flight Manual “Emergency Procedures” in order to incorporate clear and complete information about the procedure to be applied in case of in-flight engine fire.

About this report

As per Annex 13 and EU regulation EU 996/2010, each safety investigation shall be concluded with a report in a form appropriate to the type and seriousness of the accident and serious incident. For this occurrence, a limited-scope, fact-gathering investigation and analysis was conducted in order to produce a short summary report.

It is not the purpose of the Air Accident Investigation Unit to apportion blame or liability. The sole objective of the investigation and the reports produced is the determination of the causes, and, where appropriate define recommendations in order to prevent future accidents and incidents.

AAIU-2015-AII-12

Air Accident Investigation Unit - (Belgium)
City Atrium
Rue du Progrès 56
1210 Brussels

Phone: +32 2 277 44 33
Fax: +32 2 277 42 60

air-acc-investigation@mobilit.fgov.be
www.mobilit.belgium.be