Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

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Safety Investigation Report

ACCIDENT SIKORSKY 269C AT EBCF AIRFIELD ON 13 JUNE 2014

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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 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) with the support of the NTSB and Sikorsky Aircraft Corp.

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)
AccRep	Accredited Representative of a State Investigation Unit
AGL	Above Ground Level
AMSL	Above Mean Sea Level
APR	Approach
ARC	Airworthiness Review Certificate
ATC	Air Traffic Control
ATPL	Airline Transport Pilot Licence
BCAA	Belgian Civil Aviation Authority
CAMO	Continuing Airworthiness Management Organisation
CAVOK	Ceiling and Visibility OK
CG	Centre of Gravity
CPL	Commercial Pilot Licence
CPL(H)	Commercial Pilot Licence helicopter
E	East
EASA	European Aviation Safety Agency
EBCF	Cerfontaine airfield
EU	European Union
FAA	Federal Aviation Administration (USA)
FE(H)	Flight examiner helicopter
FH	Flight hour(s)
FI(H)	Flight instructor helicopter
FOCA	Federal Office of Civil Aviation (Switzerland)
FSTD	Flight Synthetic Training Device
ft	Foot (Feet)
GA	General Aviation
Gal	US gallon (+/- 3,8 litres)
GPS	Global Positioning System
HMI	Basic Handbook of Maintenance Instructions
HT	High tension
IPC	Illustrated Parts Catalog
kt	Knot(s)
lbs	Pounds
LH	Left hand
LOC-I	Loss of Control In-flight
m	Metre(s)
Hz	Hertz
MSN	Manufacture’s serial Number
MTOW	Maximum Take-off Weight
N	North
NTSB	National Transportation Safety Board (US)
O/H	Overhaul
PIC	Pilot in Command
PFM	Pilot’s Flight Manual
PPL	Private Pilot Licence
PPL(H)	Private Pilot Licence helicopter
QNH	Pressure setting to indicate elevation above mean sea level

RH	Right hand
RPM	Revolutions per Minute
RWY	Runway
SAIB	Swiss Accident Investigation Board
SEP	Single Engine Piston rating
SN	Serial Number
TRI(H)	Type rating instructor helicopter
TRE(H)	Type rating examiner helicopter
US CARs	Civil Aviation Regulations (former US legal requirements preceding the current Title 14 of the Code of Federal Regulations – aka FARs)
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 of 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 disseminate 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.

Federal Public Service
Mobility and Transport
Air Accident Investigation Unit

AAIU-2014-11

SYNOPSIS

Date and time:	13 June 2014 at 15:00 UTC
Aircraft:	Sikorsky S-300C/ 269C[1]
Accident location:	Aerodrome of Cerfontaine (ICAO:EBCF)
Aircraft owner:	Private
Type of flight:	General Aviation - Proficiency Check
Phase of flight:	Approach (APR) – Final
Persons on board:	2
Injuries:	1 fatal, 1 seriously injured

Abstract:

The purpose of the flight was to perform the annual proficiency check of the pilot. The helicopter took off from the EBCF airfield with the pilot and an examiner on board. The proficiency check started with the performance of 2 circuits. At the end of the second circuit, when flying in short final of runway 30R, the helicopter was seen falling vertically from a height of 10-15m. The helicopter hit the ground with a high vertical speed and was destroyed. The examiner succumbed to his injuries a few minutes later. The pilot was seriously injured.

Occurrence type:
Inadequate engine power management followed by a loss of control-inflight (LOC-I)

Cause(s):
The probable cause of the accident is an inadequate engine power management by the pilot when flying in the final leg, that neither the pilot (the examinee) nor the examiner detected in time, leading to an unrecoverable low rotor RPM situation.

After the pilot handed over the controls to the examiner, the engine stopped during the attempt to recover. This was probably caused by a rapid roll on of the throttle, combined with a high torque demand.

Contributing safety factors:

- The pilot's total and recent experience flying helicopters was low.
- The examiner's recent experience flying this helicopter type was very low.
- The examiner's reduced hearing capabilities and the use of an active noise cancelling headset likely resulted in difficulty hearing a low rotor RPM situation early on.
- The spark plug failure, which likely increased engine tendency to stop when at low RPM, the throttle was rapidly rolled on.

[1] Since the initial type certification the type certificate holder changed repeatedly and so did the trade name of the aircraft model. In this report we will use the names that are stated in both the FAA and EASA type certificates; namely 269 and 269C for respectively the type and model name. For the type rating on the EASA license, the endorsement HU 269 will be used.

Other safety factors identified during the investigation:

- Undetectable wear of the tail rotor cable
- Inconsistent medical examination
- Vagueness about who is responsible for updating the Aircraft Flight Manual (AFM)

1 Factual information.

1.1 History of flight.

Accident flight

The pilot needed to renew the type rating on his helicopter private pilot license (PPL(H)). He made an appointment with an examiner and planned a flight with the 269C helicopter on 13 June 2014, for the performance of the annual proficiency check. The proficiency check started with 2 circuits[2] followed by other exercises.

The pilot stated the examiner helped him actively to perform the pre-flight inspection. Amongst others, the examiner checked the fuel quantity and found that the fuel available was between 16 and 17 Gal. He determined it was sufficient to perform the intended 30 to 40 minute flight.

The pilot sat on the left seat while the examiner took place on the right side. The pilot started the engine and performed the engine check with the support of the examiner, including the magneto check.

The helicopter took off from EBCF at 14:52 UTC, performed a hover taxi to the runway 30R, took off and made a first circuit, ending by a landing on the same runway 30R. Upon completion of the second circuit, the helicopter came in short final for a normal landing on runway 30R.

The pilot stated that everything was normal during the entire flight except at the end of the second circuit when he saw, at an approximate height of 50 m, that the final approach slope was too flat. He tried to correct the slope by pulling the collective. According to his recollection, he neither monitored the engine/rotor RPM nor adjusted the throttle position. When flying approximately at 30 m height, it became evident to him that something was wrong. The engine was running roughly and heavy chocks were felt in the helicopter structure.

At that moment the pilot handed over controls to the examiner. This is the last action the pilot could recall having performed when he was interviewed.

Witnesses standing on the terrace of the airfield located about 450 m from the crash site stated they saw the helicopter in final, at a height of 10-15 m, when suddenly rotating clockwise around its vertical axis and falling almost vertically to the ground

Flight the day before

The day before the accident, the pilot flew 30 minutes (3 circuits at EBCF airfield) with the owner of the helicopter acting as a safety pilot. The owner stated he had to ask 3 times the pilot to adjust the engine RPM/throttle during the flight, the first time after the take-off and 2 times in final. In fact, the safety pilot adjusted the throttle himself 2 times out of the 3, not awaiting the pilot’s action. The owner also stated he had the impression that the pilot was not comfortable with the use of the throttle as he sometimes hesitated about the direction of rotation of the grip (clockwise or counter clockwise) to increase or to decrease power.

[2] Circuit: The specified path to be flown by aircraft operating in the vicinity of an aerodrome.

<u>Engine check</u>
The engine mixture check to be performed at the end of the last flight of each day was never performed. This check should have been performed in accordance with the last edition of the Pilot's Operating Handbook 4-15 *Pilot's check of idle mixture, idle speed, and fuel boost pump.*

1.2 Injuries to persons.

Injuries	Crew	Passenger	Others	Total
Fatal	1	0	0	1
Serious	1	0	0	1
Minor	0	0	0	0
None	0	0	0	0
Total	2	0	0	2

1.3 Damage to aircraft.

The helicopter was totally destroyed but did not catch fire.

1.4 Other damage.

Minor damage to the grass surface.

1.5 Personnel information.

Pilot:

Sex:	Male
Age:	68 years old
Nationality:	Belgian
Licenses:	For aeroplanes: Holder of a Private Pilot License (Aeroplane) (PPL(A)), first issued in 1982, last issued in 2014 by BCAA. Rating: SEP(Land). For helicopters: Holder of a Private Pilot License (Helicopter) (PPL(H)), first issued in 2002, last issued in 2013 by BCAA, valid until June 2014. Rating: HU 269. Medical certificate: class 2 valid up to 28 June 2015
Experience:	Helicopter total flight experience: about 100 FH (on 269C only). Helicopter last 12 months flight experience: 9:34 FH. Last 3 months flight experience: 0:42 FH (on the day before the accident).

Examiner:

Sex:	Male
Age:	69 years old
Nationality:	Belgian
Licenses:	Holder of a Commercial Pilot License for helicopter (CPL(H)), first issued in 1999, last issued in 2013 by BCAA.

Helicopter ratings: EC120B, AS350/EC130, AS355, HU 269, R22 and R44. The last proficiency check on the 269C helicopter was passed on 27 March 2014 (Rating valid up to 31 March 2015).
Other ratings: Night. Instructor rating; FI(H), TRI(H). Examiner rating: FE(H), TRE(H).
Medical certificate: Class 1 (CPL/ATPL) valid up to 18 July 2014. Last medical examination performed on 15 January 2014.

Experience: Former military pilot. Extensive flight experience (helicopter and aeroplane), the pilot totalized more than 17000 FH. Total helicopter experience over 15000 FH. More than 3500 FH experience on 269C and more than 3600 FH as helicopter flight instructor.
Reportedly, the pilot flew regularly Robinson 44 helicopter and turbine engine helicopters.
Based on the documents and information available, the examiner flew less on 269C helicopter. In the last 2 years. He performed:

- 2 instruction flights on 1 June 2012
- 1 flight as examiner on 1 June 2012
- 1 flight for his own proficiency check on 27 April 2013
- 1 flight as examiner on 12 January 2014
- 1 flight for his own proficiency check on 27 April 2014

Finally, the only flights during which he actually flew the 269C helicopter in the last 2 years was during his own proficiency check.

1.6 Aircraft information.

Airframe:

- Manufacturer: Schweizer Aircraft Corporation at the time of mfg. Sikorsky Aircraft Corporation since 2004.
- Type: 269
- Model: 269C
- Serial number: S 1749
- Built year: 1997
- Certificate of registration: N° 5296, delivered by the Belgian CAA
- Certificate of airworthiness: Delivered by BCAA on 19 May 2008
- Airworthiness Review Certificate: Form 15a delivered by BCAA on 3 August 2012. Extended for one year by the CAMO on 30 July 2013. Valid up to 23 July 2014
- Helicopter total time: 1606:8 FH

Engine:

- Manufacturer: Lycoming Engines
- Type: HIO-360-D1A
- Serial number: RL-30801-51A
- Last engine overhaul: 25 June 2010 (Total time: 1999:5)
- Total time: 2302:4 (306:9 since overhaul)

Helicopter general information:

The Model 269 was initially designed as a low-cost, lightweight two-seat helicopter by Hughes Helicopters in 1955. It was created with a fully articulated, counter-clockwise rotating, three-bladed main rotor, and a two-bladed teetering[3] tail rotor that would remain as distinctive characteristics of all its variants. The flight controls are directly linked to the control surfaces of the helicopter.
In 1964, Hughes introduced a slightly-larger three-seat Model 269B which was marketed as the Hughes 300. This was followed in 1969 by the Model 269C (also known under the trade name Hughes 300C). This new model introduced the more powerful 190 hp (140 kW) Lycoming HIO-360-D1A engine and increased diameter rotor.
In 1983, Schweizer Aircraft Corporation obtained the licensing rights and changed the trade name of the aircraft into Schweizer 300C (or Model 269C). In 2004, Schweizer Aircraft Corporation was purchased by Sikorsky Aircraft Corporation and in 2009, the helicopter model was rebranded as the Sikorsky S-300C. Sikorsky Aircraft Corporation is the current type certificate holder for the 269C. The certification basis is US CAR (former US aviation regulations) Part 6, dated 15 January 1951.

A central tubular steel open frame forms the load-carrying structure for the helicopter. The cabin is formed of two cabin doors, a floor section and a wide visibility windshield.
The right-hand flight controls are removable and two different configurations of the cockpit are available:

- Two seat configuration with the optional right-hand flight controls installed facilitates the helicopter to accommodate two crew members (student and instructor).
- Three side-by-side seat configuration, with the pilot's position on the far left side of the cabin. In this configuration, the optional right-hand controls are not installed.

The landing gear features two non-retractable horizontal skids fixed by hydraulic shock mounts on the helicopter structure.
The tail boom assembly extends rearwards from its attachment to the centre frame section. It is a monocoque structure of aluminium and houses the tail rotor drive shaft and tail rotor control rod. At the aft end, it supports the tail rotor gearbox and tail rotor, in addition to the horizontal and vertical stabilizers.

The engine is a Lycoming four-cylinder, horizontally opposed, air-cooled engine with fuel injection. The engine is mounted horizontally on shock mounts within the centre frame section. The engine control system consists of a throttle control, fuel shut off control, and mixture control.
Rotation of the throttle grip located on the collective pitch stick(s) is transferred through the throttle control tube inside the collective pitch stick(s) and moves the throttle bellcrank and interconnecting linkage to change the engine servo power setting. Additionally, the linkage (also called correlator) automatically increases engine power with an increase in collective pitch and decreases engine power with a decrease in pitch, thus maintaining relatively constant rotor RPM.

[3] Teetering rotor: An arrangement in which one pair of rotor blades are joined at the hub, which is free to move in a flapping sense, with the common flapping hinge line lying on the rotor axis. Also called a *seesaw rotor*.

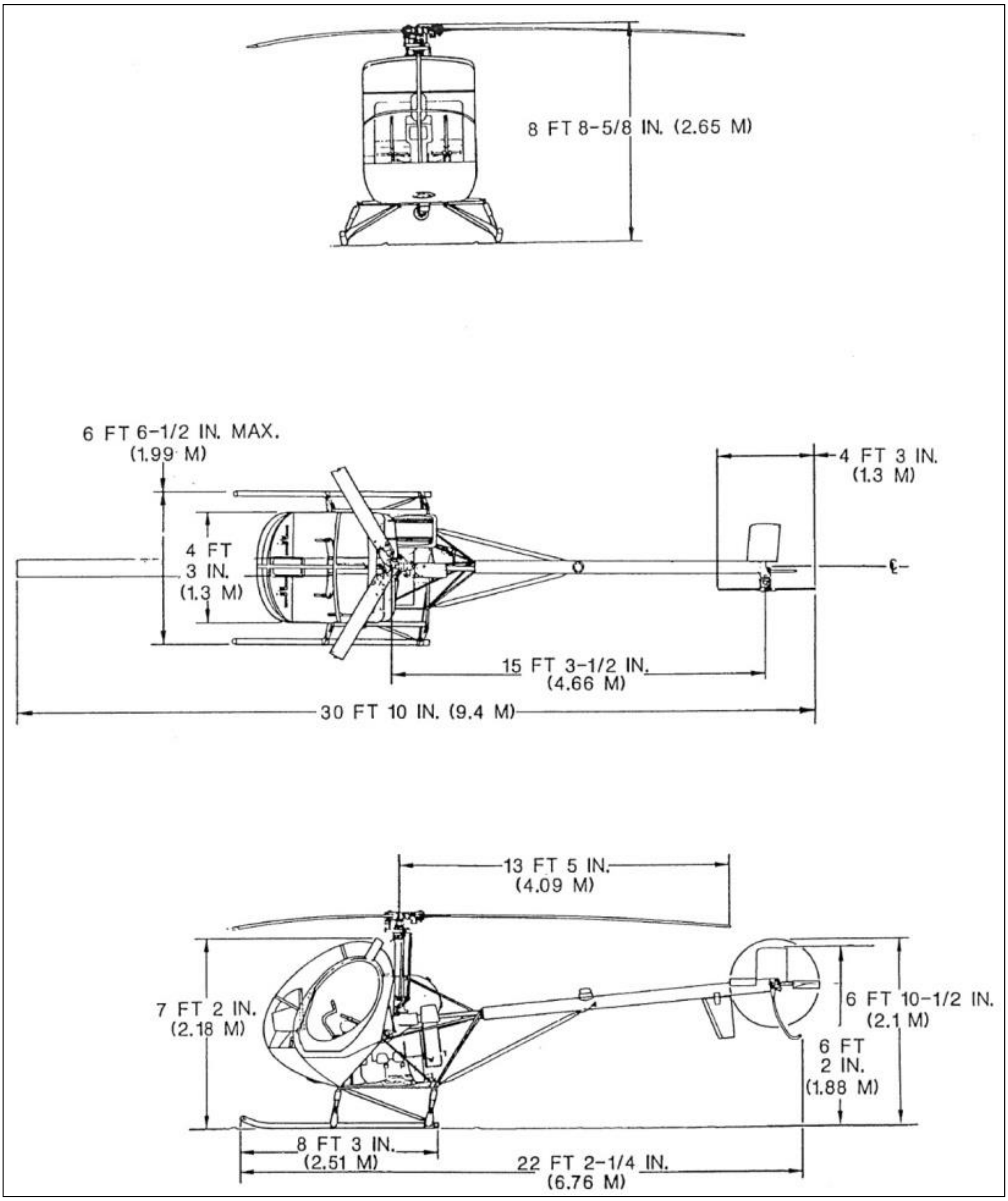


Figure 1: 3-view of the 269C

Pilot's Flight Manual (PFM)

The PFM found in the helicopter was the publication N° CSP-C-1 reissued #1 on 21 September 1988 by Schweizer Aircraft Corp. This PFM incorporates revisions up to the revision dated 20 April 2010 corresponding to the revision 18 of the reissue #2.

At the time of the accident, the current version of the PFM, was the publication N° CSP-C-1, reissued #2 by Sikorsky Aircraft Corp. on 07 Dec 2012. This reissue #2 incorporates all previous revisions, up to revision N°20 dated 28 June 2011.

The revisions N° 19, 20 and the last improvements contained in the reissue #2 were thus not incorporated in the PFM[4] found in the helicopter.

Date	Event	Action
20/04/2010	Last update found in the helicopter PFM (revision is dated – no revision number)	
05/07/2010	CAMO states they update the PFM	No revision reference and/or date mentioned. The more likely it is the revision dated 20/04/2010
27/10/2010	PFM revision 19 released by Sikorsky	Not incorporated in PFM
28/06/2011	PFM revision 20 released by Sikorsky	Not incorporated in PFM
03/08/2012	Airworthiness review performed by BCAA in order to issue of a new ARC	PFM revision dated 20 April 2010 considered by BCAA as being up-to-date
07/12/2012	PFM issue #2 released by Sikorsky	Not obtained by owner
30/07/2013	ARC extension by the CAMO	PFM not verified

Figure 2: Summary of last PFM revisions

Maintenance

The helicopter was regularly maintained by an EASA Part 145 approved maintenance organization. This same organization was also duly approved as a Continuing Airworthiness Management Organisation (CAMO) and as such was in charge of both the maintenance and the airworthiness management of the helicopter.

The management of the continuing airworthiness was performed following an agreement between the CAMO and the owner and in accordance with a BCAA approved maintenance program.

The last maintenance was performed on 9 April 2014 at 1603:06 FH (helicopters total time), corresponding to 303:12 FH engine time since the last overhaul. This maintenance, for the engine, consisted of the oil/oil filter change according to SB 480E and the verification of SB

[4] A copy of the last page of the summary of revisions of both POH is enclosed at the end of this report.

608, SB 606 and SB 613. At the same time, an unscheduled repair was performed on the cyclic trim.

A *Basic Handbook of Maintenance Instructions* (HMI) is published by the manufacturer to support the maintenance organizations performing the maintenance of this helicopter type. Appendix B of this HMI covers amongst others the *Periodic Inspections, Overhaul and Retirement Schedule*.

The maintenance schedule is available in the HMI appendix B. The following text is provided in the 100-hours inspection schedule to inspect the tail control cable and bellcrank.

6. Tail rotor control cables 269A7315-() for fraying, chaffing, broken strands and corrosion; control bellcrank 269A7325 for corrosion and cable wear in groove.

Figure 3: Extract of HMI 100-hour inspection.

Engine history

The engine was overhauled by its manufacturer Lycoming Engines in June 2010 and was installed on the helicopter on 10 August 2010. On 28 August 2012, when totalizing 245h since the overhaul, the engine was removed from service due to the presence of metal particles in the oil. The engine was sent to an engine workshop for investigation and repair. After repair, it was reinstalled on 30 November 2012. From the time of the engine reinstallation to the date of the accident 4 engine oil/oil filter changes, including one during a periodical 100hrs inspection, were performed in accordance with Lycoming SB 480E. No new oil contamination was detected. On 13 December 2013, at 293:54 engine time since overhaul, the exhaust valve clearance was measured in accordance with SB 388C and found to be within the limits. A few other Service Bulletins and airworthiness directives were verified and found to be complied with or determined as not being applicable.

Fuel available

The helicopter was refueled with 100 litres of 100LL at EBCF on 11 June 2014.

1.7 Meteorological conditions.

Temperature: 26,3° C, Wind variable between 360° and 050°; 5-8 kt with peaks at 10 kt, Visibility +10 km and QNH: 1022 hPa.

1.8 Aids to navigation.

Not applicable

1.9 Communication.

As stated by the airfield supervisor, three normal radio transmissions were emitted by the helicopter during the 8 minutes that the flight lasted. No anomaly message was transmitted by the pilot.

The examiner wore a Bose A20 Aviation headset, engineered to provide an active noise cancellation. This part is recognized and approved by EASA under the approval number EASA.IM.21O.10046405, REV. A. This means that the part complies with a minimum performance standard which is ETSO (European Technical Standard Order) C139 in this case.

Sound is a pressure wave, which consists of alternating periods of compression and rarefaction. An active noise-cancellation headset picks up the environmental sound and emits a sound wave through the speakers with the same amplitude but with inverted phase (also known as antiphase) created by the internal circuitry to the original sound. The waves combine to form a new wave, in a process called interference, and effectively (more or less) cancel each other out.

This type of sound cancelling works well on monotonous continuous sounds, such as motor noise, air duct noise, etc. It does not work well on sounds that continuously change in frequency and amplitude, such as human voice (conversation) and even music (especially the more dynamic variety).

The use of an active noise cancelling headset requires also an acclimatization period to adjust the noise perception of each helicopter type. The following warning is incorporated in the headset handbook:

> **Safety Warnings:**
>
> • **Be aware of sound differences while wearing the headset.**
> With the headset's active and passive noise reduction, typical aircraft sounds (such as from engines, propellers, and stall or gear up warnings) will not sound familiar on your first few flights. Such important sounds may be quieter than you are used to. You are responsible for making sure that you can hear, notice and recognize these sounds when using the headset while operating any aircraft.

Figure 4: Warning from the headset manual

1.10 Aerodrome information.

The airfield of Cerfontaine EBCF is located N 50°09'10" – E 004°23'14", at 2,7 km south of the city of Cerfontaine (Belgium - Province of Namur). The operator is EBCF S.A. and the use of the airfield is subject to prior permission from the operator. The aerodrome is provided with basic radio information called 'Cerfontaine Radio' on the frequency 125.875 MHz (Information only, no ATC).

The elevation is 955 ft (291 m) and it is equipped with two parallel 30 m wide grass runways oriented 117° / 297°. The circuits are left hand for runways 30 and right hand for runways 12, at a height of 945 ft AGL for motorized aircraft and 645 ft AGL for gliders. The runways 12L/30R (798 long) are recommended for motorized aircraft and runways 12R/30L (675 long) are recommended for gliders.

Runway 30R was in use when the accident occurred (Runways 12R/30L not available due to recent rehabilitation of the soil surface).

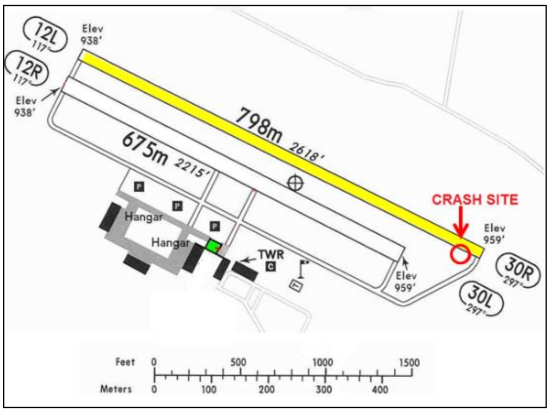


Figure 5: layout of the aerodrome

Figure 6: aerial view showing both runways and the crash area

1.11 Flight recorders.

The helicopter was not equipped with a flight recorder, nor was it a requirement.

A Garmin 150 GPS was installed in the dashboard and a portable Garmin GPSMAP 296 was found on board. These GPSs could not be used for the purpose of the investigation. According to the helicopter owner, the Garmin 150 GPS, which is an old model, wasn't used anymore. The GPSMAP 296 was sometimes used but its battery was unserviceable, requiring an electrical feed by the helicopter through an external wiring. No trace of an external wiring connection was found in the wreckage.
Additionally, an annual proficiency check is not a type of flight during which a GPS is normally used.

1.12 Wreckage and impact information.

Preliminary findings

The impact zone was located in the grass area on the left side edge of the threshold runway 30R.

The first witnesses arriving on the crash site found the right side of the cabin in contact with the ground with the nose of the helicopter pointing approximately opposite the flight direction. They lifted the cabin to facilitate access to the victims in such a way that when the AAIU(Be) investigators arrived at the crash site, the front side of the cabin was directed upwards and the right hand fuel tank was in contact with the ground.

Figure 7: front side pointing upwards

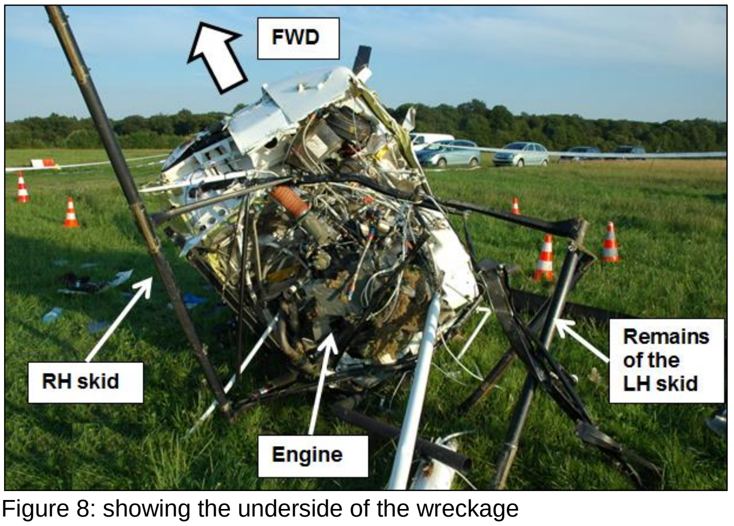


Figure 8: showing the underside of the wreckage

The first impact traces were originating from the skids. The cabin was located about 13,5 m further, with the tail boom beyond it with respect to the flight direction. The wreckage parts were scattered along an axis (yellow dotted line) pointing about 25° left to the axis of the runway.
There were more separated parts lying on the left side of this imaginary line than on the right side.

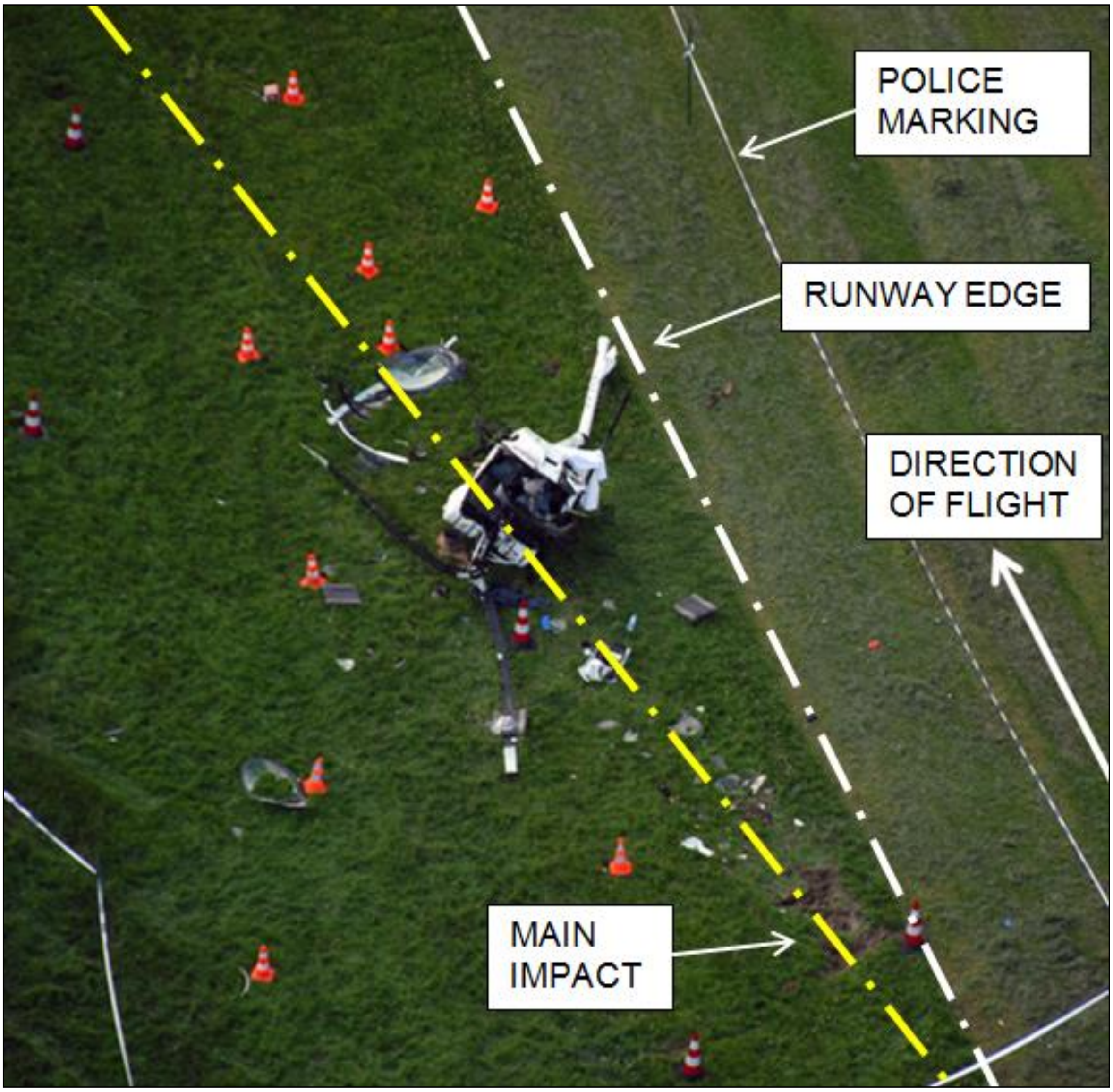


Figure 9: Top view showing the approximate path of impact (yellow dotted line)

The main wreckage damage was essentially located on the lower side of the structure, including the lower side of the engine.
The left landing skid was totally destroyed including significant damage to the supporting structure. By contrast, the right hand skid was almost intact. In a general way, the impact damage was more extensive on the left side.

The control cable of the tail rotor was found broken at the forward bellcrank located under the flight compartment floor.

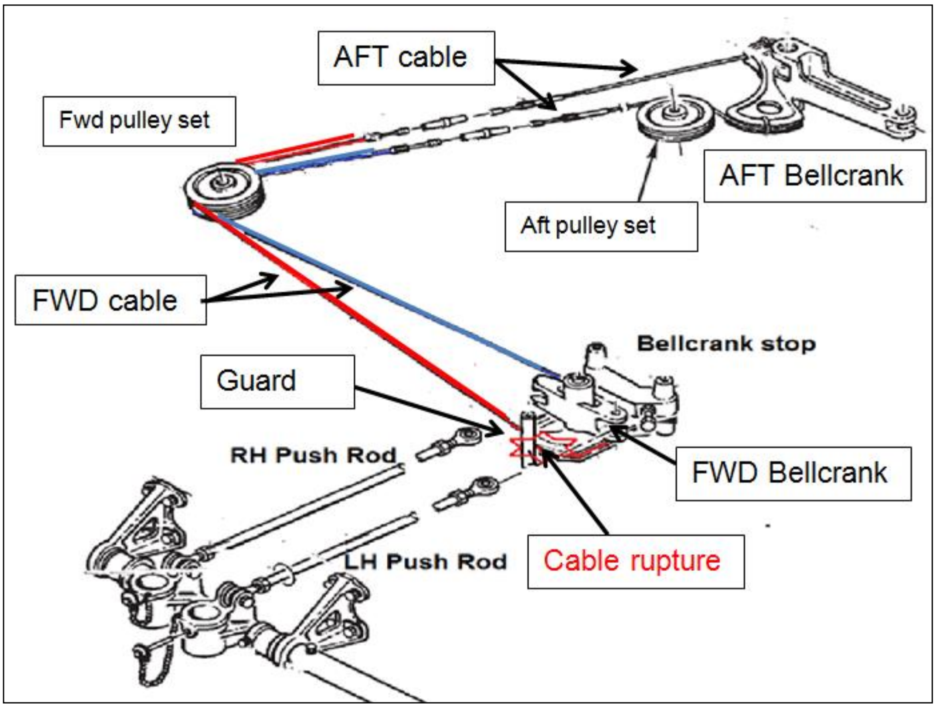


Figure 10: tail rotor control system

The rupture occurred at the location of the cable guard pin. Examination of the cable rupture shows evidence of cable friction both on the guard pin and on the groove of the Bellcrank.

Thorough examination of the cable wires shows some of them are extremely worn and black “oily” by-products are also visible in the area of the cable rupture.

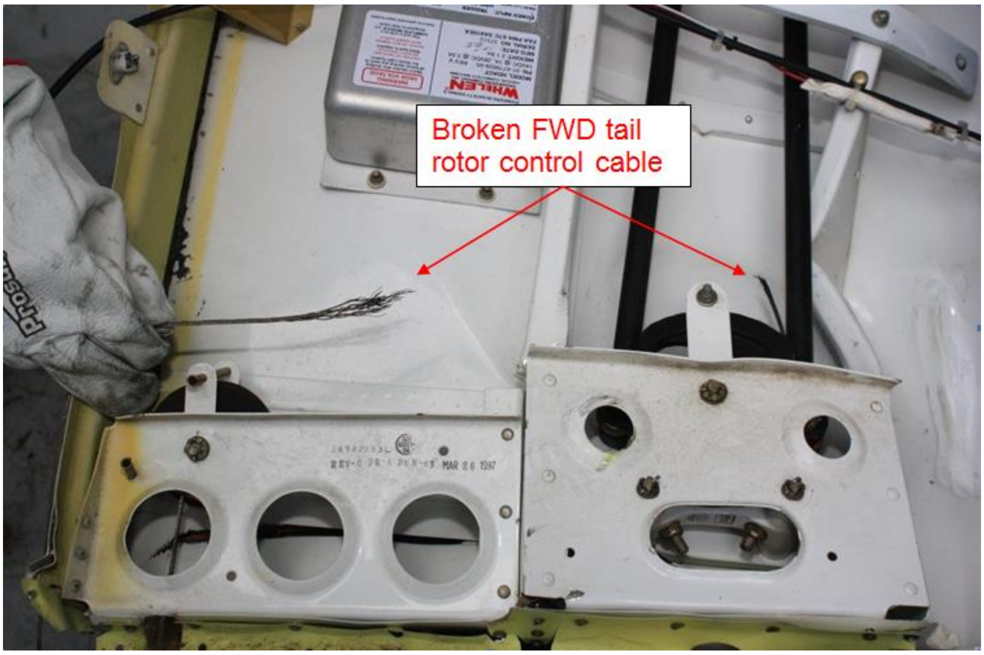


Figure 11: broken control cable

The tail boom was severed and was lying next to the main wreckage.

The 3 main rotor blades exhibited no important bending, which is consistent with a low rotational energy at ground impact.


Figure 12: tail boom on the left – rotor blade in front showing no major bending

The furthest separated part found was the tail rotor, located about 32 m from the skid traces.

The tail rotor blades didn't show any trace of rotational impact either.


Figure 13: The tail rotor was found torn away from the tail boom

Left and right collective controls remained interconnected and were found in full down position. All the controls on the examiner's side were damaged: the right cyclic control was severed at its base, both right cockpit tail rotor control pedals were separated and the right cockpit collective control was bent downwards. By contrast, all the left cockpit flight controls (examinee side) were undamaged.

The engine controls were found in the cabin in the following positions: magnetos on, mixture rich, electrical fuel pump on. The fuel shut off valve control was pushed (open position).

Engine inspection.

Engine and engine accessory external examination could determine that the alternator was moved upwards, in the direction of the starter gear wheel due to the helicopter impact with the ground. This caused the alternator pulley to collide with the starter wheel pulley.

Inspection of both pulleys determined that there was only one single matching bent on each pulley, without any circumferential friction mark. This definitely demonstrates that the engine was no longer running at the time of the ground impact.

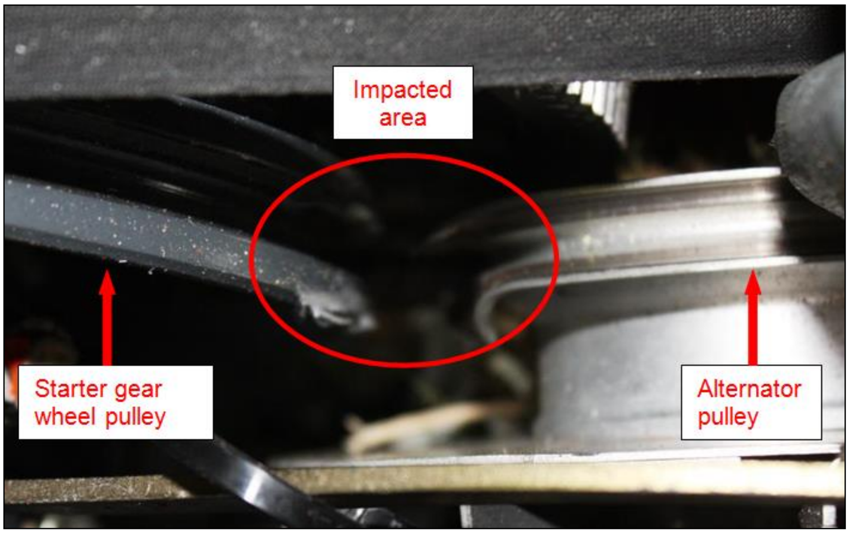


Figure 14: only local impact damage, showing there was no rotation on impact

The throttle control was thoroughly inspected in order to try determining the position of the throttle on impact. Due to the impact forces, the throttle control mechanism ruptured at the connection of the throttle with the collective control (correlator system).

The throttle valve, located inside the fuel injection body, was found with its stop in contact with the idle adjustment screw, in closed position. The throttle lever was found bent upwards and was also slightly twisted backwards, which suggest a rotating movement of the lever towards the close position on impact. The above mentioned damage to the throttle lever and to the correlator system made it impossible to determine the position of the throttle control on impact.

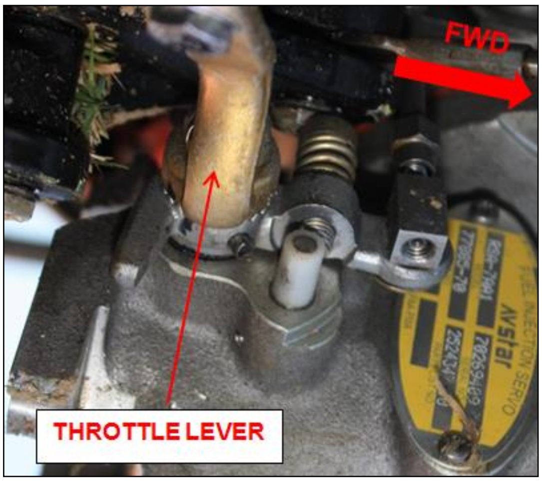


Figure 15: throttle lever bent upwards

The magnetos, spark plugs, mecanical fuel pump and rocker valve covers were removed in order to perform a visual examination, as far as possible of the internal moving parts of the engine.
The inside of the engine didn't show any sign of anomaly. In particular all the components visible after removal of the rocker valve covers (valves, springs, rocker, etc.) were in good condition and free of corrosion, sludge,traces of overheating or contamination by exhaust gases. A visual inspection of all 4 combustion chambers, performed through the spark plug holes, did not reveal any sign of anomaly. The cylinder heads' external appearance did not show any trace of overheating (burned or discolored paint) in the area of the exhaust ports.
Manual rotation of the crankshaft resulted in the normal movement of all roker valves. All exhaust and intake valves could be moved freely and returned in contact with their valve seats normally. A normal compression was present in all 4 cylinders at the end of the compression cycle.
The mechanical drive of the magnetos was rotating normally as well as the lift rod of the mechanical fuel pump rocker arm which was moving up and down under the action of the engine cam.
The oil suction screen and the spin-on oil filter were removed for inspection. The spin-on oil filter was cut open and its paper element was unfolded for examination of the material trapped. No trace of contamination was found.

<u>Fuel system inspection</u>
Thorough inspection of the fuel system determined that:

- Sufficient fuel was present in the fuel tanks and the tanks were properly vented.
- The fuel shut-off valve was in open position and the valve was free of any obstruction.
- The fuel lines were in good condition and free of any obstruction or leak.
- The mechanical fuel pump was disassembled and found in good working condition.
- The electrical fuel pump was tested and found to be working properly.
- The fuel filter / gascolator was opened and found to be free of contamination.
- The injection lines, the fuel flow divider and the nozzles were inspected and were determined to be free of contamination or any other anomaly.
- The fuel injection body was disassembled and thoroughly inspected. No anomaly was found.

Ignition system inspection

Inspection of the ignition system determined that:

- Two high tension (HT) ignition leads on the left hand magneto and one high tension ignition lead from the right hand magneto suffered sqeezing damage during the accident.
- Bothmagnetos were bench tested first using their own ignition harnesses. Both magnetos delivered normal sparks to the test bench spark gap assemblies only from the undamaged high tension leads. No spark was produced by the 3 damaged ignition leads.
- Both magnetos' ignition harnesses were dissassembled from the magnetos in order to repeat the same test using a serviceable HT harness. During the removal of the HT harness caps, the presence of a clear grease was noticed on all HT lead spring ends and also inside their corresponding locations on each distributor block.
- A second test on the test bench of the magnetos equipped with a serviceable HT harness was performed without removing the remaining clear grease from the distributors blocks. This test demonstrated that both magnetos were able to deliver normal sparks to all 4 spark gap assemblies.
- Then, both magnetos were entirely disassembled and inspected, showing that no other anomaly was present.
- All spark plugs were visually examined showing that they were, at first sight, in good condition except that one of them had been bent on impact. They were clean (meaning without carbon), lead residue or oil deposit. No visual anomaly was detected.
- The test of all 8 spark plugs, using a spark plug tester, showed that 7 of them were working properly, including the bent one. By contrast, one spark plug without visual damage didn't deliver any spark. All spark plugs were tested a few times under different air pressure with the same result.

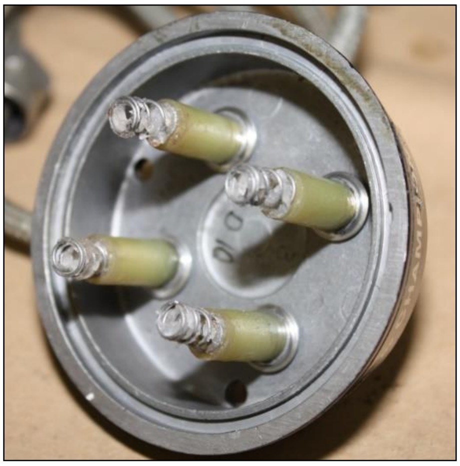


Figure 16: grease on the HT leads spring ends

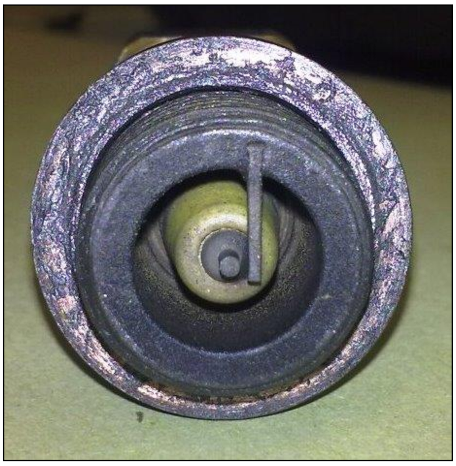


Figure 17: electrodes of one spark plug

1.13 Medical and pathological information.

When the first persons arrived on the crash site to provide relief to the victims, the pilot and the examiner were still strapped to their respective seats. The pilot, conscious, was lying on top of the examiner. The victims were removed from the wreckage taking all necessary precautions to avoid additional injuries.

The examiner:
The examiner, fatally injured, never regained consciousness after the accident, although he quickly received first-aid care. No autopsy was performed, meaning the exact cause of death is unknown, but is likely related to significant spinal injuries and/or internal bleeding. Moreover, based on the interview of the pilot, it was determined that the examiner did not show any sign of sickness during the flight.

As a part of the annual medical examination, an audiogram was performed one year out of two to determine the existence and the extent of a possible hearing loss. The audiogram reports of the examiner (Period from 1999 to 2013) were consulted showing, up to the year 2009, a stable hearing loss between 25 dB and 50 dB in the 2000 Hz and 3000 Hz frequencies.
By contrast, the 2 last audiograms performed in 2011 and 2013 show an improvement of the hearing abilities. Namely, the hearing loss in all the frequencies tested (500, 1000, 2000 and 3000 Hz) is going down in 2011 and is further reduced to an identical loss of 10 dB in all the frequencies in 2013.
As the 3 last medical examinations were performed in Switzerland, support was requested from the Swiss Accident Investigation Board (SAIB) in order to perform a deeper examination of the 3 last audiograms. This was performed by an aeronautical medical expert in Switzerland who corrected the different values of hearing loss. However these corrected values also show the previously mentioned hearing improvements.

The pilot:
The pilot, although he suffered serious back injuries and was in shock, remained more or less conscious after the accident. He was first interviewed at the hospital one week after the accident and again one month later, after he had been transferred to a rehabilitation clinic. The pilot could recall most of the flight except the last seconds, from the time the examiner took control.

The last audiogram was performed in January 2002. Recurrent audiogram examination is no longer required by regulation for the holders of a class 2 medical certificate.

1.14 Fire.

The helicopter did not catch fire

1.15 Survival aspects.

The pilot, suffering significant back injuries was not in a medical condition to escape the wreckage. This would have cost him his life in case of fire before the arrival of the rescuers.

The damage to the helicopter was consistent with a combination of relatively low horizontal speed and high vertical-impact forces that characterize an almost unsurvivable accident. The impact forces, as based on the examination of the damage, were concentrated on the lower side of the cabin and the engine with more damage on the left side. This would logically conclude that the occupant sitting on the left seat had been submitted to a more significant vertical deceleration than the one sitting on the right seat.

However, the left occupant survived while the one on the right was fatally injured.

1.16 Tests and research.

Not applicable

1.17 Organizational and management information.

Not applicable

1.18 Additional information.

Regulation regarding helicopter instructor and examiner experience

All requirements regarding the examiners licence, rating or certificate and qualification are listed in Regulation EU 1178/2011.

FCL.1000 Examiner certificates

(a) General. Holders of an examiner certificate shall:

(1) hold an equivalent licence, rating or certificate to the ones for which they are authorised to conduct skill tests, proficiency checks or assessments of competence and the privilege to instruct for them;

(2) be qualified to act as PIC on the aircraft during a skill test, proficiency check or assessment of competence when conducted on the aircraft.

All requirements regarding the revalidation of type rating for helicopters are listed in Regulation 1178/2011 FCL.740.H.
In summary, the applicant shall:

- Pass a proficiency check each year. He may achieve revalidation of all the relevant type ratings by completing the proficiency check in only 1 of the relevant types held.
- Have completed at least 2 hours (including the proficiency check) as a pilot of the relevant helicopter type within the validity period of the rating.

FCL.740.H Revalidation of type ratings — helicopters
(a) Revalidation. For revalidation of type ratings for helicopters, the applicant shall:
(1) Pass a proficiency check in accordance with Appendix 9 to this Part in the relevant type of helicopter or an FSTD representing that type within the 3 months immediately preceding the expiry date of the rating; and
(2) Complete at least 2 hours as a pilot of the relevant helicopter type within the validity period of the rating. The duration of the proficiency check may be counted towards the 2 hours.
(3) When applicants hold more than 1 type rating for single-engine piston helicopters, they may achieve revalidation of all the relevant type ratings by completing the proficiency check in only 1 of the relevant types held, provided that they have completed at least 2 hours of flight time as PIC on the other types during the validity period. The proficiency check shall be performed each time on a different type.
(4) ….
(5) A pilot who successfully completes a skill test for the issue of an additional type rating shall achieve revalidation for the relevant type ratings in the common groups, in accordance with (3) and (4).

(6) The revalidation of an IR(H), if held, may be combined with a proficiency check for a type rating.

Annex to ED Decision 2011/016/R

AMC1 FCL.740.H(a)(3) Revalidation of type ratings — helicopters

Only the following SEP helicopter types can be considered for crediting of the proficiency check. Other SEP helicopters (for example the R22 and R44) should not be given credit for.

Manufacturer	Helicopter type and licence endorsement
Agusta-Bell	
SEP	Bell47
Bell Helicopters	
SEP	Bell47
Brantley	
SEP	Brantley B2
Breda Nardi	
SEP	HU269
Enstrom	
SEP	ENF28
Hélicoptères Guimbal	
SEP	Cabri G2
Hiller	
SEP	UH12
Hughes or Schweizer	
SEP	HU269
Westland	
SEP	Bell47

FCL.740.H allows achieving revalidation of all the relevant type ratings by completing the proficiency check in only 1 of the relevant types held.

AMC1 FCL.740.H(a)(3) listing contains 6 different types helicopters, meaning that theoretically, a pilot holder of all 6 ratings shall only pass a proficiency check on a particular type every 6 years.

The examiner held only a HU 269 rating. Consequently, he had to pass each year a proficiency check using this type of helicopter to hold his HU269 rating.

AMC1 FCL.050 allows the examiners to log all flight time as flight experience, when they are acting as an examiner in an aircraft.

AMC1 FCL.050 Recording of flight time
(b) Logging of time:
(1) PIC flight time:
(i) the holder of a licence may log as PIC time all of the flight time during which he or she is the PIC;
...
(iii) the holder of an instructor certificate may log as PIC all flight time during which he or she acts as an instructor in an aircraft;
(iv) the holder of an examiner's certificate may log as PIC all flight time during which he or she occupies a pilot's seat and acts as an examiner in an aircraft;

Regulation 1178/2011 Part FCL.915 requires that the hours flown by an examiner during skill tests or proficiency checks shall be logged as flight time towards revalidation requirements for all instructor certificates held.

FCL.915 General prerequisites and requirements for instructors
(c) Credit towards further ratings and for the purpose of revalidation:
(1) Applicants for further instructor certificates may be credited with the teaching and learning skills already demonstrated for the instructor certificate held.
(2) Hours flown as an examiner during skill tests or proficiency checks shall be credited in full towards revalidation requirements for all instructor certificates held.

All requirements regarding minimum recent experience of pilots are listed in Regulation 1178/2011 FCL.060. However, these requirements are only applicable in commercial air transport or when carrying passengers. Consequently, there is no requirement of recent experience towards pilots acting as instructors or examiners because they are not operating an aircraft in commercial air transport or carrying passengers when acting as instructor or examiner.

FCL.060 Recent experience
(a) Balloons. …..
(b) Aeroplanes, helicopters, powered-lift, airships and sailplanes. A pilot shall not operate an aircraft in commercial air transport or carrying passengers:
(3) as PIC or co-pilot unless he/she has carried out, in the preceding 90 days, at least 3 take-offs, approaches and landings in an aircraft of the same type or class or an FFS representing that type or class. The 3 take-offs and landings shall be performed in either multi-pilot or single-pilot operations, depending on the privileges held by the pilot; and

as PIC at night unless he/she: ...

1.19 Useful or effective investigation techniques

Not applicable

2 Analysis.

2.1 Helicopter attitude at impact

The main wreckage and tailboom were resting almost opposite with respect to the axis of runway (and thus flight path), which suggests that the helicopter rotated around its axis prior to impact.

The debris pattern on the crash site, showing more separated parts on the left side of the wreckage and more significant damage to the left skid are consistent with the witness statement indicating that the helicopter yawed to the right while simultaneously falling down from an approximate height of 10 to 15 meters in the original direction.

This is consistent with the helicopter hitting the ground crabbed to the right in a nose down attitude, first with the left skid contacting the ground, which on its turn caused the helicopter to rotate approximately 205° clockwise after the first impact.

2.2 Tail rotor cable failure

The pilot stated that during the last phase of the flight he felt a few shocks in the helicopter structure and handed over the controls to the examiner. To the best of his recollection, he didn't notice any yaw control anomaly.

Therefore, it is assumed that the tail rotor cable failed either on impact or in flight during the short period of time the examiner took control.

The tail rotor cable tension, as per the manufacturer specifications, must be set between 60 to 65 lbs which is deemed sufficient to maintain the cable in the groove of the bellcrank in all circumstances and avoid any contact with the guard pin. As some traces of friction had been found on the guard pin, it is likely the helicopter had been operated for a while with insufficient tail rotor cable tension. The investigation could not determine when and for which period of time the cable tension was out of the manufacturer specifications.

Additionally, the cable tension can also vary depending on which pedal is pushed by the pilot. The study of the tail rotor cable routing shows that the failed section of the cable is only submitted to an additional load when the right pedal was pushed on.

Given the yaw to the right, as witnessed during the last seconds of the flight and confirmed by the analysis of the wreckage, it is very likely that the yaw was the result of a pilot action on the right pedal, reflecting the tail rotor cable integrity at that moment.

Therefore, it can be concluded that the cable failure occurred due to the structure deformation when the helicopter impacted the ground. The rupture of the cable took place at the weakened worn area of the cable located at the forward bellcrank.
Shortly after the accident, AAIU(Be) investigators examined the tail rotor cable system of another similar helicopter in order to observe the routing of the cable and evaluate its accessibility during the periodic inspections. Examination could determine that the inspection of the cable was extremely difficult at the forward bellcrank without removing the cable. After removal, cable inspection showed that a few wires of the tail rotor control cable were worn and some of them were broken at the same location as the crashed helicopter.

Sikorsky Aircraft Corporation, notified of this finding, issued on 21 November 2014 two Alert Service Bulletins ASB B-306 and ASB C1B-042 requiring a one-time inspection with a request for a response on the conditions found. There were several responses that indicated that the engineers found wear. As a solution to this issue, a temporary revision[5] dated 14 July 2015 has been issued to the HMI Appendix B calling for a 400 hour periodic removal of the cable for inspection. In place cable inspections already existed in the manual but the addition of an inspection of the cable while removed will expose those cables that are wearing and force their replacement.

2.3 Low rotor RPM on final

The pilot stated that he tried to correct the approach slope on final by pulling the collective. Shortly after, he felt shocks in the structure of the helicopter. This is consistent with the aerodynamic stall of the main rotor blades caused by a low rotor RPM.

The engine problems are discussed in paragraph 2.12. As no yaw to the left of the helicopter was reported either by the pilot or the witnesses, it can be assumed with a high degree of certainty that there was no brutal loss of engine power in flight.

Pulling the collective pitch lever while the rotor RPM is already too low, without simultaneous throttle adjustment, will automatically cause an additional reduction of the rotor RPM because of the increased blade drag torque, see Figure 18. In this case, the correlator, which is supposed to adjust approximately the engine power to the power absorbed, will not be able to maintain, and certainly not to recover, a preexisting too low rotor RPM. Pulling on the collective control will aggravate the loss of rotor RPM phenomenon.

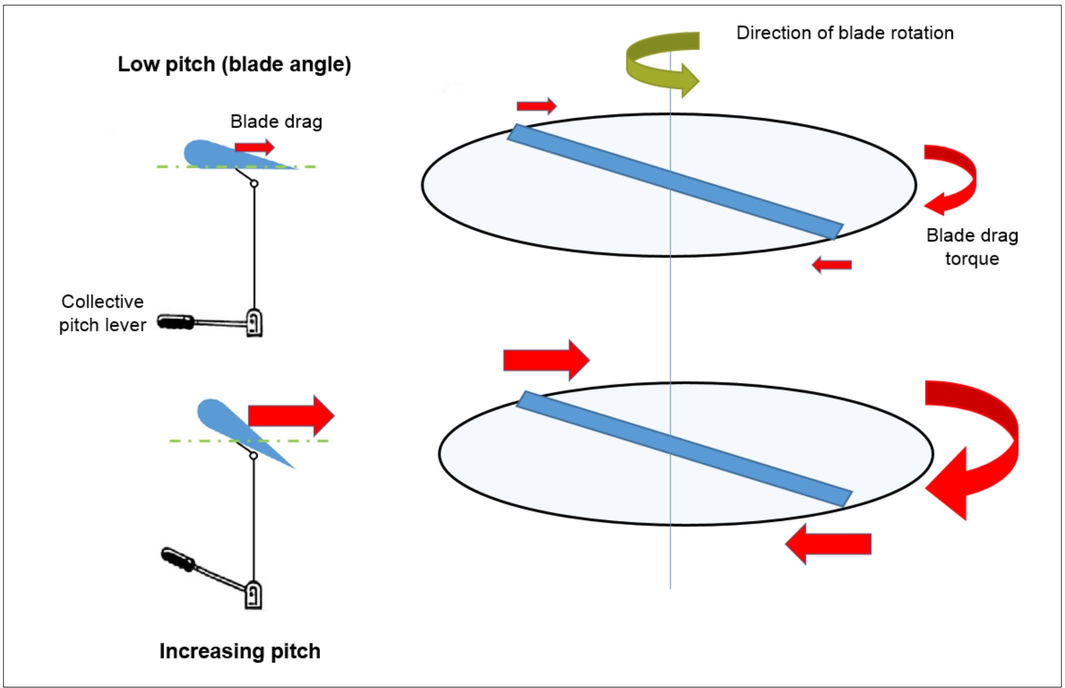


Figure 18: Sketch showing the increase in drag torque when pulling the collective lever

[5] A copy of this TR is enclosed at the end of this report

This scenario is compatible with the pilot showing some inabilities to control the engine power in a recent past, as witnessed during the flight performed the day before.

2.4 Pilot experience

The pilot had no recent experience on helicopters, with the exception of the 42 minute flight performed the day before the accident. His low total and recent experience was conducive to pilot errors and/or reduced flying skills. The pilot had little throttle manipulation skills and also likely little awareness of the insipient stages of low RPM.

2.5 Examiner recent experience

The examiner did not regularly fly a 269 helicopter which could have reduced his ability to detect on time a technical or operational problem.
The examiner had extensive experience on various types of helicopters. In the preceding years his experience was gained mostly on turbine and piston engine helicopters equipped with a governor automatically maintaining the rotor RPM within limits.
As seen on the examiner licence, the Model 269 was the only helicopter type with no governor on which he was qualified. Flying almost exclusively governor equipped helicopters tends to influence a pilot’s vigilance to check the rotor RPM. The examiner’s very low recent experience on type also probably reduced his aural perception of what should be the noise produced by the helicopter at standard rotor RPM.
This could partially explain why he did not detect the low rotor RPM on time and did not take control before the situation became unrecoverable.

2.6 Regulation regarding examiner rating and licence

In summary:

- An examiner shall hold an equivalent licence, rating or certificate to the ones for which they are authorised to conduct skill tests, proficiency checks or assessments of competence and the privilege to instruct and be qualified to act as PIC on the aircraft during a skill test, proficiency check or assessment of competence when conducted on the aircraft.
- The examiner shall pass a yearly proficiency check, however he may achieve revalidation of all the relevant type ratings by completing the proficiency check in only 1 of the relevant types held.
- The examiner shall also have completed at least 2 hours as a pilot of the relevant helicopter type within the validity period of the rating, including the hours flown when acting as instructor or when acting as examiner during skill tests and proficiency checks.
- There is no requirement of minimum recent flight experience, such as found in FCL.060, when flying as instructor or examiner.

2.7 Examiner hearing capabilities - Use of an active noise cancelling headset

Active noise cancelling headset

For a helicopter pilot, the noise produced by the engine and the rotating parts (transmission and rotors) is a good indication of the RPM. The pilot's helicopter noise perception adequately complements the observation of the engine and rotor RPM on the tachometer.

Each helicopter type generates a typical noise to which the pilot's hearing must be familiar in order to be able to identify an abnormal RPM and/or engine noise. Pilots with a wide experience flying a specific helicopter type can immediately identify any RPM anomaly and/or engine problems.

The examiner used an active noise cancelling headset that is designed to drastically reduce the perception of environmental noise, particularly if the noise is relatively stable. This way, the cabin noise perceived by the examiner certainly appeared differently to him and was significantly reduced as long as there was no sudden RPM and/or engine noise modification.

Examiner hearing capabilities

The pilot's hearing loss detected in the period from 1999 to 2009 is not unusual considering the age of the pilot and is acceptable. The hearing loss for the frequencies between 500Hz and 2000Hz may not exceed 35dB and 50Hz at 3000Hz frequency.

The pilot's hearing loss was, since the medical examination in 2001 just at the upper limit for the frequencies 2000Hz and 3000Hz. However, an aeromedical examiner stated that this level of hearing loss doesn't raise many problems provided the person remains in a "listening mode" for the noise he is supposed to listen to. In this case, the pilot's brain acclimates and allows a certain compensation for the hearing loss.

That being said, the aeromedical examiner stated also that it is impossible that an improvement of the hearing abilities occurred during the last 4 years as observed in the 2 last audiograms. At best hearing abilities would remain stable, at worst it would deteriorate.

Individuals who knew the examiner stated that he was still able to conduct a normal conversation. However it was sometimes noticeable, in particular during radio conversation, that his hearing abilities were somewhat reduced.

It is thus very likely that an anomaly occurred during the 2 last audiograms showing an unexplained improvement of his hearing capabilities. The cause of this anomaly could not be determined.

2.8 Pilot's Flight Manual (PFM)

The PFM had been reviewed in order to determine if the missing information, caused by the improper updating, could have influenced the occurrence of the accident.

The PFM was revised enhancing Section 4 paragraphs 4-10, 4-11 and 4-15 to identify the potential for shutdowns and to warn about rapid throttle reduction to the idle position.

- Paragraph 4-10 *Engine idle at altitude* incorporates a revised warning about possible engine stoppage when the throttle is rapidly reduced to full idle at altitude.

Comment: the helicopter was not flying at high altitude and there was no reason to rapidly reduce the throttle when the accident occurred.

- Paragraph 4-11 *Practice autorotation* incorporates an additional warning about possible engine failure when the throttle is abruptly retarded to the idle position when initiating a practice autorotation or simulated forced landing.
  Comment: the pilot was not initiating practiced autorotation or simulated forced landing.
- Paragraph 4-15 *Pilot's check of idle mixture, idle speed, and fuel boost pump* adds a sentence and a procedure requiring, in the event that the idle mixture check was not accomplished and recorded, to perform it before the first flight of the day. Another sentence requires notifying maintenance personnel to make a mixture adjustment if engine quits during the check.
  Comment: interview of the owner showed that the ground idle and the throttle override were checked following the starting check list during all engine ground checks. In the same way, the engine parameters were systematically compared when setting the boost pump in both 'on' and 'off' positions. The owner also stated that the engine RPM slightly raised when the mixture control was moved towards the cut off position to stop the engine which tends to indicate that the setting of the injection system was adequate. In conclusion, although the procedure of the PFM was not exactly applied, it appears that the necessary checks were more or less properly performed and were satisfactory.

The helicopter was not flying at high altitude and the pilot was not performing a practiced autorotation when the accident occurred. Therefore, it is unlikely that the lack of information available to the pilots, caused by the outdated PFM, would have increased the risk of engine failure in the circumstances of the flight.

Who should update the PFM?

The owner, interviewed about the updating of the PFM stated he was convinced that the updating was a task attributed to the CAMO. This belief was supported by the fact that the last update had been performed by the CAMO on 5 July 2010.

Regulation (EC) N° 216/2008 states that the PFM must be available to the crew and kept up to date for each aircraft.

4. *Aircraft performance and operating limitations*

4.a. An aircraft must be operated in accordance with its airworthiness documentation and all related operating procedures and limitations as expressed in its approved flight manual or equivalent documentation, as the case may be. The flight manual or equivalent documentation must be available to the crew and kept up to date for each aircraft.

Figure 19: Extract of Regulation 216/2008 Annex IV

As no legal text was found specifying something else, the updating of the PFM is deemed to be the responsibility of the owner or the operator of the aircraft. Moreover, PART-M AMC M.A.201(h)(1)(6) doesn't include the updating of the PFM in the list of tasks that the operator can subcontract. This suggests that the operator is primarily responsible for the updating of the PFM.

AMC M.A.201(h)(1) Responsibilities (*)
6. In order to retain ultimate responsibility the operator should limit sub-contracted tasks to the activities specified below:

(a) airworthiness directive analysis and planning
(b) service bulletin analysis
(c) planning of maintenance
(d) reliability monitoring, engine health monitoring
(e) maintenance programme development and amendments
(f) any other activities which do not limit the operators responsibilities as agreed by the competent authority.

Figure 20: Extract of PART-M

In addition to the regular updating by the owner or the operator, the PFM should be verified during each airworthiness review performed in order to deliver (≠ to extend) an airworthiness review certificate, i.e. once every three years in this case, as the airworthiness of the aircraft is under the survey of a CAMO (See M.A. 901 (e)2 and AMC M.A.901(e)2).

M.A.901 Aircraft airworthiness review
(e) For aircraft not used in commercial air transport of 2730 kg MTOM and below, and balloons, any continuing airworthiness management organisation approved in accordance with Section A, Subpart G of this Annex (Part M) and appointed by the owner or operator may, if appropriately approved and subject to paragraph (k):
1. issue the airworthiness review certificate in accordance with point M.A.710
2. for airworthiness review certificates it has issued, when the aircraft has remained within a controlled environment under its management, extend twice the validity of the airworthiness review certificate for a period of one year each time;

As seen in AMC M.A.901(e)2, the extension of the validity of the airworthiness review certificate does not require an airworthiness review, meaning that the verification of the PFM is not required at that moment.

AMC M.A.901 (e)2 Aircraft airworthiness review
When the aircraft has remained within a controlled environment, the extension of the validity of the airworthiness review certificate does not require an airworthiness review but only a verification of the continuous compliance with M.A.901 (b) (Aircraft in a controlled environment)

In summary, the continuous updating of the PFM is under the responsibility of the operator. However, the proper updating of the PFM must be verified during the airworthiness review of the aircraft performed in order to deliver a new airworthiness review certificate i.e. every 1 year if the owner/operator manages the airworthiness himself, or 3 years in the case the owner/operator has delegated the management of the airworthiness to a CAMO.

2.9 The spark plug failure

Although evidence was found showing that the engine was stopped when the helicopter impacted the ground, a close examination of the engine and its accessories, including the helicopter fuel system, could not reveal any technical significant anomaly susceptible to explain why the engine stopped operating.

Although a satisfactory run up, including the magnetos check was performed before flying, demonstrating that all 8 spark plugs were operative at that time, investigation showed that one spark plug was inoperative when tested after the accident.

A non-visible internal damage to the insulator of the spark plug, caused by the shock of the impact, cannot be excluded. However, there is a possibility that the deficient spark plug stopped operating during the flight. This hypothesis is supported by the fact that another spark plug, severely damaged during the accident, was still operating.

When a spark plug becomes inoperative in flight, it will cause a limited loss of engine power and an associated reduction of engine and rotor RPM. This loss of power, if detected by the pilot, can be easily recovered by an adequate throttle grip adjustment to recover the engine power, except when full engine power was already applied.

2.10 Presence of grease on all HT leads spring ends of the magnetos

The presence of a clear grease on all HT lead spring ends and also inside the corresponding receptacles in the distributor blocks, while not recommended by the magneto's manufacturer, does not appear to affect the electrical connection between the magnetos and their HT leads. Post-accident test benching of the magnetos equipped with their HT leads showed a normal working of the ignition system.

However, this test cannot completely exclude possible adverse consequences of this grease. Therefore, shortly after the accident, AAIU(Be) recommended the maintenance organization conduct an internal investigation aiming to determine why the grease was put at this location, in order to avoid such an inadequate maintenance action in the future.

The maintenance organization conducted an internal investigation and concluded that the grease had been likely placed during the last 100h inspection due to a misinterpretation of the workshop maintenance schedule used by the engineer. To avoid the repetition of this event, the maintenance schedule was improved and it was also clarified to all the engineers that no grease shall be applied at this place.

2.11 Possible scenario of the engine stoppage and the yaw to the right

A brutal loss of power is normally accompanied by a left yaw of the helicopter. As the movement witnessed was a right yaw, an engine failure[6] can be excluded.

Moreover, as no technical anomaly was found to explain why the engine stopped, an inadequate operational action of the pilot and/or the examiner was investigated.

An expert from the aircraft manufacturer, in response to a question about possible uncommanded engine shutdown, stated amongst other the following:

> "*Uncommanded engine shut down have been reported when the idle mixture setting is out of tolerance and the throttle is aggressively rolled to the idle stop. This may cause the engine RPM to drop below a sustainable point.*
> *The other condition that has been reported to cause an uncommanded shutdown, is a rapid roll ON of the throttle after a simulated engine failure.*

[6] Engine failure: Stoppage of the engine due to a technical failure or breakage of one or more engine components, thus rendering the engine inoperable.

There are no known occurrences of engine stoppage during normal flight with engine at operating RPM, except for those instances where the shutdown was the result of pilot error …"

As has happened during the flight performed the day before, it is possible that the pilot was not sufficiently effective to maintain adequate rotor RPM.

A possibility would be that the pilot rapidly rolled the throttle in the wrong way, towards the idle stop, instead of opening it when realizing the low rotor RPM. Rapidly rotating the throttle towards the close position will cause the clutch to disconnect and consequently removes the positive flywheel effect produced by the rotating parts of the helicopter to the revolving stability of the engine. This situation is known to have the potential to stall the engine, in particular if the idle speed and/or the idle mixture are not properly adjusted. Turning the throttle's twist grip the wrong direction is an error frequently encountered with 'young' pilots or pilots with low recent experience. Especially when the rotor RPM is already low and they have to react quickly. In this case there is no time to think on the action and natural instinct (possibly associated to the operation of motorcycles) takes over.

On the other hand, the late reaction of the examiner, reacting after the pilot gave him the control, shows that he didn't closely monitor the rotor RPM. It is likely that his reduced hearing capabilities combined with the use of an active noise cancelling headset, adding to his low recent experience on this helicopter type, prevented him being alerted by the abnormal propulsion system noise caused by the too low rotor RPM. The recovery action by the examiner would have been to promptly increase the power of the engine and pulling the collective to reduce the rate of descent of the helicopter. If, due to the urgency, the collective was pulled way before the engine regained its ideal RPM, the torque available would not have been enough to overcome the torque required (higher blade drag due to higher collective pitch), finally ending in the engine stoppage.

Improper adjustment of the engine mixture and/or idle speed is known to have the potential, in certain circumstances, to cause uncommanded engine shut down. Although no record of the tests prescribed in 4-15 of the POH could be retrieved, no indication was found showing that the engine mixture and/or idle speed was improperly adjusted.

Besides that, it is important to underline that the inoperative spark plug could have induced quite the same effect that an incorrect idle speed or mixture, i.e. a tendency for the engine to knock and even to shut down if the throttle grip is aggressively rolled on or engine stall if the throttle is rapidly rolled off at low RPM. Combination of an inadequate rapid throttle reduction or a rapid roll on of the throttle with a minor technical problem could have resulted in the engine stoppage.

The right yaw immediately before the impact was likely caused by the examiner pushing too much full right hand pedal to compensate a left yaw by the remaining tail rotor torque.

AAIU can conclude that the engine stoppage is not the cause of the low rotor RPM but more likely it is the low RPM, associated with the recovery actions requiring more power and more lift at the same time that caused the engine stoppage.

3 Conclusions.

3.1 Findings.

- The pilot was holder of a private pilot licence for helicopter (PPL(H)), delivered by BCAA and valid until June 2014. The pilot total and recent experience flying helicopter was low.
- The purpose of the flight was to extend the type rating (proficiency check) on the PPL(H).
- The examiner was holder of a valid commercial pilot licence for helicopter (CPL(H)). He had a wide flying experience flying helicopters. However, his recent experience flying the accident type helicopter was very low.
- The examiner regularly flew helicopter types equipped with a rotor RPM governor while the accident type helicopter did not have such equipment.
- The examiner hearing capability was on the lower limit on previous audiograms. The 2 last performed audiograms showed an unexplained, unrealistic, improvement of the hearing capability.
- The examiner was using an active noise cancelling headset during the fatal flight.
- The helicopter was registered in Belgium and was granted with a valid Airworthiness Review Certificate.
- The helicopter was regularly maintained by an EASA Part 145 approved maintenance organization. This organization, also approved as a CAMO, was in charge of the management of the airworthiness.
- The Pilot's Flight Manual found in the helicopter was outdated.
- The tail rotor cable failed in a weakened worn area located at the forward bellcrank. Investigation concluded that this cable failed at impact, not prior.
- The investigation did not find any evidence showing that the engine idle speed, the idle mixture and the fuel boost pump were tested at the end of the last flight of each day as prescribed by the POH 4-15. However, it could be determined that the necessary checks were adequately performed during the pre-flight checks and that no engine anomaly was detected.
- Interview of the pilot concluded that the helicopter suffered a low rotor RPM in short final, shortly before landing.
- Inspection of the wreckage concluded that the main rotor RPM was extremely low on impact.
- Inspection of the wreckage concluded that the engine was stopped on impact.
- During a bench test, one spark plug (out of 8) was found to be inoperative.
- Extensive inspection of the power system did not find any anomaly susceptible to cause an engine failure or even a significant loss of power.
- Although not part of a maintenance instruction, clear grease was present on all HT leads spring ends and also inside the corresponding receptacles in the distributor blocks. Ignition system tests could not conclude that it caused a degradation of the ignition capabilities.

3.2 Causes.

The probable cause of the accident is an inadequate engine power management by the pilot when flying in the final leg, that neither the pilot (the examinee) nor the examiner detected in time, leading to an unrecoverable low rotor RPM situation.

After the pilot handed over the controls to the examiner, the engine stopped during the attempt to recover. This was probably caused by a rapid roll on of the throttle, combined with a high torque demand.

Contributing safety factors:

- The pilot's total and recent experience flying helicopters was low.
- The examiner's recent experience flying this helicopter type was very low.
- The examiner's reduced hearing capabilities and the use of an active noise cancelling headset likely resulted in difficulty hearing a low rotor RPM situation early on.
- The spark plug failure, which likely increased engine tendency to stop when at low RPM, the throttle was rapidly rolled on.

Other safety factors identified during the investigation:

- Undetectable wear of the tail rotor cable [safety issue].
- Inconsistent medical examination(s) [probable safety issue]
- Vagueness about who is responsible for updating the Aircraft Flight Manual (AFM) [safety issue].

4 Safety actions and recommendations.

4.1 Safety issue: vagueness about who is responsible for updating the aircraft flight manual

The responsibility for updating flight manuals in GA is not clearly defined in the regulation. Although not being the cause of the accident, this led in this particular case to a flight manual lacking crucial safety information. Therefore:

Recommendation BE-2015-0013:
It is recommended that the Belgian CAA informs the general aviation aircraft owners and operators that it's their own responsibility to ensure that the aircraft flight manual or equivalent documentation is made available and is kept up to date at any time.

4.2 Safety issue: inconsistent medical examinations

As the actual reason of the unrealistic data found in the 2 last audiograms performed by an aeromedical examiner in Switzerland could not be determined, the possibility exists that the audiogram of other pilots is also unreliable. Therefore:

Recommendation: BE-2015-0015:
It is recommended that the Federal Office of Civil Aviation of the Swiss Confederation (FOCA) performs an investigation aiming to understand why this pilot's hearing test showed improved (and inconsistent) data and takes appropriate action to avoid the reoccurrence of such an inconsistency.

4.3 Safety issue: Undetectable wear of the tail rotor cable

The maintenance schedule found in the HMI Appendix B requested the inspection of the tail rotor cable without removal. The cable could therefore not be properly inspected on its whole length causing possible late cable wear detection.

Safety action:
In response to this safety issue, Sikorsky implemented the following safety action: *"A revision has been issued to the HMI calling for a periodic removal inspection of the cable. The addition of an inspection of the cable while removed will expose those cables that are wearing and force their replacement".*

4.4 Safety issue: Unapproved grease on the high tension lead ends of the magnetos

Although not part of a maintenance instruction, clear grease was present on all HT lead spring ends and also inside the corresponding receptacles in the distributor blocks.

Safety action:
In response to this safety issue, the maintenance organization conducted an internal investigation concluding to a possible misinterpretation of the workshop maintenance schedule used by the engineers. To avoid the repetition of this event, the maintenance schedule was improved and it was also clarified to all the engineers that no grease can be applied at this place.

4.5 Safety factor: the use of an active noise cancelling headset

When using an active noise cancelling headset, the cabin noise sounds differently to the pilot and is reduced. This is not a problem provided the pilot has familiarized himself with the new sound. Therefore:

Safety message:
Pilots should keep in mind that each aircraft type generates a typical noise that can be differently modified by the active noise cancelling headset. It is therefore crucial that the pilot's hearing is accustomed to this, which is a challenge if the pilot doesn't regularly fly an aircraft type.

5 Appendices

Extract of the 100 hours inspection schedule regarding the tail rotor cable inspection.

Models 269A, TH-55A, A-1, B & C - Appx B   Section 2

Table B-2. PERIODIC INSPECTIONS

What to Inspect - 100-hour Inspection

NOTE

Perform a complete Daily Inspection, 25, 50-Hour and any required Special Inspections as part of the 100-Hour Inspection listed below.

INITIALS

1. All engine and electrical wiring and systems for security, broken insulation and wires, fraying, corrosion, evidence of arcing and damage.

2. Radio equipment for operation and security. (Refer to manufacturer's maintenance manual.)

3. Instruments and instrument systems for operation and security.

4. (269C, Serial Numbers 0004 through 1456, unless 269A9989-1 spacer tube has been installed) Check worm clamp and AN735-9 clamp on 269A9940-7 lower longitudinal cyclic control rod assembly for security.

5. Inspect tail rotor pedals, torque tubes and associated parts for cracks, corrosion and other defects. Inspect tail rotor pedal retaining pins and tail rotor pedal arm to socket quick release lock pins for security of retention, wear and looseness. Inspect visible portions of tail rotor control linkage for security and obvious damage.

5A. Inspect magnesium tail rotor pedal arms 269A7336-( ) and sockets 269A7330-( ) for cracks, corrosion and other defects with special attention to attachment areas; dye penetrant inspect for suspected cracks (Basic HMI, Section 9, and HMI, Appendix A, Group 2).

6. Tail rotor control cables 269A7315-( ) for fraying, chaffing, broken strands and corrosion; control bellcrank 269A7325 for corrosion and cable wear in groove.

7. Inspect engine air inlet duct assembly for security of attachment brackets at lower forward fairing and engine adapter; check ducting for cracks, damage, wear, deterioration and general conditions.

8. Entire fuselage frame section and support struts for structural integrity of tubes, visible openings, cracked welds and evidence of local corrosion.

9. Without disassembly, inspect tailboom assembly strut fittings for cracks, corrosion or other damage. Using a 10X magnifying glass, inspect center frame aft cluster fittings for cracks, corrosion or other damage.

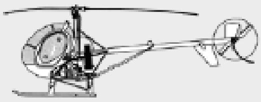
WARNING

IMMEDIATELY RETIRE FROM SERVICE AND TAG UNSERVICEABLE ANY CENTER ATTACHMENT FITTING FOUND TO HAVE CRACKS OR OTHER STRUCTURAL DAMAGE. REMOVAL AND REPLACEMENT SHALL BE PERFORMED IN ACCORDANCE WITH BASIC HMI, SECTION 11.

10. Perform dye penetrant inspection of 269A2324(BSC) and -7 center attachment fitting for cracks (Basic HMI, Section 11). (Tailboom life reduced with these P/N center attachment fittings installed. See Table B-5 for limits.)

Reissued: 20 May 1993
Revised: 10 Apr 2003   2-17

Temporary revision of the 400 hours inspection schedule regarding the tail rotor cable inspection



269A, TH-55A, A-1, B & C™
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TEMPORARY REVISION NO. 269A-102

FILING INSTRUCTIONS: Insert in Appendix B, Section 2, facing page 2-24.1, dated 17 Mar 2006.

SUBJECT: What to Inspect - 400-Hour Inspection

This temporary revision adds step 12. to Table B-2, Periodic Inspections, What to Inspect - 400-Hour Inspection.

MANUAL CHANGES:

On page 2-24.1, add step 12. to Table B-2, Periodic Inspections, What to Inspect - 400-Hour Inspection as follows:

12. Conduct an on-aircraft inspection of the tail rotor control cables, pulleys and forward and aft bellcranks (Basic HMI, Paragraph 9-40) and verify proper cable tension. Pay particular attention to the routing and alignment of the cables around the bellcranks, pulleys and through the routing holes on the airframe and along the side of the engine. No rubbing or chafing is allowed.

    (a) Remove tail rotor control cables per Basic HMI, Paragraph 9-39. Perform only the steps necessary to remove cables.

    (b) With cables removed, inspect tail rotor control cables, forward and aft bellcranks, pulleys and hardware (Basic HMI, Paragraph 9-40).

    (c) Make sure that the forward bellcrank is secure and is not rubbing against the forward spacer and/or the aft stop. Grasp forward bellcrank and apply slight force to the bellcrank (if possible) and make sure that forward bellcrank mounting bolt hole is not loose or elongated. If repair is required, refer to Basic HMI, Section 13.

    (d) Inspect tail rotor cable pulleys, and aft bellcrank per Basic HMI, Paragraph 9-40. Inspect pulleys for worn cable grooves and the bearings for wear.

    (e) Inspect all tail rotor cable components, bellcranks, mounts and hardware for cleanliness and corrosion. If corrosion is found or protection is needed, refer to Basic HMI Appendix D.

    (f) Replace any worn or damaged cables, and/or any unserviceable parts beyond limits.

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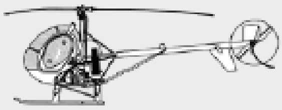

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(g) Reinstall the tail rotor control cables per Basic HMI, Paragraph 9-43. Inspect tail rotor control cable routing. Make sure that the cable is routed around the forward bellcrank in the intended guiding slots and NOT over the forward spacer. Make sure that the cable is not chafing anywhere including against the forward spacer, the aft stop or any other part of the airframe.

(h) Conduct rigging check of tail rotor controls per Basic HMI, Paragraph 9-3.

(i) Annotate compliance with inspection and all work performed in aircraft log records.

Page 2 of 2
Jul 14/15

Last page of the current PFM "*Summary of Revisions"* (released by Sikorsky Aircraft Corp.).

Pilot's Flight Manual

SIKORSKY AIRCRAFT CORP.
Model 269C Helicopter

SUMMARY OF REVISIONS (con't)

Revision No.	Configuration Letter	Revision Date	Pages Revised	Remarks	FAA Approval
17	C	18 Dec 2006		Revised to incorporate new format weight and balance forms and misc. typo's.	
18	C	20 Apr 2010		Revised to incorporate new gauge configuration and revised Warning/ Caution information.	
19	C	27 Oct 2010		Revised to update lubrication specifications.	
20	C	28 Jun 2011		Revised to include additional information on engine operation.	
Reissue #2	C	Reissued 07 Dec 2012		Added Sikorsky name, reformat. Added idle mixture information to Pilot's Check of Idle Mixture, Idle Speed, and Fuel Boost Pump procedure.	[signature] 12/11/12

viii.2

Reissued: 07 Dec 2012

Last page of the accident helicopter PFM "*Summary of Revisions*" (released by Schweizer Aircraft Corp.)

SCHWEIZER AIRCRAFT CORP.
Model 269C Helicopter **Pilot's Flight Manual**

Summary of Revisions (con't)

Configuration Letter	Revision Date	Remarks
C	24 Oct 2001	Addition of Noise Level Information and miscellaneous other changes.
C	12 Apr 2002	Addition of Heated Pitot Tube Information
C	27 Aug 2002	Revised and/or added additional information on tail rotor emergency procedures, clutch control cable inspection and misc. other changes.
C	18 Dec 2006	Revised to incorporate new format weight and balance forms and misc. typo's.
C	20 Apr 2010	Revised to incorporate new gauge configuration and revised Warning/Caution information.

Reissued: 21 September 1988 **viii.1**
Revised: 20 Apr 2010

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