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INVESTIGATION REPORT

Accident to the AIRBUS AS350 - B2 registered 3A-MLC

on 26 September 2019
at Col de Véry (Savoie)

Time	Around 18:25[1]
Operator	Monaco Heli-Loc
Type of flight	Cross-country
Persons on board	Pilot and three passengers
Consequences and damage	Helicopter damaged
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation published in June 2021. As accurate as the translation may be, the original text in French is the work of reference.	

Engine in-flight shut-down, autorotation, damage to the drive shaft by the main rotor when landing in a field

1 - HISTORY OF THE FLIGHT

Note: the following information is principally based on the flight recorder, statements and examinations.

Accompanied by three passengers, the pilot took off from Carros, near Nice (Alpes Maritimes), bound for Villers le lac (Doubs).

In cruise flight, when flying over the Alps, the pilot detected the illumination of the MOT.LIM[2] indicator light signalling the presence of chips in the engine. He decided to head towards Megève mountain airfield (Haute Savoie) (point ❶ in Figure 1) which was located a few flight minutes away[3] and he started descent. Around three minutes later (point ❷), he heard an unusual noise, reduced the engine power to idle and initiated an autorotation (point ❸). A witness saw the helicopter fly by in descent. He also heard a bang and saw smoke coming out of the engine. At the end of the final approach, during the flare, the pilot felt a jolt through the pedals and observed a yaw movement of the helicopter. He performed a running landing (point ❹).

[1] Except where otherwise indicated, the times in this report are in local time.

[2] The associated procedure advocates landing as soon as possible in a suitable area. The illumination of the indicator light is controlled by one of the magnetic plugs installed on the engine oil system.

[3] Approximately 10 NM from its position.

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The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.

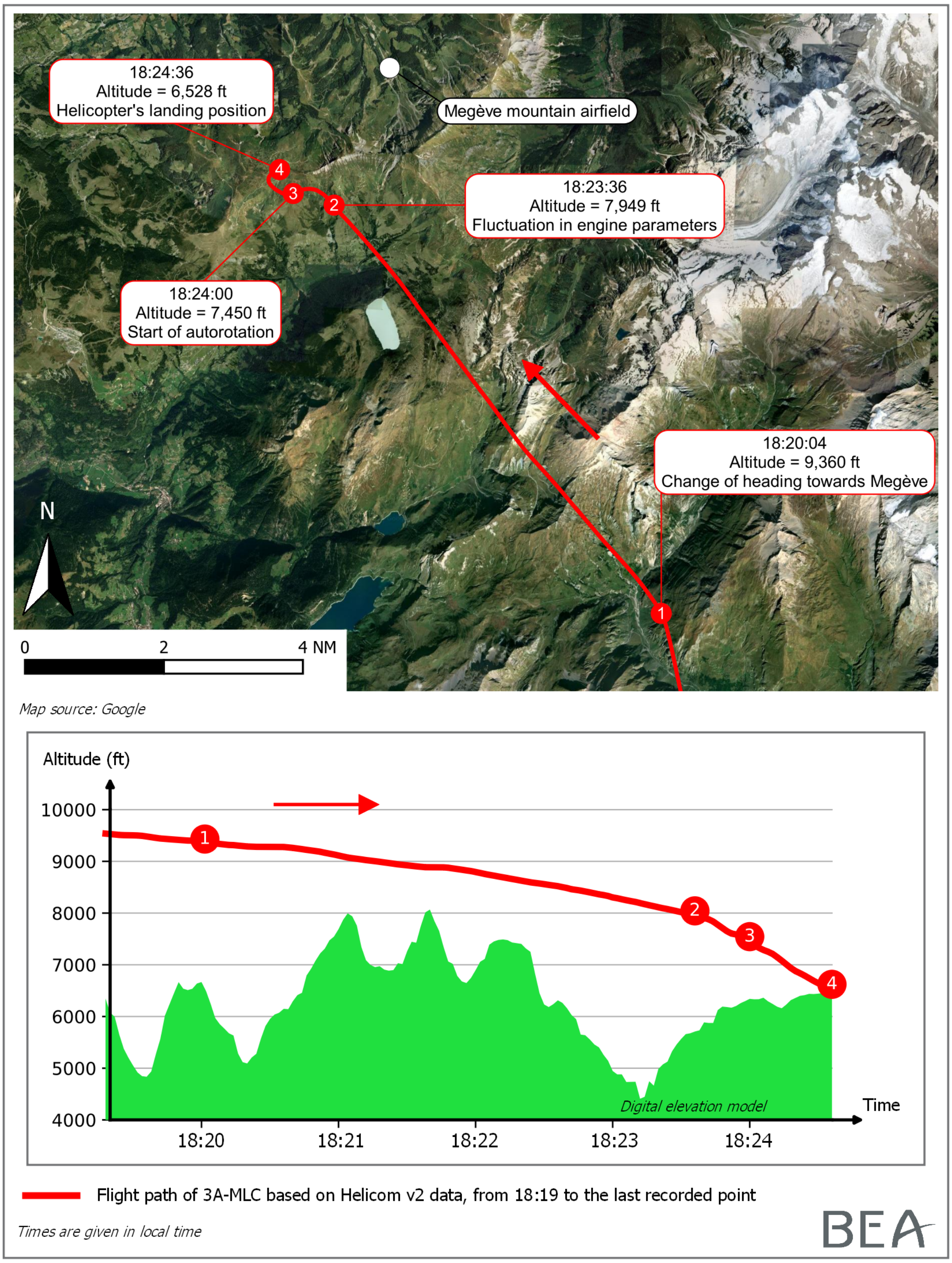

Figure 1: Path taken by the pilot

2 - ADDITIONAL INFORMATION

2.1 Pilot experience

The pilot held a Private Pilot Licence - Helicopters (PPL(H)) and had logged around 600 flight hours, 550 hours of which as captain and 25 hours in the last three months, all on 3A-MLC.

2.2 Meteorological information

The conditions recorded at the site by the pilot were a southwesterly wind of around 5 kt, CAVOK.

2.3 Analysis of flight parameters

The helicopter was equipped with a Helisafe computer. The flight data was extracted.

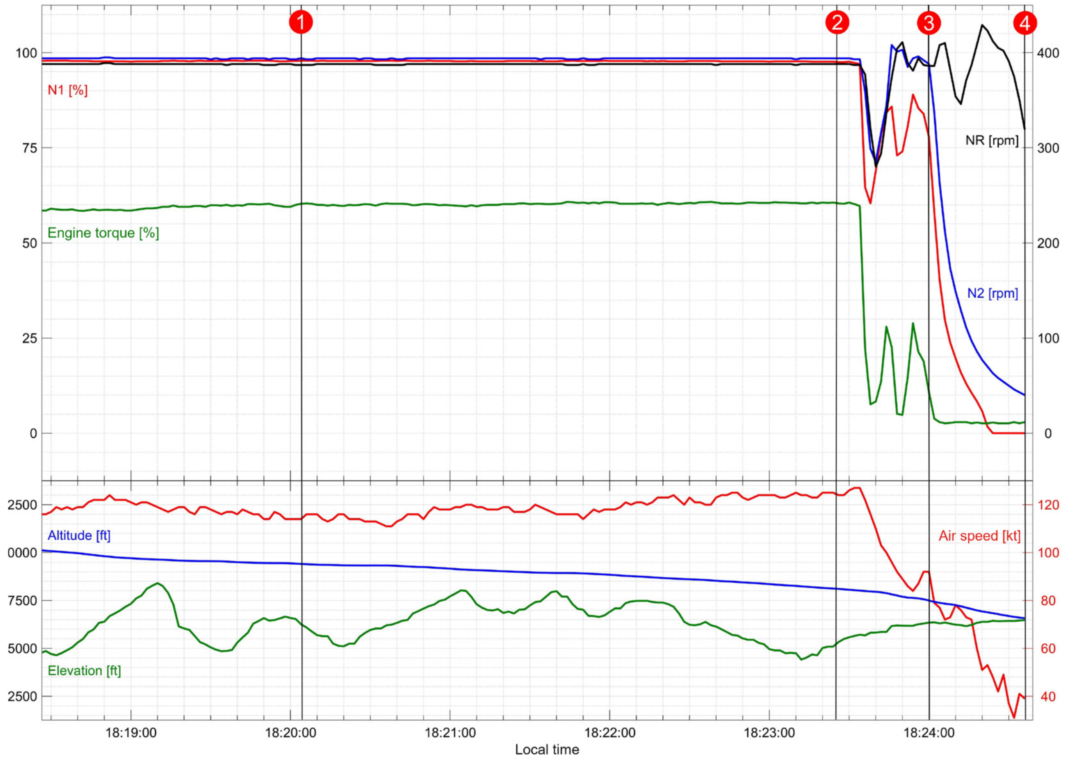

Figure 2: Fight parameters

Taking the pilot's statement into account, the MOT.LIM indicator light illuminated shortly before point ❶ which corresponds to the change of heading towards Megève mountain airfield.

Up to point ❷, i.e. for around four minutes, the engine parameters were nominal.

Between points ❷ and ❸, the fluctuations in engine parameters indicated a rapid deterioration of the engine and an abnormal operation.

From point ❸, the rapid decrease in free turbine rotation speed (N2) and gas generator speed (N1) indicated that the engine shut down. The engine torque of 0 showed that the engine was no longer transmitting power to the rotor. The rotor rotation speed (NR) was no longer synchronised with the free turbine speed (N2), which indicated the start of the autorotation.

A drop in rotor rotation speed in the nine seconds preceding contact with the ground was also visible and very likely corresponded to the flare made by the pilot to land.

2.4 Examinations

2.4.1 Examination of the site and the helicopter

The accident site is located at Col du Véry in a hostile mountainous area at 2,000 m. The helicopter was found on its skids.

The helicopter had two areas of damage on the tail boom:

- The tail rotor drive cover was torn at its boss (Area 1).
- The tail rotor drive cover was partially torn off in the horizontal stabilizer area (Area 2). The tail drive shaft was cut. The tail rotor pitch-change rod was distorted.

Source: BEA

Figure 3: External damage on the tail boom

Examinations conducted on site and in the workshop showed that one of the main rotor blades (yellow blade) had two contact marks on its lower surface, approximately 30 cm from the tip, as well as paint marks (of a colour identical to that of the tail drive shaft) at the blade tip leading edge.

This contact, which led to the fracture of the tail drive shaft, probably resulted from the combination of several factors, such as a slow rotation speed of the main rotor associated with a substantial movement of the cyclic pitch stick backwards and a tipping effect of the airframe associated with the contact of the tail boom skid with the ground.

When the tail rotor drive shaft broke, the tail rotor came into contact with the tail rotor pitch-change rod (yaw) thus causing its forced movement and its distortion, which almost certainly caused the jolt in yaw felt by the pilot.

The steel short shaft (engine side), still driven in rotation, was no longer coupled to the rear drive shaft. It then started to flutter, which caused the damage observed at the boss.

The examination of the landing gear was able to determine that the helicopter landed with a low vertical speed.

During the complete examination of the helicopter airframe, no defect prior to the accident or any anomaly was observed.

2.4.2 Examination of engine

The examination of the engine revealed:

- The presence of metallic particles on all of the magnetic plugs.
- A significant level of erosion (approximately 3 mm) on the leading edge of the blades of the axial compressor wheel (module 2).
- A significant level of erosion, greater than the tolerance values recommended by the manufacturer, of the leading edge of the centrifugal diffuser blades (module 3).
- Damage to the gas generator rear bearing presenting substantial wear of the rollers caused by friction with the internal track and an adhesive material due to seizure of the rollers.
- A large quantity of laterite on all module 3 components, and in particular the collection of 13.5 g of laterite from inside the hollow shaft[4].
- Various damage on all of the rotating parts of the engine due to the failure of the gas generator rear bearing.

[4] The model of the hollow shaft of the engine was pre-modification TU 360: improvement of the air system of the hollow shaft to reduce the build-up of dust and laterite.

Source: BEA

Figure 4: Presence of laterite inside the hollow shaft (on the left) and the injection wheel (on the right) coupling with the hollow shaft

The damage to the gas generator rear bearing is characteristic of a deterioration due to the imbalance phenomenon. The imbalance was very probably caused by the partial detachment of the laterite present in the hollow shaft. The imbalance led to the damage of the rotating parts of the engine including the bearings, with the generation of chips which ended up in the engine oil system and caused the illumination of the warning indicator light during the flight.

2.5 Maintenance procedures to help prevent the build-up of laterite

2.5.1 Standard maintenance procedure

The maintenance manual specifies the frequency of the check for wear on axial compressor blades at 400 or 750 hours based on the helicopter equipment (sand filter) and the environment in which the helicopter flies.

This procedure is described on work cards 72-32-00-280-801-A01 (installed engine) or 72-32-00-280-802-A01 (with removal of module 2).

2.5.2 Specific procedure

Service Bulletin (SB) A292 72 0230 (original version drafted in 1998 and last update in 2001) concerns pre-mod TU 360 engines that have been operated in a dusty environment or when the history of operation in a dusty environment could not be determined. By monitoring the wear of module 2 axial compressor blades, the SB can be used to determine whether a procedure to clean the rotating assembly of the gas generator needs to be carried out. The aim of this SB is to prevent the build-up of laterite in the hollow shaft that could create an imbalance and a deterioration of the rear bearing roller and lead to an uncommanded in-flight shut-down of the engine.

The wear criteria are as follows: wear of more than 1 mm for 1,000 hours of operation or greater than 3 mm.

An update (version C) of the Service Bulletin, which became a Mandatory Service Bulletin (MSB), was published in 2012. The SB was updated because the monitoring of wear on axial compressor blades could, in some cases, be insufficient. A criterion pertaining to the visibility conditions in which the helicopter operates was added in order to calculate the cleaning frequency of the hollow shaft.

An airworthiness directive (reference AD N 2012-0071) published by the EASA incorporates the MSB version C and imposes its implementation unless the engine was already meeting the requirements of the previous versions of the Service Bulletin.

The MSB also states that when the engine is returned to the workshop (level 3 maintenance), if the hollow shaft is accessible, it must be inspected and cleaned. The accessibility of the hollow shaft is dependant on a maintenance procedure that requires work on modules 2, 3 or 4.

If the wear criteria are not met, the MSB remains active and associated with the check requested during standard maintenance procedures to be carried out every 400 hours or 750 hours.

In addition, it is specified that the MSB must be applied after every change of helicopter configuration, mission type or geographical area.

2.6 Logs

2.6.1 Engine

The log of the engine (S/N 9821) shows that:

- This engine was assembled in April 2002 and installed on the AS350B2 registered F-GHUT (then registered 3A-MTA from 2007) up to October 2010. The engine had logged 2,864 operating hours.
- It was installed on the AS350B2 registered F-GEDF up to September 2015. The helicopter was operated in Madagascar during this period.
- When the engine was removed, it had logged 4,875 operating hours.
- In October 2015, it was installed on the AS250B2 helicopter registered 3A-MLC that had been sent to Madagascar.
- It was removed from 3A-MLC in February 2016 to undergo a maintenance procedure and was reinstalled on the same helicopter in March 2016.
- In August 2016, the helicopter was repatriated from Madagascar to France, where it arrived in December 2016. The engine had logged 5,713 operating hours.

- From April 2017 to January 2018, the helicopter was operated in Guyana before being repatriated to mainland France.
- In February 2019, the engine was removed from 3A-MLC due to the presence of chips on a magnetic plug. At the end of the maintenance procedure and after replacement of module 5, the engine was reinstalled on 3A-MLC in March 2019. The engine had logged 5,941 operating hours.
- On the date of the accident, the engine had logged 5,995 operating hours.

2.6.2 Engine maintenance

Information from the maintenance documentation indicates that the 150-hour, 300-hour, 750-hour and 1,500-hour inspection engine maintenance procedures were performed throughout the service life of the engine.

With the compressor blade wear check due every 750 hours, the analysis of the maintenance documents focused principally on these inspections.

The analysis of the engine log book showed that in September 2010, during the installation of a new module 3, the implementation of SB A292 72 0230 by Safran Helicopter Engines (UK) revealed an erosion of the axial compressor wheel blades (module 2) of around 1 mm. On this date, the module 2 had logged 2,859 operating hours. With extent of wear not being a criterion for determining a frequency, no specific mention was recorded in the engine log book.

Up to the date of the accident, the engine log book no longer mentioned the extent of wear due to erosion of the axial wheel blades, nor the implementation of MSB A292 72 0230.

The record sheet[5] corresponding to the check of wear on the module 2 axial compressor blades during 750-hour inspections indicates "*Aire d'atterrissage aménagée*" (prepared landing area) and is followed by the "*RAS*" (NTR) indication, which means that the wear was within tolerance.

[5] Table listing all of the inspection tasks to be performed during an inspection and indicating the specific applicable conditions, the date of execution and any observations.

Up to the date of the accident, no procedure was required on modules 2, 3 and 4. Because of this, during returns to the workshop, the hollow shaft was not accessible and only the check of the wear of the axial compressor blades (module 2) could be performed. Therefore the build-up of laterite was not visually detected.

2.7 Maintenance organisation and follow-up

The owner of F-GEDF and 3A-MLC delegated the management of maintenance and airworthiness to an approved Continuing Airworthiness Management Organisation (CAMO). The latter is tasked with issuing work orders to maintenance workshops in compliance with the aircraft maintenance programme. It also has to ensure the applicability of Airworthiness Directives (AD) and SBs or any other procedure required to maintain aircraft airworthiness.

Between 2012 and 2019, two CAMOs succeeded each other from 2012 to the end of 2014 and from the start of 2015 up to the date of the accident.

2.7.1 Interview with CAMOs

The telephone interview with the two CAMOs shows that they clearly knew about the MSB but that, given the information at their disposal in terms of the helicopter operating conditions, they thought that the helicopter (equipped with a sand filter) had flown in a non-dusty environment. Because of this, in accordance with the MSB, the standard maintenance programme was applicable and only the blade wear check was performed during the engine's 750-hour inspections.

2.7.2 Examination of the laterite

The sample analysed by the Institute of Mineralogy, Materials Physics and Cosmochemistry (IMPMC) is typical of a laterite-type ferralitic soil. These ferralitic soils cover approximately 40% of Madagascar's surface. The laterite analysed was wholly compatible with that widely found in Madagascar. However, it was not possible to completely rule out that the laterite found came from somewhere other than Madagascar.

3 - CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation. They are not intended to apportion blame or liability.

Scenario

The separation of some of the laterite that had built up in the hollow shaft of the engine's module 3 and that had not been detected during the previous years of engine operation, caused an imbalance on the engine's rotating parts. This imbalance caused damage to the gas generator rear bearing and the generation of chips, which triggered illumination of the MOT.LIM indicator light.

Faced with this warning when flying over a hostile mountainous region, the pilot initially attempted to reach Megève mountain airfield located a few flight minutes away. With the engine's condition rapidly deteriorating during the descent, the pilot reduced the engine power to spare the engine and initiated an autorotation to land in an area clear of obstacles in the vicinity of Col de Véry. The pilot pulled on the collective pitch lever when approaching the ground during the flare. This latter action resulted in a rapid decrease in the rotation speed of the main rotor. The nose-up action on the cyclic pitch stick during the flare caused the rotor disk to tilt backwards and to subsequently come into contact with and damage the top of the tail boom.

Contributing factors

The build-up of laterite in the hollow shaft of module 3 shows that the engine installed on the helicopters had operated in a dusty environment and very probably for a prolonged period of time given the amount of laterite that was found during the examination of the engine. The incorrect assessment by the successive approved Continuing Airworthiness Management Organisations (CAMO) of the environment in which the engine had operated did not enable a frequency for cleaning the hollow shaft of module 3 to be implemented, as specified in Mandatory Service Bulletin (MSB) A292 72 0230 version C. In the absence of a periodic inspection, the laterite was able to build up.

Determining the cleaning frequency of the hollow shaft of module 3 depends on the helicopter operating conditions. With the CAMO responsible for initiating the implementation of the MSB and associated procedures, the determination of a cleaning frequency (and therefore the implementation of the MSB) by the CAMO requires pilots, operators and aircraft operators to be aware of the importance of notifying the CAMO of the exposure-to-dust time, mission changes and flight conditions encountered. It is very likely that this communication between the different stakeholders did not take place or was incomplete and led the successive CAMOs to underestimate the conditions in which the helicopter had flown over these years.