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Swiss Transportation Safety Investigation Board STSB

Interim Report by the Swiss Transportation Safety Investigation Board STSB

concerning the serious incident involving the helicopter Guimbal Cabri G2, HB-ZPU,

on 26 June 2021

Bola, Lostallo (canton of Graubünden), Switzerland

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General information on this report

This interim report from the Swiss Transportation Safety Investigation Board (STSB) was prepared further to article 44 of the Ordinance of 17 December 2014 on the Safety Investigation of Transport Incidents (OSITI), version as at 1 February 2015 (SR *742.161*).

In accordance with article 3.1 of the 10th edition, applicable from 18 November 2010, of Annex 13 to the Convention on International Civil Aviation of 7 December 1944, and article 24 of the Federal Act on Civil Aviation (AviA; SR 748.0) of 21 December 1948 (version as at 1 August 2021), the sole purpose of an investigation into an aircraft accident or serious incident is to prevent further such accidents and incidents. The legal assessment of the circumstances and causes of aircraft accidents and serious incidents is expressly excluded from the scope of the aircraft accident investigation. It is therefore not the purpose of this report to determine blame or to determine liability.

Should this report be used for purposes other than those of accident prevention, this statement must be given due consideration.

The German version of this report is the original and is therefore definitive.

Unless otherwise indicated, all information relates to the time of the serious incident.

Unless otherwise indicated, all times in this report are stated in local time (LT). For the region of Switzerland, Central European Summer Time (CEST) was the local time at the time the serious incident occurred. The relationship between LT, CEST and coordinated universal time (UTC) is: LT = CEST = UTC + 2 hours.

Summary

Aircraft model	Guimbal Cabri G2				HB-ZPU
Operator	Air Evolution Ltd., CH-6527 Lodrino				
Owner	MP Aviation SA, via Canova 9, CH-6900 Lugano				
Flight instructor	Swiss citizen, born 1988				
Licence	Commercial Pilot Licence Helicopter (CPL(H)) in compliance with the standards of the European Union Aviation Safety Agency (EASA), issued by the Federal Office of Civil Aviation (FOCA)				
Flying hours	**total**	1179:55	**during the past 90 days**		80:35
	in the model concerned	610:12	**during the past 90 days**		66:09
Trainee pilot	Swiss citizen, born 2002				
Licence	None				
Flying hours	**total**	11:29	**during the past 90 days**		11:29
	in the model concerned	11:29	**during the past 90 days**		11:29
Location	Bola, municipality of Lostallo (GR)				
Coordinates	734 172 / 128 754 (*Swiss Grid* 1903) N 46° 17’ 48’’ / E 009° 10’ 48’’ (WGS[1] 84)		**Altitude**		401 m AMSL
Date and time	26 June 2021, 09:55				
Type of operation	Training				
Flight rules	Visual Flight Rules - VFR				
Origin	Lodrino (LSXR)				
Destination	Lodrino (LSXR)				
Flight phase	Cruising				
Nature of serious incident	Drop of main rotor speed				

Personal injury

Injuries	Crew members	Passengers	Total no of occupants	Third parties
Fatal	0	0	0	0
Serious	0	0	0	0
Minor	0	0	0	0
None	2	0	2	n/a
Total	2	0	2	0

Damage to aircraft	Not damaged
Third-party damage	Not applicable

[1] WGS: *World Geodetic System*: The WGS 84 standard was adopted for aviation in 1989 by resolution of the International Civil Aviation Organization (ICAO).

1 Factual information

1.1 Background and history of the flight

1.1.1 General

The following information has been available to date as a basis for the investigation:

- Information by the flight crew;
- Data stored by the electronic pilot monitor (EPM);
- Technical investigation of the helicopter.

1.1.2 Background

The Guimbal Cabri G2 helicopter, registered as HB-ZPU, entered service at the beginning of 2021 at Air Evolution Ltd. and was used primarily for pilot training.

Crews noticed from the beginning that, when starting the engine and in normal operation, the oil pressure was always displayed within the permitted range, but at its upper end.

As part of the first 100 hours inspection after the aircraft entered service, the aircraft maintenance company reduced the oil pressure by approximately 0.6 bar, in accordance with the engine manufacturer's specifications.

In the subsequent test run on the ground, the oil pressure was displayed in the centre of the permitted range on the gauge. The helicopter then re-entered service.

1.1.3 Description of the serious incident

On the morning of 26 June 2021 the crew, consisting of a flight instructor and a trainee pilot, met to prepare a training flight. On the programme for the flying lesson were the introduction of navigation, and off-field landings in the Misox area. This was the first flight after the 100 hours inspection.

After approximately 45 minutes' flying time, during which a range of exercises and one off-field landing at Soazza had been performed, the crew decided to set off on the flight back to Lodrino.

As the helicopter was flying at an altitude of approximately 2,500 ft AMSL, cruising above Lostallo, the clutch light flickered on. After a further approximately 10 seconds, during which the flight instructor also noticed yaw movement by the helicopter and drop in the main rotor speed, a so called needle split,[2] the clutch light remained steady on. In response, the flight instructor commenced an autorotation to a suitable field. When levelling off and performing a flare with power recovery, the flight instructor once again notice a needle split, in which the speed of the main rotor dropped to the bottom of the permitted operating range in relation to engine output (see Figure 1).

[2] A *needle-split* is a colloquial way of describing were the instrument indicators for engine and rotor speed do not match each other, i.e. they are decoupled.

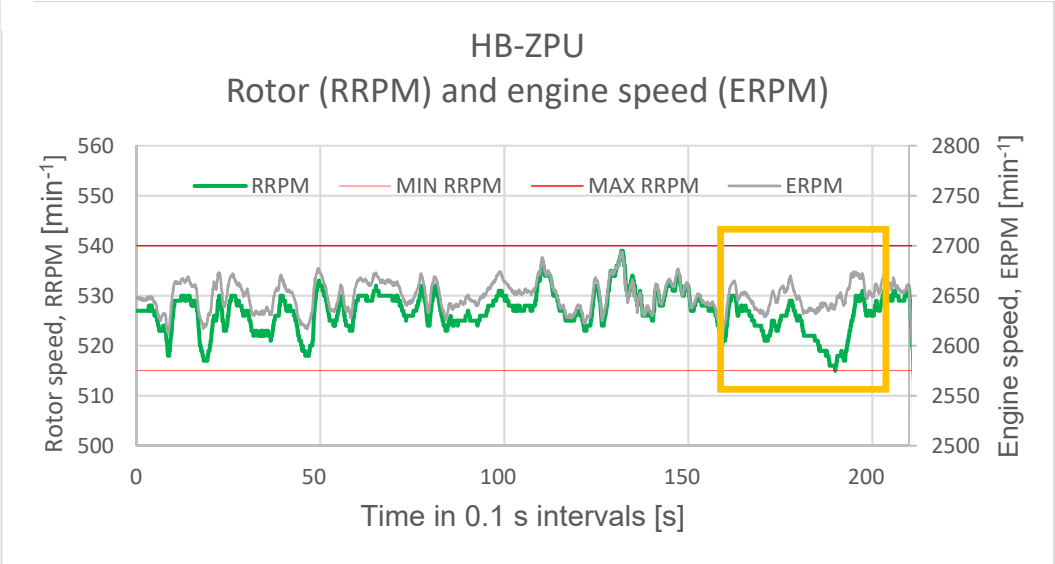

Figure 1: Illustration of rotor revolutions per minute (RRPM) and engine revolutions per minute (ERPM) prior to and during the serious incident. The needle split is especially visible from 160 s onwards, when it was noticed by the crew (orange square).

In this phase the crew heard grinding noises from the drive belt, as are also typical when starting this type of helicopter.

The helicopter then touched down without incident, but the lack of RRPM meant that the pilot was no longer able to apply full engine power and it became impossible to continue the flight.

1.2 Information on the aircraft

1.2.1 General information

Registration mark	HB-ZPU
Aircraft model	Hélicoptères Guimbal Cabri G2
Characteristics	Single-engine light helicopter with two seats and skid landing gear, three-blade main rotor, Anti-torque system with enclosed tail rotor
Manufacturer	Hélicoptères Guimbal, Aix-en-Provence (F)
Year of manufacture	2020
Serial number	1276
Engine	Lycoming Engines O-360-J2A, air-cooled four-cylinder boxer engine, works number L-43578-36E, built 2020, maximum take-off power for five minutes 119 kW (160 HP at 2700 RPM), maximum continuous power 108 kW (145 HP at 2700 RPM).
Operating hours	Airframe 110:36 (TSN[3])
	Engine 110:36 (TSN)
Max. permissible take-off mass	700 kg

[3] TSN: time since new

Mass and centre of gravity	The mass of the helicopter at the time the serious incident occurred was 638 kg. Both the mass and the centre of gravity were inside permissible limits as per the aircraft flight manual.
Maintenance	The most recent scheduled maintenance work was conducted on 23 June 2021 at 109:30 hours.
Modifications	Engine modified by Hélicoptères Guimbal: Modification no J45-002 (STC EASA 10015311 rev. 3, initially EASA.E.S.01001)

1.2.2 Functioning of the drive belt tensioning system (clutch system)

Power is transmitted between the engine and the main gearbox via a drive belt. For the engine to be able to start, it must be decoupled from the main gearbox. This is achieved by loosening the tension of the drive belt.

The belt is then tensioned by taking pressurised oil from the engine through a restrictor and non-return valve into a hydraulic cylinder. This moves the engine around the axis of the engine mount, increasing the distance between the belt pulleys on the engine and main gearbox and tightening the drive belt.

Oil pressure is maintained using a non-return valve. The yellow clutch light goes off to notify the crew that the minimum drive belt tension has been reached. The threshold value for this clutch light is set at 3.6 bar (see Figure 2).

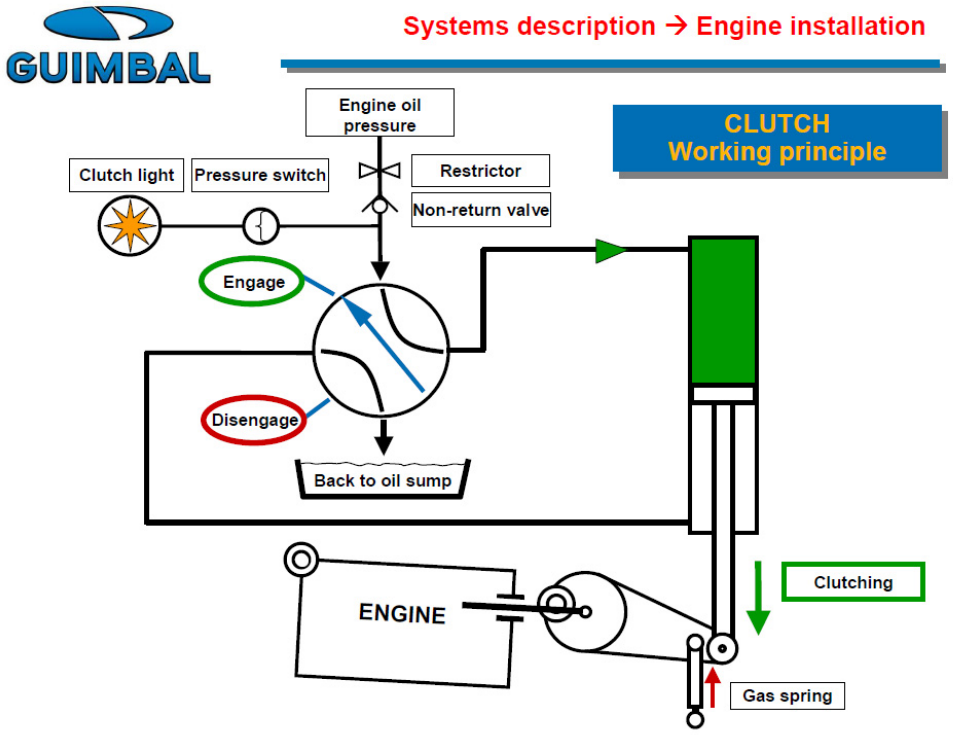

Figure 2: Illustration of the drive belt tensioning system (Source: Hélicoptères Guimbal training documentation)

1.2.3 Setting the oil pressure for the engine lubrication system

The oil pressure sensor pick-up point and the pick-up point for the feed to the hydraulic cylinder used to tension the drive belt are found at two separate locations on the engine's accessory housing (see Figure 3).

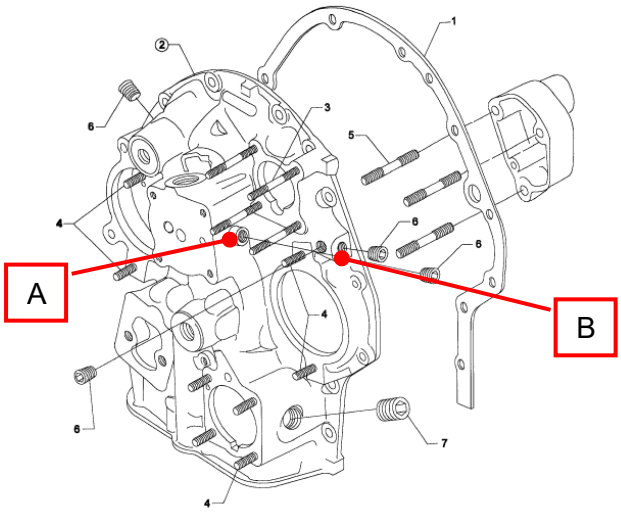

Figure 3: Accessory housing: (A) marks the oil pressure sensor pick-up point, (B) the installation point for the restrictor and simultaneously the pick-up point for oil flow through to the clutch system (Source: Lycoming Engines, Illustrated Parts Catalog)

With Lycoming engines, the engine oil pressure is set after production during the test run. Oil pressure is measured at pick-up point (B), without the restrictor (see Figure 3).

If the oil pressure needs to be reset or adjusted during subsequent operations, the value is read off the EPM. In the Cabri G2 model, the oil pressure sensor pick-up point is located at position (A) on the accessory housing (see Figure 3).

1.3 Technical findings

The helicopter inspection produced the following findings:

- The settings and values read from the sensor system (oil pressure gauge, oil pressure switch, clutch light oil pressure switch) corresponded to specifications;
- The restrictor was removed and examined. The nominal diameter of 1 mm and the free flow of oil were checked. Both corresponded to specifications;
- There was a difference of around 2 bar (see Figure 4) between the oil pressure displayed on the EPM, measured by STSB with an additional manometer between pick-up point (A) on the accessory housing, and pick-up point (B) downstream of the restrictor (see Figure 3).

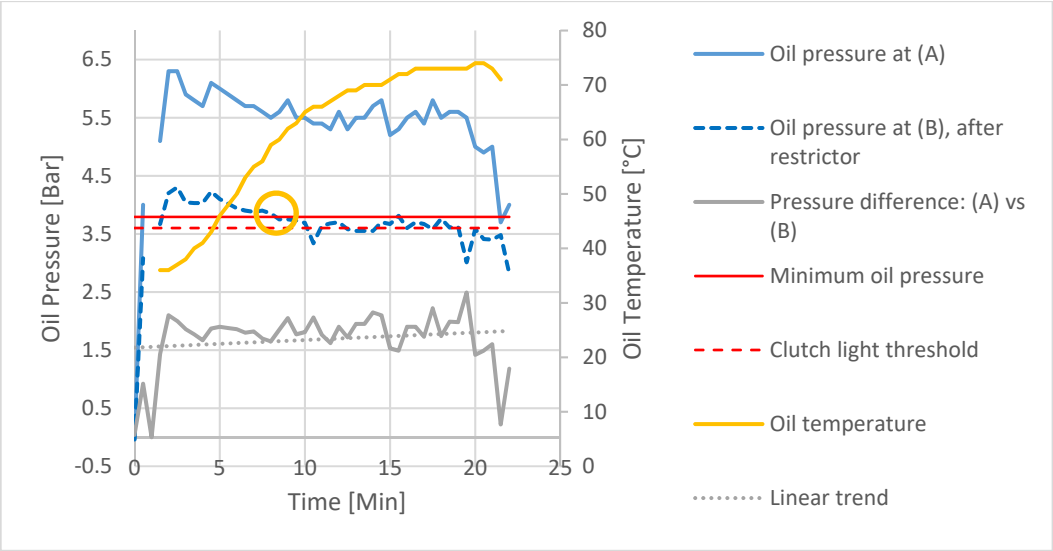

Figure 4: Oil pressures at the two pick-up points (A) and (B) during a ground run. The graph shows clearly how, from minute 8:30 of the trial onwards, the oil pressure at the pick-up point for the clutch system falls slightly below the minimum permissible operating pressure for continuous operation of 3.8 bar. It is also striking that the difference in pressure tends to widen at a higher oil temperature.

Lycoming Engines notified Hélicoptères Guimbal that free through flow and foreign object damage between the two pick-up points (A) and (B) should be checked, specifically where the oil duct turns at a virtual right angle (see Figure 5).

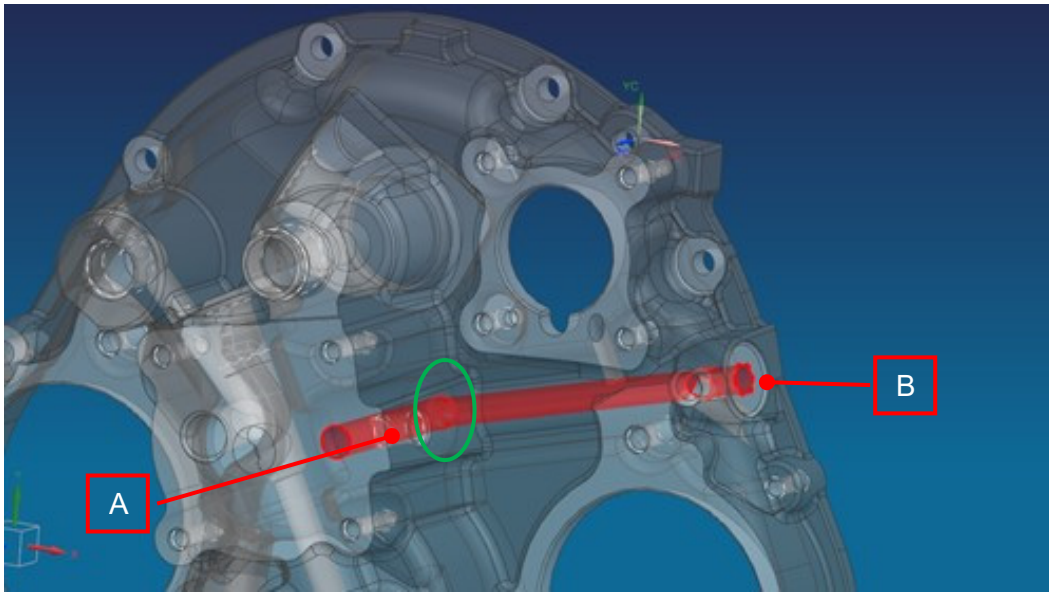

Figure 5: Three-dimensional illustration of the oil duct in the accessory housing. The green circle shows the area to be inspected. (A) and (B) are the two aforementioned pick-up points. The restrictor is installed at (B) (Source: Hélicoptères Guimbal, Lycoming Engines)

A borescope examination of this area showed that the central axes of the passages in question were not fully centred, meaning that the point of intersection had a reduced pass through section. Machining chips and non-deburred edges could also be seen (see Figure 6, left-hand picture).

Another engine, built in 2017, that had not shown any anomalies in operation also underwent a borescope examination to provide a comparison (see Figure 6, right-hand picture).

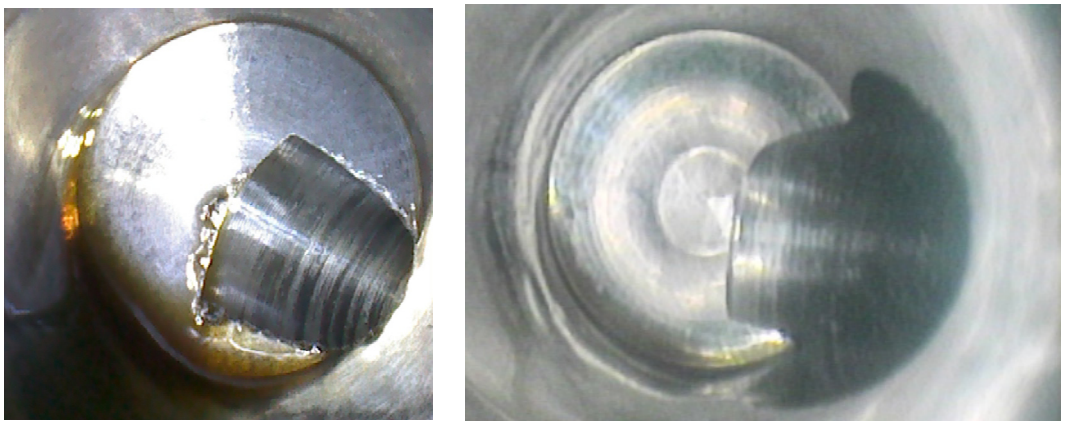

Figure 6: Passages for engine oil feed (see Figure 5, area circled in green). The left-hand picture was taken during the borescope examination of the HB-ZPU engine. The right-hand picture shows the same area on another Cabri G2 that did not show any anomalies.

The helicopter manufacturer conducted random borescope examinations of installation-ready engines in its production line, with similar findings as the ones made by the STSB.

Another helicopter in Switzerland of the same type as HB-ZPU displayed similar problems. Here, too, a borescope examination produced similar findings.

The engines that had been inspected and found faulty up to the publication date of this interim report were all constructed in 2020 and 2021.

The engine manufacturer stated that the intersection point with the reduced section does not represent a problem for the engine operation, as far as the lubrication is granted by means of a correct setting of the oil pressure relief valve.

To date operators had not been instructed by any Airworthiness Directive (AD) or manufacturer Service Bulletin (SB) to conduct any engine inspection.

2 Analysis

2.1 Technical aspects

2.1.1 Lycoming Engines O-360-J2A engine

Oil circulates through the duct in the accessory housing from the oil filter towards the main housing. This oil flow has multiple function: to lubricate and cool the engine, and to engage the clutch system.

The borescope examination of this area found a narrowed section in the duct and also observed chips and non-deburred drill holes. No assessment can be made of whether chips had broken loose and entered the oil system in the course of operation to date. In the present case, STSB estimates the cross-section of this passage was approximately 25–30 % of that of the full cross-sectional area for this channel. In this case, the narrowed section reduced the pressure between the two ends of the duct, as measured after the restrictor, by about 2 bar. This resulted in the pressure going into the engine lubrication system and at the pick-up point for the clutch system falling below the 3.8 bar threshold for normal operations after a certain time. This is due to the reduction in viscosity when temperature rises. At times this pressure even fell below 3.6 bar, which is the threshold at which the tensioning system operates.

Before this interim report was published a similar anomaly in the same duct was found in further engines from the 2020 and 2021 series. These were all engines used on Cabri G2. However, since the O-360 engine series is also very widely used in other types of aircraft, as things stand it cannot be ruled out that other aircraft might be affected by this problem.

Lycoming Engines states that the irregularities found in the cross-section and in manufacturing are not relevant to safe engine operation.

In the Cabri G2 helicopter model, the engine oil is also used to engage the drive belt tensioning system, passing through a restrictor with a diameter of 1 mm. This through flow may be partly or wholly obstructed by tiny chips of metal. In an essential system such as power transmission between engine and rotor this represents a considerable risk.

Since no airworthiness directive or other publication were sent to the operators of these engines prior to the issue of this interim report, and the problem is not familiar to aircraft maintenance companies, the STSB issues three safety recommendations.

2.1.2 Drive belt tensioning system

The operating pressure of the oil in the clutch system is maintained by means of a non-return valve. It is monitored by a pressure switch that turns off the clutch light at a pressure of 3.6 bar or above, and switches it on again if the pressure falls below that threshold.

Oil is cold and highly viscous during the engine starting and coupling process, so its pressure is higher than in normal operations until after the warm-up phase.

In this case, pressure built up in the tensioning system was enough to extinguish the warning light and to transmit power to the main gearbox and rotors correctly via the drive belt. Pressure was then very nearly maintained by the return valve, even though the now-warm engine was no longer delivering sufficient oil pressure to keep the drive belt tensioned. After a certain time, the pressure contained by the non-return valve fell so far that the drive belt was no longer able to transmit power

to the rotors and a loss of the rotor RPM happened, prompting the crew to enter autorotation.

2.1.3 Indication and warning system in the Guimbal Cabri G2

The lines measuring the oil pressure in the engine and feeding oil to the clutch system were attached at two separate pick-up points on the engine. The pressure sensor pick-up point was located upstream of the narrowed section in the oil duct. The EPM thus showed the level as within the normal range.

The pick-up point for the feed into the clutch system was located downstream of the narrowed section in the oil duct, close to the point the oil flows into the lubrication system which resulted in a pressure reduced by approximately 2 bar. This lack of pressure going into the clutch system was not measured or shown on the EPM, so the crew could not have been aware of it.

The clutch light went on when the pressure in the tensioning system fell below 3.6 bar. Below this pressure the drive belt is no longer able reliably to transmit power, so that engine revs and rotor revs become decoupled. This is known as a needle split.

In the course of the inspection the helicopter manufacturer recognised this safety deficit, responding on 20 August 2021 by issuing Service Bulletin No 21-014 A, '*Engine Oil Pressure Sensor Pick-up Point Change*'. This provides for the modification of the corresponding oil pressure measurement pick-up points. With this modification, the engine oil pressure displayed on the EPM corresponds to the one at the pick-up point for the clutch system.

2.2 Human and operational aspects

Further information will be given in the final report.

3 Conclusions

3.1 Findings

Further information will be given in the final report.

3.2 Causes

In order to achieve its objective of prevention, a safety investigation authority must express its opinion on risks and hazards that have been identified during the investigated incident and that should be avoided in the future. In this sense, the terms and formulations used below are to be understood exclusively from the prevention perspective. The identification of causes and contributory factors does not, therefore, in any way imply blame or determination of administrative, civil or criminal liability.

Further information will be given in the final report.

4 Safety recommendations, safety advice and measures taken since the serious incident

4.1 Safety recommendations

In accordance with international[4] and national[5] legal bases, all safety recommendations are addressed to the supervisory authority of the competent state. In Switzerland, this is the Federal Office of Civil Aviation (FOCA), or the supranational European Union Aviation Safety Agency (EASA). The competent supervisory authority must decide on the extent to which these recommendations are to be implemented. Nonetheless, each agency, organisation and individual is invited to strive to improve aviation safety in the spirit of the safety recommendations expressed.

The STSB shall publish the answers of the relevant federal office or foreign supervisory authorities at http://www.sust.admin.ch, to provide an overview of the current implementation status of the relevant safety recommendation.

4.1.1 Finishing of drilled oil feed passages in the Lycoming Engines O-360 series

4.1.1.1 Safety deficit

The crew of a Guimbal Cabri G2 helicopter constructed in 2020, equipped with a Lycoming Engines O-360-J2A engine that was also manufactured in 2020, performed an autorotation following a drop in engine oil pressure that resulted in too little tension on the drive belt and thus a reduction in rotor speed.

The subsequent investigation showed a narrowed section, as well as chips and non-deburred drilling work in one of the oil ducts in the accessory housing. An inspection of further engines constructed in 2020 and 2021 revealed similar findings.

It may therefore be assumed that further O-360 series engines will display similar shortcomings that, depending on use, might result in a considerable risk during flight operations.

4.1.1.2 Safety Recommendation No 578

The European Union Aviation Flight Safety Agency (EASA) should take appropriate action to ensure that all operators of O-360-series Lycoming Engines identify and remedy narrowed sections of the oil duct in the accessory housing caused by possible manufacturing deficiencies.

4.1.1.3 Safety Recommendation No 579

The US Federal Aviation Administration (FAA) should take appropriate action to ensure that all operators of O-360-series Lycoming Engines identify and remedy narrowed sections of the oil duct in the accessory housing caused by possible manufacturing deficiencies.

[4] International Civil Aviation Organization (ICAO) Annex 13 and article 17 of Regulation (EU) No 996/2010 of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation and repealing Directive 94/56/EC.

[5] Article 48 of the Ordinance on the Safety Investigation of Transport Incidents (OSITI) of 17 December 2014, version as at 1 February 2015 (SR *742.161*)

4.1.1.4 Safety Recommendation No 580

The US Federal Aviation Administration should take appropriate action to ensure that engine manufacturer Lycoming Engines takes the proper steps to remedy the manufacturing deficiencies that have been identified.

4.2 Safety advice

The STSB may publish general relevant information in the form of safety advice[6] if a safety recommendation in accordance with Regulation (EU) No. 996/2010 does not appear to be appropriate, is not formally possible, or if the less prescriptive form of safety advice is likely to have a greater effect.

None

4.3 Measures taken since the serious incident

The measures taken, of which the STSB is aware, are mentioned below without further comment.

On 20 August 2021, helicopter manufacturer Hélicoptères Guimbal issued Service Bulletin No 21-014 A, which provides for the modification of the engine oil pressure sensor pick-up points.

This interim report was approved by the Board of the Swiss Transportation Safety Investigation Board (STSB) (Art. 10 lit. h of the Ordinance on the Safety Investigation of Transportation Incidents of 17 December 2014).

Bern, 21st September 2021 Swiss Transportation Safety Investigation Board

[6] Article 56 of the Ordinance on the Safety Investigation of Transport Incidents (OSITI) of 17 December 2014, version as at 1 February 2015 (SR *742.161*)