Bundesstelle für
Flugunfalluntersuchung

German Federal Bureau of
Aircraft Accident Investigation

Investigation Report

Identification

Type of Occurrence:	Accident
Date:	26 July 2016
Location:	Senheim
Aircraft:	Helicopter
Manufacturer / Model:	MD Helicopters Inc. / HU 369E
Injuries to Persons:	Pilot slightly injured
Damage:	Aircraft severely damaged
Other Damage:	None
State File Number:	BFU16-1037-3X

Factual Information

History of the Flight

On the day of the accident the pilot conducted several vineyard spraying flights during the morning. After a break of several hours, in the afternoon he conducted another flight with a HU 369E helicopter above the vineyard at the eastern shore of the river Mosel in the vicinity of the towns of Mesenich and Senheim.

The pilot stated that after he had refuelled and filled up with spraying agent for the last planned flight of the day, at 1602 hrs[1], after approximately one minute in flight,

[1] All times local, unless otherwise stated.

during the approach of the spraying area the following occurred: sudden bang, massive loss of engine power, indication of warning lights, and sounding of the engine-out warning horn. Then he immediately initiated autorotation in low altitude and turned parallel to the slope.

With low horizontal velocity he touched down on the slope, which declined by about 40°. The helicopter slid down the slope by about 20 m and came severely damaged to a stop standing upright on a street opposite the flight direction.

The pilot was able to disembark having suffered only slight injuries.

Overview flight path and local conditions — Source: BFU/Google Earth™

Overview accident site and final position of the helicopter Source: BFU

Personnel Information

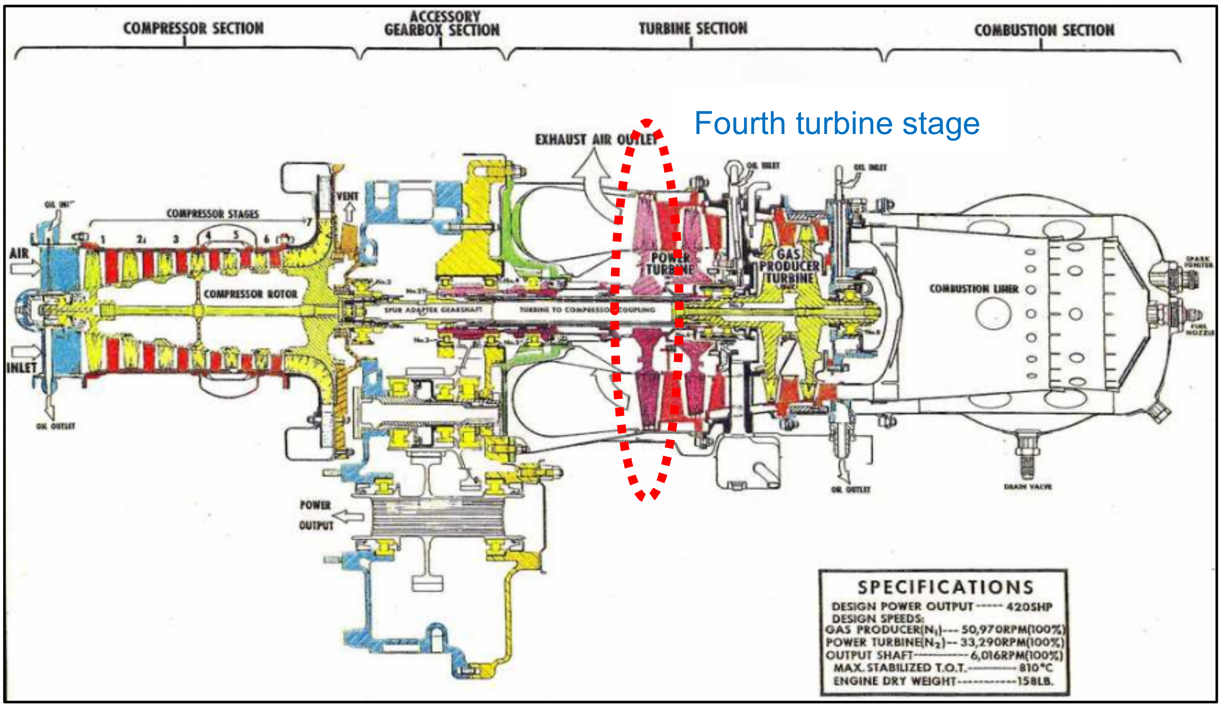
The 34-year-old pilot held a Commercial Helicopter Pilot's Licence (CPL(H)) issued in accordance with Part FCL. The license listed the type rating as Pilot in Command (PIC) for HU369/MD500N/600N. He held a class 1 medical certificate without restrictions; valid until 17 March 2017.

He had a total flying experience of about 2,010 hours. Since he acquired the type rating in March 2016 he had flown about 84 hours on type.

Aircraft Information

The single-engine helicopter HU 369E, manufactured by MD Helicopter Inc. (MDHI), is a lightweight multi-purpose helicopter for up to five occupants. In 1982 the helicopter type was certificated in accordance with CAR 6. The helicopter propulsion system features a five-blade rotor and an anti-torque tail rotor, powered by a Rolls-Royce M250-C20R/2 turboshaft engine. The helicopter was equipped with landing skids. Maximum take-off mass is 1,360 kg.

Since 1962 the American Rolls-Royce M250-C20R/2 engine (former Allison M250-C20) is a widespread two-shaft engine, which different manufacturers install mostly in single and twin-engine helicopter types. The engine manufacturer stated that more than 31,000 engines were produced; of which presently about 16,000 are in civil and military use.



Engine structure and position of the fourth turbine stage Source: Allison

In 1999, all new production engines were fitted with an enhanced power turbine assembly which improved power and fuel efficiency (Service Bulletin (SB) CEB-1365). At the end of 1999, the enhanced power turbine assembly was also offered as an option for older engines. Since August 2009 only this type of power turbine was produced. The manufacturer estimates that at present about 3,800 enhanced CEB-1365 power turbines are in service. It is further estimated that approximately 900 of them were installed in MDHI helicopters.

The accident helicopter was built in 1989 and had the manufacturer's serial number 0362E. The empty weight was about 790 kg. The last annual airworthiness inspection was conducted on 26 August 2015. The last 100-hour check occurred on 6 July 2016 and the corresponding acceptance flight and power check were conducted on 8 July 2016. At the time of the accident, the helicopter had a total of approximately 10,471 operating hours. The helicopter was equipped for crop dusting operation in vineyards. The spraying equipment used was ISOLAIR 3700.

The Rolls-Royce M250-C20R/2 engine with the manufacturer's serial number CAE-295214 had a total operating time of approximately 9,674 hours. The last 300-hour inspection was conducted on 3 June 2016 at an operating time of 9,541 hours. The last 100-hour inspection was documented on 6 July 2016 at an operating time of 9,630 hours. According to the report dated 12 July 2016, about 40 operating hours before the accident, a pilot had noticed power loss of the engine (increase in exhaust gas temperature) during work assignment. Subsequently, the engine was checked and a power check conducted. No deficiencies were found. The exhaust gas temperature indicator was replaced.

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE-295214	23035212	Not Applicable	9674
Gearbox	CAG-15450	23035185	Not Applicable	2908
Compressor	CAC-15543	23050833	232	3705
*Turbine	CAT-15218	23073352	1635	9406
Fuel Control	BR53847	23070609	309	Unknown
Governor	BR32431	23065121	820	Unknown
Fuel Pump	T100575	6899253	1737	5737
Fuel Nozzle	AG27284	23077068	1335	Unknown
Bleed Valve	FF54185	23073207	309	Unknown

* NOTE: The 4th-stage wheel was a post-service bulletin (SB) commercial engine bulletin (CEB)-1365 "enhanced" turbine assembly configuration. The part number was 23055944 and the serial number was X595990. The subject 4th-stage wheel was installed new during the turbine overhaul in 2013. It had accumulated a total of 1635 flight hours and 1129 cycles prior to the accident flight.

Operating times of the engine components Source: Rolls-Royce

Meteorological Information

According to the aviation routine weather report (METAR) of Buchel Military Airport (ETSB), located about 8 Nautical Miles (NM) north-west of the accident site, the following weather conditions were observed 18 minutes after the accident:

Wind velocity was 300°, 6 kt. Ground visibility was more than 10 km, scattered clouds (SCT) at 2,000 ft and at 4,000 ft. Temperature was 21°C and the dewpoint 16°C. Barometric air pressure (QNH) was 1,021 hPa.

Aerodrome Information

The area for refuelling and filling up with spraying agent was located about 1,400 m north of the accident site.

Flight Recorder

The helicopter was not equipped with a Flight Data Recorder (FDR) or a Cockpit Voice Recorder (CVR). There were no legal requirements for such equipment to be fitted.

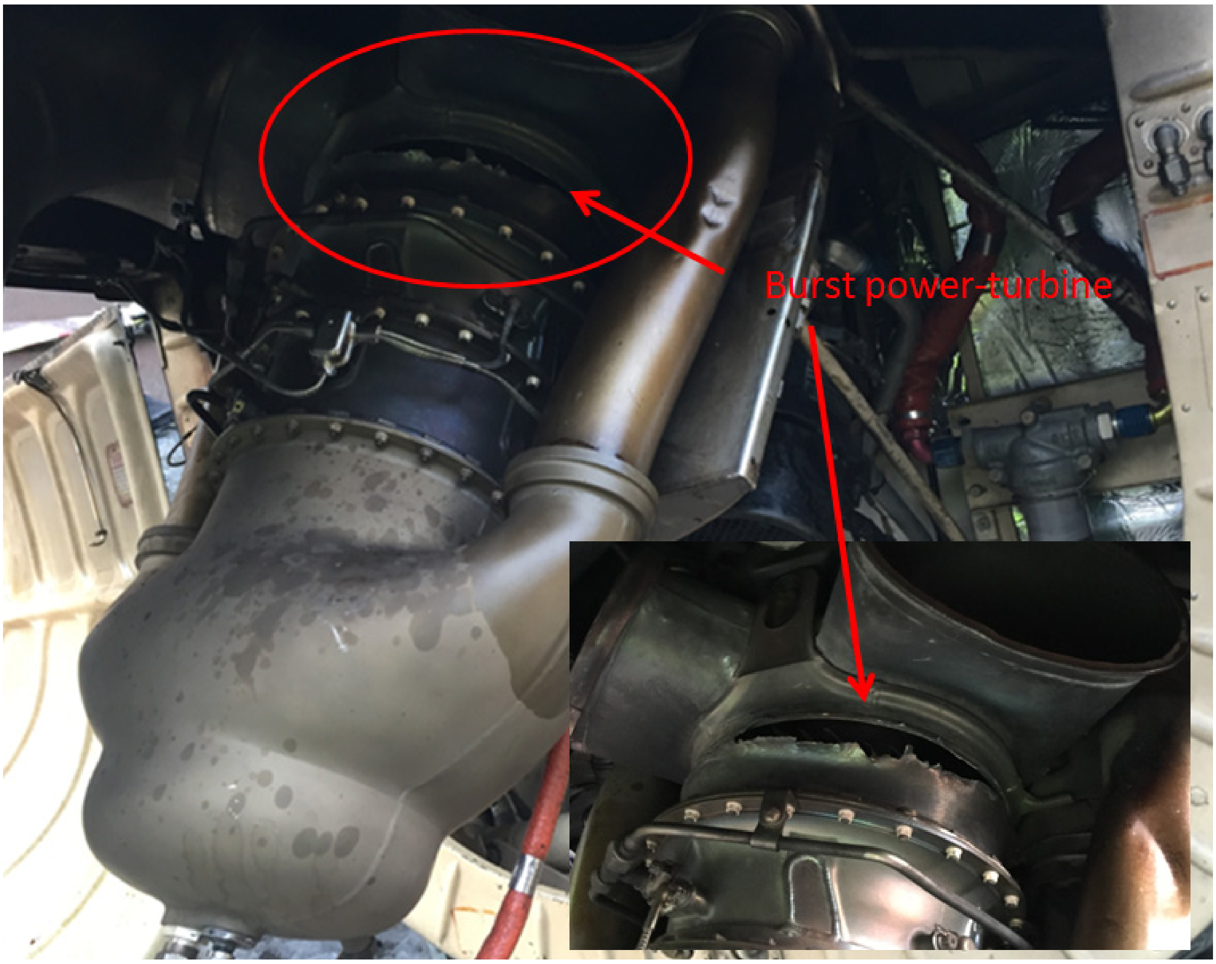
Wreckage and Impact Information

The accident site was located on the eastern outskirts of the town Senheim, Mosel. The helicopter stood upright on the fuselage surface on the street "Im Kalmet" pointing toward approximately 50°.

The left skid was found at the slope at the impact site. Between the impact site at the slope and the final position of the wreckage the tail skid, fairing pieces and fracture pieces of the cockpit were found. The tail boom had been torn off and was lying in the street next to the fuselage. The right skid had fractured and its front part penetrated the cockpit. The rotor blades were bent. The spraying agent tanks had burst open and the spraying beams were bent. Fuel and spraying agent were leaking on to the accident site.

Accident site and helicopter damages Source: BFU

The external surface of the right fuselage side above the engine was coated with a brown film (soot). The paint of the engine bay doors was discoloured which is consistent with contact by hot exhaust gases. The right side of the fuselage by the engine bay exhibited multiple holes in the plane of the engine power turbine, the edges of which were ‘petalled’ outwards. The engine had sustained an uncontained internal failure in the plane of the power turbine.



Damages in the area of the engine doors and on the turbine Source (2): BFU

The engine was removed from the aircraft and sent to the manufacturer in USA for further examination.

The disassembly of the engine occurred on 20 October 2016 at the engine manufacturer's facilities under supervision of the National Transportation Safety Board (NTSB). The examination revealed that the cause for the engine failure was a high-cycle fatigue fracture of one blade of the 2nd stage power turbine (or 4th stage turbine) wheel.

Summary of Findings:

- A single blade on the 4th-stage turbine wheel fractured in fatigue from an origin at the trailing edge approximately 0.036 inch above the rim of the wheel. The fatigue initiated and progressed approximately 0.511 inch in high cycle fatigue before separating in overload. No material anomalies were present at the origin area and no additional fatigue cracks were present in the other blades.

- Damage to the other components received by the laboratory was consistent with secondary damage as a result of liberated blade and/or the imbalance condition caused by the liberation of a fourth stage turbine wheel blade.

- The subject 4th-stage turbine wheel was a post-service bulletin (SB) commercial engine bulletin (CEB)-1365 or "enhanced" turbine assembly configuration.

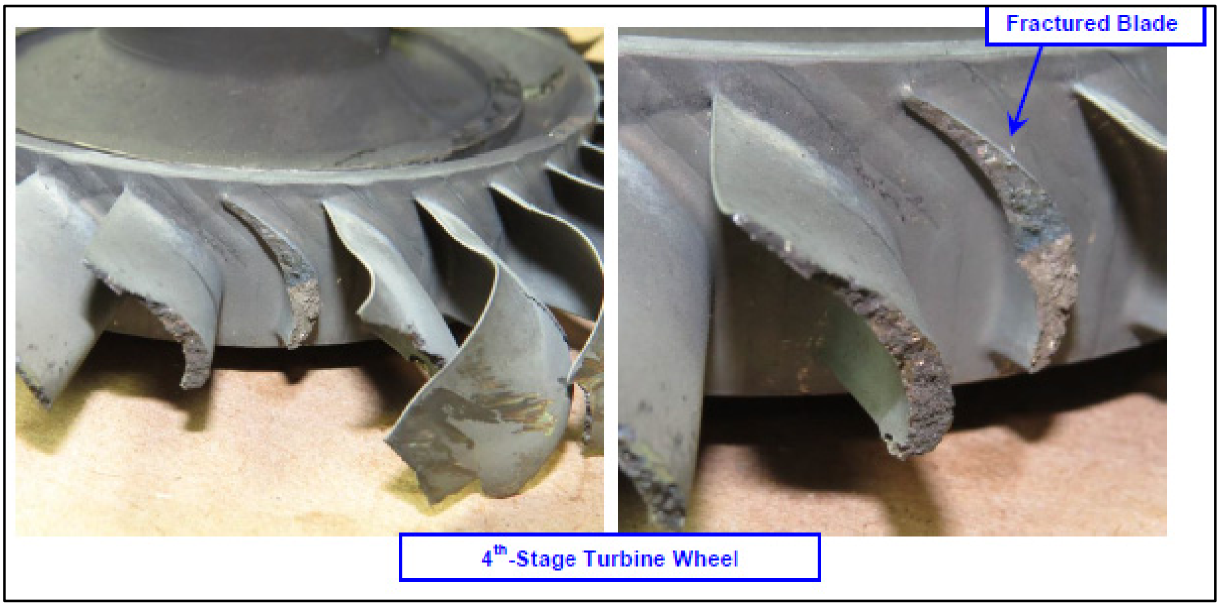
    - An NTSB report dated 20-April-2016 outlines the history of accidents involving Rolls-Royce M250 powered aircraft, specifically MDHI 369 & Bell 206 models, utilizing post-SB CEB-1365 turbine assemblies.

    - The enhanced power turbine section was developed as a product improvement, designed to increase both power and fuel efficiency consisting of changes to the airfoils in the power turbine nozzles and wheels.

    - According to the metallurgical evaluation, the pattern and appearance of the fracture on the subject accident 4th-stage turbine wheel was similar to other post-SB CEB-1365 failures.

Excerpt engine investigation report — Source: Rolls-Royce

4th-Stage Turbine Wheel (leading edge side)



Damages on the fourth turbine stage   Source (2): Rolls-Royce

Fire

There was no fire.

Organisations and their Procedures

The owner of the helicopter was an operator certified by the Luftfahrt-Bundesamt (German civil aviation authority, LBA).

The helicopter operator had a general permission for aerial work with helicopters issued by the Gemeinsamen Oberen Luftfahrtbehörde Berlin-Brandenburg (regional civil aviation authority). The permission was valid, among other things, Item 2.3 aerial work [...] in agriculture, viniculture, and forestry. *[…]*

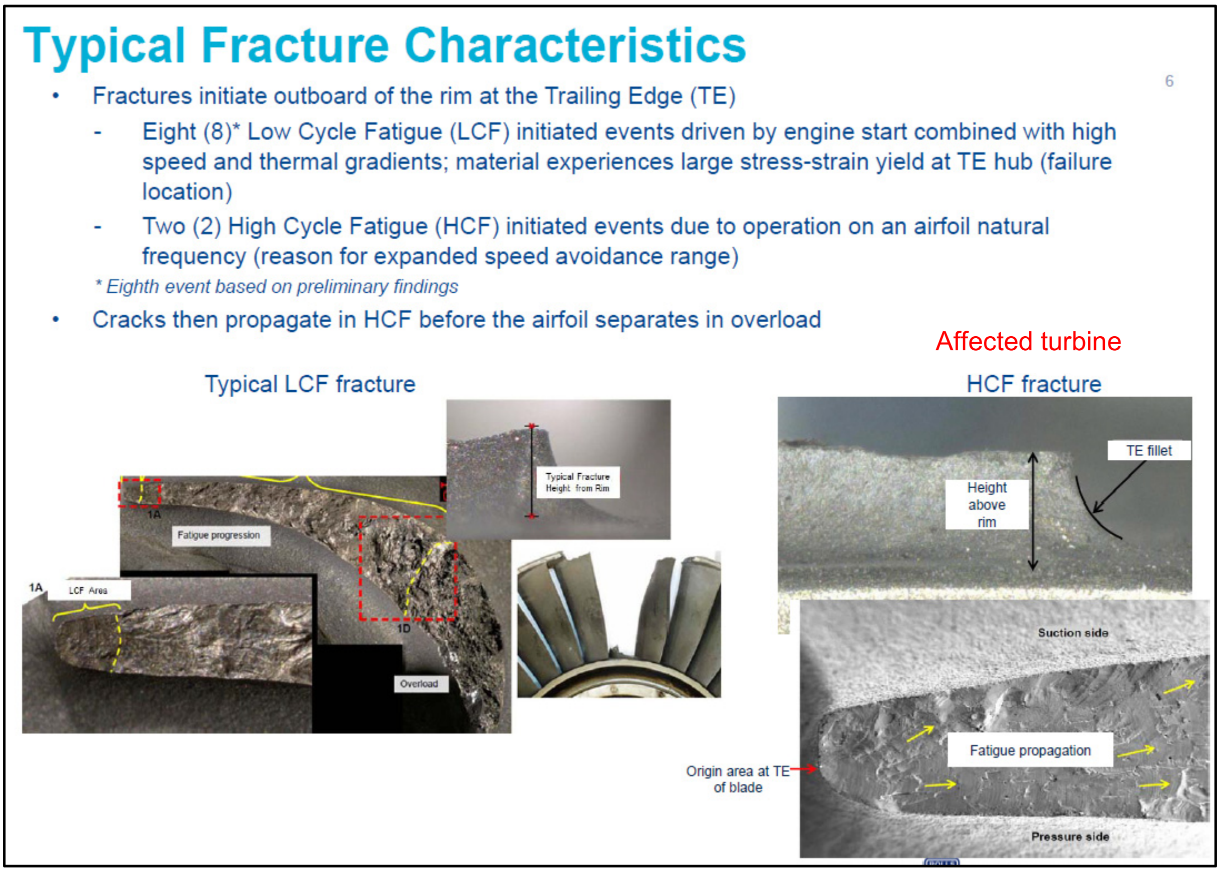
Regarding the approved pilots, the supplementary sheet (5th amendment) to the general permission referred to the effective helicopter pilot's list of the flight operations manual of the company. The corresponding pilot data sheet listed the pilot involved. The accident helicopter was listed in the list of approved helicopters in the supplementary sheet of the general permission.

The customer of the crop dusting flights held an *approval for the use of agricultural pesticides with aircraft in steep-slope viniculture [...]* issued on 27 April 2016 by the Aufsichts- und Dienstleistungsdirektion Rheinland-Pfalz.

In the Flight Operations Manual (FOM, Part A) the company had stipulated procedures for crop dusting operations in viniculture. Among other things, the altitude for aerial work was stipulated with half a rotor diameter and the speed with 0 to about 40 kt.

Additional Information

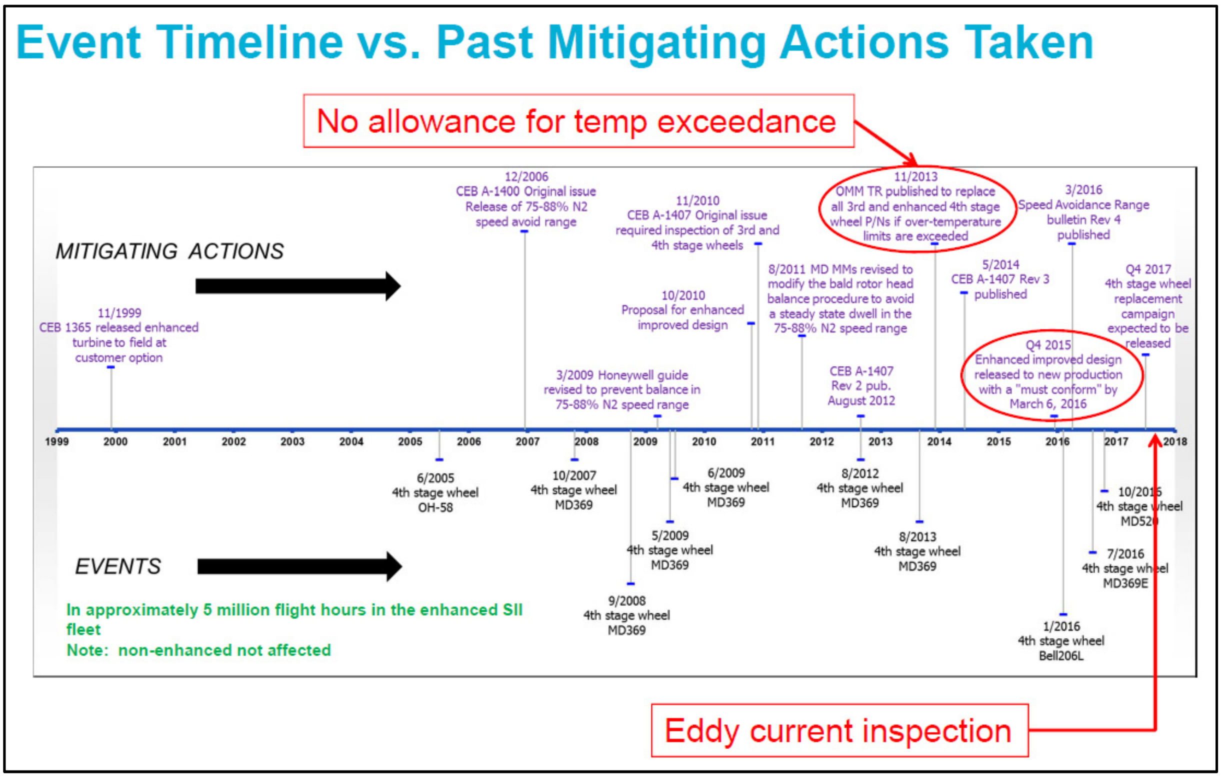
Between 2005 and 2016, seven other accidents occurred with HU369/MD520 (MDHI) helicopters and two with B206/OH58 (Bell) helicopters, all powered with Rolls Royce M250-C20 engines with the SB CEB-1365 enhanced power turbine assembly installed, sustained blade fractures on the third or fourth turbine stages, resulting in a sudden total power loss. So-called low-cycle and high-cycle fatigue fractures in the blade root were identified as causes.



Fatigue fracture development and its cause Source: Rolls-Royce

In 2016 the NTSB published the latest investigation report (file number: WPR13GA374) in which the accidents, the history of the causal SB CEB-1365 enhanced power turbines and the characteristic damage pattern were described. In addition, the corresponding actions of the engine manufacturer Rolls-Royce (Alert SB CEB-A-1400 Stady State Operation Avoidance Range Limit, CEB-A-1407 One-time Inspection of 3rd and 4th Stage Turbine Wheels), of the helicopter manufacturer MDHI (Revision 16 and 17 of the 369E Flight Manual), and the issued Airworthiness Directives (AD 2012-14-06 and AD 2015-02-22) were stated in summary.

Since 2010 the engine manufacturer is making an effort to develop an improved fourth turbine stage. Due to casting problems the first design attempt was stopped in 2013. Since March 2016 the manufacturer produces a newly developed fourth turbine stage and fits new engines with them. Currently it is planned to stipulate through an Airworthiness Directive that beginning at the end of 2017 the old versions of the fourth turbine stage are to be replaced by the new design. In addition, the manufacturer plans to make the already developed eddy current inspection mandatory by the end of 2017 so that installed turbine wheels can be checked for cracks.



Comparison of the occurrences and actions Source: Rolls-Royce

Analysis

At the day of the accident, during the approach for the last planned vineyard spraying flight an engine failure occurred, which forced the pilot to initiate an immediate low altitude autorotation. The helicopter was severely damaged and the pilot injured due to the unsuitable terrain for a successful emergency landing.

The pilot held the licences and ratings required by aeronautical regulations. He had comparably low flying experience on type. It is likely that this had no influence on the course of events due to the outer conditions.

The weather did not limit the aerial flight operation. It was slightly windy with good visibility. The density altitude was about 1,040 ft AMSL and therefore influenced engine thrust only slightly.

In accordance with aeronautical regulations, helicopter and engine had been continuously maintained. Centre of gravity and take-off mass were within the prescribed limits.

The examination of the engine determined that in this case a high-cycle fatigue fracture of one blade of the fourth turbine stage was the cause of the power turbine failure and therefore the engine failure. According to the statements of the engine manufacturer and the NTSB the damage pattern and the development of fatigue fracture correspond with the findings of past investigation of engine failures of the M250-C20 engine series with CEB-1365-enhanced power turbine.

In the experience of the engine manufacturer, such a high-cycle fatigue fracture is caused by temporary operation of the engine in the area of 71% to 88% N2 rpm. According to the Alert SB CEB-A-1400 Rev. 4 of 16 March 2016 and the flight manual (CSP-E-1 Limitations, Pages 2-7) this should explicitly be avoided. Currently the helicopter manufacturer does not intend to add a corresponding colour-coded marking of the rpm area to the N2 indicator.

The BFU is of the opinion that pilots and technicians should understand the limiting N2 rpm requirements, and the possible negative effects on the engine, as well as being able to adhere to them during flight operations and technical test runs on the ground. The owner stated that every technician and pilot had been informed and trained accordingly.

If, how long, and how often the engine had been operated in this rpm range during the last approximately 1,635 operating hours since the last overhaul in 2013 could not be determined.

After several similar accidents with the same helicopter and engine types different trials were conducted and measures taken to ensure operational reliability of the third and fourth turbine stages and of the power turbine. According to the engine manufacturer the new engines were fitted with improved turbine stages with new blade bases and in the near future it shall become mandatory to upgrade older engines. In addition, in the near future the eddy current inspection shall be able to indicate blade damage. This inspection procedure shall be conducted on the fitted engine.

Conclusions

The accident was due to the sudden engine failure in low altitude over terrain unsuitable for an emergency landing.

Safety Recommendation

The BFU will abstain from issuing safety recommendations due to the current and planned measures regarding operational reliability of the fourth turbine stage of the M250-C20 engine.

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Field Investigation:	Alfred Jung
Assistance:	Thomas Karge

Braunschweig 12 July 2017

This investigation was conducted in accordance with the 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 the Federal German Law relating to the investigation of accidents and incidents associated with the operation of civil aircraft (*Flugunfall-Untersuchungs-Gesetz - FlUUG*) of 26 August 1998.

The sole objective of the investigation is to prevent future accidents and incidents. The investigation does not seek to ascertain blame or apportion legal liability for any claims that may arise.

This document is a translation of the German Investigation Report. Although every effort was made for the translation to be accurate, in the event of any discrepancies the original German document is the authentic version.

Published by:

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