Australian Government
Australian Transport Safety Bureau

Main rotor blade cracking involving Airbus Helicopters Deutschland, BO105 CBS-5, registration VH-NVH

Near Archerfield Aerodrome, QLD on 18 August 2021

ATSB Transport Safety Report
Aviation Occurrence Investigation (Short)
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Addendum

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Safety summary

What happened

On the afternoon of 18 August 2021, an Airbus Helicopters Deutschland BO105 CBS-5 helicopter registered VH-NVH and operated by Surf Life Saving Queensland, departed Archerfield Aerodrome, Queensland to conduct aerial work operations. There were 3 crew on board.

During initial climb, the pilot noticed the onset of abnormal airframe vibration, which became more severe as airspeed increased. The pilot returned the helicopter to Archerfield, where it was landed without incident. The pilot subsequently identified a crack in one of the main rotor blades.

What the ATSB found

The main rotor blade crack was consistent with the in-flight vibration experienced. The crack originated at the location of a previous blade repair, and minor damage was also present in the same location on the other 3 rotor blades. There were no manufacturing or operational factors identified for the blade damage.

Safety message

This occurrence is a reminder for pilots to be vigilant for changes in aircraft noise and vibration. While the threshold for acknowledgement of changes can be subjective, based on an individual's familiarity and experience, mild deviations from normal flight conditions could still be an indication of a developing technical issue.

The investigation

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

On the afternoon of 18 August 2021, an Airbus Helicopters Deutschland BO105 CBS-5 helicopter registered VH-NVH and operated by Surf Life Saving Queensland, departed Archerfield Aerodrome, Queensland to conduct aerial work operations. There were 3 crew on board.

After a normal start, the pilot brought the helicopter into a hover with no issues. However, during initial climb through about 40 kts, the pilot noticed the onset of abnormal airframe vibration. The vibration worsened through 60 kts, where the pilot likened it to a significant rotor track-and-balance issue. The pilot reduced power, levelled off at about 500 feet and returned the helicopter to Archerfield, where it was landed without incident.

After landing the pilot examined the rotor head and found no defect. The pilot then spoke with the operations officer, who had been on the most recent flight for VH-NVH, the previous day. They discussed that the helicopter had developed a very mild vibration towards the end of that flight. The occurrence pilot also spoke with the previous day's pilot, regarding the minor change in vibration levels. That pilot reported to the ATSB that the vibration was noticeable, but they had observed similar vibrations previously, and it was not at all concerning. In addition, the change in vibration had been attributed to additional payload that the helicopter was carrying, and nothing was identified in the post-flight inspection. The occurrence pilot subsequently returned to the helicopter and identified a crack in one of the main rotor blades.

Context

Aircraft information

The BO105 is a light, twin engine, 4 blade helicopter. VH-NVH was airframe serial number S 923, which was manufactured in 1996 and first registered in Australia in 2012. The helicopter employs a rigid rotor head, with flexible main rotor blades of glass fibre-reinforced composite construction. VH-NVH was fitted with 'Type 2' blades, part number 105-15108V001, which had a rectangular blade planform and a tapered tip.

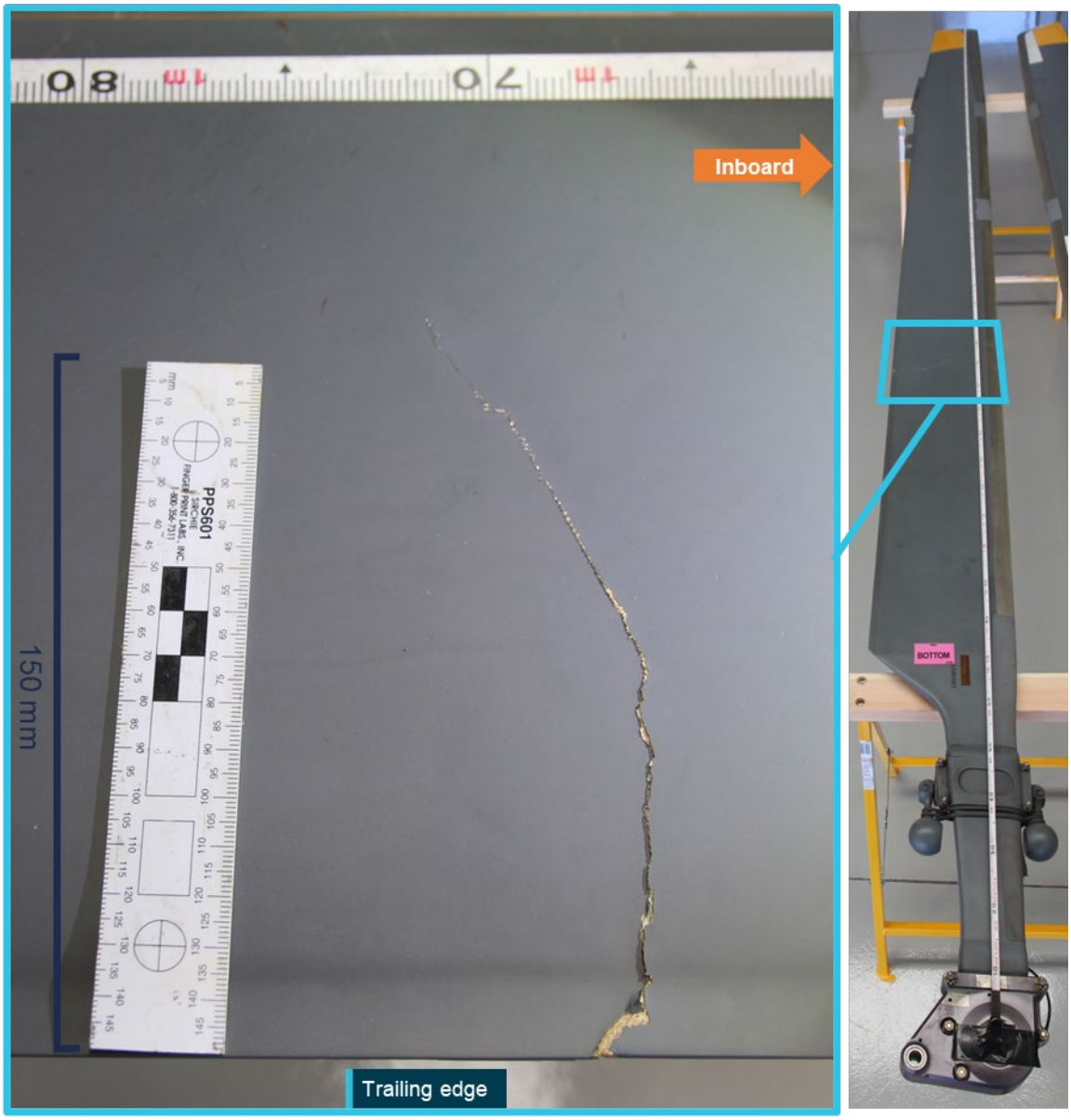
Main rotor blade examination

ATSB investigators visually inspected the blades at the operator's facility.

Blade serial number 783 was cracked approximately 1,700 mm from the blade root. The visible crack on the underside of the blade extended from the trailing edge of the blade for approximately 160 mm. The first part of the crack was parallel to the blade chord, before deviating at an angle towards the blade tip (Figure 1). On the upper blade surface, the crack extended chordwise for approximately 140 mm from the trailing edge.

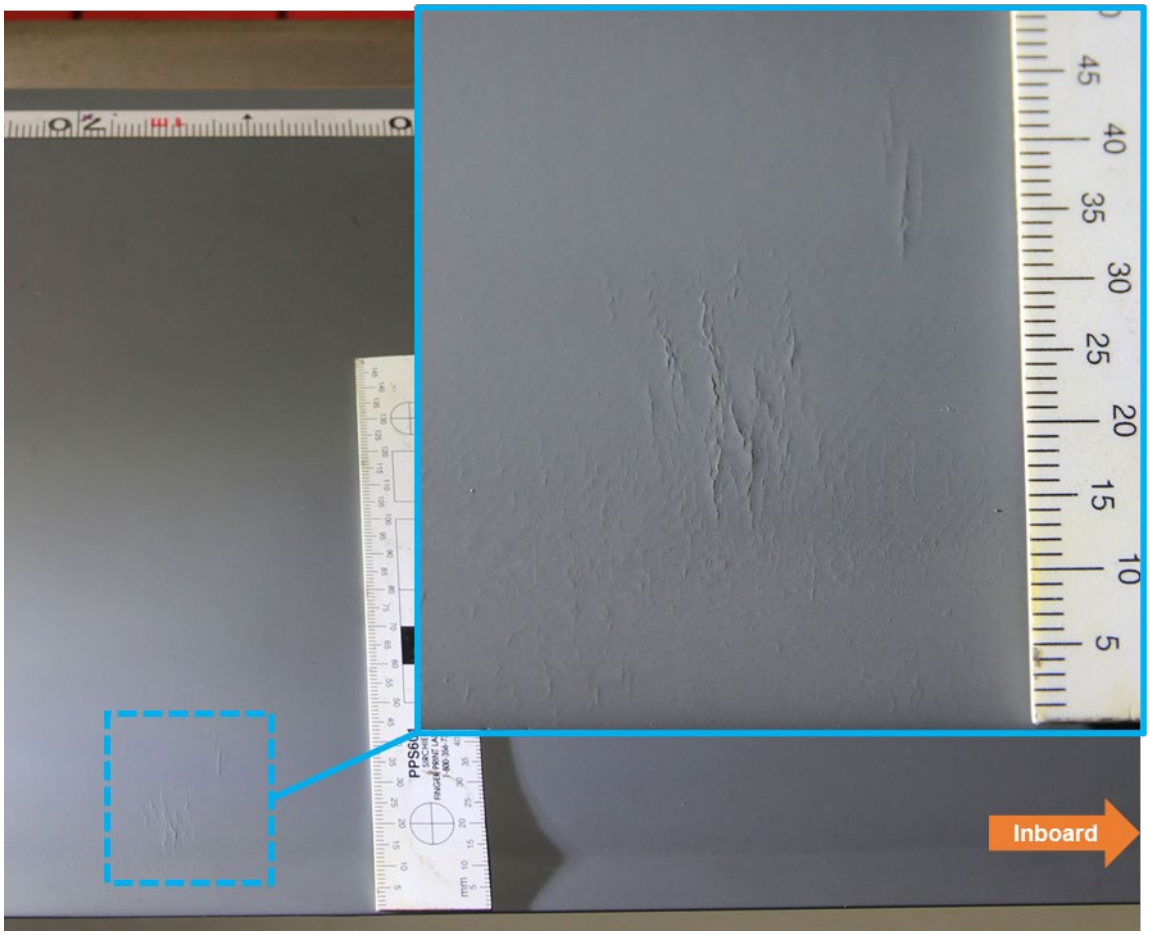
The remaining 3 blades from VH-NVH (serial numbers 780, 786 and 787) had visible indications of damage in the form of paint cracking or wrinkles, measuring 20-30 mm in length, at the same location along the blade (approximately 1,700 mm) from the inboard end. An example is shown in Figure 2.

Figure 1: Main rotor blade crack



Underside of main rotor blade S/N 783, 1,700 mm from the inboard end, showing crack extending over 150 mm from trailing edge.
Source: ATSB

Figure 2: Main rotor blade damage indication



Underside of main rotor blade S/N 780, 1,700 mm from the inboard end, showing paint wrinkles indicative of underlying damage.
Source: ATSB

Manufacturer's examination

Blade 783 was shipped to Airbus Helicopters Deutschland (AHD) where it was examined in July 2022, under the supervision of the German Federal Bureau of Aircraft Accident Investigation (BFU) on behalf of the ATSB.

Following initial visual examination and measurement, the paint layers were scraped back to examine the cracked area further. The cracked portion of the blade was also subjected to computerised tomography (CT) scan to examine for internal abnormalities. The examination found that the crack on the underside of the blade went through the middle of a previous repair. The repair had been conducted in accordance with the applicable blade repair instruction and there were no anomalies noted. No specific reason for the blade cracking was identified, although it was noted that cracks at repair sites were not unusual. It was also determined that the cracked blade, in its post-occurrence condition, was within repair limits.

Main rotor blade maintenance history

The main rotor blade set, part number 105-15107V001, serial numbers 780, 783, 786 and 787 fitted to VH-NVH were manufactured in 2004. At the time of the occurrence, the blades had accrued 6,412.8 hours since new. When fitted with inner balance weight repaired to a specific procedure, the main rotor blades had a service life of 2,500 flight hours. However, the blade set fitted to VHNVH did not have the repaired inner weights and therefore did not have a defined service life. A record for the structural repair to blade 783 that was identified during AHD's inspection was not located.

The main rotor blades were required to be removed from the helicopter for detailed inspection every 1,200 flight hours. Additionally, inspection of the blade root fitting and blade thimble was required initially at 3,600 hours and then every 1,200 hours thereafter. The blade set had most recently been removed and sent to an approved overhaul facility for detailed inspection and maintenance, including the 3,600-hour inspection, in June 2020. The blades were then fitted to VH-NVH in September 2020 and had accrued 891.8 hours since that time.

The most recent 600-hourly airframe periodic inspection, which required detailed visual examination of the main rotor blade, including for cracks and damage at the trailing edge, was carried out in April 2021, 382 hours prior to the occurrence. AHD indicated that the periodical inspection had a high probability of detection of blade cracks and skin anomalies.

An airframe supplementary inspection was carried out in July 2021, 66 hours prior to the occurrence. However, that inspection only specifically required a check of the upper and lower blade surfaces for 'bulging' in the vicinity of the balance weights, which was not applicable to this blade set. The main rotor blade leading-edge polyurethane erosion protection strips were replaced during both of those inspections. No other repairs or defects were noted.

Aside from the scheduled inspections, the helicopter flight manual included a pre-flight check of the main rotor blades 'for condition'. Both the occurrence pilot and the previous day's pilot indicated that this check was carried out, however they reinforced that it was not a detailed inspection that was unlikely to identify relatively minor cracks and defects. AHD advised that the pre-flight item prior to the blade check was a check for rotor hub oil level on top of the main rotor head, which requires the individual to stand sufficiently high on the helicopter that they could also see both blade surfaces. However, AHD similarly commented that smaller cracks or skin defects further away from the rotor head, such as those seen on the uncracked blades, would probably not be detectable.

The operator commented that they had flown BO105 helicopters for over 18,000 hours and had not previously experienced any issues with the main rotor blades. They were unaware of any operational factors that may have contributed to the cracking.

Similar occurrences

AHD indicated they were not aware of any instances of similar BO105 blade cracking in the past 10 years. This was also the first occurrence with damage to all 4 blades that AHD was aware of. They commented that the damage was unlikely to have resulted directly from flight manoeuvre loads, but raised the possibility of previous blade damage and/or a similar repair to that identified on the cracked blade.

The rigid rotor head and composite blades employed by the BO105 were similarly used in the BK117 helicopter. The EC135 helicopter also has a similar main rotor blade design and structure. As such, the ATSB asked AHD about the cracking and failure history regarding helicopter blades with similar construction.

In response, AHD indicated that the EC135 fleet has had a significant number of blade cracks that have occurred for various reasons. Cracks have also been experienced on the BK117, which have been attributed to a trailing edge repair process and manufacturing anomalies. Blade damage in these cases was identified either by visual inspection or by abnormal in-flight noise and vibration. The blade crack characteristics were consistent with this occurrence. The cracks progressed either chordwise or diagonally from the trailing edge, before transitioning to spanwise upon reaching the rear of the blade spar. The presence of the spar acts to arrest any further crack progression towards the leading edge.

AHD advised that in all cases of blade cracking, a safe landing was achieved. They also provided examples of BK117 occurrences involving blade strikes with loose cowlings and foreign objects, where large sections of blade rear of the spar, around 2 metres in length, had separated in flight. One example resulted in a safe landing from 2,000 ft. Another occurred at 120 kts and the flight

was continued for 1-2 minutes before a safe landing was carried out. AHD attributed this to the internal design of the blade spar, which results in a solid load carrying element. The spar has shown to be unaffected by cracks developing in the skin and core material of the rear section of the blade, and therefore does not lose the main functionality of carrying the centrifugal, in-plane (lead-lag) and out of plane (flap) forces. As a result of AHD's analysis of these events, they considered the cracking to be a failure mode with low probability of a hazardous outcome.

Safety analysis

The main rotor blade crack found post-flight by the pilot was consistent with the in-flight vibration experienced. Considering the damage to all four blades, there were no reported operational conditions, including blade strikes or ground handling events that might have directly damaged or placed excessive stress on one or all of the rotor blades.

There were also no blade material or manufacturing defects identified in the cracked blade, with the exception that the crack passed through the centre of a prior blade repair. The fact the blade was previously repaired in this location, in addition to the concurrent damage on the other 3 blades in the same location, suggested it was probably a region of high blade stress. The manufacturer also indicated that cracks at prior blade repair sites was not unusual and therefore, the blade repair probably influenced to some extent, the rate of cracking compared to the other blades. Despite this, there were no common factors identified outside of normal operation that likely contributed to the damaged blade set.

No vibration was noted during the take-off phase of the previous flight, and the onset of mild vibration was only observed towards the end of that flight. This indicated not only that the blade crack was present to some degree at the conclusion of the previous flight, but that it then progressed rapidly to produce the severity of vibrations experienced on the occurrence flight. This meant that, compared to the size of the post-occurrence crack, the crack present at the commencement of the occurrence flight would have been comparatively smaller and less conspicuous to the 'general condition' pre-flight check. In addition, the period of operation since the most recent, detailed, periodic inspection, meant it was unlikely that cracking or damage existed at that time to be identified.

In the absence of crack detection through inspections, the most likely avenue for crack detection was for the mild vibration on the previous flight to be brought to the attention of maintenance personnel. However, the vibration was below that pilot's threshold for concern and was coupled with an association of the helicopter loading condition. Even so, the mild deviations from normal flight conditions were an indication of a developing technical issue. Communication of the same, may have resulted in additional inspections or pilot awareness ahead of the occurrence flight.

Despite not being recognised ahead of the occurrence flight, blade cracking of this type was considered unlikely to result in a significant flight risk. The failure mechanism is progressive, with significant, abnormal airframe vibration accompanying a crack beyond a certain size, providing a warning to the pilot. Transitory continued flight with severely damaged blades has also been demonstrated, where a safe landing has been achieved in each occurrence.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the Main rotor blade cracking, involving Airbus Helicopters Deutschland BO105 CBS-5, registered VH-NVH.

Contributing factors

- A cracked main rotor blade caused abnormal airframe vibrations and resulted in a precautionary landing. The reason for the blade cracking was not determined.

Other findings

- There were no manufacturing or operational factors identified to explain concurrent damage across the main rotor blade set, and which likely led to the blade cracking on one blade.

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Pilot of the occurrence flight
- Pilot of the previous flight
- Airbus Helicopters Deutschland
- Operator of VH-NVH

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- Pilot of the occurrence flight
- Pilot of the previous flight
- Operator of VH-NVH
- Airbus Helicopters Deutschland
- German Federal Bureau of Aircraft Accident Investigation (BFU)
- Civil Aviation Safety Authority (CASA)

Submissions were received from:

- Airbus Helicopters Deutschland.

The submission was reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

Date and time:	18 August 2021 – 1735 EST	
Occurrence class:	Incident	
Occurrence categories:	Propellers / Rotor malfunction, Diversion / Return	
Location:	Archerfield Aerodrome, Queensland	
	Latitude: 27° 34.217' S	Longitude: 153° 0.483' E

Aircraft details

Manufacturer and model:	Airbus Helicopters Deutschland GMBH BO105 CBS-5	
Registration:	VH-NVH	
Operator:	Surf Life Saving Queensland	
Serial number:	S 923	
Type of operation:	Part 138 – Aerial work operations – Other – Aerial work	
Activity:	General aviation / Recreational – Aerial work – Observation and Patrol	
Departure:	Archerfield Aerodrome	
Destination:	Archerfield Aerodrome	
Persons on board:	Crew – 3	Passengers – 0
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	None	

Australian Transport Safety Bureau

About the ATSB

The ATSB is an independent Commonwealth Government statutory agency. It is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers.

The ATSB's purpose is to improve the safety of, and public confidence in, aviation, rail and marine transport through:

- independent investigation of transport accidents and other safety occurrences
- safety data recording, analysis and research
- fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia, as well as participating in overseas investigations involving Australian-registered aircraft and ships. It prioritises investigations that have the potential to deliver the greatest public benefit through improvements to transport safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, international agreements.

Purpose of safety investigations

The objective of a safety investigation is to enhance transport safety. This is done through:

- identifying safety issues and facilitating safety action to address those issues
- providing information about occurrences and their associated safety factors to facilitate learning within the transport industry.

It is not a function of the ATSB to apportion blame or provide a means for determining liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner. The ATSB does not investigate for the purpose of taking administrative, regulatory or criminal action.

Terminology

An explanation of terminology used in ATSB investigation reports is available on the ATSB website. This includes terms such as occurrence, contributing factor, other factor that increased risk, and safety issue.