Australian Government

Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation
AO-2009-031
Final

Collision with terrain
120 km west of Paraburdoo, WA
25 or 26 June 2009
VH-HXO, Robinson R22 Beta II

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Robinson Helicopter Company R22 Beta II

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CONTENTS

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Collision with terrain – 120 km west of Paraburdoo, Western Australia – 25 or 26 June 2009 – VH-HXO, Robinson Helicopter Company R22 Beta II

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Figure 1 map courtesy of Geoscience Australia.
Figure images courtesy of Garmin.

Abstract

On 24 June 2009, the pilot of a Robinson Helicopter Company R22 Beta II, registered VH-HXO, departed Mareeba, Queensland on a private flight to Uaroo, Western Australia (WA) as the helicopter had been contracted to an operator for aerial mustering tasks. After an overnight stay at Alice Springs, Northern Territory, the pilot departed for Uaroo on 25 June 2009. The last known stop for the pilot was the night of 25 June 2009, at Newman, WA. After refuelling, the pilot departed some time during that night. The following morning, after the expected arrival time of the helicopter, and after several attempts to contact the pilot, Australian Search and Rescue commenced a search for the missing helicopter. The wreckage was located about 120 km west of Paraburdoo, WA. The pilot was fatally injured as a result of the accident.

The investigation found no evidence of a pre-existing mechanical problem with the helicopter. After consideration of the available evidence, the investigation concluded that the accident may have been a function of the pilot's control inputs, possibly resulting from pilot fatigue, carburettor icing, night flight, or a combination of these factors.

The investigation did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the accident does provide a timely reminder of the need for pilots conducting private operations to consider the impact of fatigue; particularly, during a long flight over a number of days, as was the case in this occurrence.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: 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 that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

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

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine 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.

Developing safety action

Central to the ATSB’s investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

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. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

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.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.

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.

Risk level: The ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 24 June 2009, the pilot of a Robinson Helicopter Company R22 Beta II (R22), registered VH-HXO (HXO), departed Mareeba, Queensland, on a private positioning flight to Uaroo, Western Australia (WA). The pilot was conducting the ferry flight as a means to increase his flying hours and experience. Another pilot was at Uaroo in preparation to utilise the helicopter for mustering operations upon its arrival.

On the night of 24 June 2009, the pilot had landed HXO and stayed in Alice Springs, Northern Territory. The following morning, HXO departed Alice Springs, heading towards Uaroo. The pilot made several scheduled fuel stops as expected, but was running behind the expected schedule due to a westerly headwind. A witness on the ground at Carnegie, WA, saw the pilot of HXO refuelling the helicopter as well as three fuel containers. At about 1700 Western Standard Time[1] HXO then departed Carnegie heading for Newman WA.

The last known stop for the pilot was on the night of 25 June 2009, at Newman. Another Robinson helicopter operator reported seeing a Robinson R22 helicopter near Newman at about 2030, flying at a height of about 400 ft. The helicopter navigation and strobe lights were visible at the time. The witness reported seeing only a 'sliver of a moon', which was obscured about half of the time due to cloud. A fuel company swipe card registered to HXO was used to activate the fuel bowser pump at about 2030 WST. At some stage after refuelling, HXO departed Newman, heading towards Paraburdoo, WA (Figure 1). From the pilot's telephone records, it was confirmed that several calls were received and made within the mobile coverage range of Tom Price, WA and Paraburdoo. One of the calls received within mobile coverage of Paraburdoo was from a friend of the pilot. During the conversation, the friend got the impression that the pilot was going to sleep at that location, although his location was not clarified during the conversation. The last recorded mobile usage was at about 2229. Mobile phone activity resumed the following morning at about 0630 with calls diverting to the phone message bank service.

On 26 June 2009, after the expected arrival time of the helicopter, and after several attempts to contact the pilot, Australian Search and Rescue was notified and a search for the missing helicopter commenced. The wreckage was located that afternoon at approximately 1430, about 120 km west of Paraburdoo. The pilot, the sole occupant, was fatally injured and the helicopter sustained serious damage.[2]

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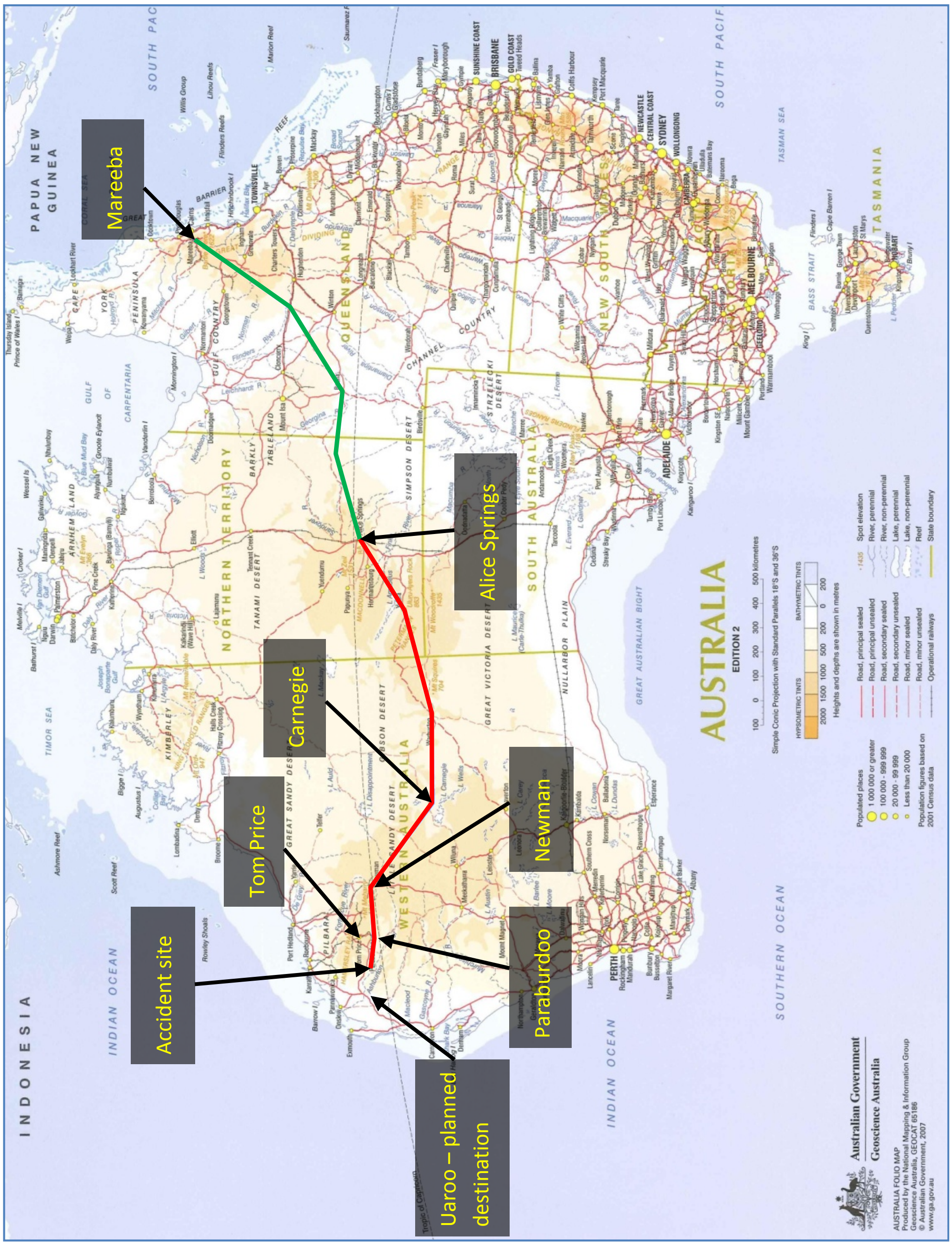
1 The 24-hour clock is used in this report to describe the local time of day as particular events occurred. The nature of the flight was that it crossed the Eastern (EST), Central (CST) and Western Standard Time (WST) zones. Eastern Standard Time was Coordinated Universal Time (UTC) +10 hours, Central Standard Time was UTC + 9.5 hours and Western Standard Time was UTC + 8 hours.

2 The *Transport Safety Investigation Regulations 2003* definition of 'serious damage' includes the 'destruction of the transport vehicle'.

Figure 1: Flight path across Australia



Personnel information

A review of the pilot's flying logbook indicated that he gained a Private Pilot (Helicopter) Licence in September 2004, a Commercial Pilot (Helicopter) Licence in October 2004 and a night visual flight rules (NVFR) rating in January 2005. The pilot was endorsed on the R22 helicopter type in July 2007. The pilot's total helicopter flying experience at 26 September 2008 was about 420 hours. There were no further flights documented in the pilot's log book after that date.

The pilot held a current Class 2 Aviation Medical Certificate that was issued by the Civil Aviation Safety Authority (CASA) with no restrictions.

Aircraft information

The Robinson Helicopter Company R22 Beta II helicopter, serial number 2935, was manufactured in the United States (US) in 1999, and had accumulated about 1537 hours total time in service at the time of the occurrence. The helicopter was powered by a Textron Lycoming O-360-J2A, four cylinder, normally-aspirated, air-cooled, horizontally-opposed piston engine.

Airworthiness and maintenance

A review of the maintenance logs indicated that the helicopter had been maintained in accordance with the Robinson Helicopter R22 maintenance schedule. The helicopter had a current Certificate of Registration and Certificate of Airworthiness. The current maintenance release was found in the helicopter and showed that there were no outstanding maintenance items or defects identified. The helicopter was maintained to a day visual flight rules (VFR) standard.

A 100-hourly periodic inspection was completed the day prior to the departure from Mareeba, with no major defects identified or requiring rectification at that time. Witnesses along the route reported that there did not appear to be any mechanical issues with the helicopter.

Meteorological information

The Bureau of Meteorology (BoM) conducted a post-accident analysis of the weather conditions likely to have affected the flight. That analysis indicated that a broad, weak high pressure system was located over the area resulting in light surface winds and diurnally[3] driven convective, cumulus, cloud. Overnight cooling and recent rain resulted in high humidity and was shown by equal temperature and dewpoints[4] at both Newman and Paraburdoo during the evening on 25 June 2009 and early morning on 26 June 2009. The weather conditions in the vicinity of Newman to Uaroo Station were likely to be fine with light winds with possible areas of fog or low cloud present between 0200 and 0930 on 26 June 2009.

The BoM area forecast valid for the accident area indicated light westerly winds and broken cloud above 4,000 ft above mean sea level (AMSL). The Paraburdoo Aerodrome Forecast[5] (TAF) indicated light westerly winds, visibility greater than 10 km and cloud few[6] at 2,000 ft above ground level (AGL). Weather observations for Paraburdoo recorded at 2100 on 25 June 2009, indicated light winds with a temperature of 15° C and dewpoint of 13° C. By 2200, the temperature and dewpoint were both 13° C. Over the next few hours, both the temperature and

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3 Diurnal means daily, or in 24 hour cycles.

4 Dewpoint is the temperature at which water vapour in the air starts to condense. It is used among other things to monitor the risk of carburettor icing.

5 Aerodrome forecasts are a statement of meteorological conditions expected for a specific period of time, in the airspace within a radius of 5 NM (9 km) of the aerodrome.

6 Cloud amounts are reported in oktas. An octa is a unit of sky area equal to one-eighth of total sky visible to the celestial horizon. Few = 1 to 2 oktas, scattered = 4 to 4 octas, broken = 5 to 7 oktas and overcast = 8 oktas.

dewpoint continued to fall and remained at or about the same value. By 0600 on 26 June 2009, the temperature and dewpoint were both 10° C.

The temperature recorded at Paraburdoo at about the time of the last recorded mobile phone activity was 13° C with a corresponding dew point of 13° C. Application of those temperatures to a carburettor icing[7] probability predictive chart (Appendix A) indicates a serious icing risk at any power setting.

Last light[8] at Newman, where the helicopter made its last known stop prior to departing for Uaroo, was 1748. First light[9] in the vicinity of the accident site the following morning was 0630. On 25 June 2009, there was a crescent moon of less than one quarter located in the western sky, moonrise was at 0754 and moonset was at 2125. At the time of the last mobile phone activity, the moon would have been below the western horizon.

Wreckage and impact information

Wreckage distribution

The helicopter had impacted the ground in an almost inverted, right-side low, attitude. The main wreckage of the helicopter came to rest facing back along the planned flight path and the initial impact mark of the helicopter was directly beside the main wreckage (Figure 2).

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7 Carburettor ice is formed when the normal process of vaporising fuel in a carburettor cools the carburettor throat so much that ice forms from the moisture in the airflow and interferes with the operation of the engine.

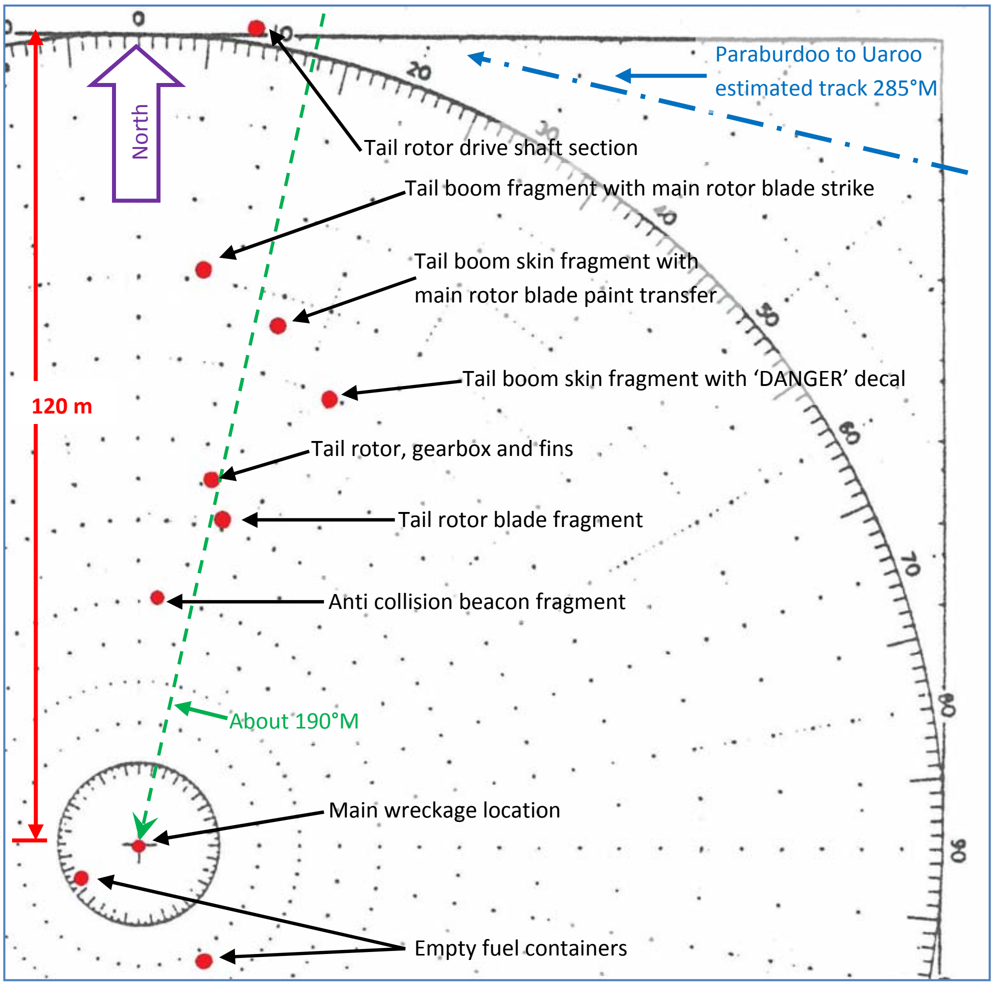
8 Last light is consistent with the end of evening civil twilight, when the centre of the sun is at an angle of 6° below an ideal horizon.

9 First light is consistent with the beginning of morning civil twilight, when the centre of the sun is at an angle of 6° below an ideal horizon.

Figure 2: Main wreckage

The wreckage, including pieces of the tail boom skin, tail rotor driveshaft and tail rotor, was dispersed over a distance of about 120 m on an approximate bearing of 190° magnetic. Pieces of the tail boom, including the fin, tail rotor and tail rotor gearbox were located to the north of the main wreckage (Figure 3).

Figure 3: Wreckage site map

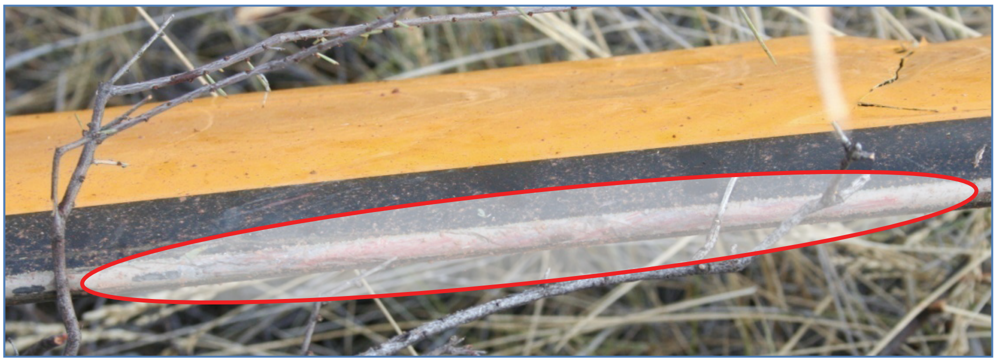


Tail boom damage

The distribution of the tail boom assembly along the wreckage trail, and damage to the assembly showed that it had separated from the helicopter in flight. There was extensive deformation of the assembly and indications of at least two main rotor blade contacts (Figure 4). There was also paint transfer from the red tail boom onto the main rotor blades (Figure 5).

Figure 4: Tail boom section with main rotor blade impact

Figure 5: Red paint transfer onto the leading edge of the main rotor blade

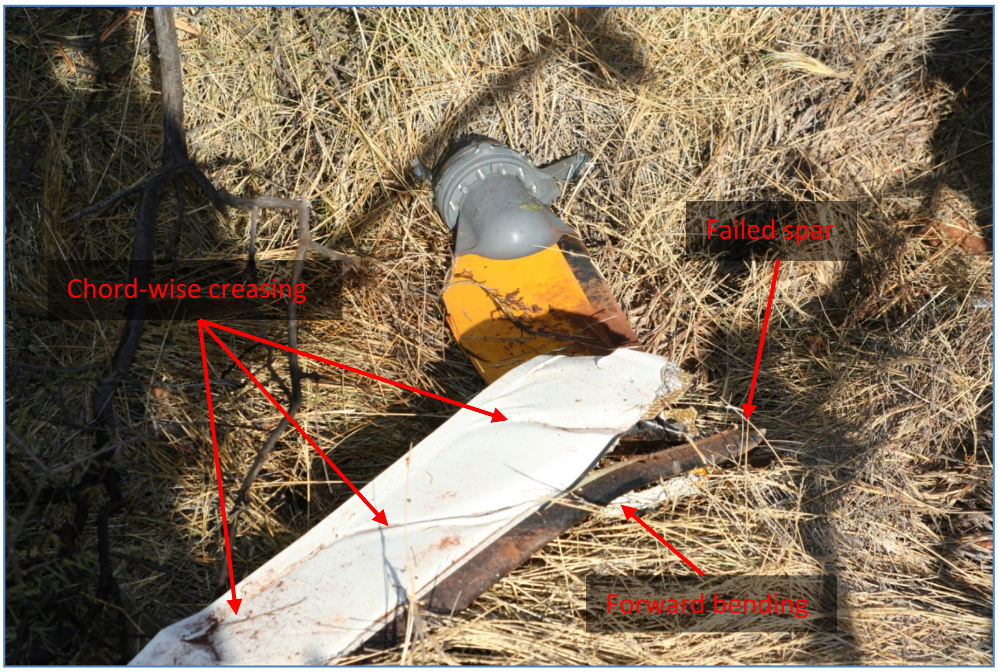


Main rotor blade damage

Both of the main rotor blades remained attached to the main rotor hub. Both of the blades displayed chord-wise creasing from bending rearwards, as well as paint transfer from contact with the tail boom.

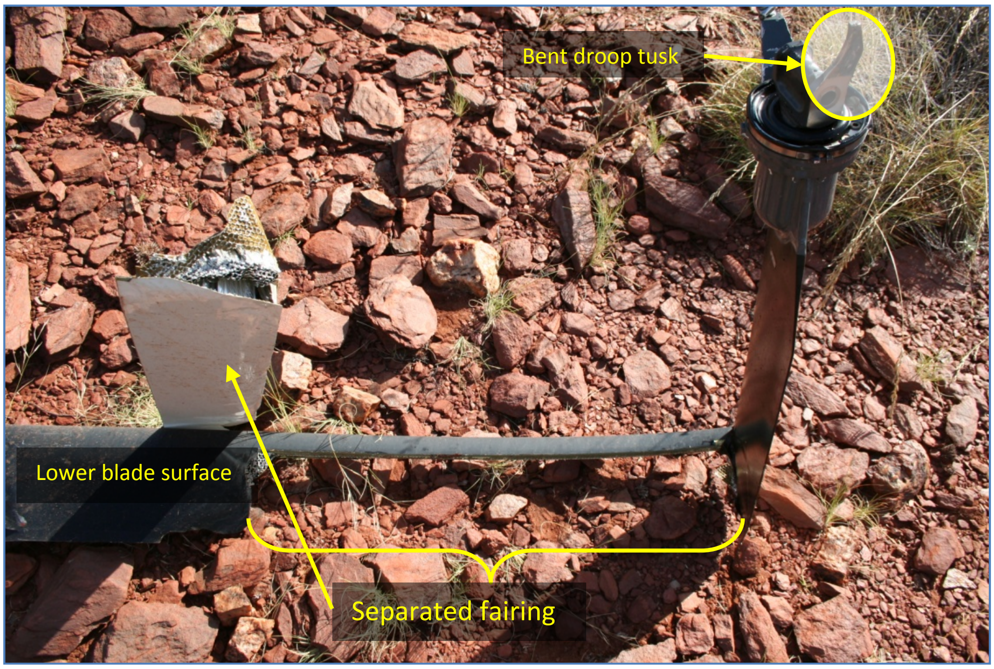
The spar had failed on one main rotor blade, near the root end of the blade, consistent with an overstress failure (Figure 6). Forward bending was evident just outboard from the point of failure. The droop tusk had also failed in overstress on that blade.

Figure 6: Main rotor blade removed from hub, showing chord-wise creasing, forward bending and failed spar.



The other main rotor blade had bent downwards at right angles close to the blade root (Figure 7), and the tip of that blade had been compressed inwards. A section of the main rotor blade fairing had separated from the spar, outboard from the right angle bend, and the droop tusk had been bent down.

Figure 7: Main rotor blade removed from hub, showing downward bend and separated fairing



Helicopter component examination

Airframe

The Australian Transport Safety Bureau (ATSB) removed the helicopter wreckage to Perth, Western Australia, for a detailed examination at an approved maintenance facility. Examination of the airframe, aircraft systems and flight controls, did not reveal any condition that would have precluded their normal operation. Due to the level of disruption as a result of the accident, the flight controls and throttle position at the time of the accident could not be determined.

Engine

The engine was subsequently examined at an approved engine overhaul facility. That examination did not reveal any condition that would have precluded normal operation of the engine. Several of the engine components were also examined in an attempt to determine if the engine was operating at the time of the accident. The engine oil cooler had two impact marks consistent with contact with the starter ring gear during the impact sequence. One impact mark indicated a rotational abrasion in the direction of normal engine operation (Figure 8). The other mark, also from the ring gear, showed a static imprint of the ring gear teeth into the side of the oil cooler (Figure 9).

No rotational contact was identified between the engine cooling system scroll and the fan wheel assembly.

Unlike piston engine aeroplanes, a helicopter does not have a propeller to act as a windmill, which can continue to rotate the engine even after it ceases developing power. When a helicopter piston engine ceases operation, the engine ceases rotation very quickly.

Figure 8: Rotational abrasion marks on the engine oil cooler

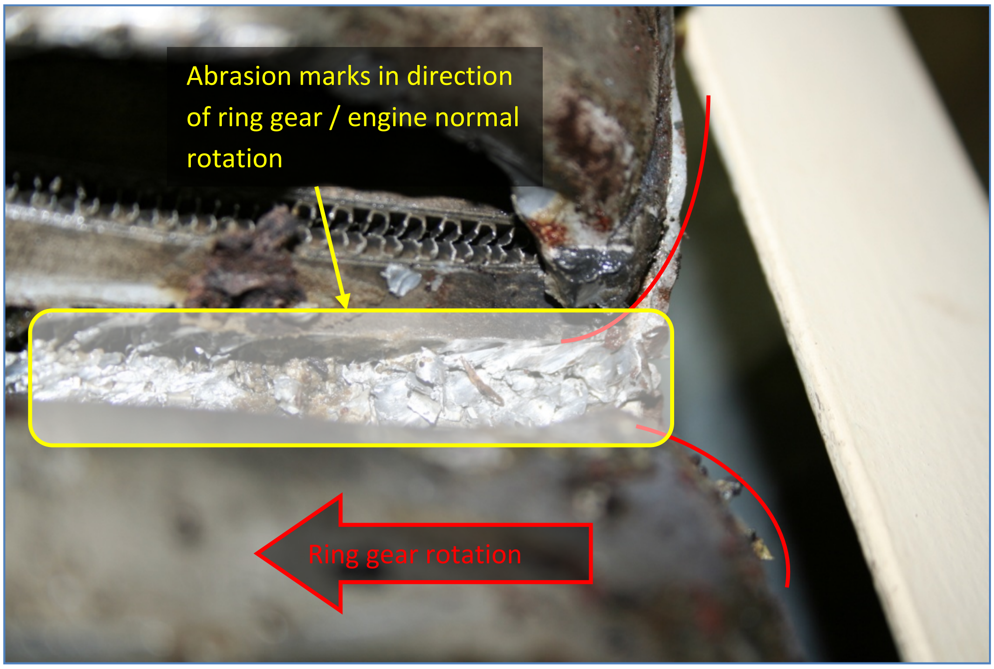


Figure 9: Static ring gear teeth imprint on the engine oil cooler

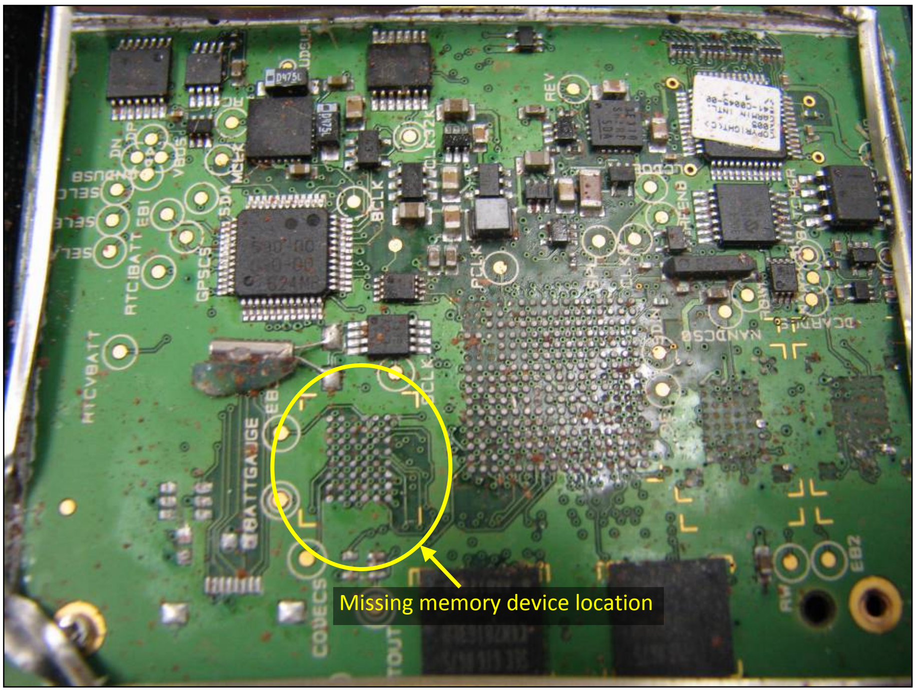
The helicopter was fitted with a carburettor heat assist system to minimise the risk of carburettor icing. The system could be locked in the OFF position or unlocked to automatically vary the amount of hot air with varying engine power demands. When activated, carburettor heat assist applied an appropriate amount of hot air to the carburettor intake, depending on power demands.

Due to the level of disruption as a result of the accident, it could not be determined if the carburettor heat assist was in the OFF or automatic position.

Global Positioning System

A Garmin GPSMAP 296 global positioning system (GPS) was recovered from the accident site and sent to the ATSB facility in Canberra for detailed examination. Data was unrecoverable due to the absence of the memory device (chip) containing the GPS data for the occurrence flight. The chip was most likely dislodged during the accident sequence, and was not identified at the accident site.

Figure 10: GPS circuit board showing location of missing memory device

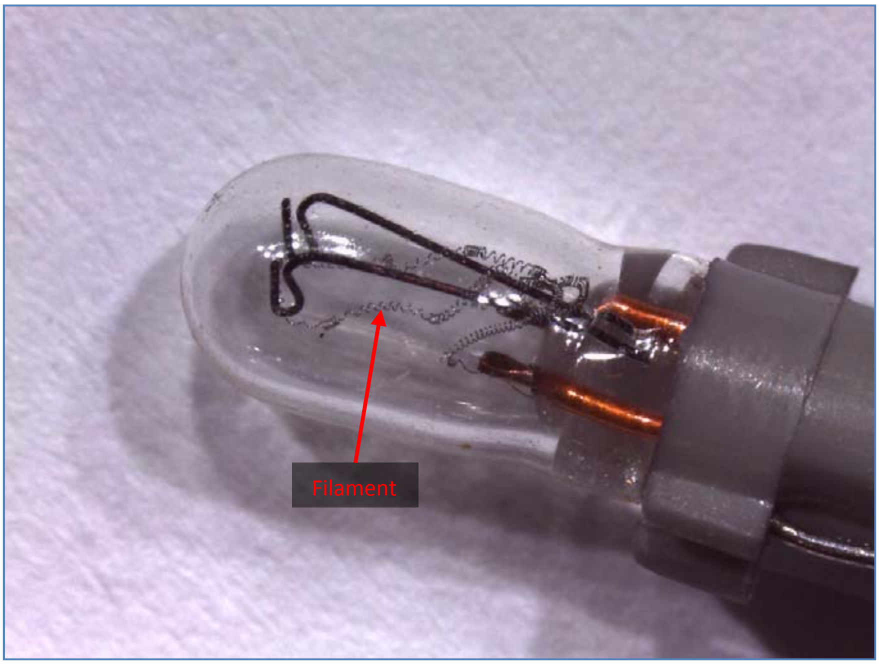


Instruments and lighting

Several instruments and light globes were recovered from the accident site and sent to the ATSB's facility in Canberra for detailed examination.

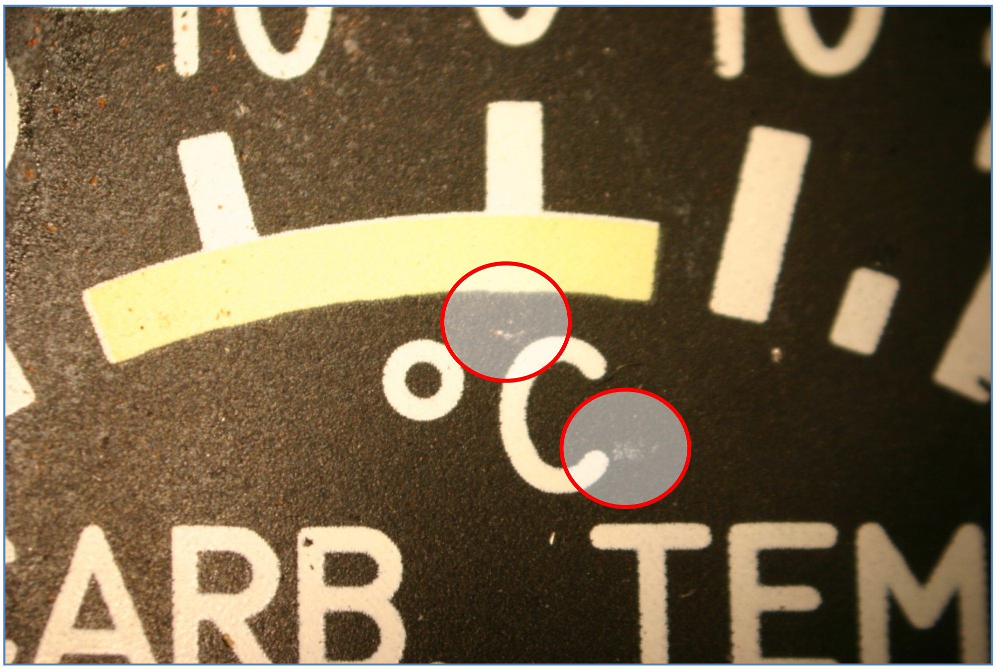
The landing light, left navigation light and instrument lighting (Figure 11) was examined. Filament stretch was identified on all of the lamps examined indicating that these lamps were illuminated at the time of impact.

Figure 11: Instrument lamp displaying filament stretch



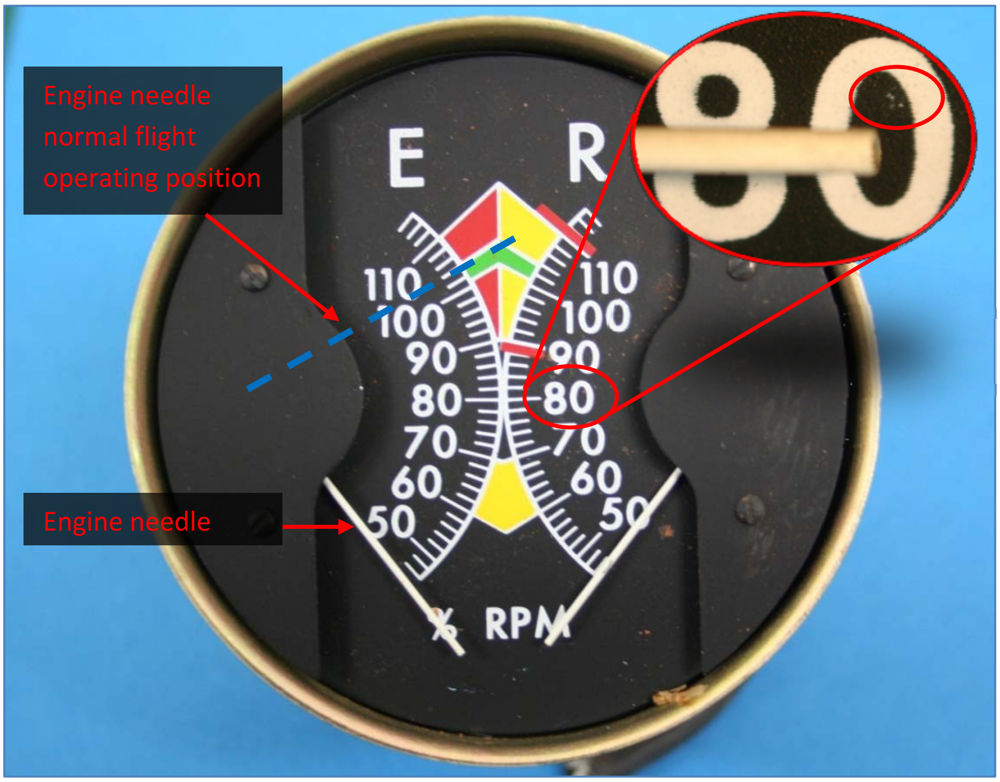
Examination of the carburettor air temperature gauge found evidence of pointer contact, possibly from impact forces. The examination found white paint particles from the rear of the instrument pointer at the 0º C and +5º C positions on the face of the gauge (Figure 12). Black paint particles were also found on the rear of the instrument pointer.

Figure 12: Carburettor air temperature gauge displaying needle contact paint transfer



Examination of the dual engine and main rotor revolutions per minute (RPM) indicator showed signs of contact between the gauge needle and the face of the instrument at about 80% engine RPM (Figure 13). The normal operating range for the engine was 101% to 104%, with a maximum continuous RPM of 104%. The engine RPM had to be maintained within this tolerance for the main rotor system to provide effective lift.

Figure 13: Dual indicator, engine needle displaying needle contact paint transfer



All of the caution and warning lights were examined, including the 'LOW FUEL' and 'LOW ROTOR RPM' lamps. No verifiable evidence of filament stretch was found on any of the globe filaments.

Fuel

The force of the impact had ruptured both the main and auxiliary fuel tanks, with any remaining contents lost overboard. Both of the fuel caps had separated from their respective filler ports, but were located adjacent to the wreckage.

The pilot had loaded three plastic 20L fuel containers on board and was known to be utilising these to extend the range of the helicopter while in transit between available refuelling locations. One of the three fuel containers exhibited signs of a hydrostatic (burst) rupture (Figure 14). That fuel container was located under the main wreckage. The other two fuel containers were found empty, but intact with the caps secured, forward of the main wreckage. The last recorded purchase of fuel was at Newman Airport, with about 128 L uplifted.

Figure 14: Burst fuel container

Emergency Locator Transmitter

There was no fixed installation of an emergency locator transmitter (ELT) fitted to the helicopter. A personal 121.5 MHz ELT was found stowed with the pilots' belongings under his seat, which had not automatically activated as it required manual activation, and therefore did not provide an emergency signal. That ELT was made obsolete from February 2009 and the signal was no longer processed by the Cospas-Sarsat[10] system. The Australian Civil Aviation Safety Authority (CASA) required a compatible ELT to be carried or installed in aircraft, in accordance with Civil Aviation Regulation (CAR) 1988, 252A.

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10 The International Cospas-Sarsat Programme provides accurate, timely, and reliable distress alert and location data to help search and rescue authorities assist persons in distress via a search and rescue satellite.

Medical and pathological information

The post-mortem examination on the pilot found no evidence of any medical condition that may have affected the pilot's performance. Toxicological testing for drugs and alcohol was negative.

Additional information

Aircraft handling

The R22 has a very low inertia rotor system and is highly responsive in pitch and roll with only small control inputs required by the pilot. There is no hydraulic assistance. A number of R22 pilots have reported that the flight controls on the R22 are more sensitive than in other light helicopters.

In 1984, a US Federal Aviation Administration (FAA) helicopter test pilot reported that the reaction of the R22 per inch (25 mm) of control input was high, making pilot-induced oscillations and overcontrolling tendencies much more noticeable than in other helicopters. Further, an FAA special certification review in 1994 stated that the R22 helicopter was very sensitive, requiring the pilot to be attentive at all times.

In April 1996, the US National Transportation Safety Board (NTSB) published a special investigation report (NTSB/SIR-96/03) titled *Robinson Helicopter Company R22 loss of main rotor control accident* (the NTSB report). A conclusion contained in that report was that: [11]

> ...the Board concludes that the low inertia main rotor blade can diverge from normal rotation to strike the body of the helicopter in just a few revolutions of the blade. This would take less than 0.5 seconds when the blade is operating at a normal rate of 530 rpm.

Main rotor stall

The main rotor of a helicopter provides for both lift and the movement of the aircraft over the ground. Normally the rotor operates at a constant RPM, but sometimes the rotor RPM can slow if too much power is commanded through the flight controls compared to that able to be delivered by the engine.

If a pilot does not respond quickly and appropriately to a developing low rotor RPM situation, the main rotor RPM will continue decreasing, with resultant coning of the blades[12] and an associated loss of lift. The result can be an accelerating rate of descent. Any application of collective[13] to arrest the descent further reduces rotor RPM. The situation can rapidly deteriorate into a vicious cycle that culminates in the rotor blades effectively stalling and losing all lift. Once the blades are aerodynamically stalled, in-flight recovery is almost impossible.

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[11] www.ntsb.gov/publictn/1996/sir9603.pdf

[12] The coning angle is the angle between the longitudinal axis of a lifting rotor blade and its tip path plane or plane of rotation (assuming no blade bending).

[13] Pilot control in helicopters that simultaneously affects the pitch of all blades of a lifting rotor. Main control for vertical velocity.

Main rotor stall was highlighted in NTSB report NTSB/SIR-96/03 (see above) as a possible factor in a number of the loss of control accidents examined. A number of ATSB investigation reports have also identified main rotor stall as a factor, including investigation 200600979 and, more recently, investigation AO-2008-062 (both available at www.atsb.gov.au).

Robinson Helicopter Company Safety Notices SN-10 and SN-24 warn pilots of the dangers of main rotor stall (Appendix B).

Low-g pushover manoeuvres

The Robinson R22 rotor system is designed for operation in a positive-g[14] condition. A rapid forward movement of the cyclic could result in a low-g condition, which could cause mast bumping and a subsequent tail boom strike.

The Robinson Helicopter Company Safety Notice, SN-10warns pilots of the dangers of low-g pushover manoeuvres (Appendix B).

Carburettor icing

The Australian Transport Safety Bureau (ATSB) has investigated several occurrences of reported partial power loss situations where carburettor icing was suspected (Appendix C). The majority of those occurrences involved low power descents and the requirement for power demand at the bottom of the descent. Robinson Helicopter Company Safety Notices (SN) SN-25 and SN-31 warns pilots of the dangers and methods of preventing carburettor icing (Appendix B).

When an aircraft is fitted with a carburettor air temperature gauge, carburettor heat is applied to a level to maintain the temperature outside the caution range.[15] The carburettor heat assist system fitted to the Robinson R22 Beta II is designed to automatically apply a level of heat corresponding to the amount of power being applied. Further adjustments are made by the pilot, if required, to maintain the temperature outside the caution range.

One of the articles in the *Lycoming Flyer Key Reprints*[16] discussed induction (carburettor) icing and the use of heat:

> An unknown amount of partial heat can actually cause induction ice in the float-type carburettor. This may occur when moisture in crystal form in the incoming air that would ordinarily pass through the induction system without any problem is melted by the partial heat. This moisture then freezes when it comes in contact with the cold metal of the throttle plate.

Introducing partial heat without knowing or monitoring the temperature in the carburettor throat may therefore increase the chance of ice formation, resulting in a reduction of available engine power.

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14 1 g is the nominal value for vertical acceleration that is recorded when the aircraft is on the ground. In flight, vertical acceleration values represent the combined effects of flight manoeuvring loads and turbulence.

15 Caution range on a carburettor gauge is typically a yellow band between about -15 °C to +5 °C.

16 www.lycoming.textron.com/support/tips-advice/key-reprints/index.html

Pilot activities

Phone records indicated that the pilot was awake on the day of departure from Mareeba, 24 June 2009, before 0545 Eastern Standard Time (EST). The actual flight time from Mareeba to Alice Springs was about 11 flying hours, arriving at Alice Springs at about 1800 Central Standard Time (CST).

Evidence from the pilot's phone records suggested that he was awake until at least 2240 CST. The pilot's phone records showed inactivity between 2240 CST and 0105 CST, when the pilot sent two text messages. There was then another period of inactivity until 0502 CST, and further phone activity suggested that the pilot was up at about 0615 CST.

The pilot departed Alice Springs on 25 June 2009 at approximately 0700 CST. The estimated flying time to Paraburdoo was about 15 hours, which was greater than the available daylight that day. The last recorded phone activity was at 2229 WST on 25 June 2009, near Paraburdoo.

Flight and duty limitations

There are no flight and duty time limitations for the conduct of a private flight. Had it been a commercial flight, the pilot would have been bound by the requirements of CASA Civil Aviation Order (CAO) 48[17], flight time limitations. CAO 48 provided a matrix of various scenarios to calculate allowed duty and flight periods. In broad terms, CAO 48 stated that a duty roster period was to be 11 hours, and could be extended to 12 hours, and the flight roster was to be 8 hours, and could be extended to 9 hours. On the 24 June 2009, the pilot had an approximate duty period of 12.5 hours and flight time of about 11 hours. In accordance with the CAO 48, a 24-hour rest period would have been required. On 25 June 2009, the pilot had an approximate duty period of 18 hours and a flight time of about 15 hours.

Fatigue

Fatigue can arise from a number of different sources, including time on task, time since awake, acute and chronic sleep debt, and circadian disruption (that is, factors which affect the normal 24-hour cycle of body functioning). A review of fatigue research relevant to flight operations has noted that fatigue can have a range of influences, such as decreased short-term memory, slowed reaction time, decreased work efficiency, reduced motivational drive, increased variability in work performance, and increased errors of omission.[18] The review also made the following observations:

- A common symptom of fatigue is a change in the level of acceptable risk that a person tolerates, or a tendency to accept lower levels of performance and not correct errors.

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17 www.casa.gov.au/wcmswr/_assets/main/download/orders/cao48/4801.pdf

18 Battelle Memorial Institute, 1998, *An Overview of the scientific literature concerning fatigue, sleep, and the circadian cycle*, Report prepared for the Office of the Chief Scientific and Technical Advisor for Human Factors, US Federal Aviation Administration.

- Decrements in alertness and performance intensify if the time awake is 16 to 18 hours. Performance decrements of 'high time-since-awake' pilots tended to result from ineffective decision-making rather than a deterioration of aircraft handling skills.
- There is a discrepancy between self-reports of fatigue and actual fatigue levels, with people generally underestimating their level of fatigue.
- Most people need eight hours sleep each day to achieve maximum levels of alertness and performance.
- Fatigue is cumulative.
- The physical environment of the cockpit, in terms of factors such as noise and vibration, can also contribute to fatigue.

Research has also shown a significant increase in accident rates for commercial pilots as their duty time increases, particularly when their duty times are more than 12 hours.[19]

Risk management

The helicopter was contracted to a mustering organisation to carry out a stock muster from Uaroo. It was to be a part of a two helicopter muster of the property. The muster had not commenced as HXO had not arrived.

The desire to get a job done, or 'mission-itis'[20], is experienced by almost everyone. 'Mission-itis' is often associated with fatigue, typically involving poor risk management leading to unsafe acts, with a pilot placing more emphasis on completing the mission.

Discussions with work colleagues, family and friends, did not identify any external pressures being placed on the pilot to arrive at Uaroo by a specific time. Those discussions also indicated the pilot would have been very familiar with working long hours, and that he was accustomed to operating machinery for extended periods of time.

It was also established that the pilot was not adequately prepared for the navigation exercise from Mareeba to Uaroo. The flight was conducted primarily by use of a portable GPS and a road atlas. Coordinates of appropriate refuelling stops were provided to the pilot by a fellow pilot, as well as an En Route Supplement Australia (ERSA).[21] The road atlas and ERSA were located at the accident site, in the storage compartment under the pilot's seat.

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[19] Goode, JH 2003, 'Are pilots at risk of accidents due to fatigue?', *Journal of Safety Research*, vol. 34, pp. 309-313.

[20] 'Mission-itis' is a term used in aviation safety literature, also synonymous with 'get-home-itis' and 'press-on-itis'.

[21] ERSA is an airport directory for Australian aerodromes which contains information vital for planning a flight and for the pilot in flight. It has pictorial presentations of all licensed aerodromes and includes aerodrome physical characteristics, hours of operation, visual ground aids, air traffic services, navaids, and lighting.

Flight operations at night

In December 2006, CASA published Civil Aviation Advisory Publication (CAAP) 5.13-2(0) [22], regarding night visual flight. The introduction in the CAAP opened with information regarding night flying accidents:

> Night flying accidents are not as frequent as daytime accidents because less flying is done at night. However, statistics indicate that an accident at night is about two and a half times more likely to be fatal than an accident during the day. Further, accidents at night that result from controlled or uncontrolled flight into terrain (CFIT or UFIT) are very likely to be fatal accidents. Loss of control by pilots of night visual flight rules (NVFR) aircraft in dark night conditions has been a factor in a significant number of fatal accidents in this country and the purpose of this CAAP is to highlight the hazards of night flying and to provide advice to NVFR pilots and others on how to fly safe NVFR operations.

Flight at night requires a balance of visual cues as well as reference to specific flight instruments. With limited illumination provided by moon or ground lighting, it may be difficult to see the natural horizon, as well as maintaining terrain and cloud separation, making visual flight impossible.

The CAAP also stated:

> Loss of control of the aircraft is highly likely if a pilot attempts to fly by visual reference instead of by reference to instruments.

Visual cues should only be used in night flight as a means of ascertaining navigation fixes, as well as to help position the aircraft approaching an airport and to maintain separation from other aircraft and lighted obstacles. Visual illusions can be minimised by use of flight instruments, rather than relying on visual cues as a sole means of reference.

ATSB Aviation Safety Investigation 200304282[23] regarding loss of control due to spatial disorientation[24], detailed the risks associated with operating an aircraft at night with minimal celestial lighting available to the pilot, in a NVFR operation with a NVFR equipped helicopter. The report discussed the potentially misleading effects of night visual illusions, and the potential to result in the pilot being susceptible to spatial disorientation.

The ATSB has investigated several occurrences where day VFR Robinson R22 helicopters have been operated at night (Appendix D). Each of those occurrences resulted in the aircraft impacting terrain, resulting in a fatal accident.

Robinson Helicopter Company Safety Notices SN-18 and SN-26 warn pilots of the dangers involved in flying at night, and the increased chance of it resulting in a fatal accident (Appendix B).

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22 www.casa.gov.au/wcmswr/_assets/main/download/caaps/ops/5_13_2.pdf

23 www.atsb.gov.au/publications/investigation_reports/2003/AAIR/pdf/aair200304282_001.pdf

24 Spatial disorientation, put simply means not knowing which way is up.

Instruments required for night flight

HXO was fitted with the basic instruments package required for day visual meteorological conditions (VMC). CASA CAO 20.18 Appendix VIII[25] detailed the required instruments for night VMC.

The following additional instruments would have been required to enable HXO to be operated at night in VMC and to provide the pilot with sufficient information to fly by reference to the instruments:

- an attitude indicator, and either another attitude indicator or a turn indicator
- a heading indicator (directional gyroscope)
- a means of indicating whether the power supply to the gyroscopic instruments is working satisfactorily.

Without the additional instruments fitted to HXO, any attempt to operate the aircraft would have been considered to be limited panel flying, or flying without sufficient information to fly by reference to the instruments.

ATSB investigation 200304282 stated:

> Limited panel flying is very demanding and previous occurrence investigations have indicated that even highly experienced instrument flight rules (IFR) rated pilots are challenged to fly safely in such a configuration. Limited panel flying by a pilot inexperienced in IFR flight and operating in low celestial or artificial lighting conditions, during flight under the night VFR, may impose a significant safety risk.

The Garmin GPSMAP296 that was found at the accident site had the additional capability of displaying a basic panel of flight instruments as well as terrain awareness information (Figure 15). It could not be determined if either of these pages were being utilised at the time of the accident.

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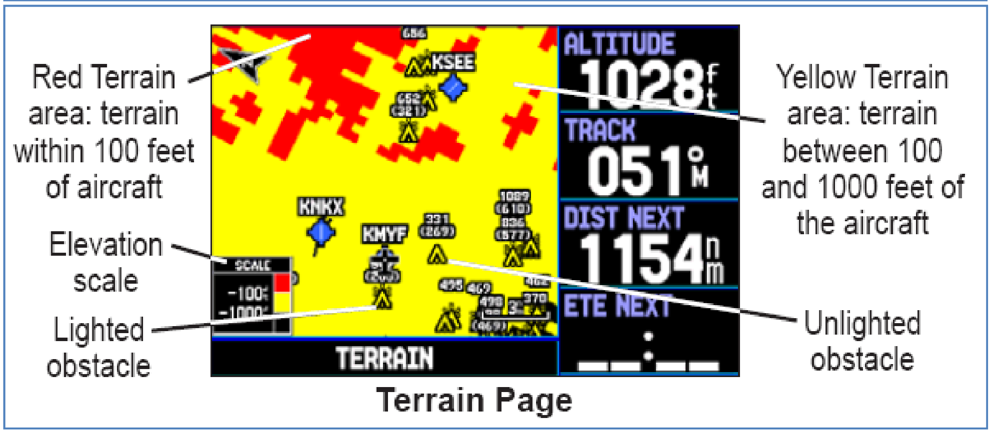
25 www.casa.gov.au/wcmswr/_assets/main/download/orders/cao20/2018.pdf

Figure15: Examples of flight instrument and terrain screens available on the GPS



ANALYSIS

Introduction

The physical and technical evidence was consistent and found no pre-existing mechanical defect associated with the airframe or engine with the potential to have contributed to the accident.

Weather around the time of the accident was benign, with light breezes, and the chance of fog or low cloud.

In the absence of any evidence that an external distraction might have lead to the accident, this analysis will review the physical evidence, and discuss a number of operational scenarios that could have precipitated the accident.

Wreckage examination

The impact damage to the tail boom showed that the main rotor blades struck the tail boom at least twice before the helicopter impacted the ground. That was consistent with the fracture surfaces of the tail rotor driveshaft, which were due to impact with the main rotor blades, and not a result of an in-flight failure.

Once the tail rotor and parts of the tail boom separated from the helicopter, the helicopter would have rotated in the opposite direction of the main rotor rotation, without the anti-torque thrust that was normally provided by the tail rotor.

The damage to the helicopter would have rapidly decreased its forward speed. That would explain the close proximity of the initial ground impact mark of the helicopter to the main wreckage. The severe deformation of the helicopter's main structure was most likely as a result of an almost inverted, right-side low, vertical descent.

Engine examination

The engine examination did not reveal any condition that would have precluded normal operation of the engine. However, that examination and the onsite wreckage examination found contradictory evidence regarding the operation of the engine at the time it impacted terrain.

The rotational abrasion marks on the engine oil cooler and the needle contact on the engine RPM indicator were evidence that the engine was rotating at the time of the initial ground impact. But, the ring gear teeth imprint on the engine oil cooler showed clearly that the engine was not rotating when that contact occurred. This last aspect was supported by the lack of any indication of rotational contact between the fan wheel assembly and the scroll from the engine cooling system that might be expected to be seen following an accident.

The RPM value identified on the engine RPM indicator from the needle contact was not considered to be reliable due to the extreme forces being experienced during the accident sequence. It is possible that the engine RPM decreased during the impact sequence.

While the evidence indicated that the engine ring gear was rotating when the aircraft initially contacted the terrain and ceased rotating prior to the final impact, the investigation could not establish with certainty whether the engine was driving the main and tail rotors. It is possible that the pilot was reacting to a carburettor icing event and thus subject to a total or partial engine failure, when the main rotor blades impacted the tail boom.

Fuel

There was no evidence that the amount or quality of the fuel on board was a factor. The pilot would have had to refuel en route to complete the journey from Newman to Uaroo, Western Australia (WA). At least two of the fuel containers had been utilised along the route as evidenced by them not being ruptured during the collision with the ground and that their caps were secure. The most likely place for refuelling would have been at Paraburdoo WA, as it had an airport and was on the track between Newman and Uaroo, and the pilot had made several phone calls within mobile coverage of Paraburdoo.

Operational aspects

The operational factors with the potential to have contributed to the main rotor impact with the tail boom include main rotor stall, a low-g pushover manoeuvre, over control by the pilot, or a combination of those factors.

The likelihood of main rotor stall would have been lessened with the helicopter in a stable cruise. However had the engine performance been affected by the onset of carburettor icing, main rotor stall could have been possible. In addition, although there was severe deformation of the mast teeter stops consistent with mast bumping, the damage to the main rotor blades did not indicate low main rotor RPM. On that basis, main rotor stall leading to severing of the tail boom was considered unlikely.

A low-g pushover may have been initiated following a pull-up for obstacle avoidance. Although there was severe deformation of the mast teeter stops, and main rotor impact with the tail boom, the main rotor mast was not bent or severed, which generally occurs during a low-g condition.

The possible effects of large, abrupt control inputs of the cyclic control could result in the main rotor blades contacting the tail boom as described in the United States National Transportation Safety Board special report. That type of control input may have been initiated by the pilot to avoid an obstacle or as a result of spatial disorientation.

In the absence of any evidence that main rotor stall or a low-g manoeuvre had contributed to the development of the accident, it was concluded that the onset of the main rotor blades contacting the tail boom was probably the result of a large, abrupt control input.

Fatigue

From when the pilot was awake at Mareeba, Queensland on 24 June 2009 to the last recorded phone activity that day, he had been awake for about 18 hours and conducted about 11 hours flying. Even though he would have had short breaks every couple of hours for refuelling, the nature of the flying activities would have been demanding. The pilot was manually flying the helicopter for extended periods without the doors being fitted, which would have added additional environmental stressors in terms of noise, buffeting or vibration, and temperature variations. Overall, the nature of the flying task would have increased the potential for fatigue.

The actual amount of sleep the pilot obtained on 24 June could not be determined. He had an opportunity for at most 3 hours sleep prior to sending some text messages, about another 3 hours before some additional phone activity, and another 1 hour of sleep prior to getting up. At most he would have obtained 7 hours sleep. However, given the phone activity, it is likely his sleep was disrupted and the actual amount of sleep he received was less than 7 hours.

Upon awaking at Alice Springs, Northern Territory on the 25 June 2009, to the last recorded phone activity that day, the pilot had been awake for more than 18 hours and conducted about 15 hours flying. In addition to the demanding nature of the flying discussed above, the last portion was conducted at night in conditions with minimal celestial or terrestrial lighting, which would have further increased his workload and the potential for fatigue. Overall, at the time of the last recorded phone activity, the pilot would have been experienced a significant level of fatigue and his performance, including his ability to make sound judgements, would have been adversely affected.

It is unknown at what time the accident occurred, or if the pilot had continued to fly at night or land to sleep on the night of the 25 June. If he had decided to sleep, there was no evidence to indicate that he had found suitable rest facilities. Even if he had obtained a reasonable sleep, given the amount and type of flying conducted in the previous two days, and the limited sleep received the previous night, it is likely the pilot would still have been experiencing some fatigue the next day. Without knowing the exact time of the accident, and what pilot actions may have contributed to the accident, the extent to which his fatigue contributed to the accident could not be determined.

Carburettor icing

Conditions around the time of the accident were conducive to serious carburettor icing at any power setting. Due to environmental conditions and the period of time between the accident and the investigators arriving on site, any icing that may have been present in the carburettor throat would have melted and not been detectable.

If the carburettor heat assist at the time of the occurrence had been locked in the ‘OFF’ position, or not correctly adjusted when operating automatically, it is probable that the air temperature in the carburettor may have been in the caution range. It was also possible that, due to the effects of fatigue, the pilot may not have been aware of a temperature drop as indicated by the carburettor temperature gauge to within the caution range.

Flight operations at night

The crescent moon, of less than one quarter that was in the western sky on 25 June 2009 may have provided the pilot with some celestial lighting for visual cues providing it was not masked by cloud cover before it set at 2125 Western Standard Time.

Examination of the instrument lights, landing lights and left navigation light, indicated that they were on at the time of collision with terrain. From the evidence available to the investigation, it was determined that the pilot was operating the helicopter at night on 25 June 2009, however it could not be definitively determined if the pilot was night flying at the time of the accident. It was possible that the aircraft lighting was utilised to aid night flight or that the pilot had forgotten to turn off the aircraft lighting when transitioning from early morning conditions into full daylight. It was also possible that the pilot was utilising the panel page of the Garmin GPSMAP 296 to assist with night flight and orientation.

Operating a day visual flight rules (VFR) equipped and certified helicopter at night under the night VFR was contrary to the requirements of Civil Aviation Safety Authority Civil Aviation Regulation (CAR) 1988, Part 174A.

Conclusion

The investigation found no evidence of a pre-existing mechanical problem with the helicopter. After consideration of the available evidence, the investigation concluded that the accident may have been a function of the pilot's control inputs, possibly resulting from pilot fatigue, carburettor icing, night flight, or a combination of these factors.

The investigation did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the accident does provide a timely reminder of the need for pilots conducting private operations to consider the impact of fatigue; particularly, during a long flight over a number of days, as was the case in this occurrence.

FINDINGS

Context

From the evidence available, the following findings are made with respect to the collision with terrain that occurred 120 km west of Paraburdoo, Western Australia on either 25 or 26 June 2009 that involved Robinson R22 Beta II helicopter, registered VH-HXO, and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- Loss of control of the helicopter was a result of pilot control inputs leading to the main rotor blades contacting the tail boom in-flight.

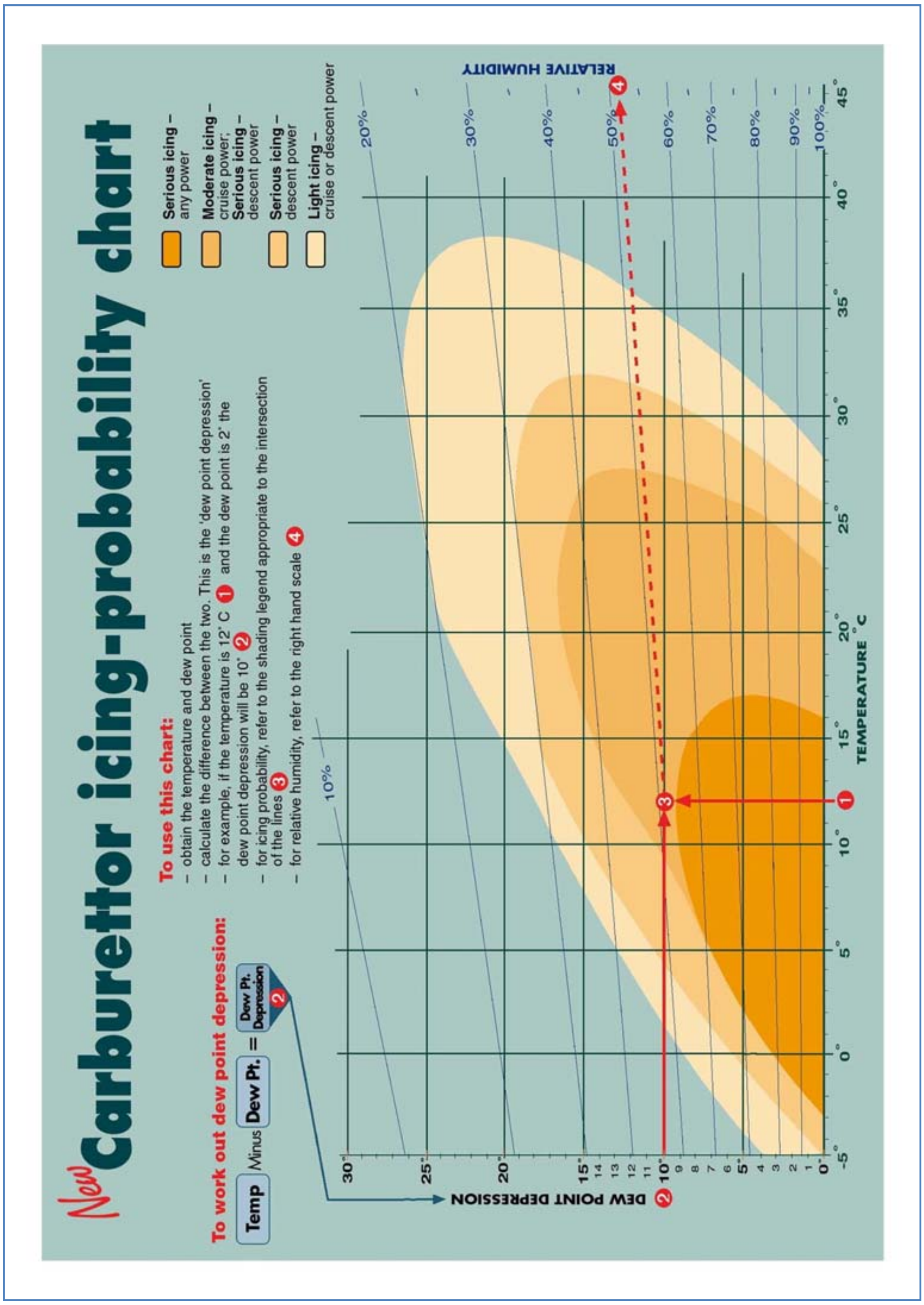
Other safety factors

- The pilot would have experienced a significant level of fatigue towards the end of the second day of his journey, but his fatigue level at the time of the accident could not be determined.
- Conditions around the time of the accident were conducive to serious carburettor icing.
- The night visual flight rules rated pilot was likely operating the day visual flight rules equipped helicopter at night.

Other key findings

- There was no pre-existing mechanical defect associated with the airframe or engine.
- Recorded fuel uploads and evidence from the fuel containers on site confirmed that the helicopter had adequate fuel for the planned flight
- The investigation was unable to determine if the engine was operating or not, at the time that the main rotor blades contacted the tail boom in-flight.

APPENDIX A: CARBURETTOR ICING PROBABILITY CHART



APPENDIX B: HELICOPTER MANUFACTURER SAFETY NOTICES

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-10

Issued: Oct 82   Rev: Feb 89; Jun 94

FATAL ACCIDENTS CAUSED BY LOW RPM ROTOR STALL

A primary cause of fatal accidents in light helicopters is failure to maintain rotor RPM. To avoid this, every pilot must have his reflexes conditioned so he will instantly add throttle and lower collective to maintain RPM in any emergency.

The R22 and R44 have demonstrated excellent crashworthiness as long as the pilot flies the aircraft all the way to the ground and executes a flare at the bottom to reduce his airspeed and rate of descent. Even when going down into rough terrain, trees, wires or water, he must force himself to lower the collective to maintain RPM until just before impact. The ship may roll over and be severely damaged, but the occupants have an excellent chance of walking away from it without injury.

Power available from the engine is directly proportional to RPM. If the RPM drops 10%, there is 10% less power. With less power, the helicopter will start to settle, and if the collective is raised to stop it from settling, the RPM will be pulled down even lower, causing the ship to settle even faster. If the pilot not only fails to lower collective, but instead pulls up on the collective to keep the ship from going down, the rotor will stall almost immediately. When it stalls, the blades will either "blow back" and cut off the tailcone or it will just stop flying, allowing the helicopter to fall at an extreme rate. In either case, the resulting crash is likely to be fatal.

No matter what causes the low rotor RPM, the pilot must first roll on throttle and lower the collective simultaneously to recover RPM **before** investigating the problem. It must be a conditioned reflex. In forward flight, applying aft cyclic to bleed off airspeed will also help recover lost RPM.

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-11

Issued: Oct 82 Rev: Nov 00

LOW-G PUSHOVERS - EXTREMELY DANGEROUS

Pushing the cyclic forward following a pull-up or rapid climb, or even from level flight, produces a low-G (weightless) flight condition. If the helicopter is still pitching forward when the pilot applies aft cyclic to reload the rotor, the rotor disc may tilt aft relative to the fuselage before it is reloaded. The main rotor torque reaction will then combine with tail rotor thrust to produce a powerful right rolling moment on the fuselage. With no lift from the rotor, there is no lateral control to stop the rapid right roll and mast bumping can occur. Severe in-flight mast bumping usually results in main rotor shaft separation and/or rotor blade contact with the fuselage.

The rotor must be reloaded before lateral cyclic can stop the right roll. To reload the rotor, apply an immediate gentle aft cyclic, but avoid any large aft cyclic inputs. (The low-G which occurs during a rapid autorotation entry is not a problem because lowering collective reduces both rotor lift and rotor torque at the same time.)

Never attempt to demonstrate or experiment with low-G maneuvers, regardless of your skill or experience level. Even highly experienced test pilots have been killed investigating the low-G flight condition. Always use great care to avoid any maneuver which could result in a low-G condition. Low-G mast bumping accidents are almost always fatal.

NEVER PERFORM A LOW-G PUSHOVER!!

Safety Notice SN-18

Issued: Jan 85 Rev: Feb 89; Jun 94

LOSS OF VISIBILITY CAN BE FATAL

Flying a helicopter in obscured visibility due to fog, snow, low ceiling, or even a dark night can be fatal. Helicopters have less inherent stability and much faster roll and pitch rates than airplanes. Loss of the pilot's outside visual references, even for a moment, can result in disorientation, wrong control inputs, and an uncontrolled crash. This type of situation is likely to occur when a pilot attempts to fly through a partially obscured area and realizes too late that he is losing visibility. He loses control of the helicopter when he attempts a turn to regain visibility but is unable to complete the turn without visual references.

You must take corrective action before visibility is lost! Remember, unlike the airplane, the unique capability of the helicopter allows you to land and use alternate transportation during bad weather, provided you have the good judgement and necessary willpower to make the correct decision.

OVERCONFIDENCE PREVAILS IN ACCIDENTS

A personal trait most often found in pilots having serious accidents is overconfidence. High-time fixed-wing pilots transitioning into helicopters and private owners are particularly susceptible. Airplane pilots feel confident and relaxed in the air, but have not yet developed the control feel, coordination, and sensitivity demanded by a helicopter. Private owners are their own boss and can fly without discipline, enforced rules, or periodic flight checks and critique by a chief pilot. A private owner must depend on self-discipline, which is sometimes forgotten.

When flown properly and conservatively, helicopters are potentially the safest aircraft built. But helicopters are also probably the least forgiving. They must always be flown defensively. The pilot should allow himself a greater safety margin than he thinks will be necessary, just in case.

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24

Issued: Sep 86 Rev: Jun 94

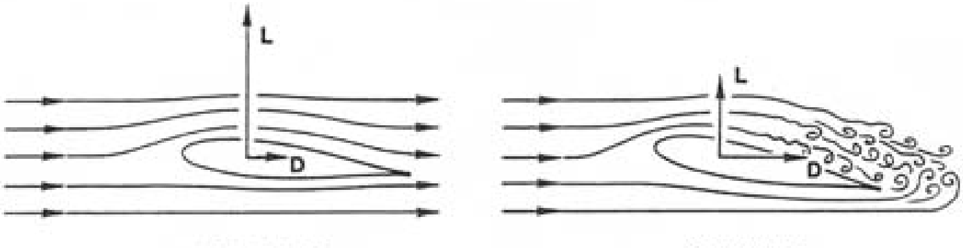
LOW RPM ROTOR STALL CAN BE FATAL

Rotor stall due to low RPM causes a very high percentage of helicopter accidents, both fatal and non-fatal. Frequently misunderstood, rotor stall is not to be confused with retreating tip stall which occurs only at high forward speeds when stall occurs over a small portion of the retreating blade tip. Retreating tip stall causes vibration and control problems, but the rotor is still very capable of providing sufficient lift to support the weight of the helicopter.

Rotor stall, on the other hand, can occur at any airspeed and when it does, the rotor stops producing the lift required to support the helicopter and the aircraft literally falls out of the sky. Fortunately, rotor stall accidents most often occur close to the ground during takeoff or landing and the helicopter falls only four or five feet. The helicopter is wrecked but the occupants survive. However, rotor stall also occurs at higher altitudes and when it happens at heights above 40 or 50 feet AGL it is most likely to be fatal.

Rotor stall is very similar to the stall of an airplane wing at low airspeeds. As the airspeed of an airplane gets lower, the nose-up angle, or angle-of-attack, of the wing must be higher for the wing to produce the lift required to support the weight of the airplane. At a critical angle (about 15 degrees), the airflow over the wing will separate and stall, causing a sudden loss of lift and a very large increase in drag. The airplane pilot recovers by lowering the nose of the airplane to reduce the wing angle-of-attack below stall and adds power to recover the lost airspeed.

The same thing happens during rotor stall with a helicopter except it occurs due to low rotor RPM instead of low airspeed. As the RPM of the rotor gets lower, the angle-of-attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter. Even if the collective is not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until the



Wing or rotor blade unstalled and stalled.

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24 (continued)

upward movement of air to the rotor provides the necessary increase in blade angle-of-attack. As with the airplane wing, the blade airfoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increased drag on the blades acts like a huge rotor brake causing the rotor RPM to rapidly decrease, further increasing the rotor stall. As the helicopter begins to fall, the upward rushing air continues to increase the angle-of-attack on the slowly rotating blades, making recovery virtually impossible, even with full down collective.

When the rotor stalls, it does not do so symmetrically because any forward airspeed of the helicopter will produce a higher airflow on the advancing blade than on the retreating blade. This causes the retreating blade to stall first, allowing it to dive as it goes aft while the advancing blade is still climbing as it goes forward. The resulting low aft blade and high forward blade become a rapid aft tilting of the rotor disc sometimes referred to as "rotor blow-back". Also, as the helicopter begins to fall, the upward flow of air under the tail surfaces tends to pitch the aircraft nose-down. These two effects, combined with aft cyclic by the pilot attempting to keep the nose from dropping, will frequently allow the rotor blades to blow back and chop off the tailboom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of rotor blades, rotor teeter stops will not prevent the boom chop. The resulting boom chop, however, is academic, as the aircraft and its occupants are already doomed by the stalled rotor before the chop occurs.

Safety Notice SN-25

Issued: Dec 86 Rev: Nov 99

CARBURETOR ICE

Carburetor ice can cause engine stoppage and is most likely to occur when there is high humidity or visible moisture and air temperature is below 70°F (21°C). When these conditions exist, the following precautions must be taken:

During Takeoff - Unlike airplanes, which take off at wide open throttle, helicopters take off using only power as required, making them vulnerable to carb ice, especially when engine and induction system are still cold. Use full carb heat (it is filtered) during engine warm-up to preheat induction system and then apply carb heat as required during hover and takeoff to keep CAT gage out of yellow arc.

During Climb or Cruise - Apply carb heat as required to keep CAT gage out of yellow arc.

During Descent or Autorotation -

R22 - Below 18 inches manifold pressure, ignore CAT gage and apply full carb heat.

R44 - Apply carb heat as required to keep CAT gage out of yellow arc and full carb heat when there is visible moisture.

Safety Notice SN-26

Issued: Jan 87 Rev: Jun 94

NIGHT FLIGHT PLUS BAD WEATHER CAN BE DEADLY

Many fatal accidents have occurred at night when the pilot attempted to fly in marginal weather after dark. The fatal accident rate during night flight is many times higher than during daylight hours.

When it is dark, the pilot cannot see wires or the bottom of clouds, nor low hanging scud or fog. Even when he does see it, he is unable to judge its altitude because there is no horizon for reference. He doesn't realize it is there until he has actually flown into it and suddenly loses his outside visual references and his ability to control the attitude of the helicopter. As helicopters are not inherently stable and have very high roll rates, the aircraft will quickly go out of control, resulting in a high velocity crash which is usually fatal.

Be sure you NEVER fly at night unless you have clear weather with unlimited or very high ceilings and plenty of celestial or ground lights for reference.

Safety Notice SN-31

Issued: Dec 96

GOVERNOR CAN MASK CARB ICE

With throttle governor on, carb ice will not become apparent as a loss of either RPM or manifold pressure. The governor will automatically adjust throttle to maintain constant RPM which will also result in constant manifold pressure. When in doubt, apply carb heat as required to keep CAT out of yellow arc during hover, climb, or cruise, and apply full carb heat when manifold pressure is below 18 inches.

Also remember, if carb heat assist is used it will reduce carb heat when you lift off to a hover and the control may require readjustment in flight.

APPENDIX C: PREVIOUS AUSTRALIAN ROBINSON R22 CARBURETTOR ICING OCCURRENCES

ATSB occurrence number 198602339, 16 July 1986

An exercise in emergency procedures was being carried out in the circuit area. A number of landings were completed, with the instructor simulating a jammed tail rotor pedal. On the last landing, a jammed right pedal was being simulated. After a standard approach for the circumstances, the student flared at about 45 centimetres above the ground and at a speed of about 15 knots. As he then began to reduce power, the engine apparently suffered a substantial loss of power and the aircraft landed heavily. The left landing skid dug in, and the helicopter somersaulted before coming to rest on its right side. No fault or defect was subsequently found with the engine or its systems which might have explained the reported power loss. Atmospheric conditions at the time of the accident were conducive to the formation of carburettor icing, particularly during descents with reduced power. The pilots had not used carburettor heat during the approach, possibly because the carburettor air temperature gauge was indicating a temperature just above the caution range. This instrument was later found to be reading in error by 9 degrees. The pilots had not checked the reading of the gauge against the ambient temperature prior to engine start, and were therefore unaware of the malfunction. When the power loss occurred, the helicopter was in such a position that it had contacted the ground before the instructor could initiate any corrective action.

ATSB occurrence number 198703519, 21 November 1987

Having taken delivery of a new helicopter the previous day, the pilot was carrying relatives on short flights over their property. On the second flight, descending through 200 ft for landing, the rotor low rpm warning horn sounded. The pilot applied full throttle and lowered the collective pitch control but this did not restore rotor rpm. As the horn continued to sound he turned the aircraft into wind and attempted a landing in a clear area. The aircraft struck the ground with the heels of both skids and the tail rotor. The tail boom was severed by the main rotor, and the helicopter came to rest on its right side. The passenger suffered bruising as a result of contact with the emergency locator beacon which was mounted between the backrests of the two seats. No fault was found with the engine or airframe which might have contributed to the accident. However, atmospheric conditions existing at the time were such that moderate to serious carburettor icing was probable.

ATSB occurrence number 199002007, 25 September 1990

A mayday call was transmitted due to an engine failure and a subsequent forced landing was carried out on the eastern bank of Berowra Waterson grassed area. The reason for the power drop was suspected to be carburettor icing, but was undetermined.

ATSB occurrence number 199603165, 30 August 1996

The pilot was conducting a steep descent and when he applied power to recover the engine failed to respond. He then carried out an autorotational landing. The engine was found to be still running after the landing. A thorough inspection of the helicopter and engine failed to find any cause for the loss of power. The engine may have suffered carburettor icing.

ATSB occurrence number 200402791, 28 July 2004

On 28 July 2004, the pilot in command, the sole occupant, of the Robinson Helicopter Company R22 was conducting circuit training at Mangalore aerodrome, Victoria. Shortly after reaching circuit height on the crosswind leg of the circuit, the helicopter began to yaw rapidly in alternating left and right directions. The pilot turned the helicopter towards the aerodrome for an immediate landing. The pilot subsequently reported that during the descent, the main rotor low RPM horn sounded twice, accompanied by the illumination of the main rotor low RPM light. The pilot also reported that about 200 ft above ground level the main rotor low RPM warnings were again triggered by the decay of engine RPM. The pilot performed an autorotation, but the helicopter was landed heavily. The helicopter was substantially damaged by impact forces and the pilot received minor injuries. At the time of the occurrence, there was broken cloud at 1,000 ft at Mangalore aerodrome. The 1000 EST Mangalore automatic weather station data revealed that the temperature was 8^{o} C and the dewpoint temperature was 6.3^{o} C. Other helicopters were operating in the Mangalore circuit at the time of the occurrence. Although the pilots of those helicopters reported that their helicopters had not been affected by carburettor icing, the investigation was unable to discount that carburettor icing may have been the factor that resulted in the abnormal operation of the helicopter engine.

APPENDIX D: PREVIOUS AUSTRALIAN ROBINSON R22 NIGHT FLYING OPERATIONS OCCURRENCES

ATSB occurrence number 199502225, 17 July 1995

The helicopter did not arrive at its destination following a ferry flight. The wreckage of the helicopter was found by chance, late at night. It had crashed during a dark night. The engine had stopped before impact. The helicopter fell several thousand feet out of control.

ATSB occurrence number 199903335, 9 July 1999

At about 2345-2400 witnesses heard the helicopter engine start and run for a period of time before the helicopter was seen to take-off and depart in a north-easterly direction. It climbed steeply to about 600 ft above ground level, after which the engine noise appeared to change and the aircraft descended quickly until impact with the terrain. Searchers found the wreckage soon after first light the next morning on a flat area of land between hills, approximately 800 m from the resort.

ATSB occurrence number 200504925, 6 October 2005

The helicopter with the pilot and one passenger onboard was returning to Yalda Downs Station from Border Downs Station after last light. As it overflew Calindary Station homestead, which is approximately 46 km west of the intended destination, the helicopter was observed to gain height and conduct a right turn. The helicopter then descended and impacted the ground about 500 m from the homestead. The helicopter was destroyed by impact forces and the post-impact fire. The pilot was fatally injured and the passenger sustained critical injuries.

APPENDIX E: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included:

- the helicopter maintenance engineer
- the Western Australian State Coroner
- the Civil Aviation Safety Authority (CASA)
- the Australian Maritime Safety Authority
- the Bureau of Meteorology (BoM)
- Airservices Australia
- Geoscience Australia
- the helicopter manufacturer
- the Global Positioning System equipment manufacturer.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003 (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act 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 helicopter maintenance engineer, the BoM, CASA and Airservices Australia for comment. All parties responded with no comments.

Collision with terrain
120 km west of Paraburdoo, WA 25 or 26 June 2009
VH-HXO, Robinson R22 Beta II