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ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2010-042
Final

Collision with terrain, VH-RPN
257 km ENE Derby, Western Australia
13 June 2010

Abstract

On 13 June 2010, a Robinson Helicopter Co. R22 Beta, registered VH-RPN, was engaged in aerial cattle mustering operations on a station property about 257 km east-north-east of Derby, Western Australia. During those operations, the helicopter collided with the ground and caught fire. The pilot, the sole occupant of the helicopter, sustained fatal injuries.

The investigation found that the helicopter had a high descent rate and some forward speed at impact but, due to the lack of evidence as a function of the type and location of the operation, was unable to positively establish any further contributing factors.

The investigation did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the accident provides a reminder of the hazards involved in aerial mustering operations that result in, or add to a number of low-level risks that require close management. Any pilot distraction, aircraft or systems failure, adverse weather or aircraft performance, or handling inattention can reduce the margins for continued safe flight.

FACTUAL INFORMATION

History of the flight

On 13 June 2010, a Robinson Helicopter Co. R22 Beta (R22) helicopter, registered VH-RPN (RPN), was one of two helicopters engaged in aerial cattle mustering operations on a station property about 257 km east-north-east of Derby, Western Australia.

The helicopters were operating from a nearby roadhouse. Information provided by the pilot of the second helicopter indicated that the muster commenced that morning between 0700 and 0730 Western Standard Time[1] and proceeded during the first part of the day without incident. Drum-stock fuel was used to refuel both helicopters at about 1030 and 1200 from the same drum and using the same hand-operated fuel pump. The helicopters departed the roadhouse at about 1230.

At about 1300, the pilot of the second helicopter remembered that he had not added oil to his engine during the last refuel and radioed the pilot of RPN that he was going to land. The pilot reported flying a short distance and landing at the old station homestead airstrip to add oil to his engine. When he took off to rejoin the muster, he was unable to contact the pilot of RPN. He then noticed smoke coming from the vicinity of where RPN had been working, flew to that location and saw that the helicopter had crashed and was on fire.

The pilot of RPN sustained fatal injuries.

1 The 24-hour clock is used in this report to describe the local time of day, Western Standard Time (WST), as particular events occurred. Western Standard Time was Coordinated Universal Time (UTC) + 8 hours.

Personnel information

The pilot of RPN held a Commercial Pilot (Helicopter) Licence that was issued by the Civil Aviation Safety Authority (CASA) on 7 March 2007 and was endorsed on the R22. CASA issued the pilot an Operational Approval for Low Flying (Helicopter) on 27 February 2007 and an Aerial Stock Mustering Approval on 19 December 2007. The pilot held a current Class 1 Medical Certificate, with nil restrictions.

The pilot's total flying experience was about 1,829 hours, all of which was in R22 helicopters with most in aerial stock mustering operations.

The instructor who conducted the pilot's last flight review on 8 April 2010 reported that the review focussed on autorotations, drive train failures and 'jammed' tail rotor pedals. The instructor recalled that the pilot's flying was sound with no apparent risk indicators.

During April 2008, the pilot completed a helicopter safety course, which was accredited by the Aviation Safety Foundation of Australia[2].

The pilot of RPN flew the helicopter from a cattle station to the roadhouse the day before the accident, arriving in the late afternoon. The pilot of the other helicopter arrived at the roadhouse at about 1700 and both pilots had a meal and stayed the night in accommodation adjoining the roadhouse. The pilot of the other helicopter reported that the pilot of RPN was in good spirits on the day.

In the 3 days prior to the day of the accident, the pilot of RPN was free of duty except for the 1.5-hour ferry flight to the roadhouse. Based on the operator's records for 2010, the pilot was within the applicable flight and duty time limitations.

Aircraft information

The helicopter, serial number 2241, was manufactured in the United States (US) in 1992 and first entered on the Australian aircraft register in January 1993. The helicopter's total time in service (TTIS) was calculated to be 8,864 hours.

The aircraft's Log Book Statement indicated that the helicopter was being maintained in accordance with the requirements of the manufacturer's maintenance manual. The maintenance documentation recorded the completion of a 2,200 hour airframe overhaul in July 2009, at 8,383 hours TTIS. That overhaul included the replacement of most drive-train components, including the two vee-belts that transferred engine power to the main rotor gearbox. An overhauled engine was installed at the same time.

The last 100-hourly inspection was completed on 13 May 2010 at 8,778 hours TTIS and a maintenance release was issued for aerial work operations by day under the visual flight rules. The last recorded maintenance was the replacement of an engine magneto on 3 June 2010 at 8,828 hours TTIS.

The helicopter was calculated to be about 70 kg below the maximum gross weight of 622 kg and within centre of gravity limits at the time of the accident.

Meteorological information

The nearest location with an aerodrome forecast (TAF) and aerodrome weather report (METAR) was Fitzroy Crossing Aerodrome, 184 km to the south of the accident site. That TAF and METAR information indicated east to south-easterly winds at 10 kts and CAVOK[3], consistent with the collective TAF and METAR information for other Kimberley locations and the recollection of the second helicopter pilot of the weather conditions at the time of the accident.

Based on the collective METAR information and the temperature recorded at a nearby cattle station at 1500, the temperature was estimated to be between 25 and 30 °C.

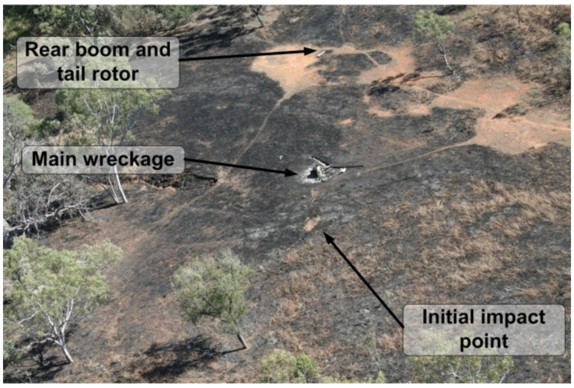
2 The Aviation Safety Foundation of Australia (ASFA) was an independent and not-for-profit organisation, promoting safety and establishing standards of practice within the aviation industry. In March 2009, ASFA consolidated its operations and became a regional base for the Flight Safety Foundation.

3 CAVOK. Visibility, cloud and present weather better than prescribed conditions. For an aerodrome weather report, those conditions were visibility 10 km or more, no cloud below 5,000 ft or cumulonimbus cloud and no other significant weather within 9 km the aerodrome.

Wreckage and impact information

The accident site was located at an elevation of about 1,300 ft (400 m) on flat, clear terrain close to a small creek (Figure 1). The terrain surrounding the accident site was slightly undulating with numerous trees and saplings. There was no evidence to indicate that the helicopter struck any of those trees or saplings prior to the impact with the ground.

Figure 1: Aerial view of the accident site



The helicopter had collided heavily with the ground, collapsing the skid-landing gear and destroying the lower of the engine components, including the carburettor and induction manifold. Associated ground contact marks were consistent with the helicopter's tailcone also striking the ground in the immediate vicinity of the initial point of impact. The geometry of the ground marks in the immediate vicinity was consistent with the helicopter being in a significantly tail-down, slightly right landing skid-low attitude at impact. Those marks were consistent with the nose of the helicopter being about 30° to the right of the probable flight path immediately prior to colliding with the ground.

The main wreckage was along the approximate direction of flight, about 10 m from the point of initial ground contact. An intense post-impact fire, the intensity of which was consistent with a significant quantity of fuel being on board the helicopter, consumed the main wreckage.

During the impact sequence, the helicopter's tailcone was struck by one of the main rotor blades, as evidenced by paint transfer marks from the tailcone on the skin of that rotor blade. The tailcone broke into three segments and the rear part was 42 m from the main wreckage, along the approximate direction of flight. A forward section from one of the helicopter's landing skids was found in line with the approximate direction of flight, about 100 m from the main wreckage.

The helicopter's main rotor blades were intact, securely attached to the main rotor hub and with the main wreckage (Figure 2). Damage to both blades was consistent with impact forces and the effects of the post-impact fire. There was no evidence of the main rotor blades striking any foliage, terrain or other objects prior to the accident, or of pre-accident skin delamination on either blade. There was no evidence of 'coning'[4].

Figure 2: Helicopter main wreckage

The tail rotor was intact and remained with the helicopter's tailcone. There was no evidence that the tail rotor struck any foliage, terrain or other objects prior to the accident.

There was evidence of the pre-impact continuity of the main and tail rotor driveshafts. The main rotor gearbox rotated normally and examination of the clutch shaft assessed it to be capable of normal operation. Pre-impact continuity of the helicopter's flight controls was evident.

The engine and its accessories were substantially damaged by the post-impact fire. There was evidence of material residue from the two rotor system vee-drive belts in the upper and lower sheaves; consistent with those belts being in position at the time of the fire.

All of the engine cooling fan vanes were damaged through 360° of rotation from ground contact, which was consistent with engine rotation at impact (Figure 3).

4 Coning in this context refers to the permanent upward-bending to main rotor blades produced by aerodynamic loads during flight with low main rotor RPM.

A number of components, including the engine, were recovered from the accident site for further technical examination.

Component examination

The engine was disassembled and examined at a CASA-approved engine overhaul facility under the supervision of the Australian Transport Safety Bureau. Although there was no evidence of any mechanical defect or anomaly, the impact and fire damage precluded any definitive assessment about the pre-impact serviceability of the engine.

Figure 3: Damage to the engine cooling fan vanes

The oil filter and main rotor gearbox chip detector[5] were examined with no contamination evident. The cockpit fuel selector valve was in the ON position and was unobstructed. Although the bump stops for the main rotor showed signs of mast bumping[6], there was no damage detected to the main rotor mast.

Medical and pathological information

Post-mortem examination and toxicological testing was conducted on the pilot by the relevant state authorities. Those examinations did not identify any pre-existing medical condition or other factors with the potential to have affected the pilot's performance, or to have incapacitated the pilot. Due to the extent of the impact forces and injuries sustained by the pilot during the initial impact, the accident was not survivable.

Abnormal helicopter operation[7]

Autorotation

In the case of a complete engine power loss, a pilot is required to immediately enter autorotation by lowering the collective control to reduce the drag generated by the main rotor blades. Once established in autorotation, the main rotor is driven by the upward airflow generated by the descent and forward airspeed.

Nearing the ground, a pilot will progressively flare the aircraft by applying rearward cyclic until the rate of descent and airspeed is sufficiently reduced, prior to the pilot levelling the helicopter for landing. Upward movement of the collective follows to cushion the landing.

Autorotative performance after an engine failure is limited at the relatively low altitudes and airspeeds typically adopted during aerial stock mustering. That limited performance is due to the height that is lost before the upward airflow from the rate of descent is sufficient to maintain main rotor RPM.

Vortex ring state

Vortex ring state (VRS) is an aerodynamic condition (sometimes referred to as 'settling with power') where, in simple terms, a large amount of the airflow generated by the main rotor blades recirculates through the blades and reduces main rotor thrust. The helicopter becomes caught in a high-rate vertical descent with substantial engine power applied, accompanied by reduced cyclic authority and increased vibration. VRS can develop when the helicopter has a combination of:

- low to zero airspeed
- engine power being applied
- a descent rate of at least 300 ft/min (some sources quote 700 ft/min or more for the R22 helicopter type).

If the pilot does not maintain the position of, or partially lower the collective control, before

5 A device that is used to gather chips of metal from engine, main and tail rotor oil as appropriate. Depending on the installation, can be linked to an in-cockpit indicating light.

6 Abnormal contact between the main rotor hub and the rotor mast which, if excessive, could severely damage the mast, or result in the separation of the main rotor system from the helicopter.

7 The information in this section has been adapted from relevant material in Chapter 11 of the *Rotorcraft Flying Handbook* (2000) published by the US Federal Aviation Administration.

increasing forward speed and flying away, the helicopter will sustain very high rates of descent.

Overpitching

Overpitching refers to the situation where there is insufficient engine power available or selected to sustain the intended flight path while maintaining the required main rotor RPM. Overpitching can be induced by engine power loss, main rotor inefficiencies or an exceedence of the helicopter's performance limitations.

If the pilot does not immediately respond by increasing power (if available) and/or lowering the collective control, overpitching can result in a rapidly decreasing main rotor RPM and a rapidly increasing rate of descent.

The application of collective to arrest a descent with the main rotor in a low RPM state will result in 'coning'.[8] Once the main rotor RPM reaches a critically low level the main rotor will effectively stall, and rotor thrust will completely collapse with typically catastrophic consequences.

Low-G manoeuvring

A low-G or weightless condition can be generated by the abrupt forward movement of the cyclic control, reducing the helicopter's lateral cyclic authority. A rapid roll to the right can result. If the pilot does not respond to the roll by gently applying aft cyclic to load the rotor and restore main rotor thrust before applying left cyclic to recover from the roll, the main rotor blades can flap[9] up and down to the extent that mast-bumping and/or blade contact with the airframe can occur.

ANALYSIS

The extensive damage to the helicopter and lack of recorded data and witnesses limited the amount of evidence available to the investigation. Of the available information, the investigation considered that the critical item was the indication of a high descent rate as derived from the nature of the damage to the helicopter's skid-landing gear, engine and firewall.

In the context of the low-level and low-speed manoeuvring that was characteristic of the aerial stock mustering flight, the investigation considered a number of factors with the potential to have resulted in a high rate of descent at touchdown. Those factors were a loss of main rotor structural integrity, a loss of main rotor torque, vortex ring state (VRS), overpitching and the effects of a low-G condition.

All of the damage to the main rotor system was able to be attributed to its disruption from the impact and subsequent fire. In conjunction with the lack of any indicators of main rotor unserviceability, that would suggest that the main rotor system was capable of normal operation at the time of the accident.

The damage to the engine cooling fan vanes was consistent with the engine rotating at the time of impact, and was a strong indicator of substantial engine power being available at that time. Also, there was no evidence of a mechanical failure to the main rotor drive system. While the impact and fire damage precluded a conclusive assessment of engine power capability and main rotor drive system continuity, a significant loss of main rotor torque as a contributor to the accident, was considered unlikely.

The potential for operational factors such as VRS, overpitching and low-G to have contributed to the development of the accident was considered in the context of the benign weather at the time, and the pilot's ability to manoeuvre the helicopter. In this case, the pilot was qualified for, and relatively experienced in, aerial stock mustering in R22 helicopters and had recently demonstrated the ability to maintain control of the helicopter during various simulated non-normal procedures and system malfunctions. In addition, the pilot had substantial time free of duty in the previous 3 days and there were no indicators of any physiological factors that would have affected his handling of the helicopter.

Although VRS results in high rates of descent, there was insufficient information to establish if two of the key preconditions, low to zero airspeed and a high rate of descent, coexisted in the lead-up to the accident. The impact speed derived

8 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).

9 Movement of a rotor blade in the vertical sense relative to the plane of rotation.

from the accident site was not consistent with developed VRS. Given the lack of information, the investigation was unable to establish the influence or otherwise of VRS on the development of the accident.

Overpitching can lead to high rates of descent. However, the lack of any permanent 'coning' of the main rotor blades indicated that the main rotor RPM probably did not drop to a critical level sufficient to have resulted in main rotor stall. There was also rotational energy evident in the severing of the tailcone by a main rotor blade that was not consistent with critically low rotor RPM. So, there was no physical evidence that overpitching occurred to the extent necessary for the helicopter to impact the ground with a high rate of descent. There was also no evidence that the operational context prior to the accident was conducive to overpitching.

An improper response to a low-G situation could lead to the type of damage observed on the helicopter's mast bump stops and in the main rotor blade striking the tailcone. However, in this instance, both of those features could also be attributed to impact-related main rotor instability. In that case, and given the pilot's extensive mustering experience in the R22, the investigation concluded that an improper response to a low-G situation was unlikely.

In addition to having a high descent rate and an amount of forward speed, the helicopter was tail-low and yawed to the right at impact. The tail-low attitude could have been indicative of a 'flare' that might have been initiated by the pilot to slow the forward speed and arrest the descent rate. The right yaw might have been the continuation of intentional yawed flight associated with the mustering task, or the unintended consequence of increased main rotor torque. Without more information about the operational context immediately prior to the accident, the investigation was unable to establish the significance of the helicopter's attitude at impact.

After consideration of the available evidence, the investigation was unable to establish why the helicopter collided with terrain at a high descent rate. However, by their nature, aerial mustering operations result in, or add to a number of low-level risks that require close management. Any pilot distraction, aircraft or systems failure, adverse weather or aircraft performance or handling inattention can reduce the margins for continued safe flight.

FINDINGS

From the evidence available, the following finding is made with respect to the collision with terrain that occurred 257 km east-north-east of Derby, Western Australia on 13 June 2010 and involved Robinson Helicopter Co. R22 Beta, registered VH-RPN. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factor

- The helicopter collided with terrain at a high rate of descent and caught fire.

SOURCES AND SUBMISSIONS

Sources of Information

The sources of information during the investigation included the:

- pilot of the other helicopter
- owner/operator of VH-RPN
- Bureau of Meteorology.

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 owner/operator, the other helicopter pilot and the Civil Aviation Safety Authority. There were no submissions from those parties.