Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report – 200600738

Final

Loss of Control – St Kilda, Vic - 12 February 2006
VH-WYS
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Loss of Control – St Kilda, Vic - 12 February 2006 – VH-WYS - Robinson Helicopter Company R44

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Abstract

On 12 February 2006, the pilot of a Robinson Helicopter Company R44 Raven II Newscopter, registered VH-WYS, was conducting aerial filming of a banner towing helicopter in the vicinity of Williamstown, Vic. On board with the pilot were a photographer in the front left seat and a gyro-stabilised camera operator in the rear left seat.

While in a turn at low airspeed, and with a quartering tailwind, the helicopter began an uncommanded yaw to the right. The pilot attempted to regain control but the helicopter continued to rotate to the right and descended approximately 1,800 ft before control was regained. The helicopter was flown to a nearby beach and landed.

The reported ambient conditions and nature of the loss of control were consistent with the pilot report that the helicopter had suffered a loss of tail rotor effectiveness (LTE). It was possible that the onset of vortex ring state had contributed to the high rate of descent during the pilot’s recovery from the LTE.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory, operator or other external bodies.

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. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and, where applicable, relevant international agreements. The object of a safety investigation is to determine the circumstances in order to prevent other similar events. The results of these determinations form the basis for safety action, including recommendations where necessary. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. 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.

Central to ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. While the Bureau issues recommendations to regulatory authorities, industry, or other agencies in order to address safety issues, its preference is for organisations to make safety enhancements during the course of an investigation. The Bureau prefers to report positive safety action in its final reports rather than making formal recommendations. Recommendations may be issued in conjunction with ATSB reports or independently. A safety issue may lead to a number of similar recommendations, each issued to a different agency.

The ATSB does not have the resources to carry out a full cost-benefit analysis of each safety recommendation. The cost of a recommendation must be balanced against its benefits to safety, and transport safety involves the whole community. Such analysis is a matter for the body to which the recommendation is addressed (for example, the relevant regulatory authority in aviation, marine or rail in consultation with the industry).

FACTUAL INFORMATION

History of the flight

On 12 February 2006, at approximately 1140 Eastern Daylight-saving Time[1], a Robinson Helicopter Company R44 (R44) Raven II Newscopter[2], registered VH-WYS, departed Essendon Airport to conduct an aerial work flight under the visual flight rules (VFR) in the vicinity of Williamstown, Vic. On board with the pilot were a photographer in the front left seat and a gyro-stabilised camera operator in the rear left seat.

The purpose of the flight was to photograph and film a promotional banner being towed by a Bell Helicopter Company 407 (B407) helicopter, registered VH-YZZ. The Australian Advanced Air Traffic System (TAAATS) replay of the flight showed that at 1229, the pilot of the R44 was flying slow anticlockwise orbits at 2,000 ft above ground level over Williamstown, while the pilot of the B407 was tracking north at approximately 30 kts and 1,600 ft over Hobsons Bay (figure 1).

As the pilot of the R44 turned through south towards the south-east, the helicopter began an uncommanded right yaw[3]. Recorded radar data indicated that the helicopter was in level flight at that time. The pilot of the R44 reported that the airspeed of the helicopter immediately prior to the yaw was less than 30 kts indicated airspeed (KIAS). The photographer, who was also a licensed helicopter pilot, reported that the helicopter had almost approached a hover as it turned downwind. That report was corroborated by a witness on the ground. The pilot, photographer and camera operator, and footage from the nose-mounted gyro-stabilised camera, confirmed that the uncommanded right yaw occurred rapidly.

The pilot reported pushing the cyclic control[4] forward in response to the rapid right yaw, but could not recall making any yaw pedal input. There was no immediate effect on the rate of rotation as a result of the pilot's control inputs and the helicopter began descending. The pilot applied more forward cyclic control and lowered the collective lever[5] in response to the activation of the main rotor low RPM warning horn. However, the low RPM warning horn remained activated until during the latter stages of the recovery. During the descent, the pilot transmitted a

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1 The 24-hour clock is used in this report to describe the time of day. Eastern Daylight-saving Time was Coordinated Universal Time (UTC) + 11 hours.

2 The Robinson R44 Raven II Newscopter has a 5-axis gyro-stabilised digital video camera system mounted on the nose of the helicopter. The camera operator's station includes monitors, a communications suite, and a lap top control console with joystick to control the camera.

3 Rotation of the helicopter about its vertical axis.

4 Can also be termed the 'cyclic stick', and is similar to an aeroplane control column. Pilot demand is passed via a number of helicopter components to tilt the main rotor disc in the desired direction. In response, the attitude of the helicopter varies in pitch and/or roll.

5 The collective lever is the pilot control in helicopters that simultaneously directly affects the pitch of all main rotor blades, irrespective of their azimuth position. It is the primary control of a helicopter's altitude or vertical velocity.

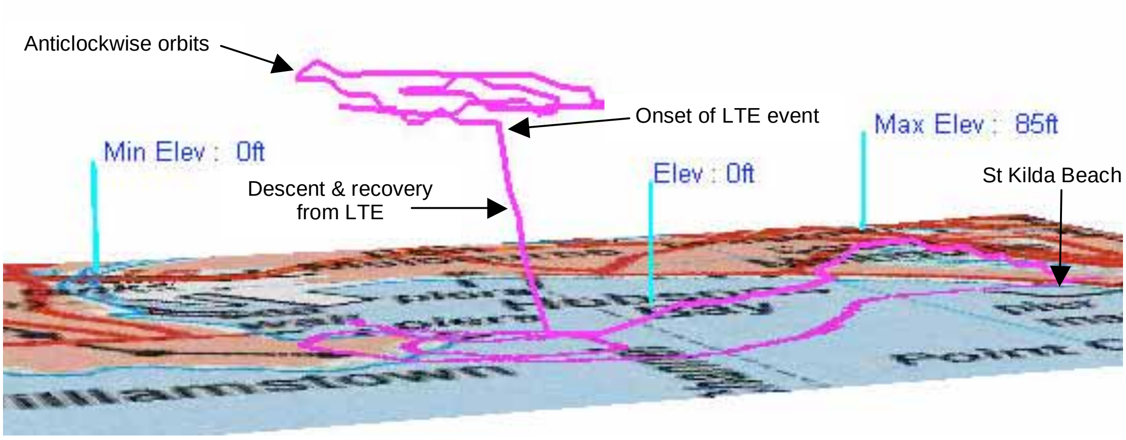
MAYDAY[6] call to Essendon Tower and the photographer transmitted a MAYDAY call on frequency 123.45 MHz to alert the pilot of the B407. The recorded radar data indicated that the pilot regained control of the helicopter about 20 seconds later, at approximately 200 ft above the surface of the water. The radar-derived vertical profile of the helicopter is presented in figure 2.

The pilot subsequently elected to fly to St Kilda Beach and land. The helicopter was later recovered by truck and transported to a maintenance facility for inspection.

Figure 1. Relative tracks of VH-WYS and VH-YZZ.

6 International call for urgent assistance.

Figure 2. Radar derived vertical profile of VH-WYS.



Operational Information

The pilot was appropriately qualified for the flight and had 863.6 hours total flying experience. That experience included a total of 790.6 hours on helicopters, of which 216.2 hours was in R44 helicopters. The pilot had accrued approximately 150 hours in aerial filming work, all in R44 helicopters. The occurrence flight was the first time the pilot had been engaged in air-to-air filming.

The pilot obtained a Private Pilot (Helicopter) Licence in the United Kingdom (UK) in 1996 and received 30 hours of flight training to upgrade to an Australian Commercial 7Pilot (Helicopter) Licence (CPL(H)) in 1999. The pilot did not recall loss of tail rotor effectiveness (LTE) being part of the training syllabus in the UK, but did recall LTE being discussed as part of the CPL(H) training in Australia. The pilot could not recall any further discussion of LTE since that training. That contrasted with the operator's report of the recent conduct of a discussion with the pilot regarding LTE.

There was no evidence of any pre-existing anomaly with the helicopter that would have contributed to the development of the occurrence. The all up weight of the helicopter at the time of the occurrence was estimated to be 1,085 kg and the maximum gross weight for an out of ground effect hover in the estimated ambient conditions was 1,134 kg. The centre of gravity was estimated to have been within limits.

The pilot of the R44 reported that the meteorological conditions on departure from Essendon were CAVOK[7], with a north-westerly surface wind ranging in speed from 15 to 20 kts. The pilot of the B407 described the wind at altitude at the time of the occurrence as a north-north-westerly at 15 kts. The relevant Bureau of Meteorology area forecast indicated a north-westerly wind of 15 kts at 2,000 ft, becoming westerly later in the day.

7 Visibility, cloud and present weather better than prescribed values or conditions – ICAO Doc 8400, 24 November 2004.

Loss of Tail Rotor Effectiveness

Loss of tail rotor effectiveness, or uncommanded right yaw, has been identified as a contributing factor in a number of helicopter accidents (for example, see ATSB occurrence BO/200003293[8]). According to the US Federal Aviation Administration (FAA) publication, FAA-H-8083-21, 'Rotorcraft Flying Handbook', LTE is not related to an equipment or maintenance malfunction and may occur in all single main rotor/tail rotor configured helicopters (such as the R44) at airspeeds less than 30 KIAS. It can result from either the tail rotor not providing adequate thrust to maintain directional control, or from the decreased aerodynamic efficiency of the tail rotor. Those circumstances can occur as a result of the combination of a number of factors, including:

- the impact on tail rotor performance of certain wind azimuths (directions) while hovering
- main rotor vortex interference with the tail rotor
- tail rotor vortex ring state (related to airflow disruption over the tail rotor)
- helicopter weathercock stability[9].

FAA Advisory Circular AC 90-95 described the conditions under which LTE can occur. Included among those conditions were:

- high all up weight
- out of ground effect (OGE) hover
- low forward airspeed
- high power settings
- wind direction from the left or rear of the helicopter.

The content of AC 90-95 was reflected in the operator's operations manual. In addition, the operations manual contained a section on filming and photographic operations, which reiterated the risk of loss of control in conditions conducive to LTE, and was cognisant of the content of Safety Notice SN-34 *Photo Flights – Very High Risk* in the R44 Approved Flight Manual. That safety notice, which includes reference to Safety Notice SN-24, is reproduced at Attachment A with the permission of the Robinson Helicopter Company. Safety Notice SN-24 *Low RPM Rotor Stall Can Be Fatal* is reproduced with the permission of the Robinson Helicopter Company at Attachment B.

8 Available at www.atsb.gov.au .

9 'Weathercocking' is the helicopter's tendency to align its longitudinal axis with the relative wind. Weathercock stability refers to the basic directional stability of the helicopter.

Recommended LTE pilot recovery techniques

In response to a number of reports of unanticipated right yaw incidents (LTE), FAA circular AC 90-95 recommends the following recovery techniques[10]:

> a. If a sudden unanticipated right yaw occurs, the pilot should perform the following:
>
> (1) Apply full left pedal. Simultaneously, move cyclic forward to increase speed. If altitude permits, reduce power.
>
> (2) As recovery is effected, adjust controls for normal forward flight.
>
> b. Collective pitch reduction will aid in arresting the yaw rate but may cause an increase in the rate of descent. Any large, rapid increase in collective to prevent ground or obstacle contact may further increase the yaw rate and decrease rotor rpm.
>
> c. The amount of collective reduction should be based on the height above obstructions or surface, gross weight of the aircraft, and the existing atmospheric conditions.
>
> d. If the rotation cannot be stopped and ground contact is imminent, an autorotation may be the best course of action. The pilot should maintain full left pedal until rotation stops, then adjust to maintain heading.

If a pilot's response to the onset of LTE is incorrect or slow, the yaw rate may rapidly increase to a point where recovery is not possible.

Vortex Ring State

The US FAA ‘Rotorcraft Flying Handbook’, describes vortex ring state (VRS) as ‘an aerodynamic condition where a helicopter may be in a vertical descent with up to maximum power applied, and little or no cyclic authority’. VRS can develop as a result of a helicopter descending through its own rotor downwash[11] as follows:

- **Main rotor tip.** At the tips of the main rotor blades, the normally-occurring main rotor tip vortices are enlarged by the recirculating main rotor downwash, decreasing the lift produced by the outboard portion of the main rotor blades and increasing the helicopter’s rate of descent (ROD).
- **Inner portion of the main rotor blades.** If the helicopter’s ROD increases to greater than the speed of the induced air flow[12], the flow of air at the inner portion of the main rotor blades becomes upward relative to the main rotor disc[13]. As a result, the inner portion of the main rotor blades stalls, and that stall progresses outboard as the ROD further increases. In addition, a secondary

10 For helicopters having an anticlockwise-rotating main rotor (including US-designed helicopters).

11 Linear velocity of the downward flow of air through a helicopter’s main rotor. Normally used to describe that flow when in the hover.

12 Flow of air drawn from above, and accelerated through the helicopter’s main rotor blades.

13 Circular area swept by a helicopter’s rotor blades.

vortex develops, creating turbulent flow over a large portion of the main rotor disc that can lead to the random pitch, roll and yaw of the helicopter.

Fully-developed VRS is characterised by an unstable condition, in which the helicopter experiences: uncommanded oscillations in pitch, roll and yaw; little or no cyclic authority; and a ROD that may approach 6,000 ft per minute.

Risk indicators for the development of VRS

Any manoeuvre that places the main rotor in a condition of high upflow and low forward airspeed increases the risk of a helicopter experiencing VRS. The following combination of conditions is listed by the Rotorcraft Flying Handbook as likely to lead to the development of VRS:

1. A vertical or nearly vertical descent of at least 300 ft per minute. (Actual critical rate depends on the gross weight, RPM, density altitude, and other pertinent factors.)
2. The rotor system must be using some of the available engine power (from 20 to 100 percent).
3. The horizontal velocity must be slower than effective translational lift.

The in-flight situations that are conducive to the development of VRS include: attempting to hover OGE at altitudes above the hovering ceiling of the helicopter; attempting to hover OGE without maintaining precise altitude control; or downwind and steep approaches in which airspeed is permitted to drop to nearly zero.

Recovery from VRS

When required to recover from VRS, pilots should discount the probable initial tendency to arrest the descent by increasing collective pitch. That action has the effect of increasing the stalled area of the rotor, thus increasing the already high rate of descent.

Recovery from VRS is accomplished by:

- initially freezing or, if altitude permits, lowering the collective pitch
- increasing forward speed to greater than translational lift
- once established above translational lift, re-establish normal flight as required.

The Rotorcraft Flying Handbook notes that, in a fully-developed VRS, the only recovery may be to enter autorotation.

The company operations manual contained a section alerting pilots to the risks associated with the development of VRS.

ANALYSIS

The turn downwind exposed the helicopter to a reported 15 kts quartering tailwind. In that case, the tailwind, the helicopter’s high all up weight and low airspeed, and the conduct of the photographic flight potentially close to the R44’s maximum predicted performance, increased the risk that an uncomanded right yaw, or loss of tail rotor effectiveness (LTE) might occur.

The pilot’s focus on positioning the helicopter for aerial filming of the banner-towing helicopter most likely prevented a full appreciation by the pilot of the potential combined effect of the ambient conditions and configuration of the helicopter. In that case, it was perhaps understandable that the pilot probably did not realise that the helicopter had been placed at increased risk of encountering LTE. That would explain the development of the uncommanded right yaw before the pilot identified the possibility of LTE and commenced the recovery.

The pilot expressed some knowledge of the recommended recovery techniques in response to LTE. The continuing rotation of the helicopter following the pilot's initial corrective actions was probably a result of the pilot unwittingly applying insufficient left pedal, and the delay in lowering the collective lever and in the application of sufficient forward cyclic. The activation of the low rotor RPM warning horn after the onset of LTE was probably a function of the combined effects of an initially high or increased collective pitch setting, the possible application by the pilot of an amount of left pedal in response to the right yaw, the violence of the uncommanded yaw and descent, and of the control inputs used to recover the helicopter.

The lack of a rate of descent (ROD) at the onset of the uncommanded right yaw indicated that vortex ring state (VRS) did not contribute to the initiation of that yaw. However, whilst LTE was the initiator of the loss of control, it was possible that the radar-derived high ROD may have been a function of the pilot’s subsequent control inputs having induced VRS. The successful recovery by the pilot from that situation was facilitated by the altitude available for that recovery.

FINDINGS

Contributing safety factors

- The pilot’s focus on positioning the helicopter for aerial filming of the banner-towing helicopter adversely affected the pilot’s situational awareness and identification of the elevated risk of loss of tail rotor effectiveness (LTE).
- The pilot unwittingly applied inadequate initial control inputs in response to the onset of LTE.

ATTACHMENT A

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-34

Issued: Mar 99

PHOTO FLIGHTS - VERY HIGH RISK

There is a misconception that photo flights can be flown safely by low time pilots. Not true. There have been numerous fatal accidents during photo flights, including several involving R22 helicopters.

Often, to please the photographer, an inexperienced pilot will slow the helicopter to less than 30 KIAS and then attempt to maneuver for the best picture angle. While maneuvering, the pilot may lose track of airspeed and wind conditions. The helicopter can rapidly lose translational lift and begin to settle. An inexperienced pilot may raise the collective to stop the descent. This can reduce RPM thereby reducing power available and causing an even greater descent rate and further loss of RPM. Rolling on throttle will increase rotor torque but not power available due to the low RPM. Because tail rotor thrust is proportional to the square of RPM, if the RPM drops below 80% nearly one-half of the tail rotor thrust is lost and the helicopter will rotate nose right. Suddenly the decreasing RPM also causes the main rotor to stall and the helicopter falls rapidly while continuing to rotate. The resulting impact is usually fatal.

Photo flights should only be conducted by well trained, experienced pilots who:

1) Have at least 500 hours pilot-in-command in helicopters and over 100 hours in the model flown;

2) Have extensive training in both low RPM and settling-with-power recovery techniques;

3) Are willing to say no to the photographer and only fly the aircraft at speeds, altitudes, and wind angles that are safe and allow good escape routes.

Please reread Safety Notice SN-24

ATTACHMENT B

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24

Issued: Sep 86 Rev: Jun 94

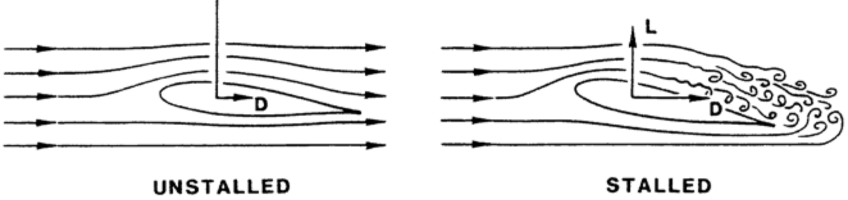
LOW RPM ROTOR STALL CAN BE FATAL

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.

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.