CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT
CAA OCCURRENCE NUMBER 12/4957

ROBINSON R22 BETA
ZK-HCG

LOSS OF MAIN ROTOR CONTROL
CARDRONA VALLEY WANAKA

8 NOVEMBER 2012

Foreword

New Zealand's legislative mandate to investigate an accident or incident are prescribed in the Transport Accident Investigation Commission Act 1990 (the TAIC Act) and Civil Aviation Act 1990 (the CAA Act).

Following notification of an accident or incident, TAIC may conduct an investigation. CAA may also investigate subject to Section 72B(2)(d) of the CAA Act which prescribes the following:

> **72B Functions of Authority**
>
> (2) The Authority has the following functions:
>
> (d) To investigate and review civil aviation accidents and incidents in its capacity as the responsible safety and security authority, subject to the limitations set out in section 14(3) of the Transport Accident Investigation Commission Act 1990

The purpose of a CAA investigation is to determine the circumstances and identify contributory factors of an accident or incident with the purpose of minimising or reducing the risk to an acceptable level of a similar occurrence arising in the future. The investigation does not seek to ascribe responsibility to any person but to establish the contributory factors of the accident or incident based on the balance of probability.

A CAA Safety investigation seeks to provide the Director of CAA with the information required to assess which, if any, risk-based regulatory intervention tools may be required to attain CAA safety objectives.

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Glossary of abbreviations

AMSL	above mean sea level
BFR	Biennial Flight Review
CAA	Civil Aviation Authority
CAR	Civil Aviation Rule(s)
CPL(A *or* H)	Commercial Pilot Licence (Aeroplane or Helicopter)
E	east
ECT	Evening civil twilight
ft	foot or feet
G	Gravitational constant
GPS	Global Positioning System
MHz	MegaHertz
m	metre(s)
NM	nautical mile
NZDT	New Zealand Daylight Time
POH	Pilot's Operating Handbook
RPM	Revolutions per minute
S	south
UTC	Coordinated Universal Time
VHF	very high frequency

CIVIL AVIATION AUTHORITY OF NEW ZEALAND

Data summary

Aircraft type, serial number and registration:	Robinson R22 Beta, 1499, ZK-HCG
Number and type of engines:	One 160 horsepower Lycoming O-320-B2C
Year of manufacture:	1990
Date and time of accident:	8 November 2012, 2035 hours[1] (approximately)
Location:	Cardrona Valley, Wanaka Latitude[2]: S 44° 46' 53.7″ Longitude: E 169° 06' 32.7″
Type of flight:	Private
Persons on board:	Crew: 1
Injuries:	Crew: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot-in-command's licence:	Private Pilot Licence (Helicopter) Commercial Pilot Licence (Aeroplane)
Pilot-in-command's age:	52 years
Pilot-in-command's total flying experience:	9134.0 hours aeroplane, 68.8 hours helicopter, 65.6 hours on type
Investigator in Charge:	Mr C P Grounsell

[1] All times in this report are NZDT (UTC + 13 hours)

[2] WGS-84 co-ordinates

Synopsis

The Civil Aviation Authority (CAA) was notified of the accident at 2100 hours on 8 November 2012. The Transport Accident Investigation Commission was in turn notified shortly thereafter, but chose not to investigate. A CAA Safety Investigation was commenced the following day.

The helicopter was in transit between Wanaka and Queenstown Aerodromes via the Cardrona Valley. A witness on the ground had observed the helicopter approaching and then looked away. On hearing an unusual noise the witness looked back towards the helicopter and saw that it was descending at a high rate with the main rotor stationary, he watched it descend and then strike the ground. Emergency services were immediately notified, the first responders to the accident site found the pilot deceased.

1. Factual information

1.1 History of the flight

1.1.1 At approximately 1900 hours on the day of the accident, the pilot met with the owner of ZK-HCG at his residence near Arrowtown where the helicopter was parked. It was intended that the pilot would fly the owner to Wanaka Aerodrome for the purposes of picking up another aircraft and then both aircraft would be flown to Queenstown Aerodrome. Following this, the pilot and ZK-HCG's owner would fly back to the owner's residence in ZK-HCG. The end of Evening Civil Twilight (ECT) for the region on the day of the accident was 2106 hours.

1.1.2 The pilot was ninety minutes late in arriving at the owner's residence, by which time the owner also a helicopter and fixed-wing pilot, had completed the pre-flight inspection and had warmed up the helicopter. The pilot and owner then departed for Wanaka Aerodrome in the helicopter.

1.1.3 According to the owner the flight was uneventful, however, the owner did notice that on a couple of occasions he had to draw the pilot's attention to a high manifold pressure (throttle) setting during the climb out from Arrowtown. The oil temperature indication was also noted to be slightly higher than usual although still in the normal operating range.

1.1.4 The helicopter owner also noted that the pilot was tending to slightly over-control in reaction to what he described as occasional 'niggly' turbulence encountered during the flight to Wanaka Aerodrome.

1.1.5 On arrival at Wanaka Aerodrome, the owner elected to take control of the helicopter for the landing.

1.1.6 After shut-down, the owner disembarked and went about preparing his other aircraft for flight. While doing so he noted that the pilot was in the process of removing the dual flight controls from the helicopter. This is standard practice when the helicopter is flown solo, these controls were later found in the wreckage stowed under the passenger's seat.

1.1.7 At 2028 hours the pilot made a radio call to Wanaka Traffic stating that ZK-HCG was lining up and rolling two-nine, departing for Queenstown. The helicopter was also observed by witnesses during its departure.

1.1.8 An experienced helicopter pilot on the ground to the west of Wanaka Aerodrome observed the helicopter fly over him. He commented that it seemed to be being flown in a professional manner i.e. landing light on, and turns being carried out at the appropriate altitudes.

1.1.9 A further witness, also an experienced helicopter pilot who was situated near Mount Barker and on the helicopter's flight path, was inside his house when he heard a helicopter sound which he recognised as a Robinson R22 fly overhead. He commented that the helicopter sounded fairly low and also that "it was working hard" indicating that the pilot was using a high power setting. This apparent high power setting was most likely due to the pilot climbing the helicopter to gain altitude en-route to Queenstown.

1.1.10 The witness who observed the accident and was familiar with the operation of the Robinson R22, initially identified the helicopter by sound as a Robinson R22 and then he sighted it visually. His initial impression was that it was flying fast based on the sound of the rotors (high rotor RPM) and then confirmed this by his visual observation of the helicopter. He looked away then heard an unusual noise or bang. Looking back towards the helicopter he observed it to be falling with the main rotor blades stationary and no sound. He was able to visually follow the helicopter until it struck terrain on the eastern side of the Cardrona Valley adjacent to him. He immediately notified emergency services.

1.1.11 The accident occurred in daylight, at approximately 2035 hours, seven NM south-south-west of Wanaka Aerodrome, at an elevation of 2500 feet amsl. Latitude S 44° 46' 53.7″, longitude E 169° 06' 32.7″.

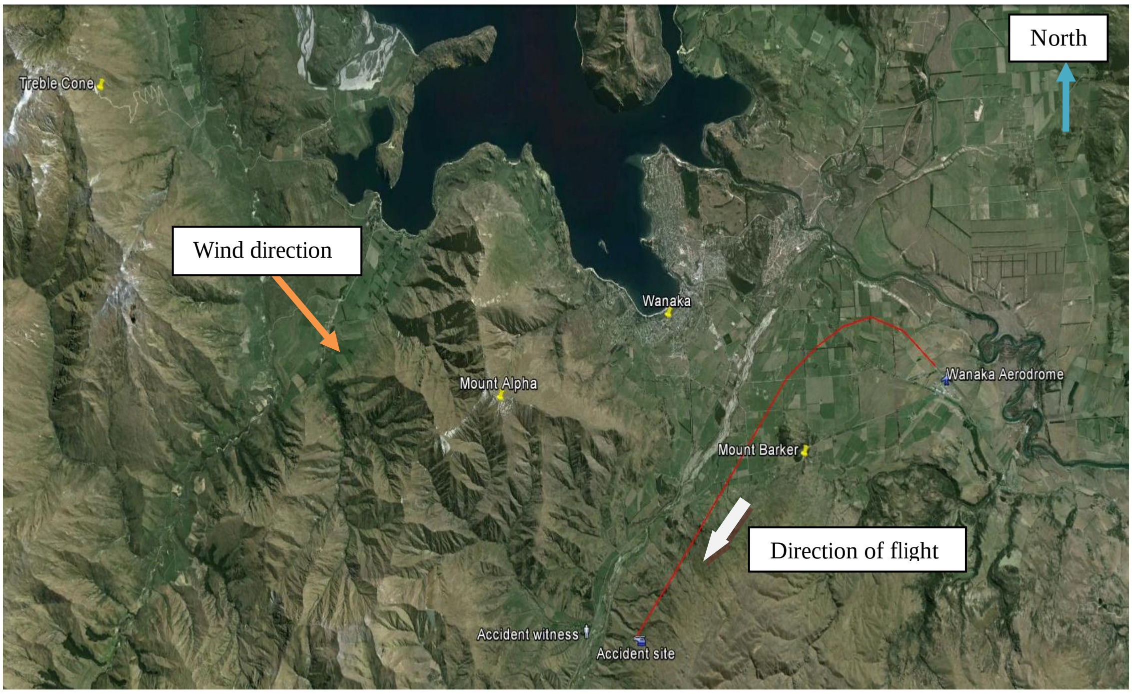

Figure 1: Overview of area

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	0	0

Table 1: Injuries to persons

1.3 Damage to aircraft

1.3.1 The helicopter was destroyed.

1.4 Personnel information

1.4.1 The pilot was an experienced fixed-wing pilot and the Chief Flying Instructor at the local aero club located at Queenstown Aerodrome. The pilot was held in high regard amongst the aviation community for their fixed wing experience and instructional abilities.

1.4.2 The pilot was issued with a CPL(A) on 11 December 1992 and a B-category Instructor Rating in September 2006.

1.4.3 The pilot commenced helicopter flight training in September 2009 and gained a PPL(H) in June 2010.

1.4.4 On 18 June 2012 the pilot completed a Biennial Flight Review (BFR) for a PPL(H) which also included the Robinson Helicopter Safety Awareness Refresher training.

1.4.5 Following completion of the BFR, the pilot had flown a further 5.2 hours up until the time of the accident which was recorded in the Pilot's Logbook.

1.4.6 The training provider who carried out the pilot's helicopter training and BFR was contacted during the safety investigation and provided the following information:

> *'On 5 December 2011 the pilot was undergoing a dual training flight with one of the training provider's flight instructors. During this flight, while entering an autorotation, the pilot became confused regarding the direction of throttle travel and rolled on throttle rather than rolling it off, resulting in a severe over speed, necessitating the grounding of the helicopter'.*

1.4.7 The last helicopter flight times recorded in the Pilot's Logbook were on 08 and 09 September 2012, two months prior to the accident, when a total of 2.3 hours were flown in a Robinson R22 helicopter.

1.4.8 On the day of the accident, the pilot had carried out a full days duties of approximately 9 hours at the local aero club. During this day the pilot had flown a total of 2.3 hours in fixed wing aircraft which was recorded in the Pilot's Logbook.

1.5 Aircraft information

1.5.1 Robinson R22 Beta ZK-HCG had been imported into New Zealand new from the USA in July 1990. The helicopter was issued with a Standard Certificate of Airworthiness by the CAA in September 1990.

1.5.2 At the time of the accident the helicopter had accrued 7068 hours total flight time. The last scheduled maintenance carried out was a 100 hour and annual inspection completed on 09 March 2012. In accordance with the Robinson Maintenance Manual, the helicopter was required to have a scheduled inspection 50 hours flight time after the 100 hour inspection. The helicopter had actually flown 75 hours since the last inspection, it was therefore 25 hours overdue for its 50 hour scheduled inspection.

1.5.3 The helicopter was powered by a Lycoming O-320-B2C, 160 Horsepower engine. At the time of the accident the engine had accrued 1121 hours flight time since overhaul and 75 hours since a repair, which required replacement of the camshaft and followers. An oil filter inspection had been carried out 25 hours after the engine repair.

1.5.4 It was determined by calculation that at the time of the accident, the helicopter was approximately 225 pounds below the maximum allowable all up weight of 1370 pounds or 55% below the maximum useful load. The helicopter's centre of gravity was within the prescribed limits.

1.6 Pertinent manufacturer's information

1.6.1 The Robinson R22 Pilot's Operating Handbook (POH) Normal Procedures Section, regarding main rotor stall states:

> *'Many factors may contribute to main rotor stall and pilots should be familiar with them. Any flight condition that creates excessive angle of attack on the main rotor blades can produce stall. Low main rotor rpm , aggressive manoeuvring, high collective angle (often the result of high density altitude, over pitching during climb, or high forward airspeed) and a slow response to the low main rotor rpm warning horn and light may result in main rotor stall. The effect of these conditions can be amplified in turbulence. Main rotor stall can ultimately result in contact between the main rotor and airframe'.*

Additional information on main rotor stall is provided in Robinson Helicopter Company Safety Notices SN-10 and SN-24 which are included in full in appendices 1 and 2.

1.6.2 Information regarding mast bumping[3] is also included in the Normal Procedures Section which in part states:

> *'Mast bumping may occur with a teetering rotor system when excessive main rotor flapping results from low-G (load factor below 1.0) or abrupt control input. A low-G flight condition can result from an abrupt cyclic pushover in forward flight. High forward airspeed, turbulence, and excessive sideslip can accentuate the adverse effects of these control movements'.*

[3] Mast bumping occurs when the helicopter's main rotor hub is allowed to make contact with the main rotor mast. In severe cases this may result in separation of the main rotor from the mast.

1.6.3 The Robinson R22 POH Safety Notices section includes Safety Notice SN-29 *Airplane Pilots High Risk When Flying Helicopters* which in part states:

> *'The ingrained reactions of an experienced airplane pilot can be deadly when flying a helicopter. The airplane pilot may fly the helicopter well when doing normal manoeuvers under ordinary conditions when there is time to think about the proper control response. But when required to react suddenly under unexpected circumstances, he may revert to his airplane reactions and commit a fatal error'.*

Safety Notice SN-29 is included in full in Appendix 3.

1.7 Meteorological information

1.7.1 The witness located in the Cardrona Valley who observed the accident, commented that at the time of the accident, the weather conditions were good with clear skies.

1.7.2 The owner of the helicopter commented that during the flight from Arrowtown to Wanaka Aerodrome the flight conditions were also good, but mentioned that some occasional 'niggly' turbulence had been encountered during the flight.

1.7.3 The witness located on the ground between Wanaka Aerodrome and Wanaka township indicated that at his location the wind was strong and gusty with small branches being blown from trees.

1.7.4 Another helicopter attempting to land at Treble Cone, 25 km north-west of the accident site, reported that the wind was 15 to 20 knots making landing conditions difficult.

1.7.5 A detailed meteorological analysis was carried out by the New Zealand Meteorological Service. Extracts from that report are as follows:

> *'At 1900 hours on 8 November 2012, an anticyclone straddled north-west to south-east across central New Zealand moving north-east. A narrow trough of low pressure was approaching from the west and the north-westerly air flow across the South Island was beginning to increase in strength. Refer Figure 2 Mean sea level analysis chart page 11.*
>
> *Although there was an approaching trough of low pressure, the pressure gradient over the Southern Lakes area was not increasing and the cause of wind variation was still dominated by the diurnal effect of surface heating and convective overturning ceasing when the sun angle lowered as the sun set.*
>
> *Evidently, there were areas on the open plain between Wanaka town and the airport that were quite gusty at the time of the accident, but the wind at the airport remained mostly less than 10 knots with hourly highest gusts mostly between 10 and 15 knots. In the shelter of the Cardrona Valley the wind was reported to be light.*
>
> *The modelled wind profiles based at Wanaka Airport at hourly intervals suggests a ridge top (about 1300 to 1400 metres AMSL) wind speed steadily*

decreasing through the afternoon and into the evening. However, this would not be the situation in the vicinity of high ground.

Therefore, in the vicinity of high ground, for example, Treble Cone and the ridges west and east of the Cardrona Valley, the wind speed would be higher than that modelled in open terrain over Wanaka. It is difficult to quantify this without suitable additional modelling, but a doubling of the highest speed in the unconstrained profile would be a reasonable estimate; 25 knots and possibly higher.

In conclusion: wind speed from the north-west at ridge height (1300 to 1400 metres AMSL) in the Cardrona Valley area in the evening of 8 November 2013 is estimated to be 25 knots and possibly higher'.

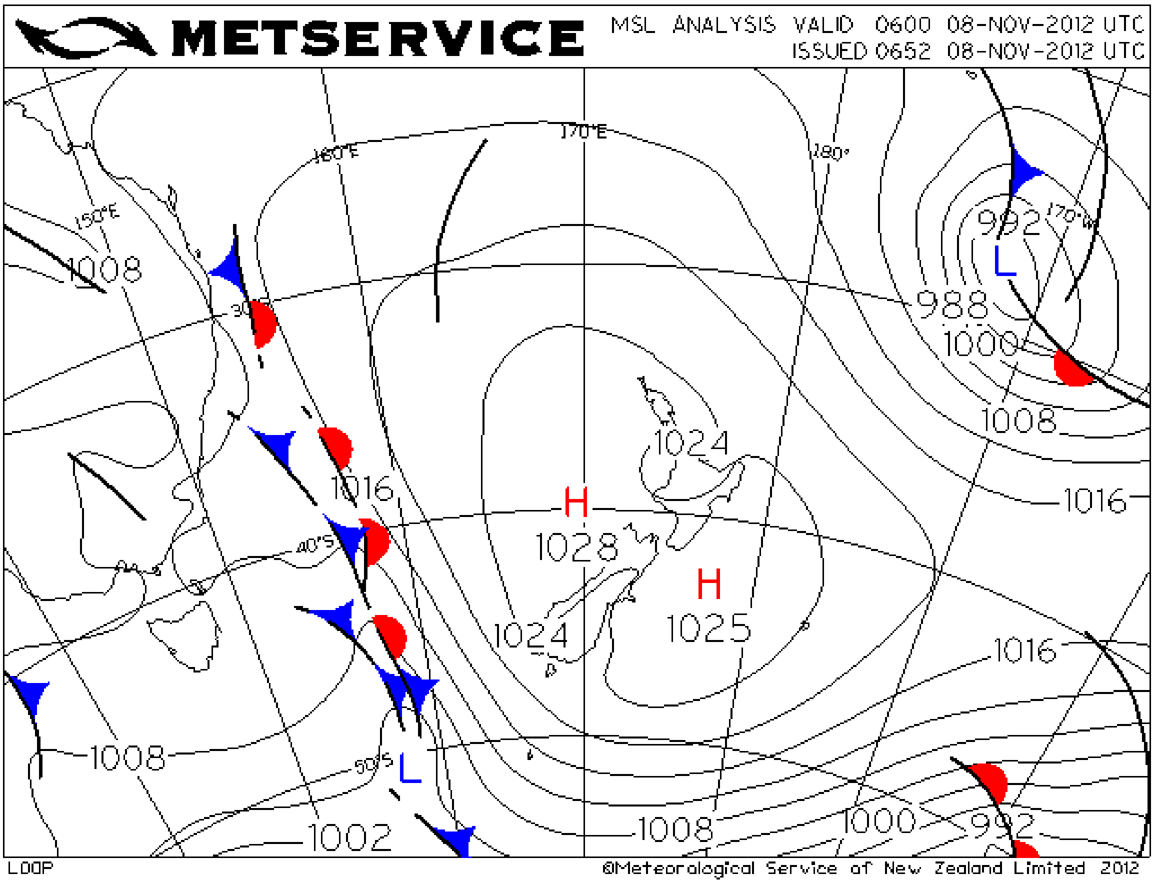

Figure 2: Mean sea level analysis

1.8 Communications

1.8.1 Wanaka Aerodrome and the surrounding Wanaka Common Frequency Zone are served by a radio frequency of 120.1 MHz. All radio transmissions made on this frequency and within range of Wanaka Aerodrome are recorded.

1.8.2 The pilot made a number of radio calls while both arriving and departing Wanaka Aerodrome. All calls were of a normal and expected nature.

1.8.3 The following is the transcript of the final radio call recorded from the helicopter at 2029:12 hours:

"Wanaka traffic Hotel Charlie Golf airborne two nine climbing to one thousand eight hundred feet left turn for Cardrona Valley and Queenstown".

No further radio transmissions were recorded from the helicopter.

1.9 Wreckage and impact information

1.9.1 The accident site was located on the eastern slopes of the Cardrona Valley approximately seven NM south-south-west of Wanaka Aerodrome. To the left of the helicopters flight path was the ridge line forming the Pisa Range and to the right the ground fell away to the relatively flat area of the valley floor. The helicopter struck the 30 degree down slope with its skids level to the slope and the nose of the helicopter orientated slightly to the left of the down slope.

1.9.2 The majority of the wreckage was located five metres downhill from the impact point. Parts of the passenger door were found approximately 200 metres from the accident site indicating that significant damage had occurred at altitude prior to ground impact. The helicopter had been severely disrupted due to the severity of the impact, the pilot had been thrown clear and was found two metres to the front left-hand side of the helicopter.

1.9.3 The aft tail boom complete with the tail rotor assembly was found eight metres prior to the impact point indicating that it had separated from the helicopter moments before the helicopter struck the terrain. The tail boom showed damage consistent with it having been struck by the main rotor blades.

1.9.4 Examination of the tail rotor assembly found no rotational damage to the tail rotor blades. Witness marks on the tail rotor drive shaft indicated no driveshaft rotation at the time of the tail boom detaching from the helicopter. The lack of rotation remained consistent with examination of the upper sheave and flexible couplings. Witness marks on both the engine and alternator cooling fans indicated no rotation of the engine at the time of ground impact.

1.9.5 The main rotor blades were found attached to the hub, one blade was intact, the other was missing a one metre section of the outer blade which was located approximately 30 metres prior to the main wreckage. Traces of paint were found on the underside of the section of the separated blade, these paint traces were matched to the paint scheme on the helicopter's tail boom.

1.9.6 Both main rotor blades showed evidence of compression buckling on the upper and lower surfaces. One blade had a distinctive upward bend, the other blade had bent downward to an angle of approximately 80 degrees prior to the one metre section of the blade separating. Examination of the rotor head revealed damage that indicated extreme angles of main rotor blade flapping[4] had occurred, both up and down.

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[4] Blade flapping: The vertical movement of the blade as a result of aerodynamic forces.

1.9.7 Inspection of the cabin area revealed that the pilot's seat structure had been severely compressed by the pilot's weight due to the high vertical impact forces involved when the helicopter struck the ground. The seat belts were intact, however, the supporting airframe structure had been compromised due to deformation and could no longer restrain the pilot in the helicopter.

1.9.8 Although the flight control system was disrupted in the accident sequence, pre-accident integrity was established as far as possible. All fracture surfaces were examined and found to be a result of overload, consistent with impact forces or those incurred when the main rotor blades struck the airframe.

1.9.9 On subsequent removal of the engine from the airframe, a large bird's nest was found to be completely covering the engine's left-hand cylinders.

1.10 Medical and pathological information

1.10.1 Post-mortem examination showed that the pilot died of multiple traumatic injuries.

1.10.2 There were no indications of any pre-existing medical condition that could have resulted in incapacitation or have affected the pilot's ability to operate the helicopter.

1.10.3 The results of toxicological testing showed no alcohol or drugs present in the pilot's blood.

1.11 Fire

1.11.1 Fire did not occur.

1.12 Survival aspects

1.12.1 Due to the high vertical velocity of the helicopter at the time of impact with the terrain, the accident was not survivable.

1.12.2 The emergency locator beacon did not operate as the unit was destroyed due to the deformation of the helicopter structure during the ground impact.

1.13 Tests and research

1.13.1 The engine was disassembled and inspected by an authorised maintenance provider under CAA supervision. The engine was observed to be in good condition and no defects were found which may have prevented the engine from providing full power at the time of the accident.

1.13.2 A Robinson Helicopter Company technical investigator viewed the wreckage and found no evidence which would indicate that the helicopter was not in a serviceable condition prior to the accident.

1.14 Additional information

1.14.1 Main rotor divergence
The evidence from the damage to the main rotor hub, mast, and teeter stops revealed that the main rotor blades had flapped to extreme up and down angles resulting in a degree of mast bumping . This extreme flapping is known as main rotor divergence as the disk of the main rotor diverges from its normal plane of rotation. There are a

number of factors that are known to cause main rotor divergence in helicopters with teetering two-bladed rotors such as the Robinson R22.
They are:

- low-G manoeuvres
- low rotor rpm
- turbulence, and
- large, abrupt control inputs.

There is an abundance of information widely available regarding the above factors.

2. Analysis

2.1 The pilot departed Wanaka Aerodrome in ZK-HCG at 2028 hours, the end of ECT for the area on the day of the accident was 2106 hours allowing 38 minutes of available daylight time. Prior to departing, the pilot and helicopter owner had discussed that if the pilot had not been able to complete the flight as originally planned due to time constraints, the pilot was to fly direct to the owner's residence at Arrowtown. This alternate route would save approximately 10 minutes of flight time allowing a greater time margin before the end of ECT.

2.2 The estimated flight time to complete the original route from Wanaka Aerodrome to Arrowtown, with a brief stop at Queenstown Aerodrome was approximately 30 minutes. This would have left a margin of only eight minutes before the end of ECT. With this time restriction in mind, the pilot would have been under a degree of time pressure with the intention of completing the flight as planned prior to the end of ECT.

2.3 It is most likely that in an attempt to complete the original route as planned within the daylight time available, the pilot was probably flying the helicopter at a high power setting and airspeed. This scenario is further supported by the eyewitness to the accident stating that his attention was originally drawn to the helicopter due to "the sound of an R22 being flown fast" along with his visual observation of the helicopter.

2.4 While in transit between Wanaka and Queenstown Aerodromes, the helicopter's main rotor blades struck the airframe due to a loss of control by the pilot. This resulted in the helicopter striking terrain. The discovery of the failed main rotor blade section, a section of the left cabin door and pieces of perspex some distance from the main wreckage, indicates that an in-flight break-up occurred prior to impact with terrain.

2.5 The strike marks on the helicopter's tail boom from contact with the main rotor blades indicate that the first strike was most likely a glancing blow or slap on the tail boom on the left-hand upper side, this also caused significant damage to one of the main rotor blades. The evidence of an initial main rotor blade strike on the tail boom is consistent with main rotor divergence.

2.6 There were further indications of successive strikes on the tail boom which weakened the aft section. This resulted in the tail rotor assembly and part of the aft tail boom separating from the helicopter prior to ground impact. Strike marks on the left side of the fuselage and skid combined with damage to the pilot and passenger doors show that at some stage during the in-flight break-up, at least one of the main rotor blades had struck the forward cabin area.

2.7 Although the safety investigation was unable to positively identify the circumstances which led to the loss of main rotor control by the pilot, the following are considered possible causal factors:

- A loss of control of the helicopter by the pilot due to a low-G flight condition. With the apparent high power setting that the pilot was using, a slight negative-G manoeuvre in flight could have caused the helicopter to roll unexpectedly and rapidly to the right. The tendency for the helicopter to roll to the right is explained in Robinson Safety Notice SN-11 *Low-G pushovers-Extremely Dangerous* (refer to Appendix 4). This rolling tendency could take the pilot by surprise and result in them making a rapid and/or possibly incorrect control input in an attempt to recover the situation, ultimately resulting in mast bumping and main rotor blade contact with the airframe.

- A review of the pilot's previous helicopter training revealed a handling error where the throttle was manipulated in the wrong direction causing a severe over speed. A further comment was provided by the pilot's training provider:

  'On the fatal flight, for whatever reason, I think the pilot has inadvertently been flying with high RPM (higher than the normal 104%) and the noise that this makes as described above was what attracted the attention of the witness who observed the accident. If the pilot did have high RPM, it is conceivable that they became confused again and has either over reacted or rolled the throttle the wrong way, resulting in catastrophic low RPM (below approx. 80% RPM)'.

  If the pilot had over-reacted in response to noting a high rotor rpm by closing the throttle, the corresponding reduction in rotor rpm would be very rapid due to a high rotor blade angle at the time and the helicopter having a low inertia rotor system. The pilot's very low helicopter flight experience and low recent currency, may have prevented timely recognition of the impending rotor stall situation to the extent that control of the helicopter was lost (refer to Appendix 1and 2 for main rotor stall information).

- Meteorological analysis of the weather conditions existing at the time of the accident would suggest that the upper winds may have been strong, possibly in excess of 25 knots in the vicinity of the ridge tops. The effect of the strong upper winds would be to create turbulence on the lee side of the high terrain. The area that ZK-HCG was flying in at the time of the accident was in the lee of the high terrain to the west-north-west of the accident site. It is therefore possible that the pilot may have experienced a degree of unexpected localised turbulence.

  The Robinson R22 POH Normal Procedures Section *Main Rotor Stall* states that the conditions pertaining to a low rotor rpm stall can be amplified in turbulence. With the apparent high power setting and high speed of the helicopter as noted by the witness, flight into unexpected turbulence and the pilot's possible reaction to that turbulence may have caused a momentary over pitching of the main rotor and subsequent rapid main rotor stall.

2.8 To the right of the helicopter's flight path was a clear flat area on the valley floor within range of the helicopter had the pilot needed to carry out an emergency auto-rotation landing. It was apparent that the pilot had not attempted to alter the helicopter's flight path prior to the loss of control. This indicates that control of the helicopter was most likely lost unexpectedly and before the pilot had time to take the appropriate recovery action.

2.9 The pilot's flying history as recorded in the Pilot's logbook, indicated that over the 24 month period between the completion of the PPL(H) training and subsequent BFR, the pilot had flown 16 hours in the Robinson R22 helicopter. After completion of the BFR in June 2012, the pilot had flown a further 2.3 hours in the Robinson R22 helicopter over the 5 month period up until the time of the accident.

2.10 The observations made by the helicopter owner, regarding the pilot's handling of the helicopter during the flight to Wanaka Aerodrome, indicate that the pilot was not overly proficient at the time. This could be attributable to the lack of recent helicopter experience and low overall helicopter flying experience. Robinson Safety Notice SN-29 (refer Appendix 3), outlines in detail the issues which have been identified in accidents where pilots have had significant fixed wing flying experience compared to low helicopter flying experience.

2.11 During the safety investigation, the helicopter was found to be 25 hours overdue for its 50 hour scheduled inspection, this inspection primarily focuses on engine maintenance. Prior to the accident flight, the pilot had not reviewed the helicopter's Technical Log; primarily due to the very late arrival of the pilot at the owner's residence and also the fact that the owner had already started the engine and warmed up the helicopter prior to the pilot arriving.

2.12 Operation of the helicopter by the pilot when it was overdue for the scheduled 50 hour servicing placed the pilot in non-compliance with CAR 91.602 *Maintenance requirements before flight.* In allowing the helicopter to be flown while this condition existed, the owner was in non-compliance of CAR 91.603 *General maintenance requirements.* Non-compliance with the above CARs is a technical infringement of the rules; no mechanical discrepancies were found with the helicopter which may have contributed to the accident.

2.13 No evidence was found during the engine disassembly and inspection that the bird's nest covering the left-hand cylinders had a detrimental effect on engine operation. It was noted that it is extremely difficult for a pilot to carry out a birds nest inspection on the left-hand side of the engine due to limited access. The nesting material found would have been deposited on the engine during the Spring 2012 bird nesting season, approximately two months prior to the accident.

3. Conclusions

3.1 The pilot was appropriately licensed and fit to carry out the flight.

3.2 The pilot was very experienced in operating aeroplanes, but in comparison, had very low flight experience in operating the Robinson R22 helicopter.

3.3 The safety investigation was unable to conclusively establish the extent to which the pilot's low helicopter flight experience or apparent lack of proficiency contributed to the accident.

3.4 With the approach of ECT, it was highly likely that the pilot was under time pressure to complete the intended flight in the time available.

3.5 Observations by the witness to the accident indicate that the pilot was flying the helicopter at a high airspeed with a high rotor rpm.

3.6 As a result of a loss of main rotor control, the main rotor blades diverged from the normal plane of rotation initially striking the tail boom. Once this had occurred recovery of the situation by the pilot was impossible.

3.7 The safety investigation could not establish with any certainty why the main rotor divergence occurred.

3.8 At the time of the accident, the helicopter was 25 hours overdue for its scheduled 50 hour servicing. The helicopter was technically not airworthy which placed both the pilot and the owner in non-compliance with the CARs.

3.9 The safety investigation found no evidence of a technical defect that may have contributed to the accident.

3.10 The bird nesting material found on the engine was not considered to be a contributing factor in the accident.

3.11 Due to the design of the R22 engine cowling, it is extremely difficult for pilots to carry out a thorough visual inspection for nesting material during a pre-flight inspection.

3.12 The current mandatory training requirements and supplemental information supplied by Robinson Helicopter Company Ltd are considered to be satisfactory.

3.13 The accident was not survivable.

4. Safety Actions

4.1 The CAA Safety Promotion Unit has been made aware of the difficulties in conducting an effective bird nest check on the Robinson R22 helicopter engine. A CAA Vector magazine article will be published highlighting this difficulty to pilots.

4.2 The CAA Safety Promotion Unit published an article in the Nov/Dec edition of the CAA Vector magazine highlighting the hazards associated with low-G flight in the Robinson R22 helicopter and how to avoid them.

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Date 24 January 2014

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Appendix 1

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24

Issued: Sep 86 Rev: Jun 94

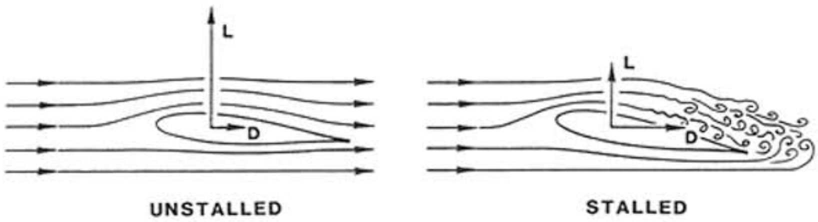
LOW RPM ROTOR STALL CAN BE FATAL

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.

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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.

Appendix 2

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 descend. 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 severly 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 tail cone 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.

Appendix 3

Safety Notice SN-29

Issued: Mar 93 Rev: Jun 94

AIRPLANE PILOTS HIGH RISK WHEN FLYING HELICOPTERS

There have been a number of fatal accidents involving experienced pilots who have many hours in airplanes but with only limited experience flying helicopters.

The ingrained reactions of an experienced airplane pilot can be deadly when flying a helicopter. The airplane pilot may fly the helicopter well when doing normal maneuvers under ordinary conditions when there is time to think about the proper control response. But when required to react suddenly under unexpected circumstances, he may revert to his airplane reactions and commit a fatal error. Under those conditions, his hands and feet move purely by reaction without conscious thought. Those reactions may well be based on his greater experience, ie., the reactions developed flying airplanes.

For example, in an airplane his reaction to a warning horn (stall) would be to immediately go forward with the stick and add power. In a helicopter, application of forward stick when the pilot hears a horn (low RPM) would drive the RPM even lower and could result in rotor stall, especially if he also "adds power" (up collective). In less than one second the pilot could stall his rotor, causing the helicopter to fall out of the sky.

Another example is the reaction necessary to make the aircraft go down. If the helicopter pilot must suddenly descend to avoid a bird or another aircraft, he rapidly lowers the collective with very little movement of thecyclic stick. In the same situation, the airplane pilot would push the stick forward to dive. A rapid forward movement of the helicopter cyclic stick under these conditions would result in a low "G" condition which could cause mast bumping, resulting in separation of the rotor shaft or one blade striking the fuselage. A similar situation exists when terminating a climb after a pull-up. The airplane pilot does it with forward stick. The helicopter pilot must use his collective or a very gradual, gentle application of forward cyclic.

To stay alive in the helicopter, the experienced airplane pilot must devote considerable time and effort to developing safe helicopter reactions. The helicopter reactions must be stronger and take precedence over the pilot's airplane reactions because everything happens faster in a helicopter. The pilot does not have time to realize he made the wrong move, think about it, and then correct it. It's too late; the rotor has already stalled or a blade has already struck the airframe and there is no chance of recovery. To develop safe helicopter reactions, the airplane pilot must practice each procedure over and over again with a competent instructor until his hands and feet will always make the right move without requiring conscious thought. AND, ABOVE ALL, HE MUST NEVER ABRUPTLY PUSH THE CYCLIC STICK FORWARD.

Also see Safety Notices SN-11 and SN-24.

Appendix 4

ROBINSON
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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!!