Report 08-007, Robinson Helicopter Company, R22 Alpha ZK-HXR, loss of control, Lake Wanaka, 1 November 2008

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Robinson Helicopter Company R22 Alpha
ZK-HXR

loss of control

Lake Wanaka

1 November 2008

Figure 1
An R22 Alpha similar to ZK-HXR
(photograph used with permission)

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Executive summary

On 1 November 2008, a Robinson Helicopter Company R22 helicopter registered ZK-HXR, which was being flown from Haast to Wanaka with the pilot only on board, did not arrive at the Wanaka aerodrome for an intended refuel. Efforts to locate the helicopter began promptly and items from the helicopter were soon found floating in Lake Wanaka, about 22 kilometres north-west of the aerodrome. Most of the fuselage of ZK-HXR, along with the deceased pilot, was retrieved from the lake bed 4 days after the accident, but some key components were not recovered.

There were no witnesses to the accident, although about 6 minutes before the estimated time of the accident the pilot had flown past a barge being skippered by a friend. Telephone company records showed that in the next few minutes the pilot had received and sent cellphone text messages, including one sent close to the estimated time of the accident to the barge skipper.

The wreckage showed that a mast bump had occurred prior to the helicopter impacting on the water. The mast bump likely followed a low-G condition caused by turbulence, or perhaps some other undetermined event. Anecdotes suggested the pilot had a preference for flying fast, which would have exacerbated the reaction of the helicopter to a low-G condition. If the pilot had been preoccupied with his cellphone, he would have had less time to take the appropriate recovery action.

The Transport Accident Investigation Commission (the Commission) has previously reported on accidents where cellphone use by a pilot or vessel skipper might have been a contributing factor and made safety recommendations to the relevant regulatory authorities. No new safety recommendation has been made.

(Note: this executive summary condenses content to highlight key points to the reader and does so in simple English with less technical precision than the remainder of the report to ensure its accessibility to a non-expert reader. Expert readers should refer to and rely on the body of the full report.)

Conduct of the inquiry

The Civil Aviation Authority (CAA) notified the Commission of the accident on 1 November 2008. The Commission initially declined to investigate and the CAA commenced its own site investigation. Subsequently, because of a potential or perceived conflict of interest between the CAA and the operator of the helicopter, the Commission agreed on 6 November 2008 to open an inquiry, and information already gathered by the CAA was passed to the Commission.

The accident site was located on 2 November, and on 4 November Police and Navy dive teams, using remotely operated vehicles, found the wreckage at a depth of about 80 metres lying on a steeply inclined part of the lake bed. The deceased pilot's body and much of the wreckage were recovered the next day. Although the engine had been seen while searching for the wreckage, efforts were concentrated on recovering the fuselage containing the body of the pilot. The engine could not be found again during a search the following day.

In December 2008, the Commission arranged for a further search for the engine, using a remotely operated vehicle. That search was also unsuccessful, as were 2 privately funded searches conducted with specialist divers in May and November 2009.

A draft final report was approved by the Commission on 19 May 2010 and sent to interested persons for comment. Having considered 2 submissions from interested persons, this final report was approved by the Commission on 21 July 2010.

The inquiry has been closed with the publication of this report, albeit without the benefit of evidence that the engine and other un-recovered components might have offered. Should any new and significant evidence or information become available to the Commission in the future, the inquiry might be reopened.

Abbreviations

CAA	Civil Aviation Authority
Commission	Transport Accident Investigation Commission
ft	feet
kg	kilogram(s)
km	kilometre(s)
kt	knot(s)
NTSB	National Transportation Safety Board
Robinson	Robinson Helicopter Company
RPM	revolution(s) per minute
TAIC	Transport Accident Investigation Commission
UTC	coordinated universal time

Glossary

autorotation	the condition of flight during which the main rotor is driven only by aerodynamic forces with no power from the engine
collective lever	the control that changes the pitch of all of the rotor blades equally and simultaneously, and consequently the amount of thrust or lift generated
cyclic stick	the control that changes the pitch of each rotor blade individually as it rotates through one revolution, which causes the rotor disc to tilt and consequently changes the direction of horizontal movement
ditching	an emergency landing on water
G	the acceleration experienced by an object due to the Earth's gravity at sea level (called one G). The total acceleration (often incorrectly called the total force) on an object can be expressed as a multiple of G. 'Low G' is a condition where the total acceleration is less than one G
mast bump	contact between the rotor head or blade and the rotor mast
rotor stall	a condition in which a high angle of attack on the main rotor blades increases blade drag to such an extent that the rotor revolutions per minute (RPM) decrease. The reduced RPM leads to reduced lift and the helicopter descends. The increased airflow coming from below exacerbates the high blade angle and the condition worsens

Data Summary

Aircraft registration:	ZK-HXR
Type and serial number:	Robinson Helicopter Company R22 Alpha, 0459
Number and type of engines:	one Textron Lycoming O-320-B2C, reciprocating
Year of manufacture:	1985
Operator:	private
Date and time:	1 November 2008, 1822[1]
Location:	near Stony Creek, Lake Wanaka, Central Otago latitude: 44° 32.6´ south longitude: 169° 07.6´ east
Type of flight:	ferry
Persons on board:	crew: one passengers: nil
Injuries:	crew: fatal passengers: nil
Nature of damage:	helicopter destroyed
Pilot's licence:	commercial pilot licence (helicopter)
Pilot's age:	31 years
Pilot's total flying experience:	approximately 6015 hours
Investigator-in-charge:	P R Williams

[1] All times in this report are in New Zealand Daylight Time (UTC + 13 hours) and expressed in the 24-hour mode.

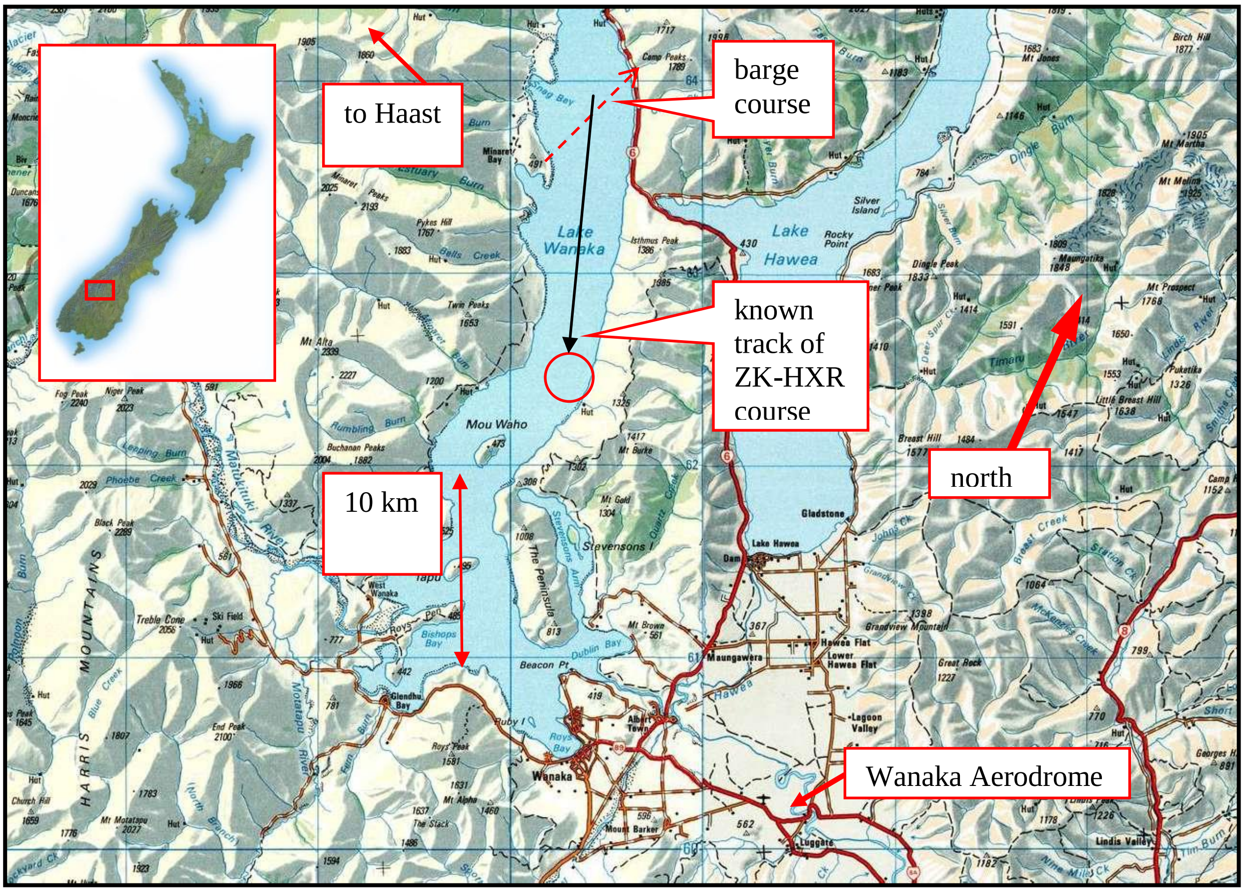

Figure 2
Location of the accident (circled)
(Source: Map Toaster, n.d.)

1 Factual Information

1.1 History of the flight

1.1.1 On the evening on 1 November 2008, the pilot left his base at Haast in a Robinson Helicopter Company (Robinson) model R22 helicopter (R22), registered ZK-HXR, to fly to Wanaka Aerodrome. The flight time via the nearly direct mountain route favoured by the pilot was about 40 minutes, or if the highway was followed, about 50 minutes. The flight was made under visual flight rules.

1.1.2 No record was kept at Haast of the fuel added or the quantity on board for the flight to Wanaka. The pilot planned to refuel at Wanaka before positioning the helicopter to Lowburn, about 35 kilometres (km) south of Wanaka in readiness for crop frost-protection flights that night. He had intended to pick up a friend and conduct deer shooting on the return flight to Haast the next day.

1.1.3 While ZK-HXR was flying down Lake Wanaka, a barge was crossing the lake heading to Camp Creek on the eastern shore (see Figure 2). The barge skipper was a friend of the pilot and also an R22 pilot. ZK-HXR flew past the barge at an estimated 100-200 feet (ft) above the water, climbed and turned sharply before flying past a second time. There was no radio contact between the pilot and the skipper. The skipper saw that the pilot was in the usual right seat and that he was wearing a baseball cap and a headset. He also saw a bag on the cabin floor, but did not recall seeing anything on the passenger seat.

1.1.4 After the second flypast, the helicopter turned and climbed before continuing down the lake in the general direction of the Wanaka Aerodrome. A photograph was taken at about 1817 of the helicopter flying away[2], an estimated few hundred feet above the lake, which has an elevation of about 980 ft. The skipper said that he thought the helicopter climbed enough for it to be able to cross the low saddle at the head of Stevenson Arm without being affected by turbulence in the lee. People on the barge soon lost sight of the helicopter against the distant hills.

1.1.5 On 30 October 2008, the skipper had sent the pilot a cellphone text message with the hours that the skipper had recently flown in another R22 (ZK-IBS) owned by the pilot. In a land-line phone call late in the morning of 1 November 2008, the pilot had told the skipper that he had not yet received the message.

1.1.6 There was no low-level cellphone network coverage between Haast and about where Camp Creek enters Lake Wanaka. The skipper said he thought the weather in the mountains could have prevented the pilot coming "over the top", meaning directly from Haast to Wanaka, which would have delayed his entering cellphone coverage until he had flown about halfway down Lake Wanaka.

1.1.7 Between 1815 and 1822, text messages were received by and sent from the pilot's cellphone. No voice calls were made from or received on the pilot's cellphone that day. Section 1.9 has more information on the cellphone system.

1.1.8 The pilot's father had flown a Robinson R44 helicopter from Haast to Wanaka about 15 minutes ahead of ZK-HXR, also to take part in the frost-protection operation. When ZK-HXR did not arrive at Wanaka as expected and the father could not contact his son by cellphone, the father arranged a private aerial search. Telephone company records show numerous calls to the pilot's cellphone after 1830. The National Rescue Coordination Centre was notified at 2011 that the helicopter was missing.

[2] The camera time setting was corrected for New Zealand Daylight Time.

1.1.9 Debris that was identified as coming from the helicopter was found floating in the lake later that evening. An oil slick seen the following day located the accident site about 100 metres offshore near the mouth of Stony Creek. There were no known witnesses to the accident.

1.1.10 On 4 November, Police and Navy dive squads using remotely operated vehicles located the wreckage of the helicopter at a depth of about 80 metres. The fuselage and the body of the pilot were recovered the next day.

1.2 Helicopter information

Robinson R22 general

1.2.1 The R22 was the most common helicopter in the world, in part because of its extensive use for basic helicopter pilot training. It was a 2-place light helicopter powered by a 4-cylinder, normally aspirated reciprocating engine.[3] A carburettor heat control and induction air temperature indication were provided. The flight controls were conventional, although the single cyclic stick was unusual in being T-shaped, with the upright mounted between the pilots (see Figure 3). Extensions from the upright went to cyclic grips in front of each pilot. On the accident flight, ZK-HXR was equipped to be flown from the right seat only.

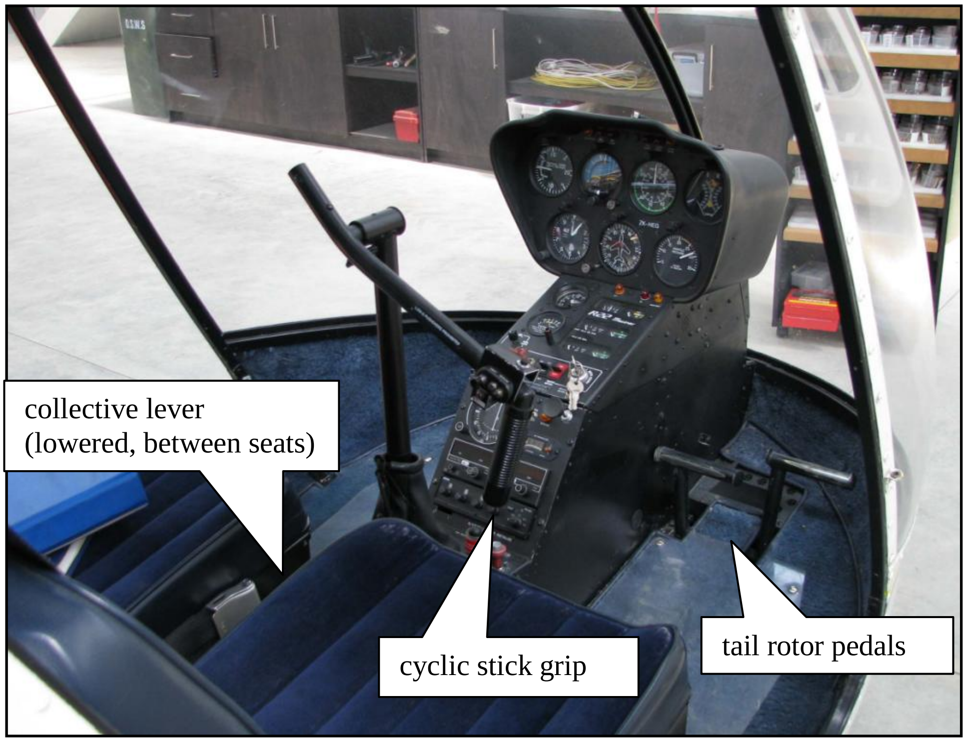

Figure 3
Typical R22 cabin

1.2.2 The 2-bladed main rotor system was a teetering, or 'see-saw', system, with the hub mounted on a teeter hinge on the mast centre-line, and the blades connected to the hub by individual flapping hinges. Upward flapping of the blades was limited by the hub and downward flapping by blade 'tusks' that contacted stops on the mast. Excessive flapping could fracture either or both tusks and lead to blade contact with the fuselage. Teetering stops protected the rotor mast from contact with the rotor blade spindles, which, in flight, was a potentially critical condition called a 'mast bump'. Figure 4 shows the rotor head (Robinson, 1979). The main rotor blades had a stainless steel spar at the leading (front) edge and stainless steel skins that enclosed an aluminium honeycomb core, but were considered lightweight, and therefore low-inertia, blades.

[3] The primary reference for this section of the report was the helicopter flight manual (Robinson, 1979).

1.2.3 The flight controls had trim springs to relieve normal flight loads and friction devices to help them retain the current position should the pilot remove their hands momentarily in flight. If the rotor and controls were properly rigged, there was little tendency for the collective lever to rise, even during light turbulence. However, the need to make a prompt entry into autorotation should that become necessary, for example if the engine failed, meant that pilots were encouraged to keep hold of the collective lever at all times. When the collective lever was lowered, the blade angle was reduced and the risk of further rotor RPM decrease was reduced.

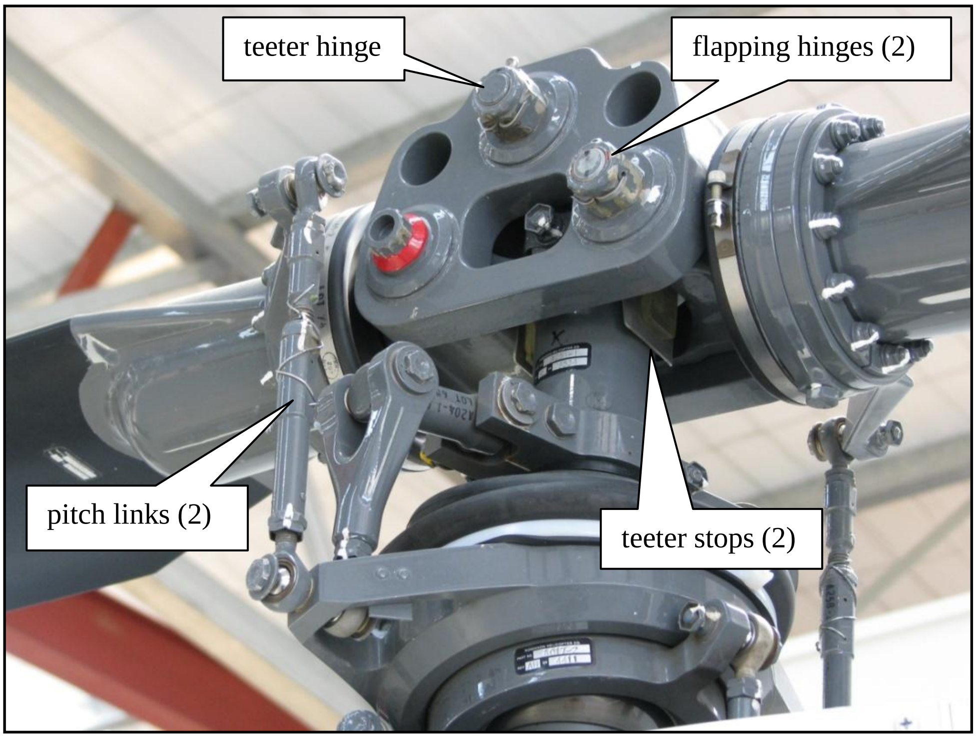

Figure 4
R22 rotor head

1.2.4 Although the R22 flight control system was considered to be more sensitive than those of other light training helicopters, a special investigation by the United States National Transportation Safety Board (NTSB) reported that the type met certification requirements (NTSB, 1996, p.29). However, the Federal Aviation Administration amended the training and experience requirements, which have since been incorporated into the Limitations section of the flight manual. An outline of the NTSB special investigation is given in Appendix 1, and section 1.9 of this report includes safety information published by Robinson.

1.2.5 The engine output was transmitted by dual V-belts to upper drive pulleys that contained a freewheeling sprag clutch. The clutch was a safety device that drove the rotor under normal conditions, but freewheeled to allow the main rotor to keep turning should the engine fail. A clutch actuator was engaged by the pilot after engine start and thereafter automatically maintained the correct tension on the drive-belts. Forward of the clutch, the drive entered the main transmission, which turned the rotor mast. Aft of the clutch was the tail rotor drive shaft. Flexible couplings were located on the main drive shaft at the gearbox input and at each end of the long tail rotor drive shaft. Figure 5 shows the R22 drive train (Robinson, 1979).

1.2.6 The RPM of the lightweight, low-inertia main rotor had to be kept within strict limits in order to conserve the rotor energy essential for proper control. The limits were 97% to 104% with the rotor powered, and 90% to 110% with power off.[4] An RPM warning horn and caution light activated when the main-rotor RPM decreased below 97%. If the main-rotor RPM decreased below 97% in flight, the recovery action was immediately to lower the collective lever while

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[4] 100% RPM was about 500 RPM.

simultaneously ensuring that the throttle was fully open. If the main-rotor RPM dropped below the in-flight limits and the rotor thrust was insufficient to support the helicopter weight, the blades would cone upwards and could crease and develop a set that would be evident later.

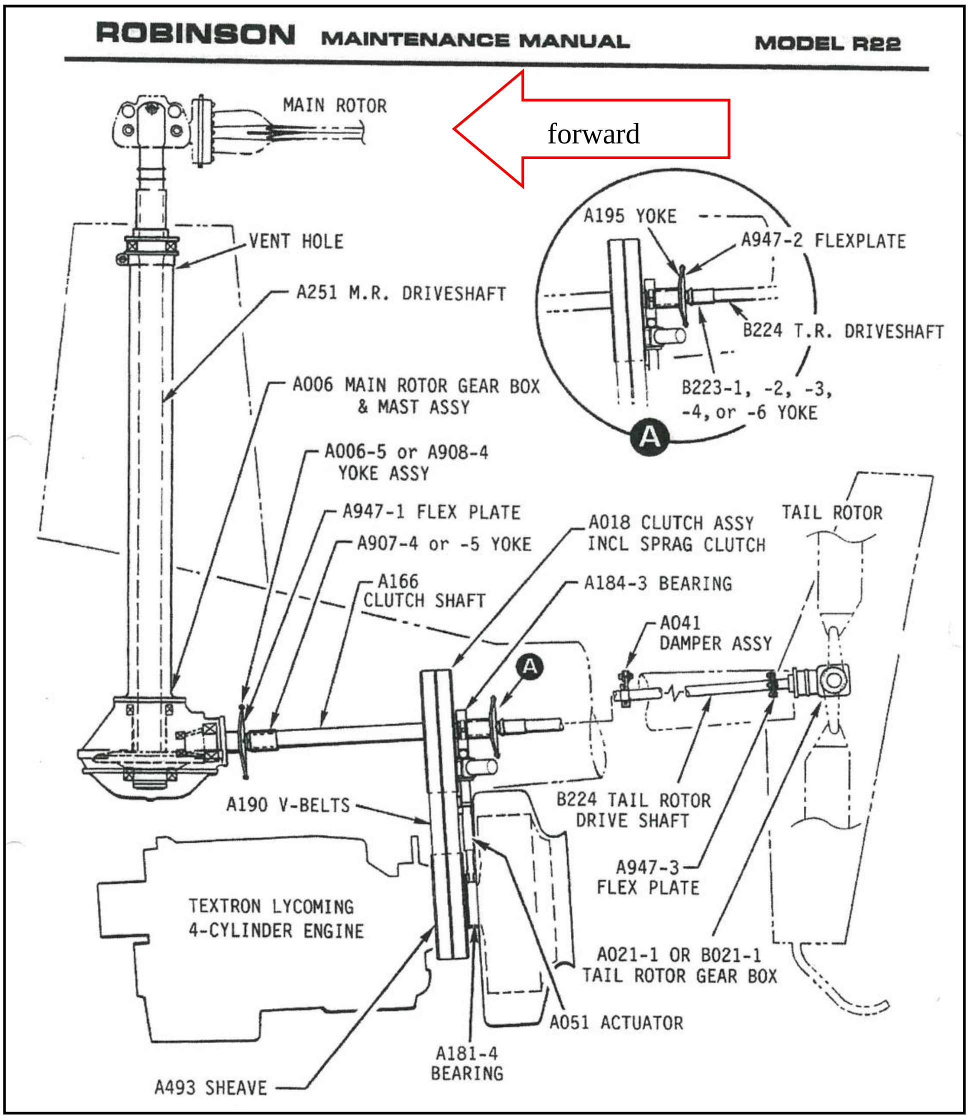

Figure 5
R22 drive train

1.2.7 There were a number of emergency or abnormal situations that could occur in the cruise for which the appropriate pilot response would be to enter autorotation. They included:

- low main-rotor RPM
- engine stoppage (for a reason such as catastrophic internal failure, fuel exhaustion or starvation[5], or carburettor icing)
- fire
- drive-belt failure
- loss of tail rotor thrust during forward flight
- sudden onset of serious vibration (which might have been a symptom of an engine or rotor defect, or detachment of some part of the airframe).

[5] Fuel starvation was an interruption of the fuel supply, whereas fuel exhaustion was the depletion of usable fuel.

1.2.8 In the event of an engine or drive-train failure, the flight manual required the collective lever to be fully lowered immediately. The flight manual cautioned that if the rotor were not driven, the RPM would decrease rapidly and a rotor stall[6] could occur if the RPM dropped below 80%. In that case, the rotor blades would likely stream above the hub as the helicopter fell.

1.2.9 A New Zealand R22 flight examiner said that a typical cruise speed was 85 knots (kt), but with one person on board the helicopter could easily achieve the maximum speed in the cruise. To fly at high forward speed, the main rotor disc was tilted forward and a higher blade angle demanded by raising the collective lever. If there were then a need to enter autorotation, the blade angle would need to be reduced by a larger amount than was the case if at a normal cruise speed, and the blade disc tilted further aft than when at a lower speed. These adjustments took additional time and could result in a more rapid and larger RPM decrease than usual.

1.2.10 The flight manual procedure for 'maximum glide distance' was to fly at 75 kt and reduce rotor RPM (by raising the collective lever) to approximately 90% if more than 500 ft above the landing surface. Below 500 ft, the rotor RPM had to be no less than 97%.

1.2.11 The ditching procedure was the same as that for an autorotation onto land, except that once the skids contacted the water, the helicopter was rolled to make the main rotor blades contact the water and stop rotating.

1.2.12 There were other abnormal conditions that could lead a pilot to decide to make an immediate, power-on landing. For example, the procedure for handling a clutch malfunction in flight was to pull the clutch actuator circuit breaker and land immediately. The flight manual warned pilots to be prepared to enter autorotation, as abnormal clutch operation could signal an impending drive-belt failure.

1.2.13 On 7 September 2009, the CAA issued a continuing airworthiness notice to draw attention to numerous reports of failure of R22 drive-belts, some of which had low times in service, and to emphasise the inspection and maintenance requirements for them (CAA, 2009). The notice included 8 recommendations that, in general, repeated Robinson's published guidance and instructions.

1.2.14 Investigations in New Zealand and Australia revealed a significant number of main drive-belt failures might be due to maintenance and/or the type of aircraft operations. R22 helicopters used on aerial work operations were subject to more strenuous operations that were likely to have detrimental effects on main rotor drive system reliability. However, there was a range of reasons for drive-belt failure, including pre-existing defects, incorrect installation or maintenance, and exceeding engine power limits. In addition, an in-flight alternator drive-belt failure could interfere with the main rotor drive belts and lead to their failure.

1.2.15 If both drive-belts failed, the sudden removal of the transmission load would cause the engine to over-speed, while the main rotor, without being driven, would slow rapidly. The engine over-speed could provoke a startled pilot into raising the collective lever in an attempt to control the engine RPM, but that incorrect response would quicken the decay in rotor RPM.

1.2.16 The R22, like other helicopters with a teetering rotor system, had to be flown to avoid low-G (near weightless) conditions. A low-G condition could be encountered during moderate to severe turbulence or if the cyclic stick were pushed forward following a pull-up or rapid climb, or even from level flight. Robinson advised that the R22's response to a low-G condition was dependent on the airspeed. At 60 kt, a pilot would feel the helicopter start to roll right; at 80 kt, the helicopter could roll through 90 degrees before the pilot could react; and, it had been reported, at the maximum speed of 102 kt, the helicopter inverted rapidly (Robinson, 2010).

1.2.17 The correct pilot response to a low-G condition was to apply gentle aft cyclic immediately to 'load' the rotor, before attempting to correct the right roll. An incorrect, or no, pilot reaction to

6 See glossary.

the condition could lead to mast bumping, mast separation and/or a rotor blade striking the fuselage.

1.2.18 The main fuel tank held 73 litres of usable fuel and the interconnected auxiliary fuel tank 40 litres. The average fuel flow for the O-320 engine was 35 litres per hour.[7]

ZK-HXR

1.2.19 The helicopter was manufactured by Robinson in the United States of America in 1985 and was first registered in New Zealand, as ZK-HXR, in 1987. The engine, which had first entered service in November 1984 in the United States, was not fitted to ZK-HXR until January 1989, and was first overhauled in November 1990.

1.2.20 ZK-HXR was issued with a standard category airworthiness certificate that was non-terminating as long as the helicopter was maintained in accordance with Civil Aviation Rules Part 43, which the maintenance log books indicated it had been. In 2006, a company owned by the pilot took possession of the helicopter and since then it had been used primarily for deer recovery, and occasionally for flight instruction and frost control.

1.2.21 In August 2007, when ZK-HXR had accrued 3735 flight hours, the engine had to be removed and sent for overhaul because of an in-flight RPM exceedance. The owner then decided to bring forward the 12-year/2200-hour overhaul of the helicopter itself. The usual maintenance provider performed the helicopter overhaul and said that it was well funded by the owner, who specified that higher-quality or newer parts be fitted in some cases.

1.2.22 During the overhaul, the main rotor hub was replaced with a part-life item. All other components of the rotor head were inspected, and tested or replaced as required. The main rotor gearbox and tail rotor drive shaft and its flexible couplings were inspected and reinstalled. A clutch assembly with nil hours and a 2200-hour life and a new fan wheel and fan shaft were fitted.

1.2.23 A new starter and ignition harness were fitted. The 2 magnetos, the alternator and the carburettor that were fitted had nil hours since overhaul. An Artex 406 emergency locator transmitter was installed, with the battery not due for replacement until August 2012.

1.2.24 The lower hinges of both cabin doors were replaced in accordance with airworthiness directive DCA/R22/45, which required cotter pins to be installed in all 4 hinges. The directive, issued on 27 March 2008, followed an accident investigation that found that an R22 cabin door not fitted with a lower hinge pin could separate in flight, particularly in turbulence, and that a separated door could strike the main rotor or the tail rotor (CAA, 2010).

1.2.25 The engine overhaul was completed on 17 October 2007 and the rebuild of the helicopter completed on 16 June 2008. An annual review of airworthiness was completed on 17 June 2008. The log book contained certification that all current and applicable airworthiness directives and manufacturers' service instructions had been met.

1.2.26 The helicopter returned to service on 20 June 2008, and pilots who had flown it since said that its condition and performance were excellent.

1.2.27 On 18 August 2008, the V-belts were routinely adjusted and the low-rotor-RPM warning horn micro-switch was adjusted because of intermittent failure of the horn. The horn control box was replaced on 3 October 2008 with a later-series item to assist troubleshooting. The horn defect was eventually traced to a broken earth wire.

1.2.28 On 10 September 2008, the engine mounting was realigned during a 100-hour inspection. That adjustment was not considered unusual by experienced maintenance engineers. At the same

[7] The fuel flow figure was provided by an R22 flight examiner who operated in similar terrain.

time, because the clutch actuator had been operating slowly, the actuator motor was replaced. Following this work, an engine performance check was carried out.

1.2.29 On 25 September 2008, metal was found on a main rotor gearbox magnetic chip detector.[8] The gearbox was flushed and the oil replaced. There was no further report of metal being found in the gearbox. Also on that date, the new starter was replaced, as were the left magneto and oil cooler, both of which had oil leaks.

1.2.30 The current technical log, commenced on 6 June 2008 and normally carried in the helicopter, was not found. The total hours recorded in a separate log kept at the Haast base were 3921.8 hours on 30 October. The next check due was a 100-hour inspection at 3934.8 hours. Apart from a check of engine airworthiness directives on 6 October 2008, the most recent maintenance activities recorded in the log books were 50-hour airframe and engine checks on 3 October 2008.

1.2.31 The helicopter had last been weighed on 6 June 2008. The empty weight, which included unusable fuel, a cargo hook and normal cabin equipment, was 876 pounds (397 kilograms (kg)). The weight and centre of gravity work sheet in the maintenance log put the longitudinal centre of gravity with full fuel and minimum solo pilot weight aft of the aft limit, and determined that 82.93 pounds (37.6 kg) of corrective nose ballast was required. The calculation was amended to 42.18 pounds (19.1 kg) and annotated '*NA – on fwd lim*'[limit]. Even the amended amount appeared to be in error, as the maximum permitted nose ballast was 10 pounds (4.5 kg). It could not be determined from the maintenance log whether any ballast had been fitted.

1.2.32 On the accident flight, a small tarpaulin, a jacket, some ammunition and a small backpack containing personal items were carried in the cabin. Although not found, it was probable that a rifle was on board for the hunting planned for the next day. The estimated weight of those items was 10 kg. The estimated weight at take-off, if both fuel tanks had been full, was 587 kg, below the maximum permitted weight of 622 kg.

1.2.33 Using the maintenance log values of empty weight and centre of gravity and the estimated load above, the longitudinal centre of gravity was calculated to have been within limits (see Appendix 2).

1.2.34 The CAA had no record of previous incidents or accidents concerning ZK-HXR.

1.3 Wreckage and impact information

1.3.1 During the initial search on the evening of 1 November, the pilot's helmet, a backpack and a down jacket were found floating up to 3 km north of where the fuselage was later located. The jacket was floating high in the water.

1.3.2 The small amount of fuel and lubricants that escaped from the wreckage was quickly dispersed by wind and wave action.

1.3.3 On 2 November, the auxiliary fuel tank, lightly compressed on all sides and without the filler cap, was found floating about 5 km north of the fuselage location, and a seat back was recovered about 5 km further north.

1.3.4 Sonar and video-equipped remotely operated vehicles were used to find the wreckage at a depth of about 80 metres where the lake bed had a slope of about 45 degrees. The engine and fan assembly had been separated from the fuselage. The aft tail boom and tail rotor assembly had been pulled away from the fuselage, but remained attached by the tail rotor drive shaft. One

[8] A magnetic chip detector has magnetic poles that attract ferrous particles that are produced within the component through normal wear or as a result of damage. If the particles are sufficiently numerous or big enough to bridge the gap between the poles, an electrical circuit is completed and a warning light annunciates.

main rotor blade was attached to the hub, but the other blade was not identified in the search video.

1.3.5 The pilot was secured in the right seat by his lap belt, but his shoulder strap, instead of being over his right shoulder, was displaced to his left side. He was not holding the cyclic stick or collective lever, but the police divers who recovered his body reported that he had earplugs and a cord for a cellphone, MP3 player or similar device clenched in his left hand. The cord was subsequently misplaced and its specific nature was not determined.

1.3.6 The fuselage, drive train and one attached main rotor blade, and the tail assembly were recovered, but the engine was not found again, despite another remotely operated vehicle search 9 weeks later and 2 attempts in May and November 2009 using specialist divers. Other significant items not recovered were the second main rotor blade, the clutch actuator and the main fuel tank.

1.3.7 Some parts of the wreckage inadvertently received slight additional damage during the recovery to the barge and transit to the aerodrome. The wreckage was inspected at Wanaka aerodrome, before being taken to Christchurch for further examination.

1.3.8 The drive train from the upper drive pulleys to the rotor hub was present, with one main rotor blade attached. The recovered blade was straight with no damage to the leading edge or tip, but had chord-wise[9] creasing , and light compression damage over the top and bottom skins (see Figure 6). The direction of the creases indicated that the blade had flexed both up and down. The droop tusk was broken off.

Figure 6
Recovered main rotor blade

1.3.9 Chord-wise creasing in the same area of the skins of both main rotor blades would most likely be caused by a low-rotor-RPM condition. Creasing on just one blade could be the result of impact or excessive flexing during a mast bump, or by a relatively soft impact that did not damage the blade spar (Robinson, 2010).

1.3.10 The missing blade had broken out of the hub at the trailing edge attachment bolt hole, the hub fracture having the appearance of tension overload. The mast was bent at the lower edge of the adjacent teeter stop (see Figure 7). Both pitch links had fractured as a result of overload.

1.3.11 The upper drive pulleys showed no sign of having been rotating at impact. The drive-belts were not found, but there was little evidence to suggest they had broken in flight. The drive shaft flexible couplings had impact damage only. There was no evidence that the tail rotor or main rotor had been rotating at water impact.

[9] The chord is the dimension between the leading edge and the trailing edge of the blade.

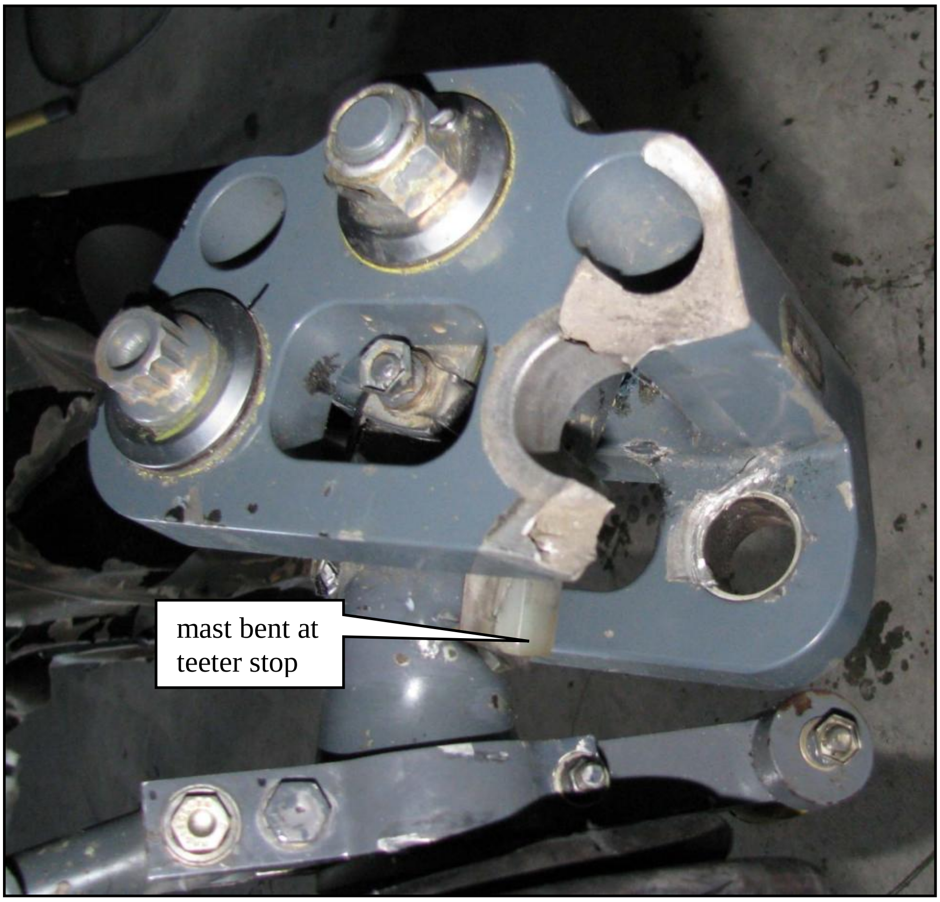

Figure 7
Rotor hub and evidence of mast bump

1.3.12 The tail boom had separated completely around the joint between bays 4 and 5, and the forward section of the boom was bent downwards at a relative angle of about 30 degrees, but there was no evidence that a main rotor blade had struck the tail boom. Apart from a few minor dents on the skin of one blade, the tail rotor assembly of ZK-HXR was in good condition, with the gearbox sight glass showing normal oil quantity.

1.3.13 The engine had separated in a downwards direction from the fuselage and pulled the lower mounts completely out of the forward firewall. The bolts of the upper mounts indicated the engine had been pulled out slightly towards the left.

1.3.14 The cabin was extensively disrupted, with the front left floor and side missing forward of a line from the front of the centre pedestal to the outside of the passenger seat. The right door frame was separated and neither door was located. The damage was very similar to that reported after other R22 accidents in which a main rotor blade had struck the cabin. When a low-inertia main rotor blade struck the fuselage, the structure could completely absorb the rotational energy and cause the blades to stop (NTSB, 2009).

1.3.15 Both teeter stops were crushed and the mast bent. The mast was also broken in line with the top of, but retained in, the main transmission. Compressive damage to the cabin and rotor mast fairing indicated the helicopter had entered the water in a near-vertical, nose-down attitude.

1.3.16 The warning and indicator light bulbs were examined, but yielded little useful information. The filament in the oil-low-pressure light bulb was slightly stretched, but not enough to conclude that it had been illuminated at the time of impact.

1.3.17 The engine and rotor tachometers showed zero RPM. All instruments and indicators were at their low, zero or ambient readings, except for the cylinder head temperature, which was 300°F.

The manifold pressure gauge was not located. The altimeter sub-scale was set to 1001 hectopascals. The ignition switch was on BOTH, but the master switch was OFF. All other switches were OFF. The clutch switch guard was raised, but the switch was ON. The content gauges for both fuel tanks were just below the quarter mark. The Hobbs meter read 3922.4 hours.

1.3.18 The circuit breaker for the low-rotor-RPM warning horn was out, as were the breakers for some non-essential services, but damage to the panel meant these were unreliable indicators of their pre-impact positions. The fuel shut-off valve was safety wired in the ON position.

1.3.19 The collective lever was found in the fully down position, but impact damage prevented a determination of the pre-impact positions of the twist-grip throttle and other engine controls.

1.3.20 The cyclic stick was bent to the left and rearwards near the base of the stick. The damper weight on the top of the stick had an indentation that matched the curvature of the main rotor blade leading edge. With the cyclic stick upright, the dent was oriented almost parallel to the longitudinal axis of the helicopter.

1.3.21 The continuity of main rotor controls was confirmed from the collective lever and cyclic stick to the rotor mast. The right lateral cyclic push-pull tube was fractured about halfway up the mast and all control push-pull tubes were bent rearwards. The main rotor pitch change links were sheared in overload at the upper adjustment threads.

1.3.22 The pilot's tail rotor pedals were found with the left pedal fully forward, but the push rods had been severed below the cyclic stick by impact damage. Tail rotor control continuity was confirmed from beneath the cabin floor to the tail rotor.

1.3.23 At Christchurch, an independent R22 helicopter engineer inspected the main gearbox, rotor hub and sprag clutch. The gearbox turned freely and was in good condition. The gearbox magnetic chip detector had a light covering of fuzz that was considered normal. There were also small pieces of Perspex that appeared to be from a cabin transparency (but these had not been ground by gearbox action), and paint flakes that matched the helicopter colour. There was no indication, such as bearing damage, to show that the gearbox had been rotating at impact.

1.3.24 The rotor hub teetering hinge was normal, but the engineer considered it was at the upper limit of tightness. The sprag clutch was noisy, but functioned correctly in both drive and freewheel directions. The rotor RPM pick-ups were in place and undamaged.

1.4 Pilot information

1.4.1 The pilot had been involved with a family-owned helicopter business for most of his working life and was also the sole director and a part-owner of the company that owned ZK-HXR.

1.4.2 He had obtained a private pilot licence (helicopter) in 1995 and a commercial pilot licence (helicopter) in 1997, and had type ratings for Hughes 269 and 369 models, and R22 and R44 models. The dates on which he obtained the type ratings were not determined.[10] His total flight experience of 6015 hours was estimated from the sole pilot log book that was available, covering the period from February 2006 until 30 October 2008. The pilot's total flight time on the R22 could not be determined.

1.4.3 The pilot had flown R22, R44 and Hughes 369 helicopters on a regular basis. His usual flight examiner said the pilot was very experienced and competent on all of the types that he flew. He said he thought the pilot flew each type frequently enough that he would not have had problems with handling skills when switching from flying one type to flying another.

[10] The requirement for the Director of Civil Aviation to be notified of the issue of a type rating was specified in Civil Aviation Rule 61.55(a)(2), which came into effect on 11 May 2006.

1.4.4 The pilot's previous competency check had been conducted in a Hughes 369C on 19 June 2008. He had last completed the Robinson Safety Awareness Training (see Appendix 1) in July 2007, in conjunction with his last crew competency check conducted in an R22.

1.4.5 In the previous 12 months the pilot had logged a total of 376 hours, but he had averaged 60 flying hours per month for the 3 months before the accident. In the previous month he had logged 52 hours in an R22, and in the previous 7 days he had flown 11 hours, of which 10 were on the R22. All of the flights in ZK-HXR were logged as private flights, primarily for deer recovery.

1.4.6 The pilot's flying skill was also well regarded by his peers, who considered him to be meticulous with the maintenance and cleanliness of the helicopter and its equipment. He was known to like to fly the R22 at high cruise speeds, close to the maximum speed of 102 kt.

1.4.7 On 17 October 2008, the CAA had advised the pilot of its decision that he was not a 'fit and proper person' to be a Senior Person for a family-owned helicopter company. The decision had been based, in part, on an earlier conviction on a charge that involved the use of helicopters. An appeal had been lodged against the conviction.

1.4.8 Family and friends of the pilot said that he was relaxed about the legal situation and, apart from the rejection of his application to be a Senior Person, there was no known personal issue that might have affected his behaviour or wellbeing. A person who knew the pilot well and had spoken with him just before he departed Haast on the accident flight said the pilot was disappointed at missing a local function that night, but 'categorically of sound mind and in good spirits'.

1.5 Medical and pathological information

1.5.1 The pilot held a class 1 medical certificate with no conditions, restrictions or endorsements, which was valid until 7 January 2009. He was not known to have had any recent complaint regarding his health or wellbeing. He weighed about 98 kg.

1.5.2 A post-mortem examination determined that the pilot had received a head injury that would have been instantly fatal. No evidence was found of any pre-existing medical condition that might have incapacitated him.

1.5.3 No evidence was found of prior consumption of alcohol, or medicinal or other drugs that could have affected the mind, altered his mood or caused sleep. The carbon monoxide saturation of blood samples was in the normal range for a non-smoker.

1.5.4 Flecks of black material and a green plastic fibre-like object taken from the site of the pilot's head injury were examined by a laboratory. The black material was identified as polyurethane paint, with an underlying layer of epoxy-based blue-green paint. These colours matched the helicopter's present and previous paint schemes. Similar paint flecks were found in the main rotor gearbox. The green plastic fibre-like material was not identified.

1.6 Survival aspects

1.6.1 The circumstances of, and damage to the cabin caused by, the main rotor strike and water impact made the accident un-survivable.

1.6.2 Family and friends said that the pilot was a non-swimmer. Civil Aviation Rule 91.525, Flights over water, required that a life jacket be carried and accessible when operating over water beyond (autorotation) range of the shore. No life jacket was found.

1.6.3 The antenna cable from the emergency locator transmitter was broken at the coaxial plug on the unit. The transmitter was examined by a specialist, who determined that the unit had activated. However, the transmitter output would not have been received with the antenna under water.

1.7 Communication

1.7.1 Apart from the recommended calls when operating near or joining to land at an unattended aerodrome, there was no requirement for the pilot to make any radio calls.

1.7.2 The very-high-frequency digital radio transceiver was examined by an avionics specialist, who found that the main reference crystal was damaged, probably as a result of the impact. After the crystal was replaced, it was determined that frequency 119.1 megahertz (the Haast Aerodrome frequency) had been in use and 118.9 megahertz selected on standby.

1.7.3 The published frequencies for the Lake Wanaka basin and the Wanaka Aerodrome were 128.0 megahertz and 120.1 megahertz respectively. A frequency above 130 megahertz was used by some local operators for informal communications.

1.7.4 If the pilot had transmitted a distress or urgency call on the frequency in use, it was unlikely to have been heard.

1.7.5 The pilot was known to have an active noise-reduction headset[11] that had wireless connectivity to suitable cellphones. The headset reduced the intensity of lower-frequency noise in the 85 Hertz to 135 Hertz frequency band (Lightspeed Aviation, 2008), which was well below the tone of the low-rotor-RPM warning horn. The headset could also receive an auxiliary input, such as an MP3 player. Manual input was required to send a cellphone text message or to select MP3 player features. The headset worn by the pilot was not recovered, so whether it was the active noise-reduction model was not determined.

1.7.6 A close friend of the pilot had observed him flying while using a cellphone for texting, without the pilot taking his hands off the flight controls. Another friend said the pilot was adept at texting with either hand.

1.8 Meteorological information

1.8.1 A daily weather briefing was received routinely each morning at the pilot's operating base, but it was not known whether he obtained a report on the current weather conditions at Wanaka immediately before departing Haast.

1.8.2 The barge skipper described the lake wind as a fresh southerly, causing small waves and some whitecaps. Others on the barge described the day as 'beautiful and clear' with 'a wee bit of a southerly wind', 'a good moderate breeze', and a 'brisk breeze'. The skipper said that conditions were unlikely to have required a reduction in normal cruise speed for an R22, but there could have been short, sharp bumps in the lee of the hill that the helicopter was approaching.

1.8.3 The pilot of a Hughes 369 helicopter who flew from Wanaka towards Haast at about the same time said the weather was dry and 'not really windy, but blowing'. He flew at about the height of the ranges to the east of Lake Wanaka and saw whitecaps on the lake.

1.8.4 Compared with the Beaufort wind scale, the above observations suggested the lake surface wind was about 20 kt (MetService, n.d.).

1.8.5 A MetService analysis of the weather at about the time of the accident indicated the following:

> A trough of low pressure had moved rapidly northeast over New Zealand. At 1800, the trough axis had moved on to the North Island and a southwest airstream covered the South Island. The winds at levels up to 10 000 ft over Wanaka at about the time of the accident were estimated to have been southwesterly at about 40 kt.

[11] An active noise-reduction headset has a microphone to detect the environmental noise spectrum. The headset then generates the exact opposite noise into a small loudspeaker in the headset to cancel out the target frequency band.

Area forecasts predicted low cloud and rain west of the main divide, easing after the passage of the front, and light showers east of the main divide, clearing from the south. Moderate turbulence was forecast over the pilot's intended route to Wanaka.

Automatic weather stations at Haast and Wanaka aerodrome did not record any rain after 1500. At 1800, the wind recorded by the Wanaka station was from the southeast, at 14 kt, but with gusts up to 30 kt. The air temperature and dew point recorded at the Wanaka station were 13°C and 2°C respectively, and the pressure 1001 hectoPascal.

1.8.6 Reference to a carburettor icing probability chart, using the meteorological conditions at the Wanaka Aerodrome, showed that moderate induction-system icing was possible with cruise power set. The higher humidity at low level over the lake could have increased the risk of carburettor icing.

1.9 Additional information

Cellphone system

1.9.1 In the cellphone system to which the pilot subscribed, the text message process included "submit" and "deliver" phases and both had to take place before the system recorded a message as "completed".[12] A message would be recorded as "sent" (from the sender's phone) when the submit phase was completed, which required the sender's phone to be in contact with the network. If the message was not delivered, perhaps because the recipient's phone was switched off or out of range, the message would be stored in the system, but still given the status "received", at that time, by the recipient.

1.9.2 When the recipient's phone next established a connection with the network, stored messages would be delivered and the system would again record their status as "received", at that later time. Simultaneously, the network would again record the messages as "sent" from the senders' phones.

1.9.3 Therefore, only the first "sent" status for a particular message was proof that the sender's phone had been in use at that time. The status "received" was not proof that the recipient's phone was in use at the recorded time.

1.9.4 Cellphone company records showed that on 1 November 2008 at 1412:53, the network received a text message addressed to the pilot's phone, and that a further 5 messages were received between 1815:08 and 1818:31. The message received at 1815:08 was the same as one received by the system more than 30 hours earlier. A message received at 1815:39 was a repeat of that received at 1412:53, and was replied to at 1819:01. The 3 other received messages were not relevant to the investigation.

1.9.5 The text message that the skipper sent to the pilot on 30 October was not one of those received by the pilot's cellphone between 1815:08 and 1818:31. However, at 1821:27, the pilot sent a message to the skipper's phone that read, "That's for the [ZK-] IBS hours ... I'm just going down to frost at Lowburn tonight".

Robinson safety information

1.9.6 The R22 flight manual included the following 'Safety Tip' (Robinson, 1979, p.10-1):

> Never push the cyclic forward to descend or to terminate a pull-up … This may produce a low-G (near weightless) condition which can result in a main rotor blade striking the cabin…

1.9.7 Robinson had issued Safety Notices addressing the following concerns:

[12] The cellphone system description was provided by the relevant telephone company.

Fatal accidents caused by low RPM rotor stall (Safety Notice 10, first issued October 1982).

> 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.
>
> When [the rotor] 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.

Low-G push-overs – extremely dangerous (Safety Notice 11, first issued October 1982).

> Severe in-flight mast bumping usually results in main rotor shaft separation and/or rotor blade contact with the fuselage. Always use great care to avoid any manoeuvre which could result in a low-G condition. Low-G mast bumping accidents are almost always fatal.

High winds or turbulence (Safety Notice 32, first issued March 1998).

> Flying in high winds or turbulence should be avoided but if unexpected turbulence is encountered, the following procedures are recommended:
>
> - Reduce airspeed to between 60 or 70 KIAS
> - … firmly rest right forearm on right leg to prevent unintentional control inputs
> - Do not overcontrol. Avoid large or abrupt control movements…
> - Avoid flying on the downwind side of hills, ridges … where the turbulence will likely be severe.

Exceeding approved limitations can be fatal (Safety Notice 37, December 2001).

> Many pilots do not understand metal fatigue. Each time a metal component is loaded to a stress level above its fatigue limit, hidden damage occurs within the metal ... If a pilot exceeds the power or airspeed limits on a few occasions without failure, he may be misled into believing he can safely operate at those high loads. Not true. Every second the limitations are exceeded, more stress cycles occur and additional fatigue damage can accumulate within the metal…
>
> **WARNING**
>
> 1) Always operate the aircraft well below its approved Vne (never exceed speed), especially in turbulent conditions.
> 2) Do not operate the engine above its placarded manifold pressure limits…
> 4) **The most damaging conditions occur when flying or manoeuvring at high airspeeds combined with high power settings** [emphasis in original].

Other accidents involving cellphone use

1.9.8 Cellphone use has been implicated in 2 other fatal aviation accidents and a fatal marine accident in New Zealand. On 19 February 2004, following the investigation of a commuter aeroplane accident that killed 8 persons, the Commission recommended to the Director of Civil Aviation that he 'develop educational material to raise awareness of the rules prohibiting cellphone use on IFR [instrument flight rules] flights" (TAIC, 2004). On 19 March 2009, as a result of an agricultural aeroplane accident, the Commission recommended that the Director 'address the safety issue whereby the Civil Aviation Rules are silent on the use of cellphones during critical phases of flight by pilots of aircraft operated under visual flight rules' (TAIC, 2009a). The marine accident, on 20 June 2008, was a collision that occurred immediately after the skipper had been using a cellphone, and resulted in the death of 2 persons and serious injuries to 3 others (TAIC, 2009b).

1.9.9 The Director of Civil Aviation took the action recommended in the 2004 report, but as at the date of the present report had not advised of any action taken in response to the 2009 safety recommendation. In August 2009, the Director of Maritime New Zealand issued a safety bulletin to alert the maritime community to the safety risk of masters and skippers using cellphones while vessels are underway.

2 Analysis

Overview

2.1 There were no witnesses to this accident and the last people to see ZK-HXR, barely 6 minutes earlier, noticed nothing unusual about its operation. The abrupt end to the flight while presumably in cruise flight over the lake suggested a sudden catastrophic event had occurred.

2.2 The wreckage distribution on the lake floor suggested that the helicopter had been largely intact when it entered the water in a near-vertical, nose-down attitude at high speed. Examination of the recovered wreckage showed there had been a mast bump. A main rotor blade had struck the cabin and almost certainly caused the pilot's fatal injury. The severe damage was not consistent with a controlled ditching.

2.3 The lack of rotational damage to the recovered main rotor blade and to the main gearbox indicated that those components had stopped turning before the helicopter impacted on the lake. The sprag clutch freewheeling unit was found to have been serviceable, so it was most likely that the rotor had been brought to a stop when the missing blade struck the cabin and that the blade then broke away from the hub.

2.4 The evidence supported a mast bump, rather than another scenario such as a main rotor stall, being the cause of the sudden catastrophic loss of control. Turbulence was likely to have been present in the lee of the hills near the accident site, and the low-G condition necessary for a mast bump could have resulted from the helicopter's natural response to a gust or from the pilot abruptly pushing forward on the cyclic stick to counter the effects, or for some other unknown reason. If the helicopter had been operated at high speed at the time, its response to low-G would have been more rapid and extreme.

2.5 The accident occurred close to the time that the pilot had been composing and sending cellphone text messages. Although the initiating event to the mast bump could not be determined, the circumstances strongly suggested that the pilot's cellphone use would have hindered his ability to respond quickly and appropriately to any abnormal condition.

Further explanation

2.6 The pilot was conducting a simple cruise flight in a helicopter that he was skilled in operating, and in an area and in weather conditions with which he was very familiar. Apart from the low flypast of the barge, there was no evidence that the operation of the helicopter had been abnormal or that its maintenance condition had contributed to the accident.

2.7 Witnesses on the barge described the helicopter making a shallow climb after the flypast, such that it was unlikely the pilot would have levelled the helicopter with a push over into a low-G condition.

2.8 Although the witnesses' observations indicated the lake surface wind speed was about 20 kt, the MetService analysis suggested the strength could have been greater, especially at the height of the ranges east of the lake. Strong wind over that type of terrain would usually generate turbulence, but whether the pilot had encountered turbulence then a low-G condition could not be proven.

2.9 Mechanical failure of a flight-control function was unlikely to have precipitated the event, because continuity of the flight controls was later established. The overload fractures of the pitch change links were a typical result of a rotor impact.

2.10 The possibility that a main rotor stall had occurred was examined and dismissed. In a rotor stall the blades cone upwards, which moves the blade spindles further away from the mast, thereby reducing the risk of a mast bump. Yet a mast bump did occur. However, what actually happens in such an event can be affected by random variables, particularly pilot control inputs.

2.11 In cruise flight, the rotor stall scenario would also have required an abnormal condition to initiate a decrease in RPM, and a slow or inappropriate pilot reaction to provoke a further decrease in RPM. The initial decrease could occur if the pilot were inattentive to RPM control or slow to enter autorotation if that were required, for example following an engine or drive-belt failure.

2.12 The recovered main rotor blade had creases in the skin, but whether they resulted from coning of the blades at low RPM could not be determined without having the other blade for comparison. The creases seen could have been, and were considered more likely to have been, caused when the recovered blade flapped excessively in reaction to the other blade impacting on the fuselage.

2.13 Wreckage examination eliminated some of the emergency situations that might have required the pilot to enter autorotation (see paragraph 1.2.7). There was no evidence of fire, and although there were a few rubber smears around the fuselage frames, these were far fewer than seen on another R22 known to have had an in-flight drive-belt failure. For this reason, the drive belts on ZK-HXR probably did not break until the engine pulled out of the fuselage on impact.

2.14 Because the engine and some ancillary components were not recovered, it could not be conclusively determined whether they were factors in the occurrence.

2.15 The Hobbs meter reading of 3922.4 hours suggested that only 0.6 hours had been flown since the last update of the daily flight log kept at the Haast base. Therefore, it was likely that the pilot had taken the direct route through the mountains from Haast to Lake Wanaka. Although the fuel on board when ZK-HXR departed from Haast was not known, and a refuel was intended at Wanaka aerodrome, fuel exhaustion was considered an unlikely event for a number of reasons. The pilot was familiar with the route requirements and it was most unlikely that he would take the bare minimum fuel when he could not be certain that the direct route was open. With only himself on board, there was no weight restriction on having both fuel tanks full.

2.16 The maintenance log empty-weight and centre-of-gravity values did not reflect the calculated need for nose ballast. No ballast was found, because the forward pedestal, where it would have been located, had been destroyed. Other pilots who had flown ZK-HXR since the rebuild did not report any unusual handling characteristic. Therefore, the weight and balance were considered to have not been factors in the accident.

2.17 Apart from the auxiliary fuel tank, the flotsam was items from the cabin, almost certainly lost overboard when the rotor blade cut through the cabin. The even crushing of the auxiliary fuel tank appeared to have been caused by hydrostatic forces before the tank floated to the surface. The finding of the jacket before it got waterlogged suggested that the blade strike occurred before water impact. The southerly wind would have blown the lightweight items up the lake. Where they were found was a function of their drift rate and unlikely to have been where they fell from the helicopter.

2.18 The pilot's death was almost certainly the result of his being struck by a main rotor blade. The paint flecks found in his wound were similar to those found in the gearbox, so were likely to have been debris that had flushed through the sinking wreckage. There was no evidence that the pilot's health or disposition had been a contributing factor.

2.19 The dismissal of the rotor stall scenario also removed the possibility that the pilot had been compelled to enter autorotation, but being a non-swimmer and not wearing a life jacket had tried to avoid a ditching by extending the autorotation range.

2.20 The finding of the earphones and cord in the pilot's left hand, with which he would have held the collective lever, suggested that those items had been in use when a sudden event occurred and he had not had time to discard them.

2.21 With its ground speed estimated to have been no greater than 80 kt in the prevailing wind, if the pilot had been flying at high speed as he was known to do, the helicopter would have taken at least 5½ minutes to fly the 13 km from the barge to the accident site. Therefore, it was probable that the accident occurred at about 1822, almost straight after the pilot had sent the text message to the skipper.

2.22 The sending of a cellphone message was unlikely to have precipitated the accident. However, composing and sending messages was very likely to have diverted the pilot's attention from monitoring the helicopter performance and could have hampered his ability to respond promptly and appropriately to control the helicopter if it had encountered turbulence or a low-G condition.

2.23 As the Commission's previous safety recommendation (TAIC, 2009a) concerning the use of cellphones by pilots when flying under visual flight rules was applicable to this accident, no further safety recommendation has been made.

2.24 The following potential initiating events were also considered:

- door opening in-flight, and/or an object, including a door, being lost overboard
- bird strike.

2.25 Neither cabin door was found, but as the airworthiness directive relating to door hinges had been met, the doors were considered unlikely to have been a cause for the accident. If a door had opened in-flight, the pilot could have landed at a suitable spot and secured it. If a door had detached in-flight, there was a risk that it would strike a main rotor blade or tail rotor blade, but there was no evidence that anything had struck the recovered main rotor or the tail rotor, and a catastrophic main rotor blade strike would likely have led to more widespread wreckage distribution.

2.26 There was no evidence of a bird having struck the fuselage or the pilot. However, the canopy was shattered and not recovered, and the wreckage flushed by immersion, so that possibility could not be excluded.

2.27 The flight manual warnings and the mandatory Safety Awareness Training that the pilot had received were considered adequate for their intended purpose of emphasising the critical importance of avoiding low-G situations, maintaining rotor RPM control and the smooth handling of the R22 helicopter.

Summary

2.28 An examination of the wreckage of ZK-HXR showed that an in-flight mast bump had occurred. The reason for the mast bump could not be determined, but with the helicopter flying at a relatively high speed it could have been the result of an encounter with turbulence inducing a low-G condition. A mast bump did not require any technical precursor, and was sufficient to cause a catastrophic loss of control.

2.29 Although not all the wreckage was recovered, particularly the engine, none of the possible abnormal technical events considered should have led to the pilot losing control. However, his use of a cellphone, and his probable use of another audio device, at about the estimated time of the accident could have been factors that contributed to his not recognising or responding appropriately to an abnormal event.

3 Findings

Findings are listed in order of development and not in order of priority.

3.1 During cruise flight a mast bump occurred, bringing about a catastrophic loss of control, followed by a main rotor blade striking the cabin and fatally injuring the pilot.

3.2 The mast bump was likely to have been caused by the helicopter encountering a low-G condition, perhaps in turbulence or for an unknown reason.

3.3 The investigation, because of the incomplete wreckage recovery, was unable to determine conclusively whether any technical factor contributed to the accident, but from the available evidence that was considered to be unlikely.

3.4 The pilot was experienced and considered skilful in operating the R22 and he met the currency requirements of the R22 Safety Awareness Training Course. However, his reported habit of flying the R22 at high speed might have contributed to the severity of the helicopter's response to a low-G situation and prevented him reacting in time to counter the situation.

3.5 The pilot's cellphone use and his probable use of another audio device would have hampered his monitoring of the helicopter performance and his ability to take prompt corrective action had that been required.

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Appendix 1

Outline of NTSB Special Investigation Report NTSB/SIR-96/03

In 1992, following an inconclusive investigation into an R22 loss of main rotor control accident in California, the NTSB commenced a special investigation into similar R22 accidents. Of particular concern was the absence in some of these accidents of factors that had been previously identified with loss of main rotor control events, factors such as abrupt pilot handling or significant turbulence. Unexplained mast bumping or rotor contact with the fuselage, particularly while operating within the approved flight envelope, threatened the certification status of this very popular helicopter.

The NTSB reviewed 31 accidents that had occurred between November 1981 and July 1995, including one in New Zealand. The R22 design and certification process were reviewed and an external study commissioned (by the Federal Aviation Administration) of the dynamics of low-inertia rotor systems.

At various times prior to 1996, when the investigation report was adopted, Robinson made several changes to the R22, including the installation of automatic throttle correlation with collective lever movement. The Federal Aviation Administration issued guidance intended to improve pilots' ability to control main-rotor RPM, and recommended lower wind and gust limits for inexperienced pilots. The guidance was later packaged as Safety Awareness Training (see below). The NTSB subsequently noted that since 1996, in the United States at least, the number of R22 loss of main rotor control accidents had decreased markedly.

The NTSB special investigation was adopted on 2 April 1996, but without determining the cause(s) of the 1992 California accident that prompted the investigation. The special investigation report made 5 recommendations to the Federal Aviation Administration. One concerned ongoing operations of the R22 and was accepted and mandated as flight manual limitations and the Safety Awareness Training. The others primarily concerned research into low-inertia rotor systems and future certification requirements. By 17 March 2000, all of these safety recommendations had the status of 'closed-acceptable action'.

Outline of Robinson Safety Awareness Training

In 1995, the Federal Aviation Administration issued Special Federal Aviation Regulation 73, which promulgated special requirements for proficiency reviews, dual training, pilot experience, operational limitations and biennial Safety Awareness Training for R22 pilots. The regulation was mandated as an addition to the Limitations section of the helicopter flight manual, which in New Zealand was done on 16 February 1996 by airworthiness directive DCA/R22/27, since amended twice.

The biennial Safety Awareness Training, which must be delivered by a helicopter instructor, can be tailored to a pilot's experience, but each time it must cover the theory and flight practice of rotor RPM control (to avoid rotor stall situations), low-G hazards (to avoid mast bumping) and enhanced autorotation procedures (with the emphasis on control of rotor RPM). The low-G segment was restricted to theoretical consideration only.

Appendix 2

ZK-HXR calculation of weight and balance

	Weight (pounds)	Arm (inches)	Moment
Empty weight (from maintenance log)	876	102.53	89 816
Pilot and baggage	238	78.0	18 564
Total, no usable fuel	1114	97.3	108 380
Add full main fuel (73 litres)	115	108.6	12 489
Add full aux fuel (40 litres)	63	103.8	6539
Assumed maximum take-off weight	**1292**	**98.6**	127 408

Limitations

Maximum gross weight 1370 lb
Minimum weight 902 lb

Allowable centre of gravity ranges:
At assumed maximum take-off weight 95.7 – 100.8 inches
At minimum weight 95.4 – 102 inches

Approved on 21 July 2010 for Publication

Mr John Marshall QC
Chief Commissioner

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09-006	Report 09-006, Cessna 207, ZK-DEW aircraft starting incident resulting in runway incursion, Queenstown Aerodrome. 5 September 2009
09-004	Report 09-004, Britten Norman BN2A-Mk III Trislander, ZK-LOU loss of engine propeller assembly, near Claris, Great Barrier Island, 5 July 2009
08-005	Report 08-005, Kawasaki-Hughes 369D, ZK-HWE, un-commanded yaw and loss of control, Maori Saddle, near Haast, Westland, 11 August 2008
08-001	Report 08-001, Cessna 152 ZK-ETY and Robinson R22 ZK-HGV, mid-air collision, Paraparaumu, 17 February 2008
07-006	Report 07-006, Hawker Beechcraft Corporation 1900D, ZK-EAK, landing gear malfunction and subsequent wheels-up landing, Woodbourne Aerodrome, Blenheim, 18 June 2007
07-010	Fletcher FU24-950, ZK-DZG, in-flight vertical fin failure, loss of control and ground impact, 5 kilometres west of Whangarei (Pukenui Forest), 22 November 2005
07-011	Cessna A152 Aerobat, ZK-KID, impact with terrain, Te Urewera National Park, 23 kilometres south-east of Murupara, 26 October 2007
07-012	Fletcher FU24-950EX, ZK-EGV, collision with terrainnear Opotiki, 10 November 2007
08-002	Eurocopter AS355 F1, ZK-IAV, spherical thrust bearing failure and subsequent severe vibration and forced landing, Mount Victoria, Wellington, 13 April 2008
07-002	Dornier 228-202, ZK-VIR, partial incapacitation of flight crew, en route Westport to Christchurch, 30 March 2007
06-007	KH369 ZK-HDJ, collision with terrain, Mt Ruapehu, 11 December 2006
06-005	Gippsland Aeronautics GA8 ZK-KLC, partial engine failure, Cook Strait, 27 November 2006
06-009	Boeing 767-319, ZK-NCK, fuel leak and engine fire, Auckland International Airport, 30 December 2006
07-003	Piper PA 32 ZK-DOJ, departed grass vector on landing, Elfin Bay airstrip near Glenorchy, 5 April 2007

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