Watchlist

Robinson helicopters: mast bumping accidents in NZ

What is the problem?

The Transport Accident Investigation Commission is concerned about the number of accidents in New Zealand in which Robinson helicopters have experienced 'mast bumping'. These accidents have raised concerns about the risks of flying these helicopters in the mountainous terrain and weather conditions that are common in New Zealand.

Mast bumping is contact between an inner part of a main rotor blade or a rotor hub and the main rotor drive shaft (or 'mast). Mast bumping usually results in the helicopter breaking up in flight, which is fatal for those on board.

Part of the problem is that the available evidence has not allowed the circumstances and causes of all of these 'mast bumping' accidents to be fully determined. However, a significant proportion have been found to have occurred in "low-G"* flight conditions. Helicopters with semi-rigid two-bladed main rotor systems, as used on Robinson helicopters, are particularly susceptible to mast bumping in "low-G" conditions. Low-G can be caused by large or abrupt flight control inputs or by turbulence. The risk of mast bumping in turbulence increases with high power settings and operating at high speed and light weight.

What is the solution?

Operators must select a type of aircraft suited to the risk profile of the intended use. Similarly, all pilots must understand the helicopter's operating limitations, avoid circumstances which could see these inadvertently exceeded, and receive proper training in the causes, dangers, and prevention of mast bumping, including in low-G conditions. It is particularly important for Robinson pilots to be aware of the risks of flying a lightly loaded helicopter at high speed in turbulence. Prohibitions against in-flight low-G demonstrations must be observed, and

* *A low-G condition occurs when an object is subjected to a net vertical force less than the force of gravity. When the vertical force is zero, the object is described as being 'weightless'.*

low-G recovery training must be conducted on the ground.

The regulatory environment must:

- support high quality training and improved pilot awareness of mast bumping risks, including in low-G conditions
- require the manufacturer to clearly state the limitations of the helicopters
- encourage use of the helicopter as appropriate to the operating conditions.

Further research should be undertaken into the factors that can lead to mast bumping.

A requirement for cockpit video recorders and/or other means of data capture would provide useful data to investigations.

Background

Robinson helicopters are relatively inexpensive to purchase and cost effective to operate; and are therefore popular. About 300 are registered in New Zealand, mostly R22 and R44 models, with a small number of turbine-powered, 5-seat R66 models. These are used for flight training, agricultural, tourism, and commercial operations. All Robinson helicopter pilot operating handbooks state that pilots should avoid flying in high winds or turbulence, and subjecting the helicopter to low-G conditions.

Since 1996 the Commission or the Civil Aviation Authority (CAA) have investigated 14 mast bumping accidents or incidents involving Robinson helicopters, including nine where low-G mast bumping is known to have occurred. Six of these were in the past four years (see the table on the last page). Eighteen people have died in all these accidents, including nine in known low-G mast bumping accidents. The low-G related rate in New Zealand is considerably higher than in other parts of the world*. The Commission's inquiries have issued safety recommendations that remain open.

Mast bumping is contact between an inner part of a main rotor blade or a rotor hub and the main rotor drive shaft. Helicopters with the semi-rigid two-bladed rotor systems used on Robinson helicopters are susceptible to mast bumping during low-G flight conditions. Mast bumping usually results in the helicopter breaking up during flight, which is fatal for those on board. For this reason, it is often difficult to determine exactly what happened to cause the mast bump.

Low-G conditions can arise in turbulence. Significant areas of New Zealand terrain are mountainous, and they are often exposed to strong wind. Therefore, New Zealand pilots are more likely to encounter turbulence than in some other parts of the world where Robinson helicopters are used. Pilots must be aware of how hazardous it can be to operate Robinson helicopters in moderate or greater turbulence.

Instructors and pilots must be clear in their understanding of the hazards of operating semi-rigid two-bladed helicopters in low-G conditions, and how inadvertent or improper flight control inputs can cause mast bumping. Low-G recovery training must be conducted as ground training only.

* For instance, the low-G mast bumping accident rate in New Zealand compared with the United States is about nine times higher. This is based on fleet size of about 300 compared to 2700, and the same number of low-G mast bumping accidents in each market since the year 2000 (data provided by Robinson Helicopters). Variations in types of use or average hours flown may explain some of this difference.

The Commission also identified that the rate of Robinson helicopter in-flight break-up accidents in New Zealand had not been significantly reduced by New Zealand's adoption of the Federal Aviation Administration (FAA) measures intended to help prevent such accidents. We also found the format of the Robinson helicopter flight manuals and their terminology did not draw enough attention to safety critical instructions and conditions that could result in serious injury or death.

We recommended that the CAA:

- conduct a review of Robinson safety awareness training in New Zealand and facilitate the development and adoption of best practice across the sector, including a level of consistency in the way instructors deliver the safety awareness training.

- review FAA SFAR 73 [Special Federal Aviation Regulation 73, which mandated special safety awareness training for all R22 and R44 pilots and set a threshold for minimum pilot experience] in the context of the New Zealand aviation system and adopt relevant improvements that would likely enhance the operational safety of Robinson helicopters in New Zealand.

- include the knowledge and training requirements of Special Federal Aviation Regulation No. 73, or an equivalent requirement, as a prerequisite for the issue of a Robinson R66 type rating.

- promptly publicise the recent changes to the Robinson R66 (and R44) Pilot's Operating Handbooks that caution against flight in high winds and turbulence, and which advise pilots to reduce power and speed if turbulence is expected or encountered.

In response, the CAA reviewed Robinson safety awareness training in New Zealand, and it has since clarified training requirements for pilots of the R22 and R44 helicopters. The CAA decided not to include the R66 in the safety awareness training, saying that the FAA had rejected the inclusion of the R66 in SFAR 73, and that it would monitor advice from Robinson Helicopters and the FAA*.

In May 2016, the Commission released its report into a mast bump and the in-flight break up of a Robinson R66 helicopter in the Kaweka Range in 2013.[1] One of the recommendations from the inquiry into that accident was that the FAA reinstate research into the dynamic behaviour of the Robinson's rotor system under conditions of low-G.

The FAA and Robinson had conducted post-certification flight testing in 1982 (for the R22), 1995 (for the R44), and 2014 (for the R66), which included limited low-G manoeuvres. Due to the dangers of low-G, it is not possible to investigate more severe conditions with test pilot flying. However, computational sciences and aerospace engineering have advanced to such a degree that a fuller understanding of the dynamic behaviour of the Robinson and other semi-rigid two-bladed rotor systems should now be possible.

Following an R44 accident,[2] the Commission has further recommended that the CAA and Secretary of Transport promote, through the International Civil Aviation Organization, the need for cockpit video recorders and/or other means of data capture in certain classes of helicopter. This action could help better determine why these accidents happen. The CAA has accepted this recommendation and agreed to initiate an assessment paper on the issue.

* The CAA and the FAA signed a Bilateral Aviation Safety Agreement (BASA) in 2002, which included enhanced cooperation and efficiency, and reciprocal acceptance of airworthiness approvals.

The Commission's recommendations are seeking concerted actions by regulatory authorities, the manufacturer, operators, instructors and pilots to promote the safe operation of Robinson helicopters in the New Zealand environment; and to better understand the helicopter's operating characteristics and the factors that can lead to mast bumping.

References

[1] Transport Accident Investigation Commission *Report 13-003: Robinson R66, ZK-IHU, Mast bump and In-flight break-up, Kaweka Range, 9 March 2013*
Open safety recommendations 002/16, 004/16, 005/16, and 011/16
http://www.taic.org.nz/ReportsandSafetyRecs/AviationReports/tabid/78/ctl/Detail/mid/482/InvNumber/2013-003/language/en-US/Default.aspx?SkinSrc=%5BG%5Dskins%2FtaicAviation%2Fskin_aviation

[2] Transport Accident Investigation Commission *Report 15-002: Mast bump and in-flight break-up, Robinson R44, ZK-IPY Lochy River, near Queenstown, 19 February 2015*
Open safety recommendations 014/16 and 015/16
http://www.taic.org.nz/ReportsandSafetyRecs/AviationReports/tabid/78/ctl/Detail/mid/482/InvNumber/2015-002/Page/0/language/en-NZ/Default.aspx?SkinSrc=[G]skins%2ftaicAviation%2fskin_aviation

Version history

This Watchlist item was first published in October 2016. The Ministry of Transport, New Zealand Civil Aviation Authority, National Transportation Safety Board (US), Federal Aviation Administration (US), and the Robinson Helicopter Company were consulted during its preparation.

Mast bumping accidents in New Zealand, as at October 2016.

Investigation reference	Report title	Fatalities
*TAIC 91-001	Robinson R22 Beta ZK-HDC, main rotor separation after mast bumping in turbulence, near Hukerenui, North Auckland, 4 January 1991	1
CAA 96/3239	Robinson R22 Beta ZK-HDD, Matawai, Gisborne, 5 December 1996	2
CAA 02/71	Robinson R22 Beta ZK-HEZ, Balfour Range, near Fox Glacier, 14 January 2002	2
CAA 03/127	Robinson R22 Beta ZK-HUL, Masterton, 17 January 2003	1
*CAA 04/39	Robinson R22 Beta ZK-HXT, 10 km north-east of Taupo, 10 January 2004	2
*TAIC 08-007	Robinson R22 Alpha ZK-HXR, loss of control, Lake Wanaka, 1 November 2008	1
CAA 10/3987	Robinson R22 Beta ZK-HIP, loss of rotor RPM, Bluff Harbour, 14 October 2010	2
TAIC 11-003	Robinson R22 Beta ZK-HMU, inflight break-up, near Mt Aspiring, 27 April 2011	2
*CAA 12/4957	Robinson R22 Beta ZK-HCG, loss of main rotor control, Cardrona Valley, Wanaka, 8 November 2012	1
*TAIC 13-003	Robinson R66 ZK-IHU, inflight break-up, Kaweka Range, 9 March 2013	1
*TAIC 13-005	Robinson R22 Beta ZK-HIE, inflight loss of control, near New Plymouth, 30 March 2013	0
*CAA 15/1229	Robinson R22 Beta ZK-HMW, mast bump, Clevedon, 19 March 2015	0
*TAIC 14-006 (open inquiry)	Robinson R44 Helicopter ZK-HBQ, in-flight break-up, Kahurangi National Park, 7 October 2014	1
*TAIC 15-002	Robinson R44 ZK-IPY, Mast bump and in-flight break-up, Lochy River, near Queenstown, 19 February 2015	2

* Known low-G accidents

For more information see Appendix 1 to Transport Accident Investigation Commission *Report 15-002: Mast bump and in-flight break-up, Robinson R44, ZK-IPY Lochy River, near Queenstown, 19 February 2015* http://www.taic.org.nz/ReportsandSafetyRecs/AviationReports/tabid/78/ctl/Detail/mid/482/InvNumber/2015-002/Page/0/language/en-NZ/Default.aspx?SkinSrc=[G]skins%2ftaicAviation%2fskin_aviation