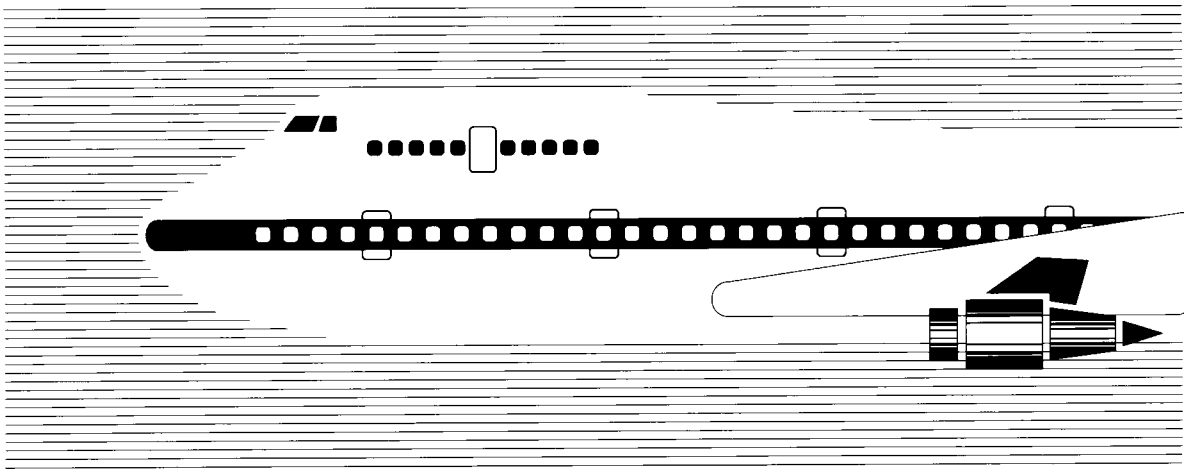
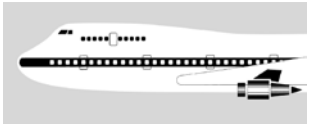
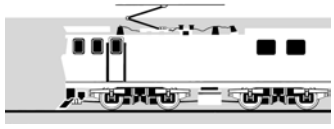


AVIATION OCCURRENCE REPORT

02-003 Schweizer 269C helicopter, ZK-HIC, loss of tail rotor authority and emergency landing, Karaka Downs South Auckland 15 March 2002


TRANSPORT ACCIDENT INVESTIGATION COMMISSION
NEW ZEALAND

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

Report 02-003

Schweizer 269C helicopter

ZK-HIC

loss of tail rotor authority and emergency landing

Karaka Downs South Auckland

15 March 2002

Abstract

On Friday 15 March 2002, at about 0945, ZK-HIC, a Schweizer 269C helicopter, lost tail rotor authority during a low-level spraying run. Normal helicopter control was lost and the pilot, unable to arrest the ensuing spin, carried out an emergency landing. The pilot, the only occupant, was uninjured.

A defective tail rotor driveshaft aft bumper plug permitted the driveshaft to disengage its drive coupling to the tail rotor gearbox.

A safety issue identified was the need for duplicate inspections of helicopter tail rotor drive trains, and a safety recommendation was made to the Director of Civil Aviation addressing this issue.

ZK-HIC after the accident

Contents

Figures

List of Abbreviations

CAA	Civil Aviation Authority
GPS	Global Positioning System
UTC	Coordinated Universal Time

Data Summary

Aircraft registration:	ZK-HIC
Type and serial number:	Schweizer 269C helicopter, S1607
Number and type of engines:	one Lycoming HIO-360 O1A
Year of manufacture:	1992
Operator:	Heli-Sika
Maintenance organisation:	Wing and Rotor Aviation Limited
Date and time:	15 March 2002, about 0945[1]
Location:	Karaka Downs, South Auckland latitude: 37° 05´ south longitude: 174° 53´ east
Type of flight:	commercial transport; agricultural
Persons on board:	crew: 1 passengers: none
Injuries:	crew: nil passengers: nil
Nature of damage:	substantial to the helicopter
Pilot's licence:	Commercial Pilot Licence (Helicopter)
Pilot's age:	29
Pilot's total flying experience:	1707 hours (569 hours on type)
Investigator-in-charge	K A Mathews

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

1 Factual Information

1.1 History of the flight

1.1.1 On Friday 15 March 2002, at about 0730, ZK-HIC, a Schweizer 269C helicopter, departed from Ardmore Aerodrome for Karaka Downs, to carry out crop spraying. The uneventful flight took about 7 minutes. The weather was reported to be suitable for crop spraying, with little wind and no rain.

1.1.2 At about 0945, during a pull-up manoeuvre to complete a low-level spraying run, the helicopter lost tail rotor authority and yawed suddenly and rapidly to the right. The run was near the completion of the 11th load of the morning. The pilot said he applied full left yaw pedal, retarded the throttle and lowered the collective lever in order to arrest the ensuing spin. The pilot's actions only slowed the rotation down and did not stop the spin. He reapplied power but was unable to regain control of the helicopter. He then closed the throttle, lowered the collective lever and reapplied it in an attempt to carry out an emergency landing. The helicopter collided with swampy ground and came to rest on its left side. The pilot, the only occupant, was uninjured. No fire occurred.

1.1.3 The pilot later said he had completed a thorough pre-flight inspection of ZK-HIC before leaving Ardmore. This included inspecting the tail rotor system and driveshaft, and ensuring the shaft moved fore and aft normally. Nothing untoward was noticed during the pre-flight. He had refuelled the helicopter with 20 litres of fuel at the start of the 10th load. He said the helicopter engine did not lose power, but was functioning normally prior to and during the loss of directional control.

1.2 Pilot information

1.2.1 The pilot was aged 29. He held a Commercial Pilot Licence (Helicopter) and a Class 1 Medical Certificate valid until 24 July 2002. He was a B category instructor. He was endorsed to carry out helicopter chemical spraying operations. His various helicopter ratings included the Schweizer (Hughes) 269. He had flown some 1707 hours, including 569 hours in Schweizer (Hughes) 269 helicopters.

1.3 Helicopter information

1.3.1 ZK-HIC was a Schweizer (Hughes) 269C single-engine helicopter, serial number S1607, constructed in the United States in 1992. A Lycoming HIO-360 O1A engine, serial number L-25818-51A, was fitted to the helicopter.

1.3.2 The helicopter had been operated in Japan since new, and was imported to New Zealand after it had flown 331 hours. An examination of the Japanese records showed the helicopter had been maintained in accordance with its routine maintenance requirements. The records did not indicate the helicopter had been involved in an accident, or that it had been subject to any major repair, modification or component change.

1.3.3 The helicopter records showed ZK-HIC had been maintained in accordance with the operator's approved maintenance programme. At the time of the accident the helicopter had amassed approximately 554 hours. The last maintenance check was a 50-hour inspection completed on 13 March 2002 at 552.4 hours. The next check, a 100-hour inspection, was due at 602.4 hours. An annual maintenance review was due on 26 April 2002.

1.3.4 An entry in the helicopter aircraft logbook showed a modification for a Global Positioning System (GPS) installation was completed on 1 November 2001. During the installation the tail rotor gearbox, tail rotor driveshaft, and tail boom were removed for the fitting of an antenna internally along the length of the boom.

1.3.5 The tail rotor driveshaft, which fitted along the inside of the tail boom, had a grease cavity at each end-fitting. Each fitting contained an O-ring to prevent grease leakage from its respective cavity. Prior to the GPS installation, the aft cavity had been leaking grease because of O-ring wear. The pilot and engineer agreed that because the tail rotor gearbox had been removed from the tail boom for the GPS installation, it was a convenient time to replace the aft O-ring. The tail rotor gearbox spline-retaining nut had to be removed to gain access to the O-ring in order to replace it.

1.3.6 The engineer said he replaced the O-ring in accordance with the helicopter maintenance manual instructions, and torqued the spline-retaining nut to the correct torque setting (350 – 400 inch pounds). A manufacturer's nyloc insert imbedded across the spline-retaining nut threads formed part of the nut, and was the locking mechanism used to prevent the nut coming loose during normal service. The engineer said the nyloc insert was in place and he believed it was serviceable when he tightened the nut.

1.3.7 No duplicate inspection of the engineer's work on the gearbox was carried out, nor was it required under Civil Aviation Rules. A duplicate inspection was required after any disturbance of control systems. For helicopters this included the attachment of all rotary control surfaces, and the means of operating collective pitch, cyclic pitch and yaw control. If a duplicate inspection was required, the engineer certifying the maintenance should not release the helicopter to service until the inspection was completed and entered in the aircraft logbook or technical log.

1.3.8 Because the GPS modification approval was pending at the time the work was carried out, the necessary helicopter aircraft logbook entry was deferred until receipt of the modification approval. A helicopter aircraft logbook entry was subsequently made, recording the GPS was fitted in accordance with the approved modification. A second engineer signed for the GPS installation and helicopter release to service. Although the logbook entry referred to job sheets, no job sheets for the GPS installation could be located. The maintenance organisation's technical director said that job sheets must have been raised, because an invoice had been issued and sent to the operator for the work carried out. He said that an invoice could only be issued after referring to information on job sheets.

1.3.9 There was no entry in the helicopter aircraft logbook recording the tail rotor gearbox O-ring replacement and releasing the helicopter to service. There was no logbook entry referring to job sheets for the O-ring replacement, nor could any job sheets for the work be found. There was no record found of a duplicate inspection of the disturbed yaw control system having been carried out. The replacement O-ring (named as "packing") appeared on the invoice, which was issued on 31 October 2001.

1.3.10 The technical director advised that because of the invoice, it could not be assumed that job sheets were not raised for the O-ring replacement, nor that a duplicate inspection of the disturbed yaw control system had not been completed. Although the invoice referred to labour for the GPS installation, it did not specifically refer to labour for the O-ring replacement.

1.3.11 The maintenance organisation's chief engineer advised that engineers were responsible for raising the necessary documentation and for correctly recording any maintenance work carried out. Under Civil Aviation Rules, licensed engineers completing general aircraft maintenance were responsible for that maintenance and its correct recording.

1.3.12 On 26 November 2001, after some 1.2 hours of flying following a 400-hour inspection, the pilot landed the helicopter at the operator's hangar. After landing he discovered that the tail rotor driveshaft forward retaining nut was loose and in contact with the bearing housing on the input driveshaft to the main transmission, and that the lock wire on the nut had broken (see Figure 1). The engineer who had replaced the O-ring, retightened the retaining nut and secured it with lock wire. The engineer who had completed the GPS installation assisted him. The pilot recalled

that the engineers retightened the nut and then secured it with lock wire. He did not see them examine other parts of the tail rotor drive train or determine why the nut had come loose.

1.3.13 The next day, on 27 November 2001, after about 0.5 hours of flying the pilot reported hearing a noise from the tail rotor driveshaft area. He reported that the forward retaining nut was again loose and in contact with the bearing housing on the input driveshaft to the main transmission, and that the nut lock wire had again broken.

1.3.14 The forward retaining nut should not be able contact the bearing housing on the input driveshaft to the main transmission, if the correct tail rotor drive train components are properly installed. There should be a minimum clearance of 0.100 inches (2.54 mm) between the nut and bearing housing. This clearance should be checked during any installation of the tail rotor driveshaft.

1.3.15 The engineer who had replaced the O-ring travelled to the helicopter and examined the tail rotor drive and anti-torque system, where he found the tail rotor gearbox spline-retaining nut completely loose. He removed the tail rotor driveshaft and gearbox and returned the gearbox to the maintenance hangar for repair. At the hangar he replaced the spline-retaining nut, put loctite[2] on the threads as an additional locking means, and torqued the nut to the correct value. The replaced spline-retaining nut was discarded. The tail rotor driveshaft was not returned to the hangar for inspection, but was inspected at the site.

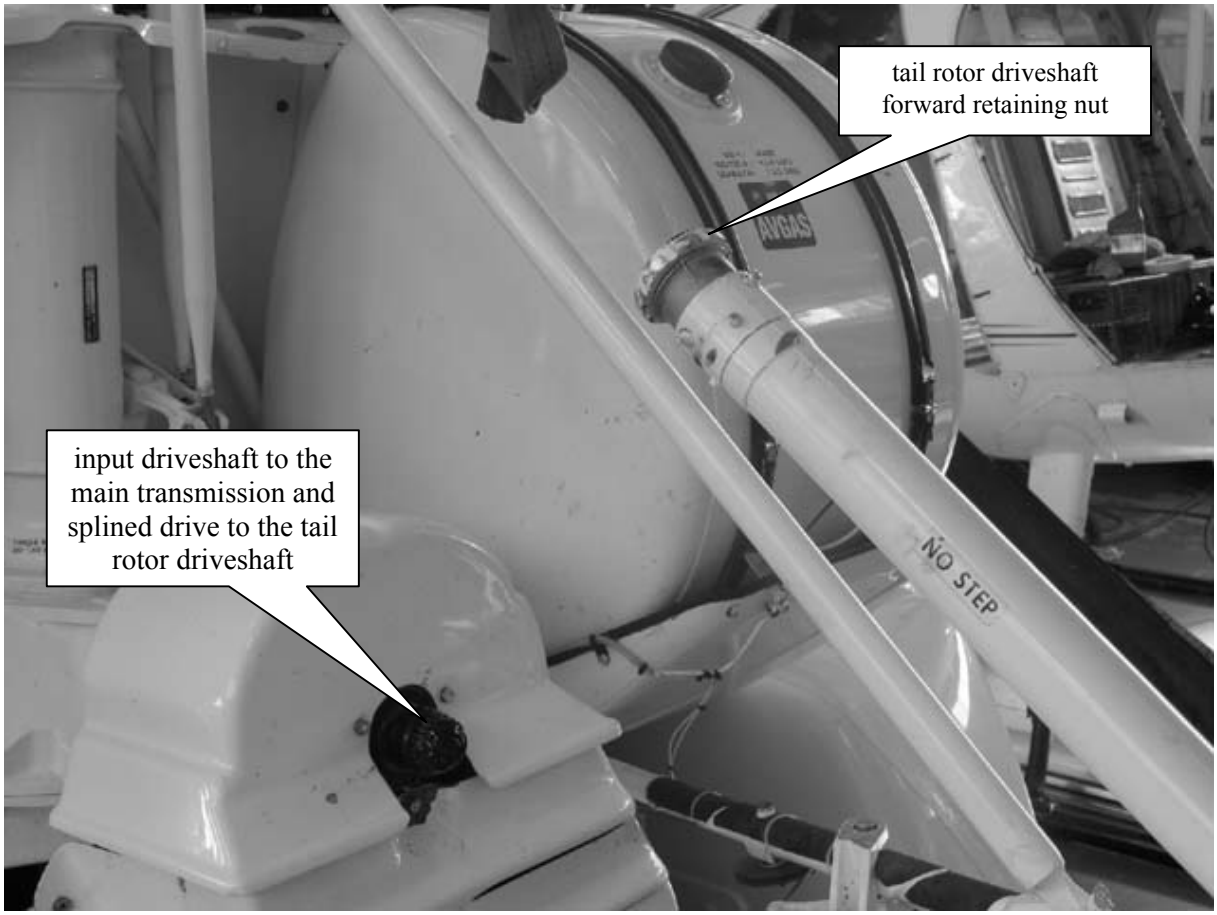


Figure 1
Forward portion of tail rotor driveshaft and spline drive

[2] A locking fluid applied to threads to help prevent loosening.

1.3.16 The tail rotor driveshaft from the main transmission to the tail rotor gearbox was attached by splined couplings, thus allowing drive and some fore and aft movement of the shaft between the main transmission and gearbox. The driveshaft contained front and rear aluminium alloy bumper plugs, which limited the fore and aft movement of the driveshaft on the splines. The rear bumper plug mechanically limited the driveshaft aft movement by contacting the face of the tail rotor gearbox spline-retaining nut. Under normal operation there was no relative rotational motion between the bumper plugs and their contact points, because the driveshaft rotated as a complete unit being coupled at each end by the splined drives. An end-fitting grease cavity surrounded each spline fitting and bumper plug. The cavities contained grease to lubricate the splines and dampen any fore and aft movement of the driveshaft. The cavities were normally greased every 50 flying hours, or sooner if necessary, by the maintenance organisation. The operator or pilot did not hold the special grease, or have any provision to grease the cavities. The helicopter maintenance manual required the bumper plugs to be inspected and checked for excessive wear or looseness at 300-hour intervals, or because of other special conditions. If wear or damage in either plug exceeded 0.58 inch in diameter, it was to be replaced. At the time of the accident the next scheduled bumper plug check was not due for another 46 flying hours.

1.3.17 The 2 engineers returned to the helicopter and refitted the tail rotor driveshaft and gearbox. The second engineer said he did dimensional checks and established the correct fore and aft movement of the driveshaft after it was refitted. The engineer responsible for the maintenance said he had inspected the rear bumper plug visually and by feel, and found no damage. The second engineer initially said he believed he saw some bumper plug damage, but later explained that the plug had a circular mark on it and a flat similar to other plugs he had examined, and that the plug was not dented. He believed the plug was serviceable. He said he had wiped the grease off the bumper plug and inspected it visually and by feel. The helicopter was successfully ground run and returned to service.

1.3.18 The helicopter had flown 20.5 hours after the GPS installation and from when the tail rotor gearbox O-ring had been replaced, up to when the spline-retaining nut came loose. The helicopter flew about 130 hours from when the spline-retaining nut was replaced until the accident.

1.3.19 Shortly after the spline-retaining nut had loosened, the pilot submitted an incident report to the Civil Aviation Authority (CAA) who commenced an investigation on 30 November 2001. At the time of the accident its investigation was continuing.

1.4 Wreckage and impact information

1.4.1 The helicopter came to rest on its left side. The main rotor blades were destroyed because of ground contact, and exhibited signs of low power rotation. The free-wheeling clutch operated normally. The engine to transmission drive belts were intact, and the drive between the engine and transmission was engaged.

1.4.2 The tail rotor driveshaft was bent about 45º near where it entered the tail boom, just aft of the main transmission. The shaft had detached from its forward splined coupling to the main transmission input drive. The shaft's forward retaining nut aft flange had failed in overload. The nut had rotational scoring on its flange face. The retaining nut was done up correctly and its lock wire was intact. There was some rotational scoring around the driveshaft where it entered the tail boom. The 2 tail rotor blades had no rotational damage to any part of their leading edges. One blade had chordwise static bending. The tail rotor gearbox rotated freely and was undamaged.

1.4.3 The helicopter was removed to a maintenance facility for further examination. When pushed aft the tail rotor driveshaft disengaged the spline drive to the tail rotor gearbox and did not rotate the tail rotor. The gearbox was removed for further examination and was found serviceable. The spline-retaining nut was tight but had some rotational scoring on its forward face.

Inspection of the tail rotor driveshaft aft bumper plug showed a neat round hole in the bumper plug, which matched the diameter of the forward face of the spline-retaining nut. This hole allowed the forward portion of the spline-retaining nut to pass through the aft bumper plug, which allowed the tail rotor driveshaft to move aft excessively and disengage the spline drive coupling to the tail rotor gearbox. Fragments of the bumper plug were located in the grease cavity, including a circular central main fragment. There was grease in the grease cavity, but no grease had transferred through the hole in the bumper plug. (See Figures 2 and 3)

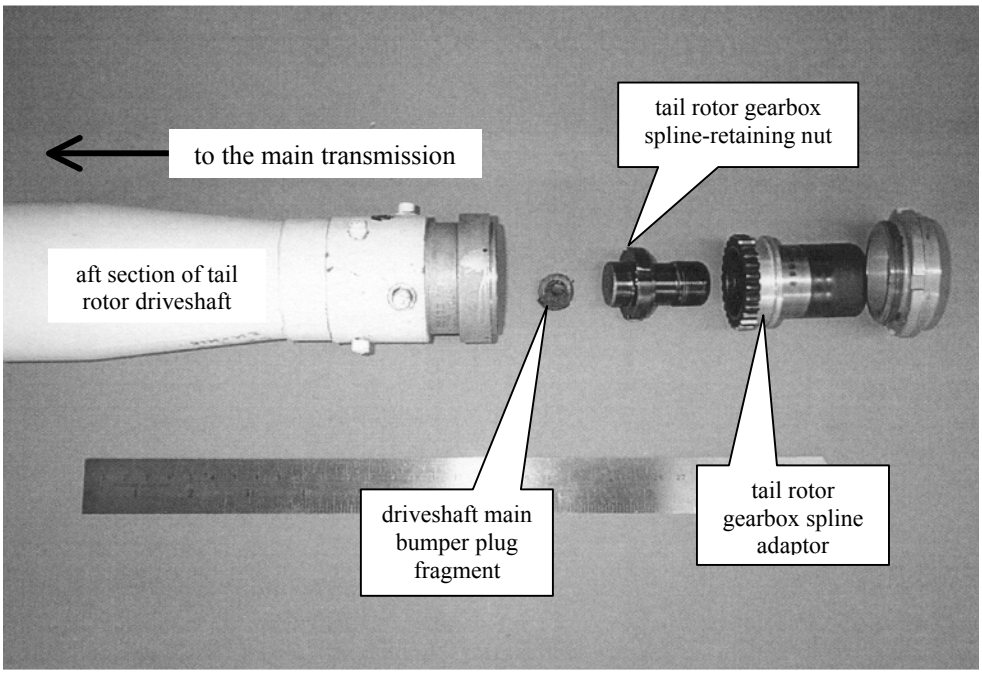


Figure 2
Components from the aft end of the tail rotor driveshaft and gearbox

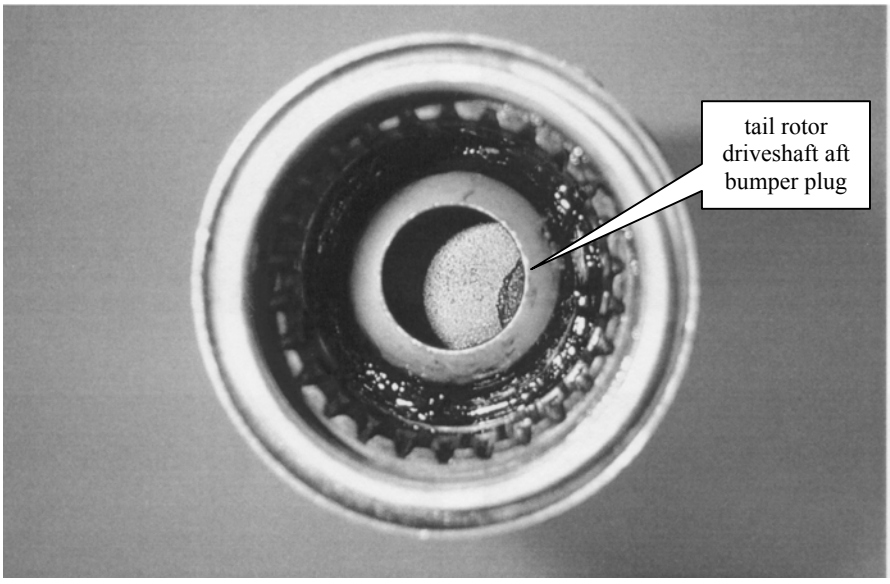


Figure 3
End view of tail rotor driveshaft showing the hole in the bumper plug

1.4.4 Examination of another Schweizer 269C helicopter tail rotor driveshaft showed that with the forward retaining nut completely loose, full rearwards movement of the tail rotor driveshaft did not allow either the forward or the aft splined coupling to disengage. Measurement and testing showed that if the aft bumper plug was not in place, such as that found on ZK-HIC, full aft movement of the driveshaft would disengage the aft splined tail rotor gearbox drive coupling before the forward splined coupling, with the forward retaining nut in place.

1.4.5 Inspection of the components of the tail rotor drive train showed they were the proper manufacturer's components installed in the helicopter, and that they had been installed correctly. Dimensional checks were not carried out because of the extent of the disruption during the accident.

1.5 Tests and research

1.5.1 Components of the tail rotor driveshaft, including the damaged aft bumper plug and fragments, tail rotor gearbox spline-retaining nut and O-ring, were independently examined by Materials Performance Technologies.

1.5.2 The main aft bumper plug fragment was heavily cracked and had been subject to high temperatures from frictional heating. A significant feature was that the fragment was convex on the forward side when it should have been concave, thus showing the fragment had been pushed inwards at some point resulting in a large dent. The edges of the fragment were very thin, showing significant material wear. Around the central region was a shiny wear pattern with a large crack around the circumference. Although initial examination suggested the fragment could be ferritic dual phase stainless steel, a full material analysis showed it was aluminium alloy, which was the correct material.

1.5.3 The tail rotor gearbox spline-retaining nut showed significant circular wear markings on its end face. The wear patterns on the spline-retaining nut end face matched the wear on the bumper plug fragment. The wear patterns were off-centre showing there was some misalignment between the bumper plug and spline-retaining nut as they rotated relative to each other. The diameter of the forward segment of the spline-retaining nut neatly matched the diameter of the circular hole cut in the bumper plug, which allowed the nut to pass through the plug.

1.5.4 The tail rotor driveshaft aft coupling nut was undamaged. The tail rotor gearbox O-ring was distorted.

1.5.5 The tail rotor gearbox forward retaining nut flange fracture occurred from overload. A ring of paint had been abraded from the forward face of the nut, including some abrasion of the underlying metal. This was consistent with the rotating nut rubbing against a stationary object.

1.5.6 The forward tail rotor driveshaft bumper plug was intact but was flattened slightly at its apex. The forward driveshaft splined coupling was intact but had some impact damage to the teeth at each respective end of the male and female coupling.

1.5.7 The helicopter manufacturer advised that it had no other reported cases of tail rotor gearbox spline-retaining nuts coming loose during normal operation, after the nuts had been tightened to the correct torque setting. A review of the manufacturer's service difficulty files and the Federal Aviation Administration service difficulty reports did not reveal any reports of spline-retaining nuts coming loose. There was one other reported case of a loss of tail rotor authority in the same helicopter type in Australia in 1999, possibly because of an aft tail rotor driveshaft bumper plug failure. This could not be confirmed. The New Zealand CAA advised it had no records of other similar failures, and no records of Schweizer (Hughes) 269 spline-retaining nuts coming loose during normal operation.

1.5.8 A number of New Zealand organisations that maintained the helicopter type were contacted. One organisation recalled an incident that occurred a number of years ago when a spline-retaining nut had come loose and backed off about half way because it was believed the nyloc insert had been unserviceable. After the nut was replaced there were no further problems. The other organisations were unaware of any instances where the nut had backed off and become loose. The organisations said it was common to have to "nip" up the nuts slightly when routinely checking the torque on the nuts.

1.5.9 One New Zealand maintenance organisation recalled an instance on the helicopter type where the tail rotor driveshaft forward retaining nut had loosened during flight and the lock wire had broken. The nut had contacted the bearing housing on the input driveshaft to the main transmission and broken the lock wire, because of some incorrect shimming in the tail rotor drive train.

1.5.10 The helicopter manufacturer advised that the tail rotor driveshaft could be preloaded to the full aft position by excessive greasing of the forward shaft grease cavity. The aft bumper plug could then contact the spline-retaining nut and wear through over time. If the tail rotor gearbox was not square to the tail boom, the shaft could be drawn aft and allow bumper plug contact with the spline-retaining nut, causing wear.

1.5.11 The helicopter manufacturer advised in a Service Letter in June 2002 of a tail rotor driveshaft change. The manufacturer said the reason for the change was to reduce driveshaft maintenance and to prevent problems from over servicing. The new driveshaft contained phenolic resin bumper plugs for better wear resistance.

2 Analysis

2.1 The accident sequence of events probably began when the tail rotor gearbox O-ring was replaced on 31 October 2001 during the GPS installation, when the tail boom, tail rotor driveshaft and gearbox were refitted to the helicopter.

2.2 After about 20 hours of flying the tail rotor gearbox spline-retaining nut came loose. This could have occurred because the nut had not been torqued up correctly or because the nyloc insert was unserviceable, or a combination of both. The engineer, however, said he recalled tightening the spline-retaining nut to the correct torque value, and he believed that the nyloc insert was serviceable when he refitted the nut. This work was not independently checked because there was no requirement for a duplicate inspection. The serviceability of the nut and the nyloc insert could not be checked after the accident, because the nut was discarded after it had loosened and been replaced. Research, however, indicated that the nuts did not loosen completely during normal service if the nyloc insert was serviceable and the correct torque had been applied to the nut.

2.3 When the spline-retaining nut loosened it probably jacked forward, because of its right hand thread and the clockwise rotation of the tail rotor driveshaft when viewed from the helicopter cabin, and contacted the tail rotor driveshaft aft bumper plug. This probably pushed the driveshaft forward causing the forward retaining nut (see Figure 1) to butt against the bearing housing on the input driveshaft to the main transmission, thus loosening the retaining nut and breaking the lock wire (see 2.4). When the retaining nut loosened it probably jacked the driveshaft aft and pushed the aft bumper plug against the spline-retaining nut face. A similar event probably occurred the next day when the forward retaining nut was found loose and the lock wire broken for the second time, although the spline-retaining nut would have been completely loose at that time.

2.4 There was clear evidence the tail rotor driveshaft forward retaining nut had butted against the bearing housing on the input driveshaft to the main transmission, before the accident. However, the forward retaining nut should not normally be able to contact the bearing housing, if the tail

rotor drive train system was correctly installed and there were no dimensional errors. If the forward retaining nut lock wire was to simply break, the nut could loosen and contact the bearing housing. This was very unlikely, especially on 2 separate occasions in 2 days, unless there was some turning force on the nut. The dimensions should be checked, and the minimum clearance between the forward retaining nut and bearing housing established, when the tail rotor driveshaft and gearbox are refitted to the helicopter, and any problems rectified. The second engineer believed the dimensions were checked, and that the correct fore and aft movement of the driveshaft was established after the driveshaft was refitted in the field after the spline-retaining nut had come loose.

2.5 During the above sequences, with the spline-retaining nut face probably having contacted the aft bumper plug, the bumper plug may have been dented inwards to some degree. This could account for the convex denting found on the bumper plug fragment.

2.6 Both engineers, however, said they had examined the aft bumper plug after the spline-retaining nut had loosened, and before refitting the tail rotor driveshaft and gearbox to the helicopter. The engineers said they recall the bumper plug being serviceable and that it was not deformed inwards. Although the second engineer originally said there was "some damage" to the bumper plug, he later explained this was a circular mark similar to normal wear he had seen on other bumper plugs.

2.7 Examination of the bumper plug fragment indicated the aft bumper plug had been deformed inwards and was damaged prior to the accident, and that this probably occurred during the loosening of the spline-retaining nut. Although the engineers said they inspected the bumper plug and said it was not unusually deformed, it is possible some deformation was missed. Alternatively, any weakening of the bumper plug wall may not have been evident.

2.8 Although some bumper plug damage or deformation could have occurred after the spline-retaining nut had loosened, and after the tail rotor driveshaft and gearbox had been refitted to the helicopter, there was no evidence to support this. If the bumper plug wall had been weakened through contact with the spline-retaining nut, deformation during normal service was more likely to occur. Any over greasing of the tail rotor driveshaft forward grease cavity could load the driveshaft aft and cause the bumper plug to contact the spline-retaining nut, and subsequently cause the bumper plug to wear over time. There was no evidence to support this, and the maintenance organisation itself greased the tail rotor driveshaft and was familiar with the greasing requirements. If the tail rotor gearbox had not been refitted squarely to the tail boom, this could also have helped draw the bumper plug into contact with the spline-retaining nut. The engineers, however, said they refitted the tail rotor driveshaft and gearbox correctly in accordance with the maintenance manual.

2.9 After the aft bumper plug was deformed or possibly worn, it could no longer correctly limit the aft movement of the tail rotor driveshaft against a properly installed spline-retaining nut. With sufficient aft movement, the tail rotor driveshaft rear splined coupling was then able to disengage from the tail rotor gearbox.

2.10 The pilot's pull-up manoeuvre just before the accident sequence probably caused the tail rotor driveshaft to slide aft excessively and disengage the splined coupling to the tail rotor gearbox. The subsequent disengagement of the driveshaft caused a loss of gearbox drive and loss of tail rotor authority, which resulted in an uncommanded right yaw and spin, and loss of control.

2.11 The wear on the aft bumper plug fragment and wear on the forward face of the tail rotor gearbox spline-retaining nut showed there was relative rotational motion between them, which would not occur in normal operation with the spline drive correctly engaged. The perforation of the bumper plug occurred because of the relative rotational motion between the plug and the spline-retaining nut. This will have occurred at the start of the accident sequence when the splined tail rotor gearbox drive coupling disengaged at the gearbox.

2.12 Examination of the helicopter records did not disclose any previous accident history or major component changes or modifications that could have altered the helicopter or its alignment from that specified. After the helicopter was imported into New Zealand it was subject to inspection for the issue of a New Zealand airworthiness certificate and ongoing routine maintenance inspections. If there were any anomalies with the helicopter and its tail rotor drive train these inspections could have detected them, and any anomalies should have been rectified. The maintenance organisation's engineers had removed and refitted the tail rotor driveshaft to the helicopter at least twice before the accident, and could also have detected any anomalies. Given the above inspection and maintenance history, it is unlikely that any significant misalignment was evident.

2.13 The operator had no problems with the helicopter tail rotor drive system until the forward retaining nut first loosened, which was some 20 flying hours after the GPS installation and O-ring replacement, and about one hour after the 400-hour inspection. During the 400-hour inspection the drive train had not been removed or subject to any detailed maintenance.

2.14 There was no record found for the O-ring replacement, or for the required duplicate inspection of the disturbed yaw control system, in the helicopter aircraft logbook or other aircraft records, nor any reference to worksheets. The only reference to the O-ring replacement was its cost listed on the invoice sent to the operator. While the invoice referred to labour for the GPS installation, it did not specifically refer to labour for the O-ring replacement. There was a logbook entry for the GPS installation with a reference to worksheets, but the worksheets could not be located.

2.15 Because no written evidence of the O-ring replacement could be found, it is possible its recording was overlooked in error. Likewise, with no written evidence found of the duplicate inspection, it is possible that this inspection or its recording was also overlooked in error. If this was so, the helicopter had not been properly released to service following maintenance.

2.16 The maintenance organisation, however, advised that although the documentation recording the above maintenance work could not be located, the invoice showed that the work had been completed and recorded, because its invoices were only produced from information contained on worksheets.

2.17 The helicopter tail rotor drive train, including the tail rotor, is a critical anti-torque control system, which also provides for pilot yaw control. Should the system fail, as was the case with ZK-HIC, helicopter control can quickly be lost. Duplicate inspections of helicopter tail rotor drive trains following maintenance were not mandatory, unless the maintenance directly involved the tail rotor blades and their pitch change mechanism. Because the complete tail rotor drive train is a critical control system for helicopters, CAA could require duplicate inspections for any maintenance work carried out on tail rotor drive trains. Had there been such a requirement in place during maintenance on ZK-HIC, any maintenance errors could potentially have been detected and rectified.

3 Findings

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

3.1 The probable initiating event to the accident was the loosening of the tail rotor gearbox spline-retaining nut during operational service, which may have deformed or weakened the tail rotor driveshaft aft bumper plug.

3.2 Any damage to the tail rotor driveshaft aft bumper plug after the loosening of the spline-retaining nut may not have been evident or detected, and the bumper plug may have remained in service in a defective state.

3.3 The aft bumper plug could have been deformed or worn, or been further deformed, during normal operational service after the spline-retaining nut had loosened and been replaced, but this could not be established.

3.4 After the tail rotor driveshaft aft bumper plug was deformed or worn it could no longer correctly limit the rearward movement of the driveshaft, which subsequently allowed the splined drive coupling at the gearbox to disengage.

3.5 Once the tail rotor gearbox drive disconnected, the helicopter lost tail rotor authority and became uncontrollable.

3.6 Because there was no requirement for a duplicate inspection of the entire tail rotor drive train following maintenance, there was no secondary defence against any maintenance errors on a critical helicopter control system.

4 Safety Recommendation

4.1 On 18 October 2002 the Commission recommended to the Director of Civil Aviation that he:

4.1.1 critically examine the requirements for duplicate inspections of aircraft control systems, with a view to including helicopter tail rotor drive trains as part of the duplicate inspection regime **(037/02)**

4.2 On 1 November 2002 the Director of Civil Aviation responded, in part:

> I accept this recommendation; I will initiate a review of Rule Part 43.113, duplicate inspection of controls. This review will examine the need for duplicate inspection of vital points in an aircraft, that if they were to fail would have a catastrophic effect on the flight. Helicopter tail rotor drive trains will be considered as part of this review.
>
> The review will be completed by 31 March 2003 however no final date for any action arising from the review can be stated.

Approved for publication 27 November 2002

Hon. W P Jeffries
Chief Commissioner

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01-007 P-68B Partenavia ZK-DMA, double engine power loss, North Shore Aerodrome, 20 July 2001

95-008 Addendum to Report 95-008, Piper PA 28-161, ZK-MBI, missing after departing from Gisborne, 21 May 1995

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01-009 Bell 206B Jetranger, ZK-HWI, perceived engine power loss and heavy landing after takeoff, Mt Pisa Station, Cromwell, 11 September 2001

01-010 Embraer EMB-820C Chieftain ZK-RDT, door open in flight, near Auckland, 31 October 2001

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02-001 Cessna 207, ZK-SEV, collision with terrain, Gertrude Saddle area 11 km southeast of Milford Sound, 19 January 2002

01-012 Robinson R44 Astro, ZK-HTK, collision with terrain, Urewera National Park, 3 December 2001

02-002 Piper PA34-200T Seneca SK-SFC, undercarriage failure and subsequent wheels-up landing, Gisborne and Hastings Aerodromes, 25 January 2002

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