Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY INVESTIGATION REPORT

Aviation Occurrence Report – 200401917

Final

Powerplant/propulsion event - 40km S Tobermorey, NT
30 May 2004
Robinson Helicopter Company R22 Mariner II
VH-MIB

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Figures 6 and 7 used with permission of Robinson Helicopter Company

Abstract

The crew of the Robinson R22 helicopter were undertaking a fence line inspection at about 30 to 40 ft above ground level. The crew had initiated a turn back along the fence line for a closer look at a particular section of fence. During the turn, a loud bang was heard and the helicopter began to rotate quickly before striking the ground.

Both occupants were able to exit the helicopter unaided after it came to rest but sustained serious injuries and burns as a result of a post-impact fire. The pilot subsequently died of his injuries.

The investigation found that one of the bolted joints linking the forward flexible coupling flex plate to the main rotor gearbox drive shaft yoke had been assembled incorrectly. This resulted in subsequent fatigue failure of the flex plate and loss of drive to the main gearbox. Control of the helicopter was then lost at a height from which it was difficult to recover.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations. Accordingly, the ATSB also conducts investigations and studies of the transport system to identify underlying factors and trends that have the potential to adversely affect safety.

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

It is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and findings. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

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

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

EXECUTIVE SUMMARY

The crew of the Robinson R22 helicopter were undertaking a fence line inspection at about 30 to 40 ft above ground level. The crew had initiated a turn back to the left, along the fence line for a closer look at a particular section of fence. During the turn, a loud bang was heard and the helicopter began to yaw quickly before striking the ground.

Both occupants were able to exit the helicopter unaided after it came to rest, but sustained serious injuries and burns as a result of a post-impact fire. The pilot subsequently died of his injuries.

Examination of the helicopter wreckage revealed that both tail rotor blades had failed due to contact with the ground. In addition, the flex plate in the forward flexible coupling of the main rotor drive was found fractured at one of the two attachment points to the main rotor gearbox yoke. The tail rotor blades and several components from the main rotor drive were recovered for detailed analysis in order to resolve the mechanism of fracture and the sequence of failure.

The flex plate in the forward flexible coupling fractured due to the propagation of a fatigue crack at one of the bolted connections between the plate and main rotor gearbox yoke. Final fracture of the flex plate occurred during operation and not because of the collision with the ground. There was no crack growth or wear damage evidence at the three remaining boltholes. Examination of the bolt installed at the failure location revealed that extensive fretting wear had occurred around the entire circumference of the bolt, in the region adjacent to the flex plate and the regions adjacent to the reinforcing washers. Fretting wear was also evident on the washer surface adjacent to the bolt head. This type and degree of wear damage was indicative of operation with insufficient clamping force in the bolted joint.

A review of the manufacturer’s original build-sheets for the forward flexible coupling in the occurrence helicopter revealed that NAS 6605-6 bolts were used and a spacer washer had been included in each bolted joint and one thin washer had been installed under each nut with a palnut (locking nut) fitted to each.

Examination of the forward flexible coupling retrieved from the accident site, found that the bolted joint had been assembled with a washer and spacer combination that was different from that identified by the manufacturer’s original build records. These differences indicated that it was likely that the joint had been disassembled and reassembled during a maintenance action subsequent to assembly in the manufacturer’s facility.

1 FACTUAL INFORMATION

1.1 Sequence of events[1]

At about 1100 Central Standard Time on 30 May 2004, a Robinson R22 Mariner II helicopter, registered VH-MIB, crashed and caught fire while being operated on a fence inspection flight at Tobermorey Station, NT. The pilot sustained fatal injuries and the passenger was seriously injured.

The passenger reported that the purpose of the flight was to inspect a fence line bordering the property and then to conduct cattle mustering operations. The helicopter was refuelled to full tanks prior to departure. The weather was fine and sunny, with a slight breeze from the south-east.

The passenger reported that while overflying a section of the fence line about 45 km south of the homestead at 30 to 40 ft above ground level, the pilot initiated a turn back to the left to enable a closer look at a particular section of fence. Part way through the turn there was a loud bang from behind the cabin, followed by "horrendous vibration" and the helicopter immediately began to yaw left and descend. The ground marks showed that the tail rotor blades contacted the ground first and then the forward section of the helicopter's right skid struck the ground, disrupting the front section of the cabin. The helicopter then came to rest on its right side and fire rapidly spread to engulf the cabin area.

The pilot was able to free himself from the helicopter through the broken front section of the cabin, but the passenger experienced difficulty undoing his safety harness and remained trapped. He was eventually able to free himself and joined the pilot at some distance from the wreckage. The passenger reported that he assessed the pilot to be badly injured and directed him to a nearby water hole. The passenger then walked to a water bore approximately 8 km from the accident site, where he met other station personnel. The pilot was deceased when medical assistance arrived at the accident site some hours later.

The passenger reported that he had flown in the helicopter several times. During the last few flights before the accident, and during the accident flight itself, he had detected a vibration that he considered abnormal. The passenger advised the investigation that he had conveyed these concerns to the pilot, who advised that he conducted a good check of the helicopter and was satisfied that there were no problems.

1.2 Wreckage examination

Examination of the wreckage by the Australian Transport Safety Bureau (ATSB) investigation team at the accident site (Figure 1) confirmed that the helicopter was yawing left and moving forward when it struck the ground. The tail rotor blades

1 Only those investigation areas identified by the headings and subheadings were considered to be relevant to the circumstances of the accident.

contacted the ground first. The helicopter then contacted the ground slightly nose down and heavily onto the right skid, causing it to separate from the helicopter. The ground impact marks showed that the helicopter continued to yaw left though about 180 degrees after it struck the ground, before coming to rest on its right side. The majority of the cabin and engine bay, including the entire floor area and cabin structure beneath the pilot and passenger seat positions were destroyed by fire.

Figure 1: Helicopter wreckage (arrow indicates bulkhead deformation behind pilot seat position)

The extent of fire damage meant that a complete examination of the helicopter was not possible. Some aluminium components such as tubing in the flight control system had been destroyed. However, all steel components in the control systems for the main and tail rotor were identified and damage to all of these components was consistent with impact forces or fire. The main rotor blades exhibited damage consistent with low rotor energy at impact. Both tail rotor blades had fractured approximately 1/4 span outboard of the rotor hub centre drive (Figure 2). The failed section of one blade was found adjacent to the main wreckage. The failed section of the other blade was found subsequently about 70 m from the main wreckage. Both blade sections were taken to the ATSB laboratories for further examination.

Figure 2: Tail rotor damage

All of the engine drive system components were identified within the wreckage. The flex plate for the forward flexible coupling of the main rotor drive system was fractured at one of the two attachment points to the main rotor gearbox yoke (Figure 3 and 4). The flex plate, including the clutch shaft, were retrieved from the accident site, for further examination. The flex plate for the intermediate flexible coupling was intact and showed evidence of rotational damage consistent with partial drive system power at impact. The rear flex plate and coupling components were also found intact.

Figure 3: Forward flexible coupling as found in wreckage

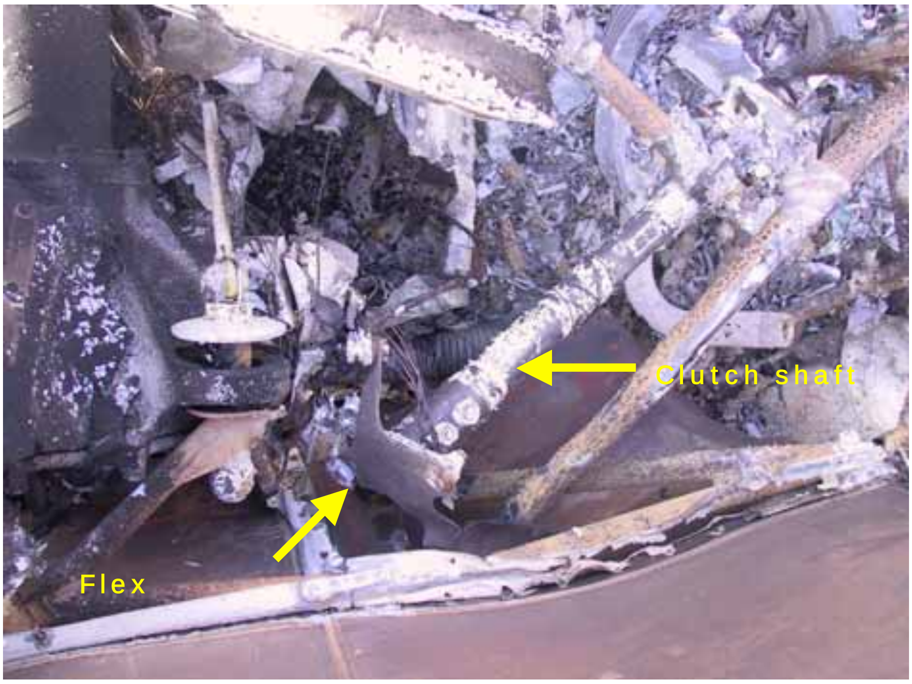
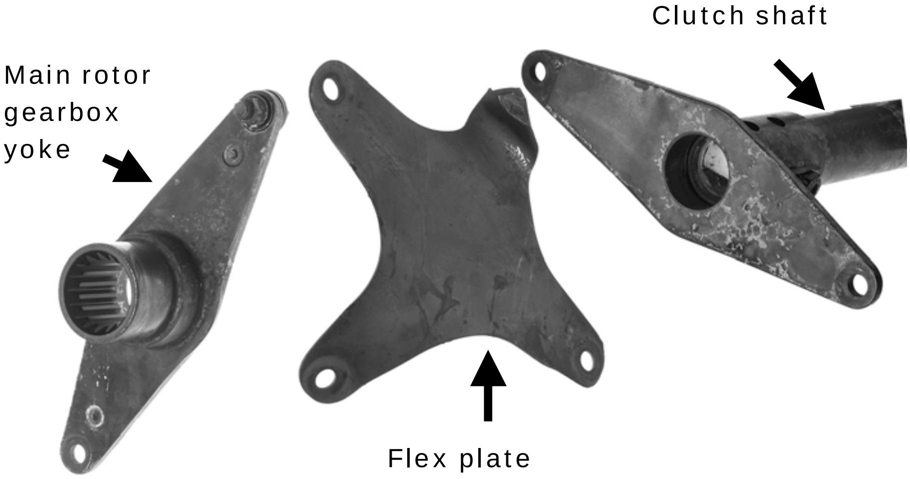


Figure 4: Components of failed forward flexible coupling



The fuel system and engine ancillaries were destroyed by the fire. There were vertical cuts puncturing the inside wall of the right fuel tank and the horizontal stainless steel firewall above the engine. The cuts in the right tank and the firewall aligned with the forward flex plate plane of rotation (Figure 5). The left fuel tank was destroyed by fire.

Figure 5: Flex plate puncture of stainless steel firewall above engine.

1.3 Personnel information

The pilot held a commercial pilot (helicopter) licence and was appropriately endorsed on the R22. He was issued with a private pilot (aeroplane) licence in 1974 and a commercial pilot (helicopter) licence in 1990. The pilot was issued with a commercial pilot (aeroplane) licence in 1995. He held a stock mustering rating and a valid class 1 medical certificate. He completed a flight review in the occurrence helicopter on 19 April 2004. At the time of the accident, the pilot had approximately 10,400 hours aeronautical experience. He flew 31 hours in the occurrence helicopter between 17 and 30 May 2004.

1.4 Medical and pathological information

Post mortem and pathology reports did not indicate that the pilot was suffering from any condition that might have affected his performance during the flight. The most significant injuries sustained by the pilot were the result of impact forces rather than fire.

1.5 Fire.

There was a fire affected area (sooting) on the ground that extended up-slope from the wreckage (Figure 6). The sooting formed a swirl pattern of decreasing radius in the direction the helicopter was yawing when it contacted the ground.

Figure 6: Sooting pattern adjacent to wreckage (arrow indicates approximate direction of flight at impact)

1.6 Survival aspects

Three-point lap/sash type safety harnesses were fitted to both seating positions in the helicopter. The passenger reported that both he and the pilot had their harnesses fastened during the flight. Fire damage precluded a detailed assessment of the seats and performance of the crush zones beneath them as well as the seat belt harnesses.

Severe crush damage to the lower cabin bulkhead was evident immediately behind the pilot's seat. (Figure 1).

Following the accident, no Emergency Locator Transmitter signal was received (refer section 1.7.6). There was no mobile telephone coverage in the area and the passenger reported that they did not carry any other communications aids, such as a portable satellite telephone.

1.7 Helicopter information

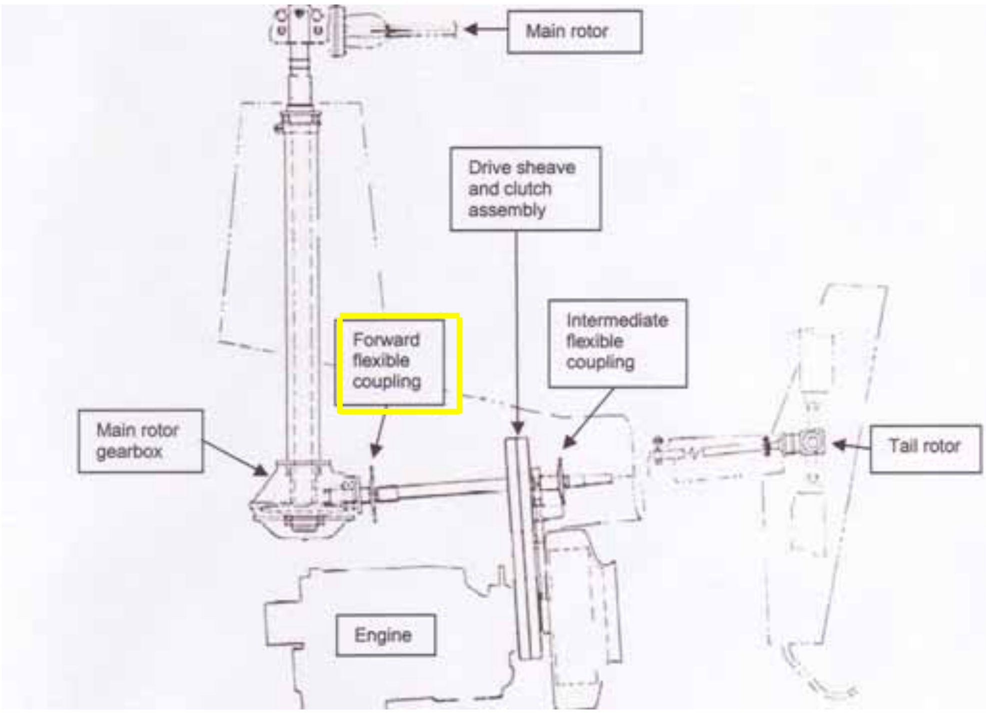
1.7.1 Helicopter data

The helicopter was manufactured in August 2002 as Serial No 3357M. The most recent maintenance release for the helicopter could not be located. It was reported to have been kept in the helicopter. If so, the maintenance release would have been destroyed in the post-impact fire. Based on other maintenance records and information contained in the pilot's personal diary, the total time in service of the helicopter on 30 May 2004 was estimated to have been 506 hours.

1.7.2 Main and tail rotor drive system

In the R22 helicopter, power to drive the main and tail rotors was transmitted from the engine to the rotor drive train via a multiple Vee belt drive and clutch system. A shaft transmitted power forward from the clutch to the main rotor gearbox and aft to the tail rotor gearbox (Figure 7).

Figure 7: Main components of main and tail rotor drive systems[2]



A forward flexible coupling, which includes a flex plate, connected the drive shaft to the main rotor gearbox. The tail rotor drive system also included an intermediate and a rear flexible coupling. Yoke assemblies at the end of each drive shaft section connected the shaft to the flex plate via bolted joints (Figure 8). The purpose of these flex plates was to accommodate small differences in shaft axial alignment during drive shaft rotation. The flex plates and the bolted joints were critical elements in drive system integrity.

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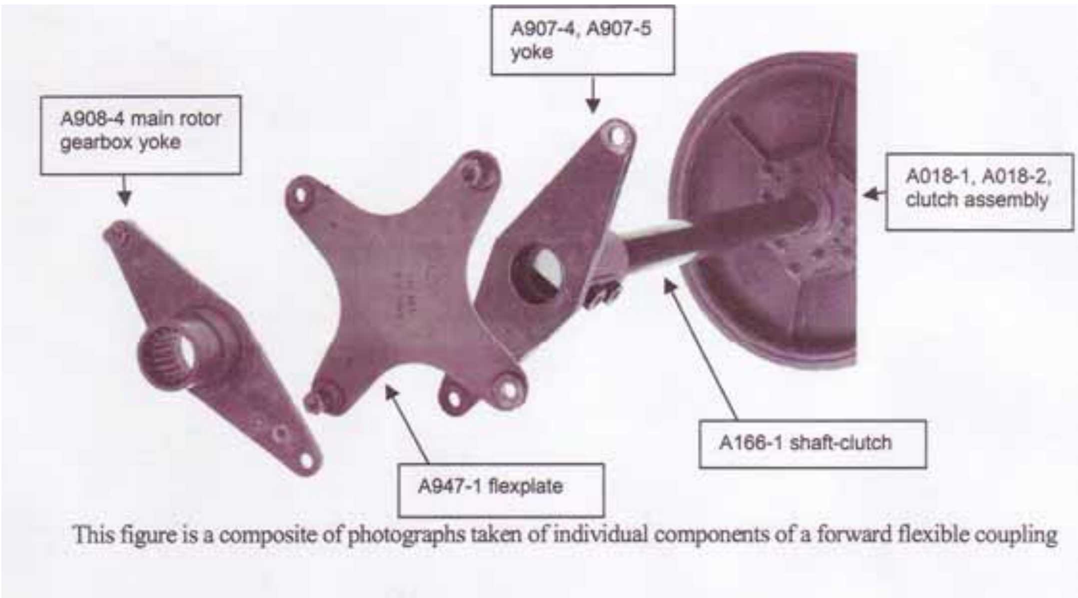
2 Diagram with permission of Robinson Helicopter Company.

Figure 8: Components of the forward flexible coupling



The helicopter manufacturer published procedures for assembling and aligning the drive system components, including the allowed tolerances. The design loads of components could be exceeded if those tolerances were not met.

1.7.3 Helicopter manufacture

The helicopter arrived in Australia partly disassembled for ease of shipment. The main drive system components within the engine compartment were assembled during manufacture and not subsequently disturbed for this method of international shipment.

In order to assist the investigation, the manufacturer supplied the investigation with the itemised build records, which included digital photographs of the rotor drive system, for the occurrence helicopter. Those records were reviewed as part of the laboratory analysis of the flexible coupling failure. The review of the build records and photographs for the forward flexible coupling in the occurrence helicopter showed that NAS6605-6 bolts had been used, and a spacer washer had been included in each bolted joint and one thin washer had been installed under the nut, with a palnut (locking nut) fitted to each. The build records showed that the build up of the bolted joint at the time of manufacture of the helicopter was correct and in accordance with the assembly procedures.

The 'Daily or Preflight Checks' section 4-2 and 4-3 of the manufacturers Pilot's Operating Handbook identified the requirement for a visual check of the flex coupling to ensure there are 'No cracks and 'Nuts tight'. Also required is a check of the yoke flanges for cracking. It further advised, in part, that 'During the following inspection, check the general condition of the aircraft and also look for any evidence of leakage, discolouration due to heat, dents, chafing, galling, nicks, corrosion and especially for cracks. Also check for fretting at seams where parts are joined together. Fretting of aluminium parts produce a fine black powder, while steel produces a reddish brown or black residue'.

1.7.4 Maintenance history

Maintenance records indicated that an Australian certificate of airworthiness for the helicopter was issued on 11 October 2002, after assembly in Australia, following manufacture and acceptance flights in the US. At that time, the total time in service was 5.1 hours. A summary of subsequent maintenance conducted on the helicopter is as follows. All references to drive system adjustments and/or maintenance have been included.

- **11 March 2003.** Total time in service 55.1 hours. 50 hourly engine inspection
- **27 March 2003.** Total time in service 98.5 hours. 100 hourly inspection. Maintenance carried out included adjustment of the engine sheave alignment.[3]
- **30 June 2003.** Total time in service 198.2 hours. 100 hourly inspection. Maintenance carried out included checking and adjustment of the engine sheave alignment and intermediate flex plate shimming to within limits.
- **15 September 2003**. Total time in service 296 hours. 100 hourly inspection.
- **17 February 2004.** Total time in service 384.1 hours. Civil Aviation Safety Authority Airworthiness Directive (AD) R22/51 'Main Rotor Clutch Shaft', dated 12 November 2003, was incorporated. AD/R22/51 was applicable to all R22 helicopters. It required disassembly of the main rotor yoke (A907) to the clutch shaft joint (A166) (see Figure 6) and inspection of the shaft and yoke for damage including fretting[4] of bolt holes, cracking in the area of the bolt holes, and the presence of an unapproved jointing compound in the mating surfaces. The helicopter maintenance worksheet indicated that no fretting was evident but that the incorrect jointing compound had been used. The worksheet stated that the AD had been complied with and that the clutch shaft and yoke were reassembled in accordance with the maintenance manual. The worksheet also recorded that a duplicate inspection of the clutch shaft installation and the yoke (A907) assembly had been performed. The licensed aircraft maintenance engineer who carried out the AD reported that he disconnected the yoke (A907) from the forward flex plate, but did not disconnect the flex plate from the main rotor gear box yoke (A908). He stated that he did not perform any maintenance on the bolted joints at the connection between the main rotor gear box yoke and the flexible coupling.
- **27 March 2004.** Total time in service 396 hours. 100 hourly inspections. Maintenance carried out included engine sheave alignment.
- **12 May 2004.** Total time in service 476.1 hours. 100 hourly inspections.

The documentation showed that maintenance had been performed on 27 March 2003, 30 June 2003, and 17 February 2004 in the vicinity of the forward flexible coupling that, while it did not specifically necessitate bolt removal, provide opportunities for the forward flexible coupling bolts to be disturbed.

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3 Drive Vee belts sometimes stretch when new and adjustments are then necessary to maintain the correct drive system alignment. Engine sheave alignment is part of that adjustment process.

4 The AD defined major fretting as 'any evidence of the machining marks in any of the bolt holes being partly or fully obliterated'.

1.7.5 Forward flex plate bolted joint component specification

A review of the diagrams contained in the manufacturer's Maintenance Manual and the Illustrated Parts Catalogue (IPC) revealed a difference in the specifications of the parts in the bolted joints. Notes contained within the IPC explained that bolts of different grip lengths and washers of different thickness were to be used in the flex plate bolted joints to expose between two and four threads beyond the end of the nut. A table comparing the different specifications between the Maintenance Manual table and the IPC is provided in section 4.1.3 of the ATSB technical analysis report attached as Appendix 1.

The manufacturer advised that the bolt length identified in the Maintenance Manual was for use in an earlier version of the manual and was out of date. Corrective action to update this information was scheduled by the company for November 2005, but at the time of writing of this report had not been accomplished.

The manufacturer advised that the company did not publish any warning to maintenance organizations about the discrepancy in bolt length between the Maintenance Manual and the Illustrated Parts Catalogue. The discrepancy was not considered by the manufacturer to be critical in that the use of either a NAS6605-5 or a NAS6605-6 bolt with the appropriate combination of spacer and washers would give the correct clamp up for proper joint integrity. In the few cases where the -5 bolt did not allow proper installation of the B330-16 palnut, the problem would be self evident. The manufacturer believed that any engineer performing the installation where the bolt was too short to install a palnut would install a longer bolt or make inquiries to resolve the problem.

1.7.6 Emergency locator transmitter

The maintenance records indicate that the helicopter was imported from the US and subsequently operated by various owners without a fixed Emergency Locator Transmitter (ELT) unit being fitted. This fact was noted on the maintenance releases issued at 5.1 airframe hours total time in service (TTIS) on 11 October 2002 and 98.5 hours TTIS on 27 May 2003, which required the pilot to observe the requirements of CAR 252 and carry a personal ELT. No further entries of this nature were found on maintenance releases issued after this date, nor could evidence be found in the aircraft logbooks that an ELT had been fitted. A search for both a fixed and personal ELT within the wreckage and surrounding accident site was conducted but nothing was found.

The passenger stated that the pilot normally carried a personal ELT on him. No personal ELT was identified among the pilots clothing or personal effects and no emergency signal was received by AusSAR from that location on the day.

1.8 Specialist examination of the failed components

The forward flex plate and the broken sections of the tail rotor blades were subject to detailed examination by the ATSB. The report on those examinations and analysis of the failures is attached as Appendix 1.

The metallurgical evidence confirmed that the failure mode of both tail rotor blades was very similar and was the result of contact with the ground during the impact sequence. The rocky material embedded in the blade tips provided clear evidence that the blades had struck the ground while rotating. The blade that was found about 70 m from the wreckage was thrown that distance as the result of tail rotor rotational energy.

The specialist examination found that the flex plate in the forward flexible coupling fractured as a result of the propagation of a fatigue crack at one of the bolted connections between the plate and main rotor gearbox yoke. Final fracture of the flex plate occurred during operation and not as a result of the collision with the ground. No crack growth or wear damage was observed at the three remaining boltholes. Examination of the bolt installed at the failure location revealed that extensive fretting wear had occurred around the entire circumference of the bolt, in the region adjacent to the flex plate and the regions adjacent to the reinforcing plates. Fretting wear was also evident on the washer surface adjacent to the bolt head.

The bolted joint at the flex plate failure location was found to have a single thin washer under the bolt head and nut, and no spacer washer between the yoke and flex plate. This spacer and washer combination was different from that specified by the manufacturer for use with a NAS6605-6 bolt.

2 ANALYSIS

2.1 Helicopter

The initiating event in the occurrence sequence was the failure of the flex plate in the forward flexible coupling. That event was the source of the loud noise that the passenger reported hearing. Once the plate failed, the clutch shaft yoke was retained at one end only. As a result, the diameter of the yoke and flex plate effectively doubled, allowing those rotating components to contact and puncture the fuel tanks and the horizontal stainless steel fire wall, as observed in the wreckage examination. Fuel leaking from the punctured tanks and firewall, would have fed directly into the engine compartment. The evidence indicates that the fuel then contacted either a hot engine component or some other source of ignition, which could have resulted in the helicopter being on fire before impact. The soot pattern on the ground confirmed that fuel from the punctured tanks was being ejected from the helicopter at first impact with the ground. The fuel may have ignited while the helicopter was still airborne or flash back could have occurred after impact.

One of the bolted joints in the forward flexible coupling had been assembled incorrectly, resulting in a lack of clamping force and subsequent fatigue failure of the flex plate in the forward flexible coupling and loss of drive to the main rotor gearbox.

The build records and digital photographs supplied by the manufacturer showed that the assembly of this joint at the factory had been correct.

Examination of the maintenance history of the helicopter revealed that, while maintenance had been performed on the drive system on a number of occasions since factory assembly, there was no recorded documentary evidence found that any subsequent maintenance had been performed on the particular bolted joint where the failure occurred. The stated procedure employed by the engineer who carried out AD/R22/51 was appropriate and consistent with accepted practices and did not require disassembly of the bolted joint that failed.

Examination confirmed that both tail rotor blades failed as a result of contact with the ground during the impact sequence.

At the time of the incident the helicopter was being operated close to the ground with low forward air speed. That would have left the pilot with little time to respond effectively to failure of a critical flight system such as the main rotor drive system.

The manner in which the failure of the forward flex plate occurred resulted in an unusual emergency situation for the pilot. As well as the obvious noise and out of balance caused by the still rotating but partially separated forward flexible coupling, symptoms would have included a failure of the drive to the main rotor gearbox resulting in decreasing main rotor speed and a nose-left yaw. That was consistent with some of the symptoms normally associated with an engine failure. However, in this case the engine had not failed and initially would have presented the pilot with additional and potentially confusing symptoms. Those symptoms would have included an initial indication of engine overspeed, and continuing tail rotor drive.

The normal response to an engine failure, and also relevant in this case, would be for the pilot to lower the collective control in order to recover any loss of main rotor RPM. The pilot would then allow the helicopter to enter an autorotation descent. If there was insufficient height for the descent to stabilise, main rotor RPM would not have recovered before the pilot commenced the touchdown phase of the autorotation. Low main rotor RPM during the touchdown phase would have decreased the possibility for the pilot to reduce the helicopter's rate of descent and carry out a safe touchdown.

It is evident that fatigue cracking in the flexplate initiated at the bolthole and propagated under the washers of the bolted joint towards the edge of flexplate. It was also evident from the fracture surface features that crack growth had occurred over a number of flights prior to the accident flight. Because cracking occurred under the washers in the bolted joint, the opportunity to detect cracking by a pre-flight visual inspection would have been limited to the detection of a crack at the edge of the flexplate arm.

The reliability of a general visual inspection (for example, a pre-flight inspection) is affected by lighting, the ability to get close to the component (proximity), and dirt and dust from the operating environment. Reliable detection of a specific defect would require a directed detailed inspection..

2.2 Survival

The crush damage observed to the right side of the cabin structure showed that impact forces were greater on the right side of the helicopter than the left. As a result, the pilot, who occupied the right seat, was subjected to higher impact forces than the passenger in the left seat. The impact forces in this accident were not directly aligned with the helicopters fore-aft and vertical axes. Hence, the level of protection afforded by the seat/harness combination was reduced and probably contributed to the injuries sustained by the pilot. The extent of the post-impact fire precluded any definite conclusions as to what, if any, material may have been carried under the pilot's seat.

When the helicopter came to rest on its right side, the seat in which the passenger was trapped was in an elevated position and was severely affected by the fire. It was also likely that the difficulty the passenger experienced in escaping from the helicopter was due, at least in part, to him being suspended by the safety harness. The time it took the passenger to release himself contributed to the extent of his burn injuries.

The passenger, although seriously injured himself, walked approximately 8 km to summon help. Unfortunately due to the accident site's remote location, the pilot succumbed to his injuries before medical assistance could reach him.

2.3 Communication equipment

No record of fitment of a fixed Emergency Locator Transmitter (ELT) could be found in the logbooks for the accident helicopter and no ELT unit remnants for either a fixed or personal unit were identified within the main wreckage. Given the intensity of the post-impact fire, it was probable that, had a fixed ELT been fitted, it would have only operated for a very short period of time before being destroyed.

If the pilot was carrying a personal ELT at the time, it is possible that it separated from his person either during the impact or during egress from the wreckage and was destroyed in the subsequent fire. In addition, if the occupants carried a satellite telephone, it may have reduced the time taken to summon assistance.

3 CONCLUSIONS

3.1 Findings

- There was no witness or mechanical evidence to indicate any problems with the flight controls, fuel system or engine prior to the event.
- Failure of the forward flex plate resulted in drive to the main rotor gearbox being partially disconnected.
- The failed forward flex plate coupling punctured one or both the helicopter fuel tanks and the stainless steal engine compartment firewall.
- The helicopter settled heavily and impacted with terrain.
- The helicopter was destroyed by impact forces and a post-impact fire.
- Egress from the helicopter was hampered by the unusual attitude of the cabin which caused extended exposure of the survivor to the post-impact fire.

3.2 Significant factors

One of the two bolted joints linking the flex plate to the main rotor gearbox yoke in the forward flexible coupling was previously assembled incorrectly, resulting in a lack of clamping force and subsequent fatigue failure of the flex plate and loss of drive to the main rotor gearbox.

4 SAFETY ACTION

4.1.1 Robinson Helicopter Company

In July 2006, the Robinson Helicopter Company issued Safety Notice SN-40, titled "Postcrash Fires". That Safety Notice states:

> There have been a number of cases where helicopter or light plane occupants have survived an accident only to be severely burned by fire following the accident. To reduce the risk of injury in a postcrash fire, it is strongly recommended that a fire-retardant Nomex flight suit, gloves, and hood or helmet be worn by all occupants.

5 APPENDIXES

5.1 ATSB Technical Analysis Report