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Unsecured Fasteners in Tail-rotor System Faulted for Bell UH-1H Loss of Control

New Zealand investigators said that the failure to install split pins during maintenance likely caused nuts and bolts in a tail-rotor-blade pitch-control mechanism to become loose, leading to the pilot's loss of control of the ex-military helicopter during approach and landing.

FSF Editorial Staff

About 1715 local time June 4, 2001, a Bell UH-1H Iroquois was being flown on approach to land near Taumarunui, New Zealand, when the helicopter was observed to enter a turn and then to break up while descending to the ground. The helicopter was destroyed by the impact and a postaccident fire. The three occupants were killed.

In its final report on the accident, the New Zealand Transport Accident Investigation Commission (TAIC) said, "The in-flight breakup probably started with a loss of tail-rotor control owing to the [tail-rotor-blade] pitch-control mechanism becoming loose. The tail rotor had been removed as part of a scheduled inspection of the helicopter some two months earlier. During the refitting of the tail rotor, the bolts holding part of the pitch-control mechanism in place were probably not secured by split pins [cotter pins] as required. The bolts eventually came loose, causing the loss of tail-rotor control."

The helicopter was manufactured in 1965 and was operated by the U.S. Army until late 1995. It then was modified by Western International Aviation and registered in the United States as a restricted category civil aircraft.

"In March 1996, the helicopter was imported into New Zealand, registered as ZK-HJH and issued a non-terminating airworthiness certificate in the restricted category for use in private and aerial work only," the report said. "The New Zealand Civil Aviation Authority (CAA) directed that the helicopter continue to be maintained according to the U.S. Army maintenance regime and applicable ADs [airworthiness directives]."

The helicopter, operated by Wanganui Aero Work, was used for logging, spraying and heavy-lift operations.

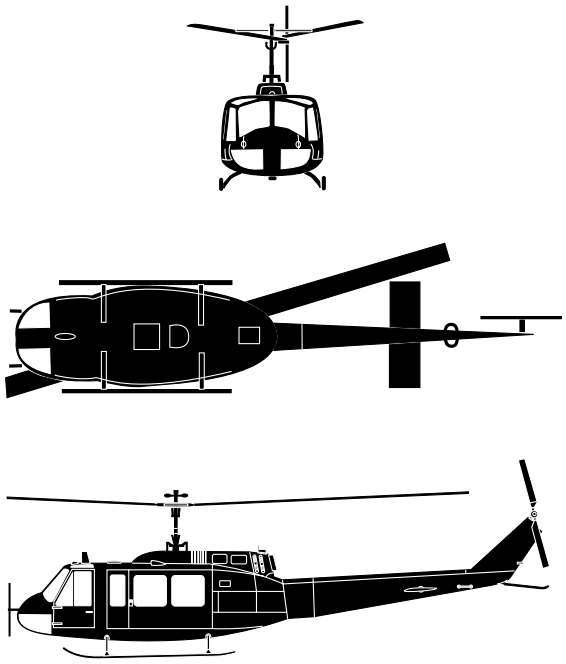
"ZK-HJH was occasionally used in the spreading of poison [bait for pest control], attracting criticism from some quarters," the report said. "While there were no reports of deliberate damage to ZK-HJH, some tooling was reported stolen from [the helicopter's storage] shed in about March 2001. The theft occurred while the shed was open and unsupervised."

The helicopter had been maintained by various licensed aircraft maintenance engineers (LAMEs) in New Zealand before October 2000; the operator then hired Air Repair Taranaki to maintain the helicopter.

"The [maintenance company] consisted of a LAME and a tradesman," the report said. "The tradesman held a pilot's license and performed maintenance under the direct supervision of the LAME, [who] was very familiar with the UH-1H

Iroquois, having worked on them for several years in New Zealand and overseas."

On March 12, 2001, the LAME and the tradesman began an annual review of airworthiness (ARA) and a 150-hour inspection of the helicopter, which had accumulated 12,000 flight hours. They were assisted by several people, including the accident pilot, at various times during the inspection.



Bell UH-1H Iroquois

Bell Aircraft (now Bell Helicopter Textron) developed the Model 204 to compete for a U.S. Army contract to build a utility helicopter suitable for evacuating casualties from front-line battle areas and for instrument flight training. The Model 204 won the contract in 1955 and was given the military designation HU-1. The U.S. Army named the helicopter the "Iroquois," but the HU-1 designation prompted the nickname "Huey." The military designation later was changed from HU-1 to UH-1, and the first production helicopters were designated UH-1A.

The UH-1A has six seats and a 770-shaft-horsepower (shp) Lycoming T53-L-1A turboshaft engine. The UH-1B, introduced in 1961, has nine seats and either a 960-shp T53-L-5 engine or a 1,100-shp T53-L-11 engine. The UH-1C, introduced in 1965, has a redesigned rotor. The UH-1D (Model 205), introduced in 1963, has longer main rotor blades and accommodates up to 14 passengers.

The UH-1H, introduced in 1967, is similar to the UH-1D but has a 1,400-shp T53-L-13 engine. Maximum takeoff/landing weight is 9,500 pounds (4,309 kilograms). Maximum rate of climb at sea level is 1,760 feet per minute. Maximum cruising speed is 120 knots. Maximum range with no fuel reserves is 284 nautical miles (526 kilometers). Hovering ceiling in ground effect is 20,000 feet. Hovering ceiling out of ground effect is 15,600 feet.♦

Source: *Jane's All the World's Aircraft*

"According to maintenance records, the tail-rotor-grip bearings and a bearing in the 90-degree gearbox on the tail rotor were replaced during the inspection," the report said. "This required removing the tail-rotor assembly, refitting the assembly and balancing the tail rotor."

Among the tail-rotor-assembly components is the crosshead (Figure 1, page 3). The two rods (pitch links) that control tail-rotor-blade pitch are attached to the arms of the crosshead and to the tail-rotor-blade horns. The crosshead is secured with two bolts and two nuts to the slider and retainer plate, which are part of an assembly — called the stack — that is fitted to the tail-rotor hub.

The LAME and the tradesman told investigators that after they reinstalled the tail-rotor assembly, they removed the crosshead again because they had forgotten to conduct a duplicate inspection of the crosshead. (New Zealand Civil Aviation Regulations require a duplicate inspection — that is, an inspection by two people — of any work performed on an aircraft control system.)

They said that after conducting the duplicate inspection, they reinstalled the crosshead and inserted split pins in the two bolts and the two nuts that attach the crosshead to the stack. [A split pin is inserted between slots in a castellated nut and through a hole in the bolt shaft; the split pin prevents the nut and the bolt from loosening.]

A post-inspection test flight was conducted on March 27, 2001, and the helicopter resumed service the next day. The helicopter was flown for 50 hours before the accident occurred.

At 1550 on the day of the accident, the helicopter departed from its base near Pukekohe [in northwestern North Island] for a positioning flight to the operator's airstrip near Taumarunui [about 200 kilometers (108 nautical miles) south of Pukekohe].

"On board [the helicopter] were the pilot, loader driver and operations coordinator," the report said. "The helicopter was to position at the operator's airstrip near Taumarunui for bait-spreading operations commencing the next day."

The pilot, 51, held a commercial helicopter pilot license and had 13,425 flight hours, including 610 flight hours in type. He had flown the accident helicopter for Wanganui Aero Work for about three years.

The pilot had flown about 54 hours in the preceding three months and about six hours in the preceding 14 days. He had been off duty more than 18 hours before reporting for the flight; he had been on duty about two hours when the accident occurred.

"The pilot was known to be cautious in his operation of ZK-HJH," the report said. "Several people had seen the pilot complete

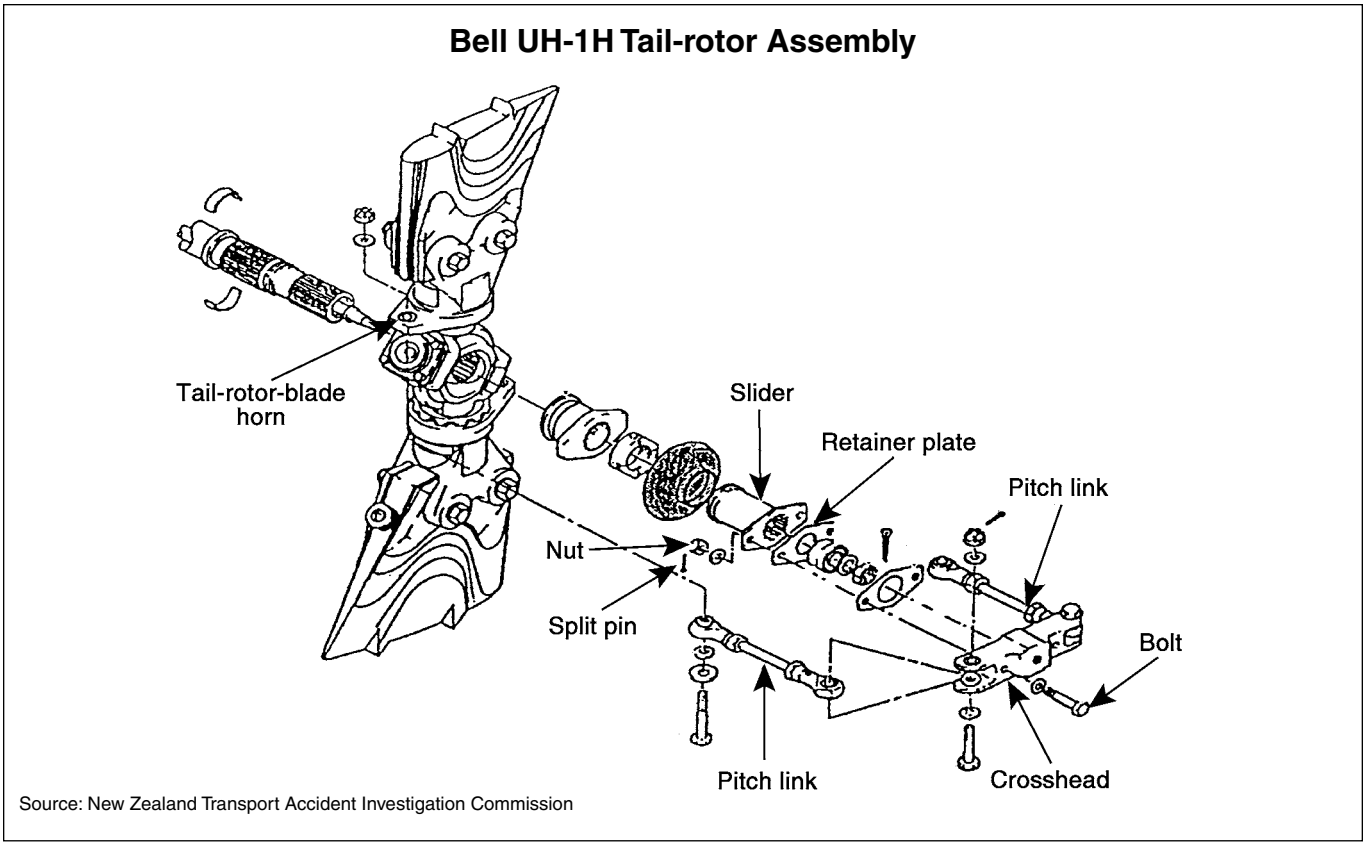


Figure 1

thorough preflight inspections of the helicopter before flying. He would use a stepladder, carried on board ZK-HJH, to access difficult places — for example, when greasing the tail rotor."

Visual meteorological conditions prevailed, with clear skies and light-and-variable surface winds. The report said that the flight time and the direction from which the helicopter approached Taumarunui indicated that the helicopter likely was flown over the area where the bait-spreading operations were to be conducted the next day.

Several people on the ground at Taumarunui said that daylight was fading but visibility was unrestricted when they observed the helicopter being flown from the northeast toward the airstrip. Witnesses' estimates of the helicopter's altitude varied; the report said that the altitude was at least 1,400 feet (600 feet above ground level).

"None of the witnesses saw anything unusual as the helicopter approached, and most of the witnesses reported that the helicopter sounded normal," the report said. "The helicopter then entered a turn. While several witnesses thought the turn was to the helicopter's left, the majority believed it turned to the right."

One witness mistook the helicopter for another UH-1H operated by a former employer. The witness observed the helicopter's tail "flick" [move slightly and rapidly] left and right several times before the helicopter began to turn right.

"The witness believed that the pilot had been signaling to him that he intended to land, as the flicks were sharper and more pronounced than usual," the report said.

The tail movements likely indicated that the pilot had begun to have tail-rotor-control problems. The helicopter then turned right.

"A turn to the right is symptomatic of a loss of tail-rotor thrust for the Iroquois if a pilot does not immediately reduce power to counter the torque effect of the main rotor when the failure occurs," the report said. "However, many witnesses observed the helicopter to remain about level for the early part of the turn, indicating that the pilot did not reduce power at the onset of the emergency. This was understandable, considering the tail initially flicked both left and right, which may have confused the pilot about the type of emergency."

During the turn, the helicopter's angle of bank increased, and the helicopter began to descend.

"The helicopter quickly became uncontrollable, and it is unlikely that the pilot could have recovered control of the aircraft," the report said.

Witnesses observed pieces separate from the helicopter before it struck the ground and began to burn. Emergency-services personnel arrived at the accident site, about five kilometers (three nautical miles) east of Taumarunui, at 1725.

"Several local residents had also rushed immediately to the scene, but no assistance could be given to the three occupants, who had died instantly," the report said.

Postmortem examinations of the occupants showed that they had received extreme traumatic injuries.

"The pilot and the person sitting in the center jump seat suffered injuries that were consistent with having been struck by a main-rotor blade or parts of it," the report said. "Witness marks on the blade support this conclusion. The third occupant's injuries were probably sustained as the fuselage impacted on the ground.

"The examination did not reveal anything that would have affected the ability of the pilot to control the helicopter. There was no medical [evidence] or pathological evidence of incapacitation or impairment for any of the occupants."

Pieces of the helicopter were found 450 meters (1,477 feet) from where the main impact occurred; the wreckage trail began with several pieces of paneling from the tail fin. The tail section, including the 90-degree gearbox and part of the tail-rotor assembly, had separated from the helicopter before the helicopter struck the ground.

"The fuselage had struck the ground vertically in a steep nose-down attitude," the report said. "Two of the occupants remained in the fuselage, while the third [occupant] had been thrown clear before impact."

The report said that the helicopter damage, wreckage distribution and occupant injuries indicate that the accident sequence began with loss of tail-rotor control.

Investigators found a bolt and a washer embedded in a tail-rotor blade. The bolt was a type that is used only to attach the tail-rotor-blade pitch links to the tail-rotor-blade horns and to attach the crosshead to the slider. (The crosshead and parts of the tail-rotor-blade pitch links were not found.)

"On ZK-HJH, the two bolts attaching the pitch links to the blade horns were still in position and accounted for," the report said. "The bolt [found embedded in the tail-rotor blade] appeared straight, and the threads were intact, although exhibiting some wear.

"The hole in the bolt for the split pin was empty, and the edges of the hole did not exhibit damage other than what would be expected for normal wear. … There was no evidence that any securing split pin had broken under load or that the nut had been pulled off. Under a microscope, a small amount of debris, possibly dirt and oil or grease, was visible in the hole through the bolt where the split pin would have been positioned."

Investigators concluded that the loss of tail-rotor control probably resulted from the crosshead becoming loose.

The report said, "There are three possible explanations for the tail-rotor crosshead becoming loose and the subsequent loss of tail-rotor control. These are:

- "The failure of a tail-rotor component;
- "The split pins were removed as a deliberate act; [or,]
- "The split pins were not inserted after the reassembly of the tail rotor during the inspection completed on 27 March."

The report said that the bolt found embedded in the tail-rotor blade, the slider and the retainer plate showed no sign of a failure in the tail-rotor-pitch-control mechanism; and the bolt showed no sign of failure of the bolt, retaining nut or split pin. Therefore, failure of a tail-rotor component was not likely the cause of the loss of tail-rotor control.

The report said that although the operator had encountered opposition and had received verbal threats for spreading poisoned bait, "there was no report or evidence of any deliberate or attempted damage to ZK-HJH or the support equipment. The police, the operator and relatives of the crew were not aware of any action that would account for the deliberate removal of the split pins. … While deliberate removal of the split pins was possible, it is considered unlikely."

The report said that the presence of debris in the bolt hole indicated that a split pin had been absent for "some time" and that omission of split pins during the inspection of the helicopter was the most likely reason for the loss of tail-rotor control.

"Having just fitted the crosshead once, including most probably the split pins, to then have to repeat the procedure again [to conduct the duplicate inspection], the LAME and the tradesman may have been inclined to rush the refitting," the report said. "In the rush, when it was time to fit and check the split pins, the LAME and the tradesman may have subconsciously reverted back to the previous fitting and assumed it had been done."

The report said that distraction might have been involved in the omission of the split pins.

"The fitting of the split pins, while a crucial element in the reassembling of the tail rotor, was, nevertheless, a small and simple task to complete — a routine automatic action for an aircraft engineer, especially one familiar with the Iroquois," the report said. "Should a distraction occur during a task, it is possible that a person could believe that the required action had been completed when it had not."

The report said that during the duplicate inspection, the tradesman might have assumed that the LAME had inserted the split pins.

"Knowing that the LAME had always inserted the split pins in the past, the tradesman may have also assumed that they had been fitted and either did not consciously check, or looked and believed he saw the split pins in place."

The report said that the unsecured nuts likely did not become appreciably loose until the accident flight.

"Over the next 50 hours of flying [after the inspection], the nuts probably backed off but still retained enough pressure on the crosshead to hold it secure and give the pilot no indication of an imminent control problem," the report said. "On the last flight, the two nuts reached the point where they were able to freely run off the bolts, initiating the loss of control."

The report said that the "lost opportunity to detect the omission" of the split pins during routine checks of the helicopter was a "significant factor contributing to the accident."

The report said that maintenance documents indicated compliance with ADs issued by CAA for UH-1H helicopters but not with U.S. Federal Aviation Administration (FAA) ADs issued for civilian versions of the helicopter (i.e., the Bell 204 and Bell 205).

"To strictly conform to its type certificate, the maintainer should have reviewed the FAA ADs for the Bell 204/205 to ensure that there were no outstanding technical matters that needed to be completed," the report said. "This needed to be done annually in conjunction with the ARA."

Some documents, including the helicopter flight manual and the technical log, were destroyed in the postaccident fire. The report said that TAIC has investigated several other accidents in which aircraft flight manuals and technical logs were not recovered — in most cases because the documents were destroyed by fire.

"The aircraft technical log contained current technical information relevant to the aircraft," the report said. "Much of the information would be repeated in other documents and remain available should the technical log be lost. However, some information — for example, maintenance carried out and certified between inspections — may not be available from other sources. This information could be relevant to an investigation should an accident occur."

The report said that the accident was among three fatal accidents involving ex-military helicopters in New Zealand during the first six months of 2001. On Jan. 15, 2001, a Bell UH-1F struck terrain in Wellington. On Feb. 12, 2001, a Westland Wessex struck terrain near Motueka.

[The report provided no details about the accidents. Airclaims said that the UH-1F was departing with an external load of debris from a construction site when it was observed "wobbling." The external load was released, and the helicopter descended in a left bank to the ground. The pilot was killed.[1] Airclaims said that the Wessex picked up a relatively small log at a hillside logging site but then lowered the log back to the ground. The helicopter hovered momentarily and suddenly dived toward the valley floor, where it struck trees and terrain. The pilot was killed.[2]]

The report said that the number of ex-military aircraft used in commercial operations in New Zealand has increased significantly in recent years.

"These aircraft often provide a cost-effective alternative to using purpose-designed or equivalent civil aircraft," the report said. "However, ex-military aircraft tend to be older than other aircraft and require specialist maintenance to continue flying. Spare parts can be difficult to source, and care needs to be taken to ensure they are both suitable and serviceable.

"Ex-military aircraft are often used in operations for which the aircraft [were] never intended. For example, while the Iroquois has an underslung-load capability, it was not intended for logging operations where there are large, rapid and frequent changes in power. The control and maintenance of these aircraft, therefore, need to be strictly adhered to and reviewed from time to time to ensure the aircraft remain airworthy."

The report said that as a result of the three ex-military-helicopter accidents, the New Zealand CAA began a review of the certification, operational use and oversight of ex-military helicopters; as a result of the accident involving ZK-HJH, CAA began a review of the maintenance company that maintained the helicopter.

Based on the findings of its investigation of the ZK-HJH accident, TAIC made the following recommendations to CAA:

- "Review the operation of the aircraft technical log to ensure [that] critical information is duplicated and [is] held separately from the log, possibly with the aircraft's maintenance documents. (064/01);

- "Educate licensed aircraft engineers who are holders of an inspection authorization, particularly those maintaining ex-military aircraft, on [ADs] and the requirement for the aircraft to conform to its type certificate. (065/01); [and,]

- "Ensure the New Zealand [AD] schedule specifies applicable [ADs] called up in the ex-military type certificates data sheets. (066/01)."

The report said that TAIC received the following response from CAA: "All three recommendations are accepted as worded and will be implemented as follows:

- "064/01: The review will be completed within six months (target date 30 June 2002), but any changes to the rule requirements will depend on negotiations between the CAA and the Ministry of Transport;
- "065/01: This will be addressed in the renewal training for inspection-authorization holders that starts in 2002, with a letter to be sent to each inspection-authorization holder by 31 January 2002; [and,]
- "066/01: [CAA] will ensure that the [AD] schedule specifies the appropriate [ADs] by 28 February 2002."♦

[FSF editorial note: This article, except where specifically noted, is based on New Zealand Transport Accident Investigation Commission Aviation Occurrence Report 01-005: *Bell (Western International) UH-1H Iroquois, ZK-HJH, tail rotor failure and in-flight break-up, near Taumarunui, 4 June 2001*. The 20-page report contains illustrations.]

Notes

1. Airclaims. *World Aircraft Accident Summary*. Supplement 125 (December 2001): H01:2.
2. Airclaims. H01:4.

Further Reading From FSF Publications

FSF Editorial Staff. "Fractured Bolts Blamed for Loss of Control of Two Helicopters." *Aviation Mechanics Bulletin* Volume 49 (May–June 2001).

FSF Editorial Staff. "Helicopter Strikes Terrain During External-load Aerial Logging Operation." *Helicopter Safety* Volume 26 (November–December 2000).

FSF Editorial Staff. "Unlatched Transmission Cowl Door Separates in Flight, Strikes and Disables Tail Rotor and Gearbox." *Helicopter Safety* Volume 24 (July–August 1998).

Rosenberg, Barry. "U.K. CAA Cites Inadequately Defined Inspection Procedures for Human Errors in Aircraft Inspection." *Aviation Mechanics Bulletin* Volume 43 (November–December 1995).

Feeler, Robert A. "Human Factors in Aircraft Maintenance and Inspection." *Aviation Mechanics Bulletin* Volume 39 (July–August 1991).

Vandel, Robert H. "The Huey Retires." *Helicopter Safety* Volume 14 (September–October 1989).

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