Australian Government
Australian Transport Safety Bureau

ATSB TRANSPORT SAFETY REPORT
Aviation Occurrence Investigation AO-2008-039
Final

Airframe vibration
Wollongong Aerodrome, NSW
11 June 2008
VH-UAH, Bell Helicopter Co. 412

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Front cover image: Brenden Scott
Figure 5: Bell Helicopter and the collective actuator manufacturer

Abstract

On the morning of 11 June 2008, a Bell 412 helicopter, registered VH-UAH, was being used to conduct training operations from Wollongong Aerodrome, New South Wales. Shortly after landing on the runway, the helicopter developed severe vertical airframe vibrations that resulted in reduced pilot control. In an attempt to mitigate the vibrations, the pilot raised the helicopter into the hover, however, the vibrations continued to increase in severity. In response, the pilot lowered the collective to set the helicopter back down onto the runway. The resulting heavy landing caused serious damage to the helicopter, but the crew were not injured.

A subsequent examination of the helicopter’s flight control system revealed an anomaly with the collective hydraulic actuator. Excessive free play was found to have developed in the bolted joint between the pivot bolt and the pilot input lever, which then allowed vertical vibrations and controllability issues to develop. It is likely that free play at the bolted joint was introduced when the collective actuator was last overhauled.

As a result of this occurrence, the collective actuator manufacturer revised the tensioning procedures and requirements for the pivot bolt assembly during the overhaul process. In addition, the helicopter operator changed its inspection regime of the collective servo-hydraulic actuator units in its fleet of Bell 412 helicopters and issued a ‘flight staff instruction’ to provide guidance to pilots on what actions to take if they experienced unusual or excessive vibrations during flight.

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The Bureau is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

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.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. 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.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

TERMINOLOGY USED IN THIS REPORT

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

Other safety factor: a safety factor identified during an occurrence investigation which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interests of improved transport safety.

Other key finding: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which ‘saved the day’ or played an important role in reducing the risk associated with an occurrence.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: The ATSB’s assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 11 June 2008, a Bell 412 helicopter, registered VH-UAH, was being operated on training and checking flights from Wollongong Aerodrome, New South Wales. On board the helicopter were two company pilots, both endorsed as Bell 412 training and checking captains. At about 0840 Eastern Standard Time[1], the helicopter was landed on runway 16, having completed a circuit of the aerodrome. The crew reported that shortly after the heli-pilot[2] system had been switched off and while the helicopter was sitting on the runway surface with the main rotor blades at 100% flat pitch, the machine began to vibrate excessively. The copilot raised the collective lever[3] in an attempt to arrest the vibrations; however, they continued to amplify.

In response to the increasing vertical airframe vibrations, and suspecting that they were related to ground resonance[4], the pilot in command announced that he was 'taking over' and raised the helicopter into a hover. As the helicopter broke ground contact, the vertical airframe vibrations and control difficulties increased in magnitude. Given the controllability issues, the pilot who had assumed control of the helicopter conducted an autorotation onto the runway. After the engines were shut down, both pilots exited the helicopter uninjured. The helicopter was substantially damaged (Figure 1).

Earlier that morning, the helicopter had flown two circuits of the aerodrome without any anomalies having been reported.

Aircraft information

The helicopter was manufactured in the United States in 1981 and had been placed on the Australian civil aircraft register the same year. The operator had first registered the helicopter in 1985.

Flight controls

The Bell 412 used conventional helicopter-type flight controls in order to control altitude and direction. Control inputs from the cyclic and collective controls were transmitted to the main rotor, and inputs to the directional pedals were transmitted

1 The 24-hour clock is used in this report to describe the local time of day, Eastern Standard Time (EST), as particular events occurred. Eastern Standard Time was Coordinated Universal Time (UTC) + 10 hours.

2 The heli-pilot system is also known as the Automatic Flight Control System (AFCS).

3 Raising or lowering the collective lever changes the main rotor blade pitch angles, thus controlling the lift produced by the main rotor system.

4 Ground resonance is a severe vibration that can develop due to the interaction between a rotating main rotor system and the undercarriage of a helicopter when in contact with the ground. This is a divergent, oscillatory condition, which if not remedied, can substantially damage the helicopter in a short period of time.

through to the tail rotor. The flight controls were hydraulically assisted in order to reduce pilot effort and counteract feedback forces from the rotor systems. Control inputs from the cyclic, collective, and directional pedals were transmitted by push-pull tubes and bellcranks to their respective hydraulic flight control actuators.

Figure 1: VH-UAH on the runway after landing

Note: A section of pylon fairing that separated from the airframe during the occurrence is shown in the foreground.

Damage to the aircraft

Operator's inspection

The Australian Transport Safety Bureau (ATSB) did not attend the occurrence site. An initial examination of the aircraft was undertaken by the operator's maintenance personnel at Wollongong. A section of cowl from the left side of the pylon had separated at some point during the occurrence, and was found on the grassy verge near to where the helicopter had landed (Figure 1).

Skid landing gear

The operator's inspection found that the rear section of both skids had been bent upward toward the fuselage and the rear crosstube that supported the skids had been flattened. Such damage was indicative that the helicopter had landed heavily in a tail-low attitude. No other damage to or anomaly associated with the skid landing gear was reported.

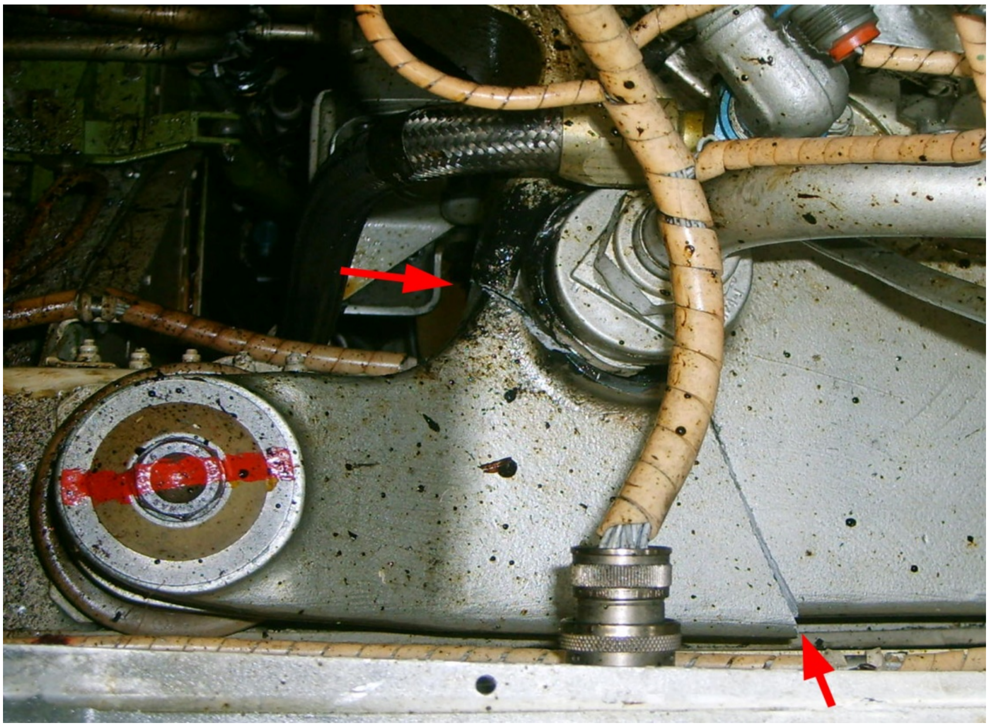
Tail rotor system and tail boom

The tail rotor blades had sustained minor rotational impact damage from contact with the runway surface. The tail rotor drive coupling was found disengaged from the rest of the tail rotor drive components and some areas of the tail boom had buckled from the hard landing.

Main rotor transmission

The operator's inspection of the main rotor transmission revealed that the right-rear and left-forward corners of the transmission support case had both fractured (Figure 2). The transmission had been attached to the airframe by a lift link and vibration isolation mounts at the support case corners. An internal inspection of the transmission was carried out by the operator and no internal mechanical defects were found. The transmission had no reported history of metal contamination, and pressure and temperature indications were reported to have been in the normal operating range prior to the occurrence.

Figure 2: One of the fractured mounts from the transmission support case (arrowed)

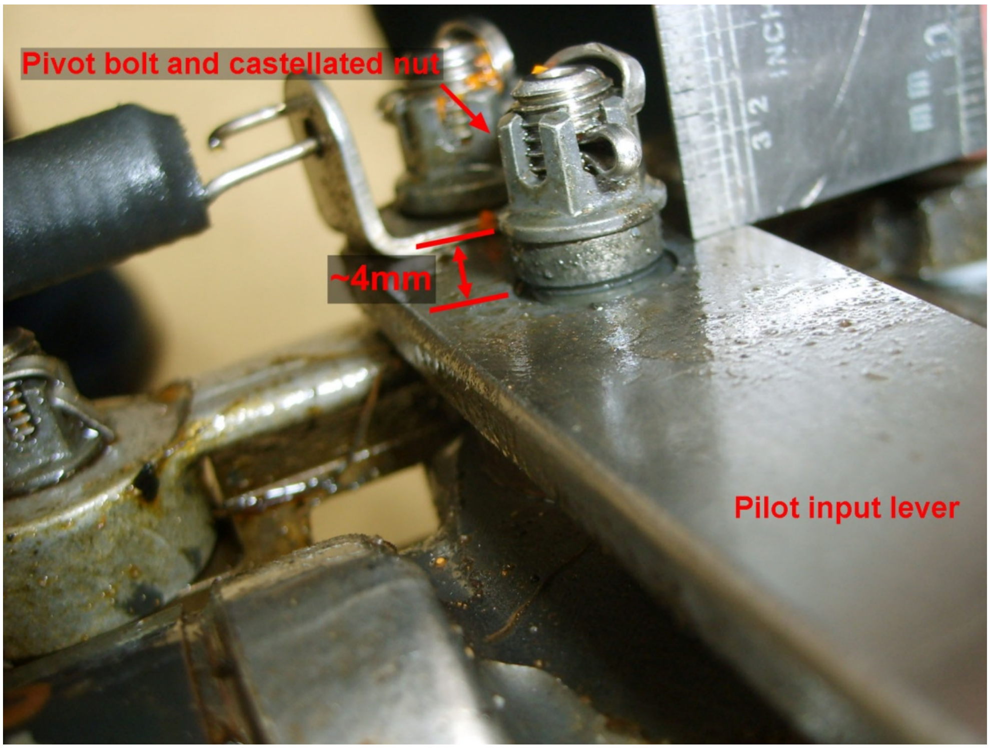


Flight controls

The collective actuator had operated for 513 hours since its last overhaul. The operator's inspection of the flight controls following the accident revealed excessive free play in the connection between the pilot's input lever (part of the collective control system) and the collective actuator assembly (Figures 3 and 4). In particular, it was noted that one of the pivot bolts on the input lever was loose, which had allowed excessive play to develop in the linkage.

The operator advised that it considered the pivot bolt free play in the collective actuator to have potentially affected the controllability of the helicopter. As a result, the operator submitted the collective actuator assembly to the component manufacturer with a request for a more detailed examination and analysis.

Figure 3: Pivot bolt to the input linkage lever displaying excessive free play



Actuator manufacturer's examination

In order to establish how the linkage free play had been able to develop during service, the collective actuator was removed from the airframe and sent to the actuator manufacturer for detailed examination. The manufacturer provided the following results from its examination.

Worn components

Dimensional inspection of the provided parts did not reveal any excessive wear that might have otherwise indicated how the pivot bolt had become loose. An inspection showed that the pivot bolt epoxy was marginally worn and the bores of the bushings were slightly oversized. However, the tolerances calculated were not sufficient to significantly affect free play in the bolted assembly.

Adjustable bushings

The actuator manufacturer reported that all bushings from the pivot bolt had been accounted for during receipt of the collective actuator.

Inadequate pivot bolt/nut torque

The Component Maintenance Manual[5] (CMM) for the collective actuator listed the following instructions for tightening the castellated nut onto the pivot bolt:

> Torque each nut to 15 inch-pounds, then tighten nut just enough to align cotter pin hole on bolt with castellations on nut (total torque shall be 15 to 25 inch-pounds). Install two cotter pins.

The torque figure referred to in the CMM only referred to installation torque[6] and did not take into account *running torque*.

Running torque was the torque required to overcome the friction between the mating threads of the castellated nut and the pivot bolt, and was measured when the fastener was in motion. To prevent the castellated nut from loosening during service, the nut was designed with an intentional self-locking feature that produced a positive running torque during assembly. Running torque of the castellated nut and pivot bolt was measured by the manufacturer to be 13 inch-pounds, which was near the lower limit as specified in the CMM for the assembly installation torque.

The component manufacturer noted that running torque values for new castellated nuts have been reported as high as 20 in-lbs, which is *above* the lower installation torque limit (15 in-lbs). While on the test stand, one of the two castellated nuts on the input lever was backed off and re-torqued to the minimum 15 in-lbs, while ignoring the 13 in-lbs of running torque. With the nut torqued to 15 in-lbs, it was further tightened to the minimum extent necessary for cotter pin installation. This left a 0.050 in gap between the spacer and the castellated nut. Manually twisting the pilot input lever resulted in observable free play at the pivot bolt joint.

On this basis, the manufacturer concluded that had running torque not been considered during the assembly process, the pivot bolt would have been inadequately tensioned, thereby allowing excessive clearance to exist between the fitted parts (as observed).

It was also reported that free play at the pivot bolt / input lever would have affected the collective actuator's null-position[7] by allowing that position to 'float', potentially allowing uncommanded and erroneous inputs to develop within the collective system at the time of the occurrence.

The manufacturer also reported that collective actuators are functionally tested following an overhaul. While the manufacturer was uncertain why the free play in the pivot bolt was not detected at the time of the testing, they concluded that the bushings in the joint may have gradually loosened and then moved out of position from the effects of vibration during normal time in service.

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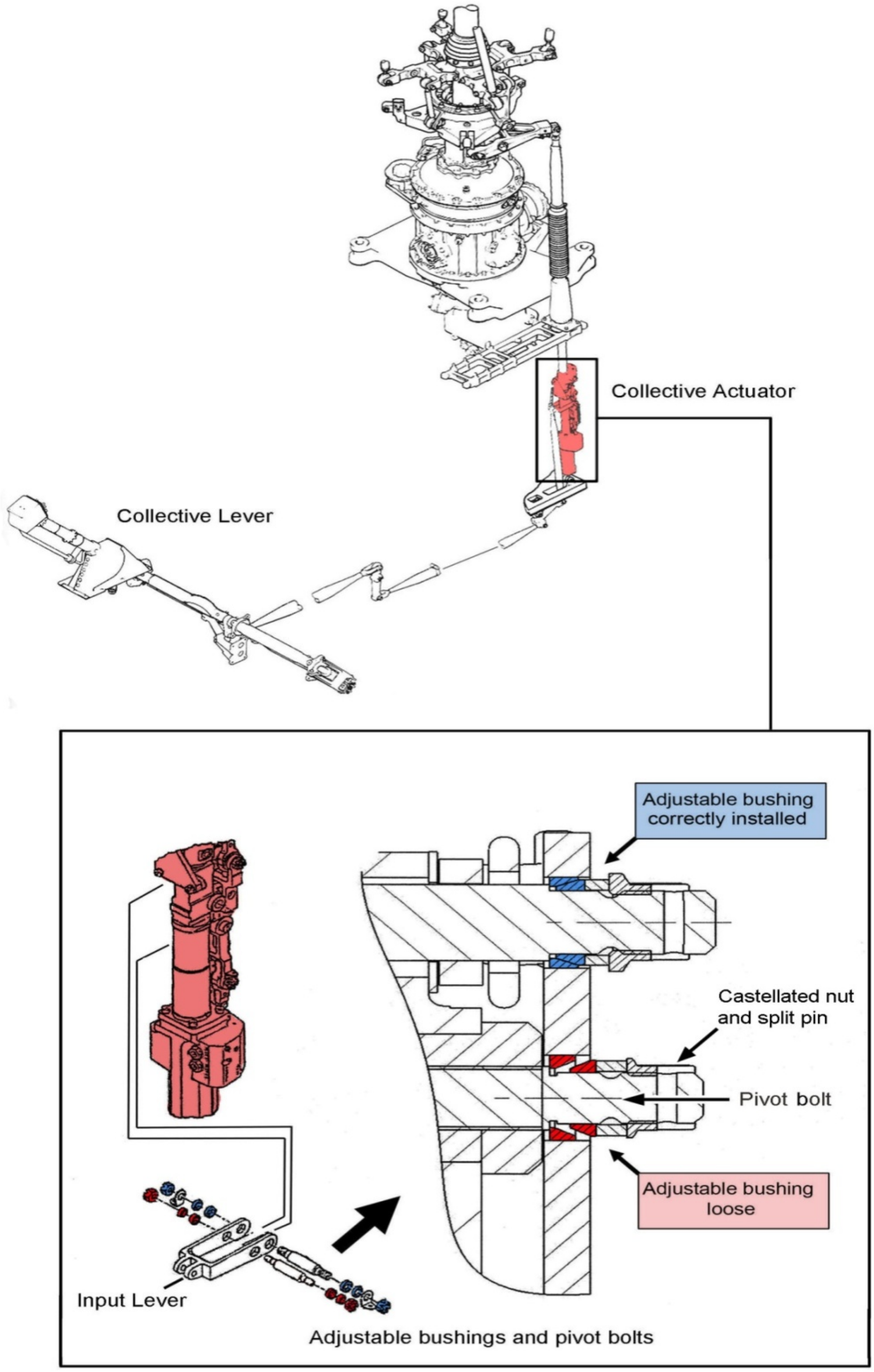
5 HR Textron, Component Maintenance Manual 'Flight Control Cylinder Assembly', 67-31-06, June 1/07, page 723.

6 *Installation torque* was the torque required to axially load the fastener to the required preload value detailed in the CMM.

7 The null-position is where both sides of the actuator cylinder have equal pressure.

Figure 4: Bell 412 collective system illustrating an incorrectly assembled adjustable pivot bolt and bushing assembly, as found during the actuator disassembly

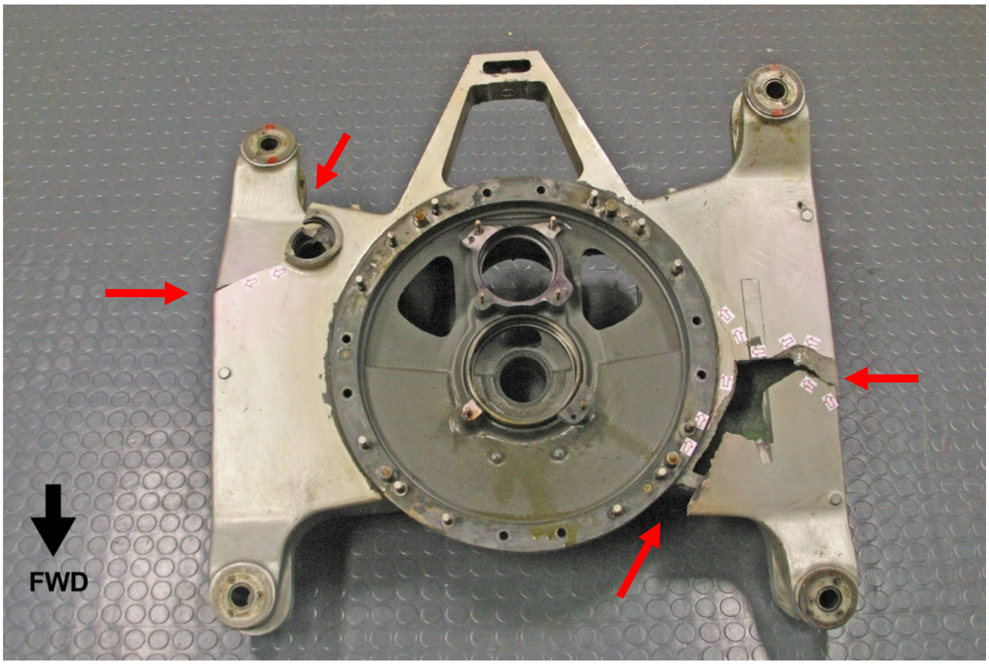


ATSB examination

A detailed examination of the fractured transmission case was carried out in the ATSB laboratories to ascertain whether the failure may have contributed to the controllability difficulties reported by the pilots. No evidence of any pre-existing defects or progressive cracking was observed across any of the transmission case fracture surfaces, with all showing brittle fracture features, consistent with exposure to gross overstress conditions.

As noted in Figure 5, the lugs had fractured diagonally through each isolation mount, which was indicative that considerable out-of-balance forces from the main rotor system had developed during the latter stages of the occurrence flight. Other damage to the transmission case included the machining of a slot into the case surface from rotational contact with the main rotor disc brake.

Figure 5: Transmission support as received by the ATSB, showing diagonally opposing fractures (arrowed)



Related occurrences

Bell 412SP - VH-LLI vibration event

About 2 months after the Wollongong occurrence involving VH-UAH, another Bell 412 helicopter (registered VH-LLI) was damaged in an apparently similar vibration event. Shortly after landing, the pilot noted that slight vertical vibrations in the machine had commenced. In an attempt to curb the vibrations, the pilot reported raising the helicopter into the hover, but the vertical vibrations increased in severity to the extent that the pilot's control of the helicopter was severely reduced. The pilot was able to successfully land and shut down the helicopter despite the controllability issues. An investigation performed by the operator revealed that the jackshaft friction for the collective lever assembly had been inadequately set during maintenance.

Bell 412SP - VH-LLB vibration event

While being operated in East Timor, a Bell 412SP helicopter also experienced issues relating to severe vertical vibrations. Information supplied by the helicopter manufacturer indicated that the vibration was probably related to a low collective friction setting. One of the pivot bolts to the cyclic hydraulic actuator was also reportedly found to be loose.

Other events

In response to the occurrence involving VH-UAH, a search of Australian and North American aviation safety databases[8] was performed for evidence of similar Bell 412 airframe vibration events that were related to the collective actuator assembly. No records of similar occurrences were found. In addition, both Bell Helicopter and the collective actuator manufacturer have reported to the ATSB that they had not experienced any other collective actuator bolt-clamping issues similar to that which had occurred on VH-UAH.

Factors affecting the onset of Bell 412 airframe vibration

The Bell 412 helicopter type can be affected by vibration at low to moderate levels during normal operation. Chapter 18 of the Bell 412 Maintenance Manual stated that the main sources of vibration stem from the main rotor, the tail rotor, or the engine-to-transmission driveshaft. Other dynamic components, including pumps and fans may also generate vibrations at various frequencies. Main rotor vibration can develop at either once (1/rev), twice (2/rev), four times (4/rev) or eight times per revolution (8/rev) of the main rotor system.

The phenomenon of vertical airframe vibration has also been given the term ‘ground bounce’ by Bell 412 operators and maintainers within the aviation community. The operator advised that it is a known characteristic of the Bell 412 to exhibit ‘ground bounce’ with the collective fully down at 100% flat pitch, and that the normal procedure for a pilot to eliminate these effects is to raise a small amount of collective pitch to smooth out the vibrations.

Although ‘ground bounce’ is not specifically defined by the manufacturer, it is mentioned within Chapter 18 of the Bell 412 Maintenance Manual. The points listed below are among some of the known factors that can affect the likelihood of vertical airframe vibration (ground bounce) occurring:

- not maintaining constant track and balance of the main rotor blades throughout the main rotor RPM[9] range from 100% flat pitch and into the hover
- control system looseness due to worn rod end bearings
- worn or mismatched[10] transmission pylon mounts

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8 Australian Civil Aviation Safety Authority (CASA) ‘*Service Difficulty Report database’*
Australian Transport Safety Bureau (ATSB) ‘*Safety Investigation and Information Management System’*
US Federal Aviation Administration (FAA) ‘*Service Difficulty Report database’*
US National Transportation Safety Board (NTSB)
Transportation Safety Board of Canada (TSB).

9 Revolutions per minute (RPM).

- collective lever jackshaft friction is set too loose and outside the specified limits, or the inputs to the collective actuator are worn
- degraded main rotor blade pendulums, or damaged trim tabs
- worn main rotor blade lead-lag dampers
- failure of the elastomeric coupling in the main rotor blade spindle
- wind blowing side on to the helicopter
- ground running while the helicopter is on a ground handling trolley.

Meteorological information

On the day of the occurrence, the Bureau of Meteorology (BOM) forecast for Wollongong predicted isolated showers and drizzle, with low broken cloud[11]. Light winds in a northerly direction were recorded for Wollongong at the time of the occurrence. The prevailing meteorological conditions were not considered to be a factor in the occurrence.

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10 Where 'new' damper mounts are installed with 'used' and degraded mounts.

11 Cloud amounts are reported in oktas. An okta is a unit of sky area equal to one-eighth of total sky visible to the celestial horizon. Few = 1 to 2 oktas, scattered = 3 to 4 oktas, broken = 5 to 7 oktas and overcast = 8 oktas.

ANALYSIS

Accident sequence

The occurrence developed due to increasingly severe vibrations that were transferred from the helicopter's main rotor system through to the airframe. The vibrations commenced on the ground after the main rotor blades had been set to 100% flat pitch and shortly after the helicopter's Automatic Flight Control System (AFCS) had been deactivated.

It was initially thought by the pilot in command that the vibrations signalled the onset of ground resonance. Breaking ground contact will normally arrest ground resonance. Given that the vibrations continued and increased in magnitude after the aircraft was brought into a hover, the vibrations and controllability problems were not due to ground resonance. The circumstances however, were consistent with the phenomenon known as 'ground bounce', induced by an anomaly within the flight control system.

Collective actuator – pivot bolt

The helicopter had flown earlier that morning without exhibiting any reported flight control anomalies or excessive airframe vibrations. The 'ground bounce' associated with this occurrence had developed after the helicopter had landed and then operated for a period of time on the ground with the main rotor blades at a 100% flat pitch setting. The onset of 'ground bounce' in the Bell 412 has been observed after periods of ground operation at 100% flat pitch, however the phenomena is complex and affected by numerous factors associated with the setup and condition of the machine. In this instance, it is probable that the excessive free play between the collective actuator's pivot bolt and the pilot input linkage, together with the period of ground operation at the 100% flat pitch setting, were the key factors that acted collaboratively to bring about the onset of divergent ground bounce behaviour and the subsequent damage that was sustained.

Bolt torque procedures

Excessive free play between the pivot bolt and the pilot input linkage was attributed to insufficient clamping at that joint – possibly originating from a failure to adhere to the actuator manufacturer's procedures for the tensioning of the assembly during the last actuator overhaul. If the running torque of the nut was not considered when the pivot bolt and castellated nut were installed, it is probable that the joint would not have received adequate initial tensioning, and as such, would have been predisposed to the development of excessive free play.

Collective actuators are functionally tested following an overhaul. While it is not possible to determine why the free play in the pivot bolt was not detected at the time of the testing, it is possible that the application of inadequate torque on the pivot bolt led to the bushings in the joint gradually loosening from vibrations during normal time in service.

FINDINGS

From the evidence available, the following findings are made with respect to the accident involving Bell 412 helicopter, registered VH-UAH, at Wollongong Aerodrome, New South Wales on 11 June 2008, and should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- The component overhaul manual did not specifically identify an allowance for positive running torque of the castellated nut, potentially allowing for inadequate tensioning of the pivot bolt and adjustable bushings during reassembly of the collective actuator. *[Minor safety issue]*
- It is likely that the castellated nut and pivot bolt arrangement was inadequately tensioned when the collective actuator was last overhauled, thus predisposing the assembly to the development of excessive free play.
- Pilot control of the helicopter was impaired due to the onset of severe, vertical airframe vibrations, stemming from an excessive free play condition within the collective actuator system.
- As a result of the severe vibrations and impaired pilot control, the helicopter landed heavily and was seriously damaged.

SAFETY ACTION

The safety issues identified during this investigation are listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Collective actuator manufacturer

Pivot bolt free play within the collective actuator assembly

Safety issue

The component overhaul manual did not specifically identify an allowance for positive running torque of the castellated nut, potentially allowing for inadequate tensioning of the pivot bolt and adjustable bushings during reassembly of the collective actuator.

Action taken by / response from the collective actuator manufacturer

- Following the occurrence, the actuator manufacturer reviewed the torque requirements for installing the castellated nut onto the pivot bolt assembly. In order to ensure proper clamping and cotter pin installation following overhaul, it was determined that the torque callout range could be increased to 30-50 inch-pounds (previously 15-25 inch-pounds).
- An amendment to the collective actuator Component Maintenance Manual and the collective actuator assembly test and inspection procedures (ATIP) that reflected the torque revision was published in September 2009.

ATSB assessment of response / action

The ATSB is satisfied that the safety action conducted by the collective actuator manufacturer adequately addresses this minor safety issue.

Helicopter operator

Pivot bolt free play within the collective actuator assembly

Safety issue

The component overhaul manual did not specifically identify an allowance for positive running torque of the castellated nut, potentially allowing for inadequate tensioning of the pivot bolt and adjustable bushings during reassembly of the collective actuator.

Action taken by / response from the helicopter operator

- After the occurrence, the operator performed an initial fleet-wide non-standard inspection of Bell 412 collective hydraulic actuator units for evidence of security or free play within the collective lever/pivot bolt joint. No defects were reported to have been found.
- The operator introduced a repetitive, non-standard inspection of the collective servo-hydraulic actuator units within their Bell 412 fleet.
- The operator released a flight staff instruction to their Bell 412 pilots, communicating that should they experience unusual or excessive vibrations during flight, that they land the helicopter and notify engineering personnel.

ATSB assessment of response / action

The ATSB is satisfied that the safety action conducted by the helicopter operator adequately addresses this minor safety issue.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of information

The sources of information for the investigation included the:

- helicopter manufacturer
- collective actuator manufacturer
- helicopter operator
- Bureau of Meteorology
- Occurrence databases maintained by the Australian Transport Safety Bureau, the Civil Aviation Safety Authority and equivalent agencies in the US and Canada.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the:

- helicopter manufacturer
- collective actuator manufacturer
- helicopter operator
- Civil Aviation Safety Authority (CASA)
- US National Transportation Safety Board (NTSB)
- US Federal Aviation Authority (FAA).

Submissions were received from the helicopter operator and the helicopter manufacturer. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Airframe vibration, Wollongong Aerodrome, NSW
11 June 2008, VH-UAH, Bell Helicopter Co. 412