Transport Accident Investigation Commission

Final report

Aviation inquiry AO-2019-001
Airbus Helicopters AS350, ZK-HEX
Forced landing
Wakefield, Nelson
17 February 2019

September 2020

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas.

The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. It is not the Commission's purpose to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. However, the Commission will not refrain from fully reporting on the circumstances and factors contributing to an accident because fault or liability may be inferred from the findings.

Figure 1: Airbus Helicopters AS350, ZK-HEX
(credit: Andy Heap)

Figure 2: Location of accident

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1. Executive summary

What happened

1.1. On 17 February 2019, an Airbus Helicopters AS350 helicopter, registered ZK-HEX was one of several helicopters assisting with the suppression of forest fires. The fires had been burning throughout the Nelson region over the preceding two weeks.

1.2. The pilot was the sole occupant while the helicopter was operating with an externally suspended monsoon bucket. After dropping a load of water on the target area, the helicopter was returning to a nearby pond to refill the monsoon bucket. The lifting line suspending the monsoon bucket made contact with and disabled the helicopter's tail rotor, resulting in a loss of directional control. The pilot initiated a descent for a forced landing. The helicopter descended into a forested area and landed heavily, resulting in significant damage. The pilot received minor injuries.

Why it happened

1.3. A tubular, segmented, stainless-steel ring was held in place at the top of the bucket with hook-and-loop fastener tabs. This ring was intended to maintain the circular shape of the top section of the bucket when it was being filled.

1.4. It was likely that during the accident flight, one or more of the hook-and-loop fastener tabs came undone, allowing the ring to become insecure and the bucket to lose rigidity. This likely resulted in a sudden change to the aerodynamic stability of the bucket in the airflow, leading to the bucket trailing behind the helicopter and the lifting line contacting the tail rotor. The reason for the hook-and-loop fastener tabs coming undone could not be determined.

1.5. The bucket manufacturer had developed design improvements to reduce the likelihood of the hook-and-loop fastener tabs coming undone, but the modification was not mandatory. Therefore, the Transport Accident Investigation Commission (Commission) has made a **recommendation** that the Cloudburst monsoon bucket manufacturer ensure that all Cloudburst monsoon buckets with this hook-and-loop fastener system are modified with the design improvements.

1.6. The monsoon bucket lifting line was of a length that likely increased the risk of the external load coming into contact with the tail rotor. The Commission found that at the time of the accident, there was insufficient guidance available to pilots on the appropriate line length for monsoon bucket operations. The aircraft manufacturer has since published a Safety Information Notice on this issue and the operator has incorporated this guidance into its operating procedures.

What we can learn

1.7. The bucket manufacturer had developed operational information on and limitations for the use of its monsoon buckets, but did not proactively promulgate this information to operators. This omission had the potential for operators to develop policies in isolation, possibly resulting in less-than-optimal safe working practices. As such, the Commission has made a **recommendation** that the bucket manufacturer review and enhance the Operation Manuals for all Cloudburst buckets to include any recommended operational and maintenance procedures, guidelines and limitations, and promulgate this information to all users of this equipment.

1.8. All occurrences that have safety implications should be reported through the operators' internal safety management system. The Civil Aviation Authority should also be notified of all occurrences that meet the Civil Aviation Rules Part 12 – Accidents, Incidents, and Statistics criteria. Not reporting a safety-related occurrence is a missed opportunity to prevent a similar occurrence.

2. Factual information

Narrative

2.1. On 17 February 2019, the pilot of an Airbus Helicopters AS350 helicopter, registered ZK-HEX (the helicopter), was using a monsoon bucket (the bucket) to drop water on a forest fire in the Wakefield area, near Nelson. The helicopter departed from a staging area at about 1408[1] to commence the firefighting task. The pilot was the sole person on board.

2.2. The pilot flew the helicopter in a pattern that involved dipping the bucket, which was suspended from the cargo hook on a lifting line, into a dipping pond then flying with the full bucket to drop the water where required. The helicopter then returned to the dipping pond to repeat the process. Each cycle of dipping, dropping and filling took about three to four minutes.

2.3. At about 1449, the pilot dropped a load of water onto the target area approximately 1.7 nautical miles[2] from the dipping pond. The pilot then turned the helicopter back toward the dipping pond, while climbing and accelerating.

2.4. The pilot reported that after reaching cruise airspeed, the helicopter unexpectedly yawed[3] violently one way and then the other. The pilot then heard a loud bang and the helicopter commenced an un-commanded turn to the left.

2.5. The pilot initiated a descent for a forced landing, jettisoned the bucket and transmitted a Mayday[4] radio call. The pilot descended towards an area of light bush close to a forest access road, but the helicopter started to spin near the ground. The pilot recalled following the recommended procedure for a loss of tail rotor control by closing the throttle, shutting the engine down to stop the helicopter spinning, and conducting an autorotative landing[5].

2.6. A number of fire service personnel were working on the ground in the nearby area. They arrived at the accident site within a few minutes and were able to assist the pilot out of the wreckage. The pilot received a minor ankle injury. The helicopter was substantially damaged.

Damage to aircraft

2.7. The helicopter struck the ground heavily with minimal sideways movement. The impact resulted in the separation of the front section of both the left and right landing gear skid tubes, and the deformation of the front section of the cabin structure (Figure 3).

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[1] Times are in New Zealand daylight time (co-ordinated universal time + 13 hours) and expressed in the 24-hour format.
[2] One nautical mile equals 1.852 kilometres.
[3] The rotation of the nose of the helicopter relative to the helicopter's direction of travel.
[4] An international radio distress message indicating a life-threatening emergency.
[5] A process whereby an unpowered rotor system produces lift by inducing an airflow up through the main rotor blades as the helicopter descends.

2.8. The main rotor blades were substantially damaged and appeared to have struck the tail boom and surrounding foliage. The rear section of the tail boom and the tail rotor assembly had separated from the main airframe (Figure 4) and landed a few metres to the right of the fuselage.

2.9. One tail rotor blade was broken at its root end but remained attached by its internal structure. The opposing tail rotor blade exhibited no external damage (see Figure 5).

2.10. The two pitch control links[6] on the tail rotor assembly were found deformed (Figure 6) and the tail rotor pitch-control slider had numerous indentations (Figure 7).

2.11. Yellow synthetic material was found on the tail rotor assembly at various locations (Figure 8). The same yellow material was also found on the leading edge of the broken tail rotor blade (Figure 9).

2.12. The tail rotor drive shaft had failed at its forward coupling (Figures 10 and 11).

2.13. The jettisoned bucket was found in a collapsed state in a forested area approximately 100 metres (m) to the south of the helicopter wreckage (Figure 12). A yellow synthetic sheathing was used to enclose the synthetic lifting line, electrical cable and pneumatic line (2.24); all of these exhibited damage at about the same point along the length of line (Figure 13).

2.14. The bucket was inspected in situ. A tubular, segmented, stainless-steel ring normally held in place by hook-and-loop fastener tabs[7] at the top of the bucket (Figure 14) had come apart and was displaced.

[6] Part of a mechanical linkage that converted movement of the pilot's foot pedals into a change in the angle of the tail rotor blades. This enabled control of the amount of tail rotor thrust being produced.
[7] Commonly referred to by the brand name of Velcro®.

Figure 3: Main wreckage at the accident site

Figure 4: Tail cone and tail rotor assembly at the accident site

Figure 5: Broken tail rotor blade

Figure 6: Pitch control links bent inward

Figure 7: Impact damage to the pitch control mechanism

Figure 8: Yellow material transfer on to tail rotor assembly

Figure 9: Yellow material transfer on to tail rotor blade

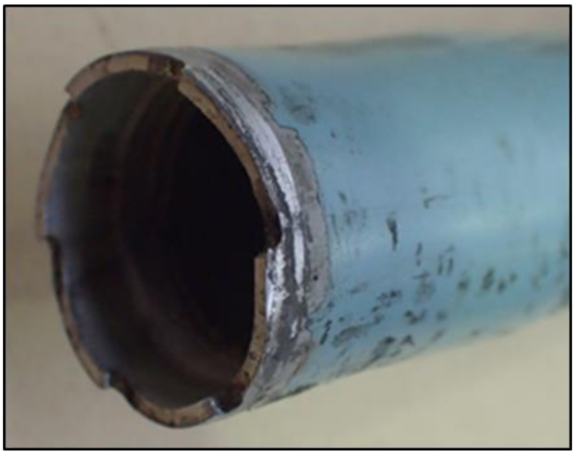

Figure 10: Forward end of the tail rotor drive shaft

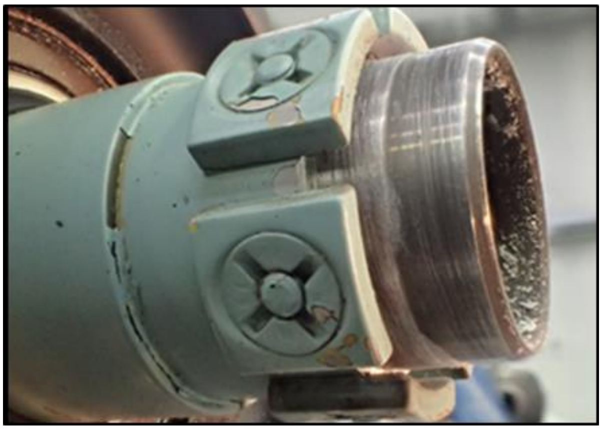

Figure 11: Forward coupling of the tail rotor drive shaft

Figure 12: Bucket in collapsed state in situ at the accident site

Figure 13: Damage to the lifting line sheathing material

Figure 14: Hook-and-loop fastener tab

Aircraft information

2.15. The helicopter was constructed in 1982 as a 'BA' variant of the AS350 helicopter type. It was later converted to an 'FX2' variant. This conversion included, among other things, the replacement of the engine with a Honeywell LTS101 700 D-2, and an increase in the allowable maximum all-up weight limit with an external load, from 2,250 kilograms (kg) to 2,500 kg.

2.16. The helicopter had recorded a total flight time of 5,816.43 hours at the time of the accident. The helicopter had been maintained in accordance with the operator's approved maintenance programme. The maintenance logbooks showed that all scheduled maintenance had been carried out as required, and the helicopter had no recorded defects at the time of the accident.

2.17. The helicopter was configured to operate with the monsoon bucket suspended from the cargo hook. The right-side pilot's door had been removed, with the right sliding door locked back in the open position. The left-side sliding door and front doors were both in their closed positions. This configuration was permitted within the helicopter's flight manual[8] but it reduced the maximum allowable airspeed to 110 knots[9].

Weight and balance

2.18. The helicopter had been fuelled to about 55% of capacity (297 litres) at the start of the fuel cycle. Since then, the helicopter had been flying for about 40 minutes. The pilot estimated that the helicopter had about 40% (216 litres) of fuel remaining at the time of the accident. This equated to about 173 kg.

2.19. The cargo hook beneath the helicopter was equipped with a load cell. This displayed the weight on the hook to the pilot in the cockpit. The pilot stated that the load cell weight was used to determine how much water was in the monsoon bucket during filling and that it was usually filled to about 800 kg.

2.20. The helicopter's empty weight was 1,309.95 kg. The maximum allowable all-up weight of the helicopter with an external load was 2,500 kg. The all-up weight of the helicopter was estimated to have remained below this limit throughout the duration of the flight.

2.21. The cargo hook was positioned directly below the main rotor mast. The helicopter's centre-of-gravity position was within the allowable limits stated in the flight manual with the monsoon bucket both full and empty.

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[8] A controlled document produced by the helicopter manufacturer and accessible to the pilot from within the cockpit, providing information on, for example, system descriptions and limitations and normal and emergency procedures.

[9] The global positioning system and satellite tracking recorded ground speeds of no more than about 80 knots. A knot is a measurement of speed in nautical miles per hour, equivalent to 1.852 kilometres per hour.

Monsoon bucket and associated lifting line

2.22. The monsoon bucket was an earlier version of the Cloudburst CB1000MF, manufactured in New Zealand by IMS New Zealand Limited (IMS). It had a maximum capacity of 1,000 litres. The bucket was constructed using a flexible urethane fabric.

2.23. The bucket assembly was purchased new by the operator in January 2013 and had been used for 300 hours. It had been maintained in accordance with the operator's Civil Aviation Authority (CAA) approved internal maintenance programme.

2.24. The synthetic lifting line was 8.5 m in length and attached to the helicopter cargo hook at its upper end and to the bucket control head[10] at its lower end. The synthetic lifting line and associated electrical and pneumatic control lines were wrapped in a yellow, abrasion-resistant synthetic sheathing with a hook-and-loop closure.

2.25. The bucket was suspended below the bucket control head by eight, 3 m-long steel cables (Figure 15). The symmetrical profile of the bucket was maintained by the pressure of the water acting on the inside surface of the bucket (Figure 16) when carrying water and by the tubular, segmented, stainless-steel ring in the upper section of the bucket when empty.

2.26. To fill the bucket with water, the pilot lowered it into a dipping pond. To help the effective filling of the bucket, lead weights were installed on one side, speeding up the submersion and filling process.

2.27. When assembling the bucket for deployment, the eight hook-and-loop fastener tabs (Figure 14) could be opened to accept the tubular, segmented, stainless-steel ring in the upper section of the bucket, then closed to secure it. This allowed disassembly for transport and storage (Figures 18 and 19). The ring had the effect of keeping the top section of the bucket rigid when empty. The operator had kept the bucket in a fully assembled state while in storage to enable rapid deployment.

2.28. A small bladder was attached to the inside wall of the bucket. This bladder could be filled with an additive[11]. Access to fill this bladder was easier with the top ring installed than without. Throughout the operation on the day of the accident, the bladder was filled during every helicopter refuelling cycle. The operator's ground crew member who had carried out this task stated in the operator's internal report that the bucket was in good condition during the last refuelling.

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[10] An assembly containing an arrangement of electrical and pneumatic controls associated with the functioning of the bucket.

[11] A variety of wetting agents or other fire-retardant additives could be mixed with the water to increase the fire-suppression effectivity of the water.

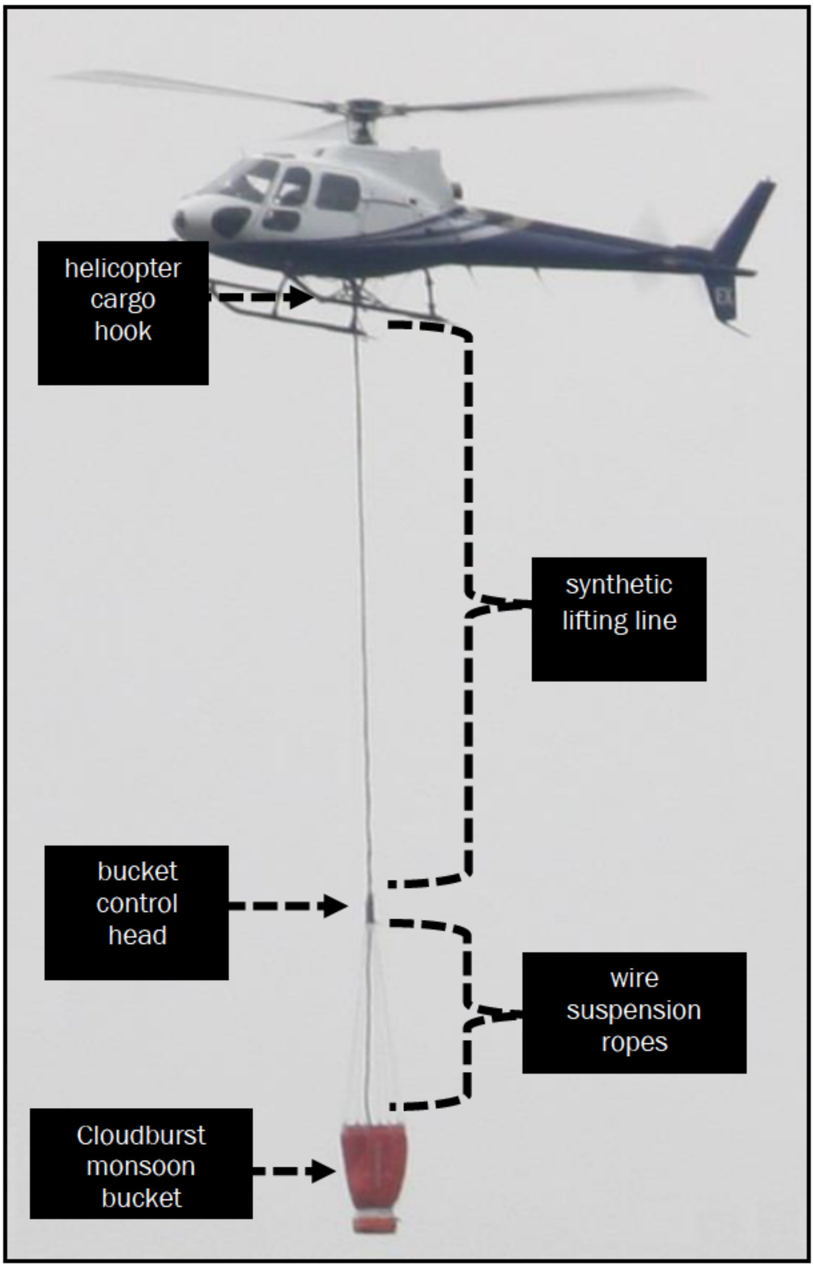

Figure 15: Bucket rigging configuration
(credit: Andy Heap)

Figure 16: Cloudburst 1000 bucket filled during testing (credit: IMS New Zealand)

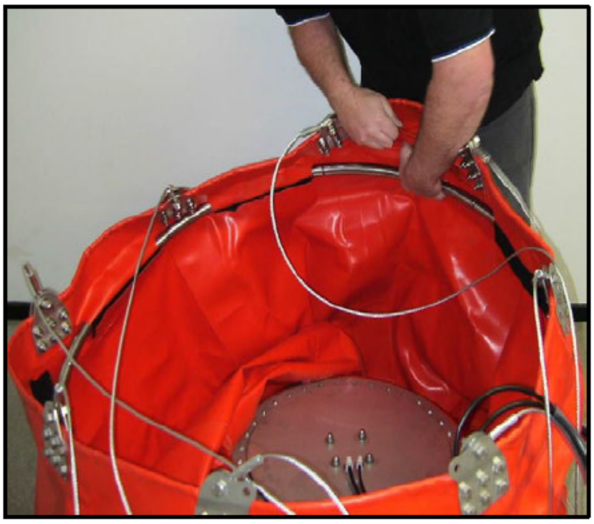

Figure 17: Stainless-steel ring retained in bucket with hook-and-loop fastener (credit: Cloudburst Operation Manual)

Figure 18: Segmented stainless-steel ring (credit: Cloudburst Operation Manual)

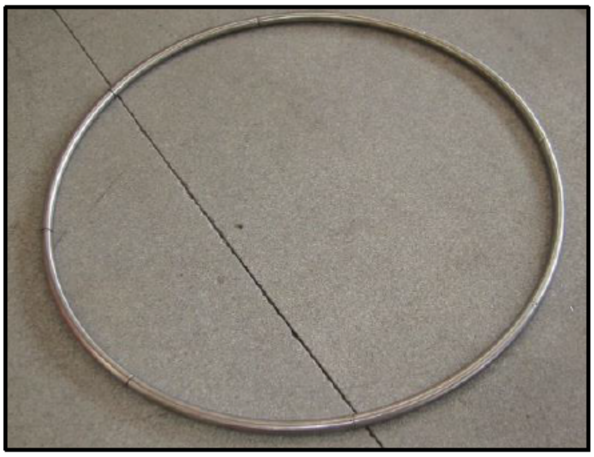

Figure 19: Stainless-steel ring assembled (credit: Cloudburst Operation Manual)

Monsoon bucket certification

2.29. No requirement exists within the Civil Aviation Rules for manufacturers of this type of role equipment[12] to be certificated or to produce operational information to assist with the safe operation of their products.

2.30. The onus was on operators to identify risks associated with the use of any role equipment and mitigate those risks appropriately. The CAA's involvement with such equipment was limited to assessing, and if satisfied approving, an operator's exposition[13], in which maintenance and operating procedures for the use of such role equipment were defined.

Personnel information

2.31. The pilot held a commercial helicopter pilot licence. All required medical and competency assessments were complete and current in accordance with Civil Aviation Rules and the operator's exposition.

2.32. The pilot had been flying helicopters with monsoon buckets in fire-fighting operations since the mid-1970s. The pilot had received recurrent training for the set-up and use of the monsoon bucket on 15 January 2019. At the completion of that training, the pilot had been authorised by the operations manager to conduct operational roles using the monsoon bucket.

2.33. Drug and alcohol tests were conducted at the hospital after the accident. The results for these tests were negative (clear) for both.

Organisational information

2.34. The operator held an operator's certificate issued by the CAA under Civil Aviation Rules Part 135 – Air Operations Helicopters and Small Aeroplanes. The operating certificate permitted the operator to conduct commercial external load operations in accordance with its exposition.

Meteorological information

2.35. Weather stations located at Nelson Airport and Richmond, both within eight nautical miles (15 kilometres) to the north-east of the accident site recorded a wind from the north of about 15 knots (30 kilometres per hour), with no significant cloud coverage and at least 19 kilometres of visibility about the time of the accident.

2.36. The accident pilot, as well as another helicopter pilot working in the immediate area, estimated that the conditions at the accident site were similar to those recorded by the weather stations.

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[12] Equipment that is fitted to an aircraft to enable it to fulfil a particular mission or task.

[13] Documentation approved by the CAA that defined the organisation, identified the senior persons, and detailed the means of compliance with the applicable Civil Aviation Rules.

Survival aspects

2.37. The helicopter structure was not specifically designed to be energy absorbing in the event of an accident, nor was it equipped with energy attenuating seats[14]. However, most of the impact forces were absorbed by the forward landing gear and cabin support structure, when they deformed, as the helicopter struck the ground vertically.

2.38. The pilot's seat was equipped with a four-point harness. The pilot advised that the lap belt component of the harness had been secured and the shoulder strap had been positioned beneath the arms to enable sufficient movement to view the external load.

2.39. The pilot was wearing fireproof overalls and a flight helmet as required by the operator's internal checklist for conducting firefighting operations.

2.40. The helicopter was equipped with an emergency locator transmitter. Impact forces during the accident automatically activated this transmitter. The MEOSAR satellite constellation[15] detected and forwarded the transmission to the Rescue Coordination Centre New Zealand. The pilot turned the transmitter off after ground personnel had arrived at the accident site.

Tests and research

2.41. The helicopter was equipped with a global positioning system (GPS) that recorded its flight path, as well as a satellite-tracking device that was configured to transmit flight data every two minutes. The data obtained from both these devices was analysed to determine the helicopter flight profile leading up to and during the accident.

2.42. An expert metallurgical and chemical analysis of the damage and material transfer observed on the tail rotor assembly was carried out. The report from this analysis concluded:

> The samples of the yellow deposit taken from the leading edge of the fractured blade and the yellow sleeve were analysed using Fourier transform infrared (FTIR) spectroscopy. This analysis showed that the FTIR spectra of both samples was very similar, indicating that both samples were the same polyvinyl chloride (PVC) type material.
>
> The evidence shows that the monsoon rope assembly had been caught in the tail rotor assembly when the tail rotor was rotating, and rotation of the rotor/driveshaft stopped abruptly as a result. Debris found on the tail rotor was analysed and found to be the same material as the yellow rope sleeve material. The rope would have very rapidly been tightly wound around the shaft until it bound, when the drive shaft failed. This process resulted in a hard object of some form impacting or embedding into the

[14] Energy attenuating seats on Airbus Helicopters rotorcraft are designed to stroke and/or plastically deform upon severe impact, absorbing all or a portion of the energy transmitted to the seat during an impact.

[15] A medium Earth orbit, search and rescue satellite constellation operated by the International Cospas-Sarsat Programme.[see https://nzsar.govt.nz/training-resources/start/sar-coordination-and-support/start-module-1/]

tail rotor shaft, bending the tail rotor blade control arms and breaking one of the tail-rotor blades.

Additional information

Fire-control activity standards in New Zealand

2.43. In 2015, the National Rural Fire Authority issued the Standard for Use of Aircraft at Wildfires (the original standard). As the National Rural Fire Authority procured the services of aircraft operators for fire-control activities, the original standard was issued with the purpose of facilitating the effective, efficient and safe use of aircraft engaged in these operations. The requirements of the original standard were imposed by the National Rural Fire Authority (as the customer) in addition to Civil Aviation Rules.

2.44. In 2017, New Zealand's urban and rural fire services combined into a single, integrated fire and emergency service organisation known as Fire and Emergency New Zealand (FENZ). FENZ provided the overarching management of the firefighting resources, which were utilised on this fire, and procured the operator's helicopter services.

2.45. On 30 August 2017, FENZ updated and issued a new standard, which was active at the time of the accident (Fire and Emergency New Zealand, 2017).

2.46. Since then FENZ has adopted an 'all-of-government' approach, which has allowed other New Zealand government agencies to utilise its new standard.

2.47. On 1 May 2020, FENZ further updated the new standard to serve as an interagency standard for the procurement of aircraft to fight wildfires[16].

2.48. The Operational Supplement to the Inter-Agency Standard for Use of Aircraft at Wildfires includes, under Section 23.1 Pilots Using Underslung Loads, the following requirements:

- Operate the helicopter within the flight manual limitations, including limitations relating to configuration and role equipment.
- Only use buckets and related equipment in accordance with the technical requirements, operating instructions and limitations set by the equipment manufacturer and have regard to the effect of the bucket on aircraft performance.
- Ensure the strop length (from the helicopter hook to the bucket attachment cables) is not less than 50ft (15.2 m) for all pilots and all helicopter types.

Operator accreditation

2.49. FENZ stated that to obtain or maintain accreditation, an operator must meet the requirements of the current standard through a verification process and ongoing audit processes. Operators that are unable to conform are subject to a recheck procedure.

2.50. The National Rural Fire Authority had conducted an audit of the operator on 4 May 2017 using the original standard. The operator was subsequently issued with a compliance certificate permitting it to provide helicopter support for fire-suppression operations with the National Rural Fire Authority.

[16] FENZ has advised that its standard will be publicly available on its website from 1 August 2020: https://fireandemergency.nz

3. Analysis

Introduction

3.1. While the helicopter was being flown with an empty monsoon bucket suspended below it, the lifting line struck the helicopter's tail rotor.

3.2. Helicopter external load operations involve hazards additional to normal helicopter flight. Civil Aviation Rules are in place to minimise these risks by restricting such operations; however, operators are required to identify risks specific to their own operations and mitigate these as much as reasonably practicable. The availability of accurate and relevant information assists operators to make well informed decisions and establish appropriate procedures.

3.3. The following section analyses the circumstances surrounding the event to identify those factors that increased the likelihood of the event occurring or increased the severity of its outcome. It also examines any safety issues that have the potential to adversely affect future operations.

What happened

3.4. The pilot stated that while dipping the bucket normally into the dipping pond immediately before the accident the bucket "looked soft" and did not fill correctly. A second attempt was made to lower the bucket into the water, after which, the pilot observed, a weight of 800 kg displayed on the load cell[17]. This confirmed to the pilot that the bucket was filled sufficiently. The pilot recalled the shape of the bucket looking normal and then continuing with the flight as intended.

3.5. The pilot flew to the target area with no noticeable problems, then dropped the load of water on the target area as planned. A climbing turn was commenced towards the dipping pond with the empty bucket.

3.6. During this flight back to the dipping pond, the synthetic lifting line for the bucket contacted the tail rotor, resulting in the failure of the tail rotor and the drive shaft. This was evidenced by:

- fire service personnel and another helicopter pilot stating that they saw the monsoon bucket in close proximity to the tail rotor, followed by the helicopter turning to the left
- the pilot's recollection of the accident sequence
- damage to the tail rotor assembly and the nature of the failure of the tail rotor drive shaft
- the chemical analysis of the material transferred onto the tail rotor assembly, which confirmed that it was the same as the lifting line sheathing.

3.7. With the tail rotor disabled, the pilot was not able to maintain directional control of the helicopter and had to descend into the forested area below to conduct a forced landing.

[17] The load cell presented a real-time weight of the load on the cargo hook to the pilot via a digital cockpit display.

Why it happened

3.8. A number of factors that could have caused the contact between the lifting line and the tail rotor were considered, including:

- environmental conditions/turbulence
- the flight regime, i.e. control inputs/airspeed
- mechanical failure
- the bucket's aerodynamic stability.

3.9. The environmental conditions at the time of the accident were reported as good, with nearby weather stations recording about 15 knots of wind.

3.10. A BK117 helicopter[18] was operating in the same circuit pattern as the accident helicopter. The pilot of that helicopter and the accident pilot had both completed numerous water drops within the circuit and had not experienced any adverse wind conditions or significant turbulence.

3.11. At the start of the accident sequence, the GPS recorded a ground speed of about 70 knots. The GPS data also showed a consistent and predictable flight path throughout the 40-minute flight, with the ground speed under 80 knots. No unpredictable flight characteristics from the bucket were reported when flown at 70 knots airspeed.

3.12. The environmental conditions that existed at the time of the accident, excessive control inputs, excessive speed and any technical/mechanical issues with the helicopter were all eliminated as possible contributing factors by the evidence. Therefore, the investigation focused on the aerodynamic stability of the bucket, which likely resulted in the contact with the tail rotor.

The monsoon bucket's aerodynamic stability

Safety issue: the initial design of the Cloudburst monsoon bucket meant the hook-and-loop fastener system had the potential to come undone during operations

3.13. As the size, shape and weight of underslung loads vary significantly, so does the potential for a load to become aerodynamically unstable. The airspeed of the helicopter also affects the amount of aerodynamic force generated by the load. A higher airspeed will result in larger forces, and a lower airspeed will result in lower forces. The Commission was made aware of previous occurrences of this type of bucket becoming unstable in flight and examined these occurrences to establish if any similarities existed.

Previous occurrences

3.14. The operator's manager of operations recalled an earlier incident involving the same bucket used on the accident flight, when they were gaining their initial experience with it. In that earlier incident the bucket had become aerodynamically unstable as the helicopter gained airspeed, and the bucket had "started to sail". The pilot had landed and found that the bucket's top ring had not been installed correctly. After reinstalling the top ring, the pilot had been able to continue without further incident.

[18] The BK117 was a light twin-engine helicopter.

3.15. The Commission received reports from other operators that used this version of the Cloudburst monsoon bucket. One pilot reported being unable to fill the bucket correctly when dipping into the sea. That pilot noted that two of the hook-and-loop fastener tabs had opened. While the ring had remained in place, the fabric of the bucket had no longer been able to maintain its circular shape. The pilot had dumped all remaining water from the bucket and returned to the staging area. The pilot reported that the bucket had been "misbehaving" and it could not be flown fast. The short flight back to the staging area had been conducted just above translational speed[19].

3.16. A pilot of a third operator also described the bucket not flying correctly due to hook-and-loop fastener tabs opening on at least two occasions.

3.17. Similarities existed between the other pilots' observations and the accident pilot's description of the bucket "looking soft" while filling. Therefore, the investigation sought to understand the bucket's hook-and-loop fastener system.

Hook-and-loop fastener

3.18. The jettisoned bucket was recovered from a forested area at a location approximately 100 m from where the helicopter came to rest. The initial examination of the bucket found that a number of the hook-and-loop fastener tabs had been displaced, the tubular, segmented, stainless-steel ring was no longer in place, and the top of the bucket had collapsed (Figure 12).

3.19. The top section of the lifting line was suspended in a tree and it appeared to have struck tree branches as it fell. One of the hook-and-loop fastener tabs appeared worn when compared to the other tabs. This particular tab was located below the weighted edge, which was at the front of the bucket in normal flight.

3.20. A post-accident examination conducted by the Commission with the assistance of the manufacturer determined that while one of the hook-and-loop fasteners appeared worn, it was capable of supporting the forces expected when filled with water. However, this did not consider the additional aerodynamic loads experienced by the bucket in flight.

3.21. Videos of various Cloudburst buckets in flight were reviewed. It could be seen that when flown empty with the stainless-steel ring secure and in place, the forward surface of the bucket exposed to the airflow was deflected inward by the pressure of the air impinging on the front of the bucket, but it remained stable in flight.

3.22. The combined effects of the fabric deflecting in flight and the flexing of the weighted edge when dipping could have resulted in forces pulling in opposing directions on the hook-and-loop fastener tabs at the front of the bucket. This action, combined with the compromised integrity of the worn hook-and-loop fastener tab, may have resulted in the forward tabs coming undone and the stainless-steel ring becoming dislodged.

3.23. Due to the lack of clear evidence to explain the displaced hook-and-loop fastener, the Commission was unable to determine whether the displaced hook-and-loop fasteners were due to incorrect installation, worn material and flight loads, abnormal forces during

[19] An airspeed after which a helicopter's rotor system generates additional lift for a given power setting. The exact speed is variable dependent on helicopter type and environmental conditions, but ranges from about 16 to 24 knots.

firefighting activities such as striking a submerged object during dipping, or a combination of these.

3.24. While the Commission was unable to determine what initiated the displacement of the hook-and-loop fastener, its displacement likely resulted in the stainless-steel ring becoming dislodged, which allowed the soft fabric of the empty bucket to collapse and change the shape of the front and top of the bucket. The airflow from forward flight acting on the misshapen and collapsed bucket resulted in the bucket becoming aerodynamically unstable and flying significantly higher and closer to the helicopter.

Bucket design evolution

3.25. Since the Cloudburst monsoon bucket's initial design, a number of improvements have been incorporated into the bucket's various components. The early design of the hook-and-loop fastener tabs to retain the tubular, segmented, stainless-steel ring was superseded. The new design was for the ring to be made out of a rigid composite material, in two sections, and for it to be permanently bolted into the bucket.

3.26. IMS advised that the change in design of the top ring enabled the bucket to be more rapidly deployed on site, and the design was not changed because of any safety concerns. IMS advised the Commission that some operators of the earlier-designed bucket had been told that, if they had concerns, they or IMS could carry out a modification to install the top ring in the bucket permanently by stitching the hook-and-loop fastener tabs together.

3.27. Monsoon buckets used for firefighting operations are inherently exposed to harsh operating conditions, where submerged objects or waves may impart forces on the hook-and-loop fasteners. This creates the potential for hook-and-loop fasteners to come undone during operations, as evidenced by the previous occurrences and this accident. Therefore, the Commission has made a recommendation to the manufacturer that all Cloudburst monsoon buckets be fitted with the new design.

3.28. IMS advised the Commission that it had produced 128 buckets with the earlier tubular, segmented, stainless-steel ring. Of these, 33 had been sold in New Zealand. As this equipment had not been controlled or tracked after the initial sale, the status of these earlier buckets could not be determined.

Operational procedures

Safety issue: The manufacturer of the Cloudburst monsoon bucket had not promulgated key operational information on and limitations of the Cloudburst monsoon bucket to operators.

Safety issue: There was insufficient guidance to pilots on the appropriate line length for monsoon bucket operations.

3.29. External loads carried by helicopters have the potential to become unstable in flight. This is a risk that operators normally manage by developing standard operating procedures applicable to each role.

3.30. The availability of information about safe working practices, developed by subject-matter experts such as bucket manufacturers and technical specialists in the field, assists operators to make well informed decisions and establish good procedures. When the relevant guidance is not available, operators may revert instead to personal knowledge and experience to formulate their procedures.

3.31. IMS had developed recommended limitations regarding airspeed, line length, and empty bucket flight configuration for the Cloudburst monsoon bucket and had also published an 'Operation Manual'. This manual provided descriptions of the bucket's components, but contained no information relating to the aforementioned limitations.

3.32. As the aviation regulatory framework did not cover this type of external load equipment, there was no requirement for a manufacturer to promulgate any operational information or limitations, and IMS had not done so. By comparison, the Commission found that a Canadian manufacturer of a similar product, known as a 'Bambi Bucket', had produced detailed operational and service manuals that were accessible to operators (see Appendices 1 and 2 for relevant extract from the Operations Manual).

3.33. When conducting external load operations, a pilot has to decide on the length of the lifting line for the underslung load. The use of a longer lifting line between the helicopter and the underslung load being carried increases the distance that the underslung load needs to move upwards before the lifting line contacts any part of the helicopter. This reduces the likelihood of such contact occurring and increases the time that the pilot has to respond. A shorter line tends to increase the accuracy and efficiency of the operation.

3.34. Section 3 of the Bambi Bucket Operations Manual described a procedure for checking tail rotor clearance when using a line length of less than 15 m. The full procedure is included in Appendix 1 of this report. It is summarised below:

- measure the distance from the cargo hook to the closest point of the helicopter tail rotor
- determine the bucket overall length – including the suspension cables, from the shackle on the head to the lowest point of the bucket
- the tail rotor clearance must be a minimum of 0.15 m.

3.35. In June 2019 Airbus Helicopters issued Safety Information Notice No. 3349-S-25 – 'Follow-up of recommendations and limitations associated with the use of bucket-type fire-fighting systems' (see Appendix 3). This notice defined the importance of following manufacturers' recommendations, reiterated the procedure contained in the Bambi Bucket Operations Manual and expanded its scope to cover all bucket-type suspended systems used for firefighting.

3.36. In summary, this procedure recommended using either a short lifting line configuration that ensured no part of the bucket could ever be closer than 0.15 m from the tail rotor, or a long lifting line of no less than 15 m in length.

3.37. The Commission found that some jurisdictions defined specific operational and equipment requirements for the procurement of helicopter firefighting operations. In the United States for example, the National Wildfire Coordinating Group[20] Standards for Helicopter Operations required lifting lines to be 50 feet (15.2 m) or longer.

[20] The National Wildfire Coordinating Group established standards defining how helicopter operations were to be conducted under the exclusive direction and operational control of federal, state and local agencies.

3.38. The FENZ standard in place at the time of the accident did not have a requirement for lifting line length at the time of the accident. The only reference to lifting line length was that "Strop length shall be optimised with the type of bucket to counter rotor wash on the fire"[21].

3.39. The lifting line used on the accident flight was 8.5 m in length. The Commission identified that three additional accidents had occurred, in New Zealand, Italy and France respectively, involving fire buckets contacting the tail rotors of AS350 helicopters[22]. All four of these helicopters were configured with lifting line lengths placing the buckets within the recommended 'no-go' zone as defined by the Bambi Bucket Operations Manual and the Airbus Safety Information Notice.

3.40. There have been no recorded accidents involving a fire bucket contacting the tail rotor of a helicopter when configured with the recommended length of lifting line.

3.41. The Commission is therefore of the opinion that the recommended limitations for tail rotor clearance, such as described in the Bambi Bucket Operations Manual and the Airbus Safety Information Notice, should be applied to all monsoon buckets.

3.42. At the time of the accident the operator's procedures did not specify the appropriate line length for monsoon bucket operations. It is noted, however, that the Airbus Safety Information Notice was not published until after the accident. The operator has since incorporated the Airbus guidance into its operating procedures and FENZ has included a similar requirement in its updated supplement for wildfire operations.

Other considerations

Comparison with previous accident (Commission inquiry AO-2017-001)

3.43. In another similar accident, which occurred in New Zealand in 2017 and was the subject of a Commission inquiry (AO-2017-001), there were common factors involved with lifting-line length.

3.44. The similarities between the two accidents were: a) each involved a Cloudburst bucket where the rigging contacted the tail rotor of an AS350 helicopter; and b) each bucket was equipped with a lifting line of a length that increased the likelihood of that contact happening. However, the likely initiating cause of the contact between the tail rotor and the bucket rigging differed between the two accidents.

3.45. The helicopter involved in the earlier accident in New Zealand had been equipped with a camera, which had recorded video of the bucket throughout the flight. This video evidence did not reveal any evidence of anomalies with the Cloudburst bucket's tubular segmented steel top ring, or its hook-and-loop fastener retaining system.

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[21] Fire and Emergency New Zealand. Standard for Use of Aircraft at Wildfires. Equipment Section 24, Para 24.1.

[22] Sainte-Rose, France, 24 January 2019, AS350-B3e, registered F-OFML (Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile Final Report, BEA2019-0023); Sardinia, Italy, 21 August 2015, AS350 registered I-GBVD (http://www.ansv.it/cgi-bin/ita/AS350%20I-GBVD%20raccomandazioni%20sicurezza.pdf); Christchurch, New Zealand, 14 February 2017, AS350 registered ZK-HKW (Commission inquiry AO-2017-001).

Notification of occurrences and reporting

3.46. The operator had not reported their earlier incident with this same bucket (see 3.14) through their internal quality and safety management system. As a result, that incident had not been advised to the CAA or used internally to promote awareness or improve operational procedures.

3.47. The operations manager advised that since the earlier occurrence the operator's safety management system had evolved and that such an occurrence would now be captured and actioned appropriately.

3.48. During a separate Commission inquiry into an accident involving a different operator[23], the Commission had determined that an occurrence that related to the likely cause of that accident had not been notified either internally in the operator's systems or through the CAA reporting system. That omission had also resulted in a lost opportunity to share experiences and learnings and potentially prevent a reoccurrence.

3.49. While Civil Aviation Rules Part 12 – Accidents, Incidents, and Statistics defined the requirements to notify the CAA of accidents and certain incidents, the reporting of all occurrences through an operator's internal safety management system should be encouraged.

3.50. On 6 April 2020 IMS issued on its website a Service Information Letter[24] detailing a pre-flight checklist for the Cloudburst bucket with the tubular, segmented, stainless-steel ring and the Velcro retention tabs.

3.51. The Service Information Letter followed an email sent to a mailing list from IMS on 7 February 2020, which included a Cloudburst Fire Bucket Safety Notice. This notice explained that IMS had discovered worn Velcro retention tabs during maintenance and therefore wished to highlight the importance of equipment checks and maintenance to operators of the buckets.

3.52. On 19 May 2020 the CAA made a submission to the Commission in response to receiving a draft copy of this report. The submission outlined that the CAA had issued Continuing Airworthiness Notice 05-012 on 16 April 2020[25]. The Continuing Airworthiness Notice outlined that the CAA strongly recommended that operators and maintainers follow the instructions in the Cloudburst Fire Bucket Service Information Letter, dated 6 April 2020 issued by IMS.

Additional information

3.53. During this inquiry the Commission learned that the CAA was in the process of developing an advisory circular to Civil Aviation Rules Part 133 – Helicopter External Load Operations. This advisory circular was intended to provide additional information pertinent to the equipment and the conduct of helicopter external-load operations. At the time of writing this report, the specific content of the advisory circular was not available to review as it was still in an early draft phase.

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[23] Christchurch, New Zealand, 14 February 2017, AS350 registered ZK-HKW (Commission inquiry AO-2017-001).
[24] https://www.imsheli.com/wp-content/uploads/2016/05/Cloudburst-Fire-Bucket-Checklist-April-2020.pdf
[25] https://www.aviation.govt.nz/assets/aircraft/airworthiness-directives/continuing-airworthiness-notices/can-05-012.pdf.

3.54. In November 2019 the CAA, in conjunction with a commercial supplier of lifting equipment, carried out a number of educational workshops for helicopter operators on how to inspect and safely use lifting equipment.

3.55. Both of these programmes were in development prior to this accident, and were initiated due to an industry-wide recent increase in helicopter external-load incidents.

4. Findings

4.1. The lifting line contacted and disabled the tail rotor while the helicopter was in forward flight.

4.2. It is likely that one or more hook-and-loop fastener tabs holding the tubular, segmented, stainless-steel in place in the monsoon bucket came undone and the bucket ring became displaced.

4.3. The reason for the hook-and-loop fastener tabs becoming undone could not be determined.

4.4. The displaced tubular, segmented, stainless-steel ring very likely allowed the shape of the bucket to change in the airflow, resulting in the bucket suddenly moving into close proximity to the helicopter and the underslung load lifting line, then striking the tail rotor.

4.5. The monsoon bucket had a hook-and-loop fastener system that had the potential to come undone during operations. The bucket manufacturer had developed design improvements to reduce the likelihood of the hook-and-loop fastener tabs coming undone, but these modifications were not mandatory.

4.6. The bucket manufacturer had developed operational information and limitations for the use of its monsoon buckets, but did not proactively promulgate this information to operators.

4.7. The monsoon bucket lifting line was of a length that likely increased the risk of the external load coming into contact with the tail rotor.

4.8. There was insufficient guidance available to pilots on the appropriate line length for monsoon bucket operations.

5. Safety issues and remedial action

General

5.1. Safety issues are an output from the Commission's analysis. They typically describe a system problem that has the potential to adversely affect future operations on a wide scale.

5.2. Safety issues may be addressed by safety actions taken by a participant, otherwise the Commission may issue a recommendation to address the issue.

Design of the hook-and-loop fastener on Cloudburst monsoon buckets

5.3. Monsoon buckets used for firefighting operations are inherently exposed to harsh operating conditions, where submerged objects or waves may impart forces on them. This creates the potential for hook-and-loop fasteners used on the Cloudburst monsoon buckets to come undone during operations. This was evidenced by previous occurrences and this accident.

5.4. The manufacturer has progressively modified the Cloudburst bucket design, which has removed this risk in newer versions. However, IMS advised the Commission that it had produced 128 buckets with the earlier tubular, segmented stainless-steel ring. Of these, 33 had been sold in New Zealand. As this equipment was not controlled or tracked after the initial sale, the status of these earlier buckets could not be determined. Therefore, the Commission has made a recommendation.

5.5. No action has been taken to address this safety issue. Therefore, the Commission has made a recommendation in Section 6 to address this issue.

Promulgation of operational information and limitations of Cloudburst monsoon buckets

5.6. Where manufacturers have information about the safe operation of an item of equipment used in a safety-critical role, but do not make this information readily accessible, operators may develop policies in isolation, possibly resulting in less-than-optimal safe working practices.

5.7. No action has been taken to address this safety issue. Therefore, the Commission has made a recommendation in Section 6 to address this issue.

Insufficient guidance to pilots on the appropriate line length for monsoon bucket operations

5.8. At the time of the accident there was insufficient guidance available to pilots on the appropriate line length for monsoon bucket operations. This increased the risk of an incorrect line length being used and aerodynamically unstable loads contacting the tail rotor.

5.9. Airbus Safety Information Notice No. 3349-S-25, which provides guidance on this issue, was published after the accident. The operator has incorporated this guidance into its operating procedures. The Commission considers this safety action to be appropriate, and has not made a recommendation.

6. Recommendations

General

6.1. The Commission issues recommendations to address safety issues found in its investigations. Recommendations may be addressed to organisations or people, and can relate to safety issues found within an organisation or within the wider transport system that have the potential to contribute to future transport accidents and incidents.

6.2. In the interests of transport safety, it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

6.3. In this case, recommendations have been issued to IMS, with notice of the recommendations given to the CAA.

New recommendations

6.4. On 25 June 2020 the Commission recommended that IMS New Zealand Limited review and enhance the Operation Manuals for all Cloudburst buckets to include any recommended operational and maintenance procedures, guidelines and limitations, and develop a current register of users and actively disseminate this information to them. (007/20)

6.5. On 25 June 2020 the Commission recommended that the Managing Director of IMS New Zealand ensure that all Cloudburst monsoon buckets with hook-and-loop fasteners are modified to incorporate improvements in the fastener design. (008/20)

On 14 July 2020, IMS New Zealand replied:

> Our actions have been:
>
> - Detailed manuals of operation and safety of the Cloudburst Fire Buckets has been significantly evolved since the hook and loop style Cloudburst [sic]. These will continue to evolve with the product development.
> - We have sent out a Safety Information Notice to all the email addresses we have available … (see Appendix 5).
> - Also we have now included in our manual a owners [sic] register to aid the tracking of the ownership on any of our Cloudburst Fire Buckets.

7. Key lessons

7.1. The notification and reporting of all safety-related occurrences by aircraft operators, both internally and externally, presents an opportunity for the sharing of safety lessons, therefore preventing reoccurrences.

8. Data summary

Aircraft particulars

Aircraft registration:	ZK-HEX
Type and serial number:	Airbus Helicopters AS350 FX2: SN: 1654
Number and type of engines:	one Honeywell LTS101 700 D-2: SN: LE-46150C
Year of manufacture:	1982
Operator:	Reid Helicopters Nelson
Type of flight:	fire suppression with monsoon bucket
Persons on board:	one

Crew particulars

Pilot's licence:	commercial pilot licence (helicopter)
Pilot's age:	66
Pilot's total flying experience:	14,980 flight hours (c4,000 hours on type)

Date and time	17 February 2019, 1450	
Location	Wakefield, Nelson	
	latitude:	41° 19′ 60″ S
	longitude:	173° 02′ 42″ E
Injuries	minor	
Damage	substantial	

9. Conduct of inquiry

9.1. On 17 February 2019 the CAA notified the Commission of the occurrence. The Commission subsequently opened an inquiry under section 13(1) of the Transport Accident Investigation Commission Act 1990 and appointed an investigator in charge.

9.2. In accordance with Annex 13 to the Convention on International Civil Aviation, the Commission notified the aircraft state of manufacture, the Bureau d'Enquêtes et d'Analyses of France (BEA), and the engine state of manufacture, the National Transportation Safety Board of the United States. On 18 February 2019 the BEA appointed an accredited representative for France and appointed Airbus Helicopters as its technical adviser.

9.3. On 18 February 2019 Commission investigators travelled to Nelson. They received briefings from the fire service and the police before continuing to the operator's base to conduct interviews with the pilot in command and the operations manager.

9.4. On 19 February a site investigation was conducted and the helicopter wreckage was recovered from the site on the same day. On 20 February the helicopter wreckage was relocated to the Commission secure facility in the Wellington region.

9.5. On 28 February the Commission investigators travelled to the monsoon bucket manufacturer's facility to conduct interviews and gather more information about the Cloudburst monsoon bucket.

9.6. On 7 May 2019 a principal consultant metallurgist from Quest Integrity Group NZL Limited conducted an examination of the damaged tail rotor assembly. Replicas of the damage were made for further laboratory analysis, and samples of the transferred material were provided to Callaghan Innovation to conduct a Fourier transform infrared analysis. On 4 June 2019 Commission investigators received a report detailing the results of these analyses.

9.7. On 14 April 2020 the Commission approved a draft report for circulation to six interested persons for their comment.

9.8. The Commission received four submissions, and changes as a result of these have been included in the final report.

9.9. On 24 June 2020 the Commission approved the final report for publication.

10. Report information

Abbreviations

BEA	Bureau d'Enquêtes et d'Analyses of France
CAA	Civil Aviation Authority of New Zealand
Commission	Transport Accident Investigation Commission of New Zealand
FENZ	Fire and Emergency New Zealand
GPS	global positioning system
Kg	kilogram
m	metre(s)
the bucket	the Cloudburst CB1000MF monsoon bucket that was suspended beneath the helicopter
the helicopter	the AS350 FX2 helicopter, registered ZK-HEX
the pilot	the pilot in command of the helicopter

Glossary

flight manual	a controlled document produced by the helicopter manufacturer and accessible to the pilot from within the cockpit, providing information on, for example, system descriptions and limitations and normal and emergency procedures
knot	a measurement of speed, in nautical miles per hour, equivalent to 1.85 kilometres per hour
monsoon bucket	a generic term to describe a bucket suspended beneath a helicopter, intended to carry and drop water as required. A vast number of different designs are utilised globally
nautical mile	one nautical mile equals 1.852 kilometres

Citations

Airbus Helicopters. (2019). Safety Information Notice No. 3349-S-25 Follow-up of recommendations and limitations associated with the use of bucket-type fire-fighting systems.

CAA. (2020) Continuing Airworthiness Notice – 05-012.

Fire and Emergency New Zealand. (2017). Standard for Use of Aircraft at Wildfires.

IMS New Zealand Limited. (n.d.). Cloudburst Fire Bucket Operation Manual.

IMS New Zealand Limited. (2020) Safety Information Letter 6 April 2020.

National Wildfire Coordinating Group (USA). (2019). NWCG Standards for Helicopter Operations.

SEI Industries Limited. (2019). Bambi Bucket Operations Manual 2019A.

Transport Accident Investigation Commission. (2018). Final Report AO-2017-001.

Transport Accident Investigation Commission. (2018). Interim Report AO-2018-009.

11. Notes about Commission reports

Commissioners

Chief Commissioner	Jane Meares
Deputy Chief Commissioner	Stephen Davies Howard
Commissioner	Richard Marchant
Commissioner	Paula Rose, QSO

Key Commission personnel

Chief Executive	Lois Hutchinson
Chief Investigator of Accidents	Aaron Holman
Investigator in Charge	Steven Walker
General Counsel	Cathryn Bridge

Citations and referencing

This draft report does not cite information derived from interviews during the Commission's inquiry into the occurrence. Documents normally accessible to industry participants only and not discoverable under the Official Information Act 1982 are referenced as footnotes only. Publicly available documents referred to during the Commission's inquiry are cited.

Photographs, diagrams, pictures

The Commission has provided, and owns, the photographs, diagrams and pictures in this report unless otherwise specified.

Verbal probability expressions

This report uses standard terminology to describe the degree of probability (or likelihood) that an event happened or a condition existed in support of a hypothesis. The expressions are defined in the table below.

Terminology*	Likelihood	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

*Adopted from the Intergovernmental Panel on Climate Change

Appendix 1: Bambi Bucket tail rotor clearance

Section 3: Deploying the Bucket

Checking Tail Rotor Clearance

WARNING

Using a Bambi Bucket with insufficient tail rotor clearance could result in a tail rotor strike which could result in serious injury or death.

NOTICE

If using a longline, the minimum recommended length is 50 ft (15 m).

When a Bambi Bucket is attached directly to the helicopter cargo hook or attached using a longline less than 50 ft (15 m) in length, it is important to confirm that there is adequate tail rotor clearance. Before using the Bambi Bucket, check the tail rotor clearance.

1. Determine the tail rotor length by measuring the distance from the cargo hook to the closest point on the helicopter tail rotor.
2. Determine the bucket overall length from the following chart:

Model	Overall Length	
BB6072	12'- 11"	3.94 m
BB8096	14'- 6"	4.42 m
BB8096S	12'- 11"	3.94 m
BB9011	14'- 6"	4.42 m
BB9011S	12'- 11"	3.94 m
BB1012	14'- 6"	4.42 m
BB1012S	12'- 11"	3.94 m
BB1214	14'- 10"	4.52 m
BB1214S	13'- 3"	4.04 m
BB1518	15'- 2"	4.62 m
BB1518S	13'- 7"	4.04 m
BB1821	15'- 11"	4.85 m
BB1821S	14'- 5"	4.39 m
BB2024	20'- 1"	6.13 m
BB2024S	15'- 10"	4.82 m

Model	Overall Length	
BB2226	15'- 10"	4.82 m
BB2732	23'- 0"	7.00 m
BB2732S	15'- 2"	4.63 m
BB3542	23'- 8"	7.22 m
BB420B	23'- 8"	7.22 m
BB4453	23'- 9"	7.25 m
BB5566	24'- 0"	7.32 m
BB680K	24'- 0"	7.32 m
BB6578	24'- 2"	7.37 m
BB7590	30'- 3"	9.21 m
BBHL4000	31'- 8"	9.65 m
BBHL5000	32'- 0"	9.75 m
BBHL7600	32'- 5"	9.87 m
BBHL9800	33'- 6"	10.21 m

Lengths are accurate to within 1%. Specifications subject to change.
If a firesock is used, add 8" (0.20m) to the above dimensions.

To confirm the bucket overall length, stretch out the bucket on the ground, pulling the suspension cables taut. Measure the distance from the shackle on the head to the bottom of the extended dump valve. If a firesock is attached, measure to the bottom of the firesock.

3. The tail rotor clearance is equal to the tail rotor length minus the bucket overall length.
4. **The tail rotor clearance must be a minimum of 6" (0.15 m).**

Bambi BUCKET Driven by Innovation

Bambi Bucket Operations Manual 7

Extract from SEI Industries Bambi Bucket Operations Manual 2019A

Appendix 2: Bambi Bucket flight operations

Section 4: Flight Operations

Section 4: Flight Operations

Flying the Bucket

The Bambi Bucket should be flown in accordance with the United States Forest Service recommendations limiting all helicopters, other than tandem rotor, to a maximum 80 KIAS while conducting external cargo hook operations.

The recommended never exceed speed (VNE) for the Bambi Bucket is 80 KIAS, however, this is not a flight manual limitation. Speeds above 80 KIAS should be approached with caution and any decision to exceed this speed should be based on flight characteristics, aircraft flight manual limitations, aircraft/bucket configuration and load stability, etc.

Any change that exceeds this recommendation should be formally authorized in your company's external load specifications. A suggested flight procedure is to build up speed slowly with the Bambi Bucket, under prevailing conditions, to determine a safe maximum flying speed.

In order to reduce drag on the bucket when empty, it can be flown in a valve open position by pressing the release mechanism once while in forward flight.

The dead weight of the load ensures different handling characteristics than when flying empty. As a result, the Bambi Bucket does not 'pulse' or 'throb' under load in flight.

Extract from SEI Industries Bambi Bucket Operations Manual 2019A

Appendix 3: Airbus Helicopters Safety Information Notice

AIRBUS HELICOPTERS

No. 3349-S-25

SAFETY INFORMATION NOTICE

SUBJECT: EQUIPMENT AND FURNISHINGS

Follow-up of recommendations and limitations associated with the use of bucket-type fire-fighting systems

For the attention of

AIRCRAFT CONCERNED	Version(s)	
	Civil	Military
EC120	B	
AS350	B, BA, BB, B1, B2, B3, D	L1
AS550		A2, C2, C3, U2
AS355	E, F, F1, F2, N, NP	
AS555		AF, AN, SN, UF, UN, AP
EC130	B4, T2	
SA365 / AS365	C1, C2, C3, N, N1, N2, N3	F, Fs, Fi, K, K2
AS565		MA, MB, SA, SB, UB, MBe
SA366		GA
EC155	B, B1	
SA330	J	Ba, L, Jm, S1, Sm
ALOUETTE II	313B, 3130, 318B, 318C, 3180	
ALOUETTE III	316B, 316C, 3160, 319B	
LAMA	315B	
EC225	LP	
EC725		AP
AS332	C, C1, L, L1, L2	B, B1, F1, M, M1
AS532		A2, U2, AC, AL, SC, UE, UL
EC175	B	
EC339		KUH/Surion
BO105	C (C23, CB, CB-4, CB-5), D (DB, DBS, DB-4, DBS-4, DBS-5), S (CS, CBS, CBS-4, CBS-5), LS A-3	CBS-5 KLH, E-4
MBB-BK117	A-1, A-3, A-4, B-1, B-2, C-1, C-2, C-2e, D-2, D-2m	D-2m
EC135	T1, T2, T2+, T3, P1, P2, P2+, P3, EC635 T1, EC635 T2+, EC635 T3, EC635 P2+, EC635 P3, T3H, P3H, EC635 T3H, EC635 P3H	

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This document is available on the internet: www.airbushelicopters.com/techpub/

AIRBUS HELICOPTERS

No. 3349-S-25

Airbus Helicopters recently participated in several investigations into accidents and serious incidents during fire-fighting operations involving helicopters equipped with Bucket*-type suspended systems installed under STC (Supplemental Type Certificate).

Airbus Helicopters reminds you that the use of such installations must be compliant with the recommendations of the manufacturer's/STC owner's Operations Manual.

Typically the Bucket-Type operations are performed on a short line or via a long line. This SIN pertains to both of these operations and gives advice for each. In summary, there is a maximum line length for short line operations and a minimum line length for long line operations.

For Bambi Bucket-type water bombing systems, the manufacturer's Operations Manual recommends a maximum speed (VNE) of 80 knots for all operations. In the case of short line operations, the total length of the system (firesock deployed) must be less than the length from the cargo sling/swing hook to the tail rotor disc decreased by at least 6 inches (≈150 mm).

Measuring the bucket. If a Firesock is to be used, attach first and then measure to the bottom of the sock. See Section 4: Flight Operations for information on how to use the Firesock.

Important Note

A) Always measure the overall extended length of your Bambi bucket.

and

B) Measure the distance from the belly hook to the closest possible point on the tail rotor.

"B" must always exceed "A" by at least six (6) inches.

Extract from the Bambi Bucket manufacturer's Operations Manual

For long line operations, the Bambi Bucket manufacturer's Operations Manual requests a minimum long line length of 50 ft (15 meters).

AIRBUS HELICOPTERS

No. 3349-S-25

Important Note

It is recommended that operators, who choose to use the Bambi bucket with a longline, ensure that the longline is at least 50' long.

Extract from the Bambi Bucket manufacturer's Operations Manual

NOTE: For Bambi Bucket-type water bombing systems validated/approved by Airbus Helicopters, these recommendations for use are taken into account in the Bambi Bucket definition published in the Flight Manual supplements of the Airbus Helicopters aircraft concerned.

In most of the recent accidents and serious incidents which occurred during fire-fighting operations with this type of system, analyses of the events showed that they were due to collision of the Bambi Bucket itself or the bombing/attachment hangers with the tail rotor during aerial maneuvers.
The systems used were not compliant with the recommendations indicated above:
- use of a long line which was too short, or
- Bambi Bucket with a total length that exceeded the distance between the hook and the tail rotor disc for short line operations, or
- speed beyond maximum speed (VNE).

Airbus Helicopters thus emphasizes the importance of complying with the recommendations of the Bambi Bucket manufacturer's Operations Manual for this type of installation and the equivalent recommendations in Operations Manuals of similar devices.

These recommendations complement those published in the Flight Manual supplements on external load carrying missions and especially the maximum speed (VNE) limitation.

As a complement to this Safety Information Notice (SIN), Airbus Helicopters also reminds you of Safety Information Notice (SIN) No. 3170-S-00 issued on October 03, 2017, which drew your attention to the risks and precautions associated with external load carrying operations. These precautions also apply to the operations with a Bucket*-type installation.

* Bucket is the generic term which represents all the systems used for fire-fighting (examples: Bambi-Bucket, Monsoon Bucket, Cloudbuster Bucket, etc.).

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This document is available on the internet: www.airbushelicopters.com/techpub/

Appendix 4: IMS New Zealand Limited Safety Information Letter 6 April 2020

IMS NEW ZEALAND LTD
HELICOPTER EQUIPMENT SPECIALISTS

CLOUDBURST FIRE BUCKET

6th April 2020

Cloudburst Fire Bucket Service Information

For those helicopter operators that are using the Cloudburst Fire Bucket with the stainless steel folding ring and Velcro retention tabs, we at IMS would like to take this opportunity to remind you of the areas that may cause concern with the use of these buckets with the Velcro.

As we strive to ensure safety in the design of the Cloudburst fire bucket with functionality following closely behind, we wish to notify operators of the areas to check and maintain to continue the safe operation of these buckets.

Some of you will have Cloudburst fire buckets with the stainless steel folding top ring and Velcro retention tabs. If you have one of these buckets please ensure that for the safe operation of these buckets the following pre-flight procedures are adhered to.

Pre-flight Safety Check List

Cloudburst buckets should receive a strict pre-flight inspection on every component according to the checklist below before each flight, to ensure the safety and the quality of the operation.

No.	Valve & Cloudburst Bag	Check	Remarks
1	Check all fastenings on the valve, ensure all are tight.		
2	Check the monsoon seal is in good condition		
3	Check the air cylinder and spear are in good condition		
4	Check all air hoses and fittings are free from damage and are not leaking		
5	Ensure there is not damage to the Cloudburst orange shell		

No.	Foam Bladder (Optional)	Check	Remarks
6	Check the bladder has no mechanical damage causing leakage		
7	Ensure all fittings are secure and free from damage		
8	Check bladder mounting is secure at top and bottom of bladder		

No.	Top section of Cloudburst	Check	Remarks
9	Check stainless steel folding top ring has no damage and bungee cord inside is tight and the bungee remains to be elastic.		
10	Inspect the Velcro tabs, ensure the Velcro is clean and their adhesion is very good and all the Velcro area is joined. You should not be able to break the grip of the Velcro by applying 30-40kgs of downward force upon the stainless ring with one hand and holding a lift cleat with the other hand. Should the Velcro not hold the ring securely then repair is required immediately		
11	Check the lifting lugs and ensure the top ring is in good repair and fastenings are tight.		
12	Check lift strops are in good condition and are secured correctly.		

No.	Lift Hub	Check	Remarks
13	Check the shackle connection to the underside of the Lift Hub		
14	Check the shackles are wire locked.		
15	Check the Lift Hub body for signs of mechanical damage.		
16	Check service cable and hose coming and out of Lift Hub are in good condition		
17	Make sure connection to the line above the Lift Hub is secured properly.		
18	Ensure that the lift lines to the Cloudburst Bucket from The Lift Hub are aligned and not crossed over.		

No.	Longline	Check	Remarks
19	Check line and cover for abnormalities		
20	Checks services at each end for damage		

Caution:

The pilot is responsible for determining the speed according to the load, line length and acknowledging the weather conditions

Flying with the Monsoon Valve open, when not filled with water, will aid in the flight stability of your Cloudburst Fire Bucket

Should anyone have any concerns about their Cloudburst fire bucket please contact us or send you bucket to us for a free assessment/inspection of its safety and operational function.

Please join our Facebook pages or sign up to our newsletters on our website to keep informed with any updates from IMS. Our links to these pages are below

Kind Regards

Richard Lane

Managing Director

IMS NEW ZEALAND LTD
HELICOPTER EQUIPMENT SPECIALISTS

Facebook: *IMS New Zealand - International Helicopter Equipment Specialists*
Cloudburst Fire Bucket for Aerial Firefighting
Ground-Effect Spreading Bucket for Aerial Agriculture

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Appendix 5: IMS New Zealand Limited Safety Information Notice 3 July 2020

IMS NEW ZEALAND LTD

FACEBOOK INSTAGRAM

Safety Information Notice

Cloudburst Fire Bucket

Stainless Steel Top Ring

CLICK HERE TO DOWNLOAD THE OFFICIAL NOTICE

If you or someone you know is the operator of a Cloudburst Fire Bucket with a stainless steel removable top ring please email IMS to arrange to have a remedy completed or a remedy procedure sent out to you.

Issue:

Possible dislodging of stainless steel top ring.

Hazard:

Can create unstable flight characteristics if the ring becomes dislodged.

What to do:

If you or someone you know is the operator of a Cloudburst Fire Bucket **with a stainless steel removable top ring** please email IMS to arrange to have a remedy completed or a remedy procedure sent out to you.

Contact details:

Email: **richard@imsheli.com** or **service@imsheli.com**

IMS NEW ZEALAND LTD
HELICOPTER EQUIPMENT SPECIALISTS

TAIC Kōwhaiwhai - Māori scroll designs

TAIC commissioned its kōwhaiwhai, Māori scroll designs, from artist Sandy Rodgers (Ngati Raukawa, Tuwharetoa, MacDougal). Sandy began from thinking of the Commission as a vehicle or vessel for seeking knowledge to understand transport accident tragedies and how to prevent them. A 'waka whai mārama (i te ara haumaru) is 'a vessel/vehicle in pursuit of understanding'. Waka is metaphor for the Commission. Mārama (from 'te ao mārama' – the world of light) is for the separation of Rangitāne (Sky Father) and Papatūānuku (Earth Mother) by their son Tāne Māhuta (god of man, forests and everything dwelling within), which brought light and thus awareness to the world. 'Te ara' is 'the path' and 'haumaru' is 'safe or risk free'.

Corporate: Te Ara Haumaru - The safe and risk free path

The eye motif looks to the future, watching the path for obstructions. The encased double koru is the mother and child, symbolising protection, safety and guidance. The triple koru represents the three kete of knowledge that Tāne Māhuta collected from the highest of the heavens to pass their wisdom to humanity. The continual wave is the perpetual line of influence. The succession of humps represent the individual inquiries.

Sandy acknowledges Tāne Māhuta in the creation of this Kōwhaiwhai.

Aviation: ngā hau e whā - the four winds

To Sandy, 'Ngā hau e whā' (the four winds), commonly used in Te Reo Māori to refer to people coming together from across Aotearoa, was also redolent of the aviation environment. The design represents the sky, cloud, and wind. There is a manu (bird) form representing the aircraft that move through Aotearoa's 'long white cloud'. The letter 'A' is present, standing for aviation.

Sandy acknowledges Ranginui (Sky father) and Tāwhirimātea (God of wind) in the creation of this Kōwhaiwhai.

Marine: ara wai - waterways

The sections of waves flowing across the design represent the many different 'ara wai' (waterways) that ships sail across. The 'V' shape is a ship's prow and its wake. The letter 'M' is present, standing for 'Marine'.

Sandy acknowledges Tangaroa (God of the sea) in the creation of this Kōwhaiwhai.

Rail: rerewhenua - flowing across the land

The design represents the fluid movement of trains across Aotearoa. 'Rere' is to flow or fly. 'Whenua' is the land. The koru forms represent the earth, land and flora that trains pass over and through. The letter 'R' is present, standing for 'Rail'.

Sandy acknowledges Papatūānuku (Earth Mother) and Tāne Mahuta (God of man and forests and everything that dwells within) in the creation of this Kōwhaiwhai.

Transport Accident Investigation Commission

Recent Aviation Occurrence Reports published by the Transport Accident Investigation Commission (most recent at top of list)

AO-2017-004	MBB BK117 A-3 helicopter, ZK-IED, Loss of control, Porirua Harbour, 2 May 2017
AO-2017-002	Robinson Helicopter Company R22, ZK-IHA, Impact with terrain, Near Reefton, 27 March 2017
AO-2017-003	ATR72, ZK-MCY, Landing gear failure, Nelson, 9 April 2017
AO-2015-003	Robinson R44, Main rotor blade failure, Waikaia, Southland, 23 January 2015
AO-2015-007	Airbus Helicopters AS350BA, ZK-HKU, Collision with terrain, Fox Glacier, 21 November 2015
AO-2017-007	Airbus A320 VH-VGY, Descent below clearance limit, Christchurch, 6 August 2017
AO-2016-007	Collision with terrain, Robinson R44, ZK-HTH, Glenbervie Forest, Northland, 31 October 2016
Interim Report AO-2018-009	MDHI (Hughes) 369D, registration ZK-HOJ, Wanaka, 18 October 2018
Interim Report AO-2018-006	Robinson R44, ZK-HTB, Stevensons Arm, Lake Wanaka, 21 July 2018
AO-2016-008	Robinson R66 helicopter, Partial power loss– forced landing, Hokonui Hills, Southland, 14 November 2016
AO-2015-009	Air traffic control incidents, Hamilton aerodrome,17 December 2015
AO-2017-001	Eurocopter AS350 BA, ZK-HKW, Collision with terrain, Port Hills, Christchurch, 14 February 2017
Interim Report AO-2017-004	Forced landing into Porirua Harbour (Pauatahanui Arm), MBB BK117A-3 Helicopter, ZK-IED, 2 May 2017
Interim AO-2017-009 and AO-2017-010	AO-2017-009: Boeing 787-9, registration ZK-NZE, Trent 1000-J2 engine failure near Auckland, 5 December 2017; and AO-2017-010: Boeing 787-9, registration ZK-NZF, Trent 1000-J2 engine failure, near Auckland, 6 December 2017
AO-2016-006	Eurocopter AS350-B2, ZK-HYY, Collision with terrain during scenic flight, Mount Sale, near Arrowtown, 12 September 2016

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