Transport Accident Investigation Commission

Final report
Tuhinga whakamutunga

Aviation inquiry AO-2024-005
Airbus Helicopters AS 350 BA, ZK-HJM
Impact with terrain
Paringa River,
40 km northeast of Haast
20 July 2024

June 2026

The Transport Accident Investigation Commission
Te Kōmihana Tirotiro Aituā Waka

No repeat accidents – ever!

"The principal purpose of the Commission shall be to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future, rather than to ascribe blame to any person."

Transport Accident Investigation Commission Act 1990, s4 Purpose

The Transport Accident Investigation Commission is an independent Crown entity and standing commission of inquiry. We investigate selected maritime, aviation and rail accidents and incidents that occur in New Zealand or involve New Zealand-registered aircraft or vessels.

Our investigations are for the purpose of avoiding similar accidents and incidents in the future. We determine and analyse contributing factors, explain circumstances and causes, identify safety issues, and make recommendations to improve safety. Our findings cannot be used to pursue criminal, civil, or regulatory action.

At the end of every inquiry, we share all relevant knowledge in a final report. We use our information and insight to influence others in the transport sector to improve safety, nationally and internationally.

Commissioners

Chief Commissioner	David Clarke
Deputy Chief Commissioner	Stephen Davies Howard
Commissioner	Paula Rose, QSO
Commissioner	Bernadette Roka Arapere (until 6 November 2025)

Key Commission personnel

Chief Executive	Martin Sawyers
Chief Investigator of Accidents	Louise Cook
Investigator-in-Charge for this inquiry	Hamish Johnstone
Commission General Counsel	Sid Wellik

Notes about Commission reports
Kōrero tāpiri ki ngā pūrongo o te Kōmihana

Photographs, diagrams, pictures

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

Time, altitude, distance and speed

Times referred to in this report are stated in the applicable local time, being either New Zealand Standard Time (NZST), which is Universal Time Coordinated (UTC) + 12 hours or New Zealand Daylight Time (NZDT), which is UTC + 13 hours. In New Zealand, in accordance with exceptions to the International System of Units and with the Aeronautical Information Publication New Zealand (AIPNZ) Gen 2.1, altitudes, elevations and heights are measured in feet. In this report these parameters are therefore only expressed in feet (ft) without a metric equivalent. Navigational distances are stated in nautical miles, vertical speed in feet per minute, and horizontal speed in knots (being nautical miles per hour).

Verbal probability expressions

For clarity, the Commission uses standardised terminology where possible.

One example of this standardisation is the terminology used to describe the degree of probability (or likelihood) that an event happened, or a condition existed in support of a hypothesis. The Commission has adopted this terminology from the Intergovernmental Panel on Climate Change and Australian Transport Safety Bureau models. The Commission chose these models because of their simplicity, usability, and international use. The Commission considers these models reflect its functions. These functions include making findings and issuing recommendations based on a wide range of evidence, whether or not that evidence would be admissible in a court of law.

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	

Figure 1: Airbus Helicopters AS 350 BA, ZK-HJM
(Credit: Amuri Helicopters Limited)

Figure 2: Location of accident
(Credit: Land Information New Zealand | Toitū Te Whenua)

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1 Executive summary
Tuhinga whakarāpopoto

What happened

1.1. On 20 July 2024, a pilot and passenger were repositioning an Airbus Helicopter AS 350 BA helicopter, ZK-HJM (the helicopter) from Queenstown to Franz Josef after maintenance.

1.2. After flying for about 52 minutes, the pilot felt a jolt in the airframe then noticed that the main rotor blade tips were no longer following the same path, as seen from the cockpit. About seven minutes later, when the pilot began a descent for a precautionary landing, the cyclic control[1] became significantly harder to push in one direction. The helicopter was still controllable, and they continued to descend for a precautionary landing near a small settlement close to the Paringa River mouth.

1.3. As the helicopter was approaching to land, at about 10 to 20 feet above the ground, it made an unintentional roll[2] to the left and then collided with terrain.

1.4. The helicopter came to rest on its left side, facing about 180 degrees from the original direction of travel.

1.5. The activation of the helicopter's emergency locator transmitter[3] alerted the Rescue Coordination Centre who dispatched a rescue helicopter to the site. Both occupants were transported to hospital with minor injuries. The helicopter suffered significant damage.

Why it happened

1.6. The left and right main rotor hydraulic servo actuators[4] (the servos) were swapped over during the maintenance check prior to the accident flight. Both parts of the duplicate safety inspection[5] had been certified as complete by trained, qualified and authorised personnel.

1.7. It is **virtually certain** that the bolt securing the lower end of the left-hand servo became detached during flight resulting in a change in the control characteristics of the helicopter and influencing the outcome of the landing.

1.8. Despite the requirement for a duplicate safety inspection, and the number of pilot pre-flight inspections that were undertaken, it is **very likely** that the engineers who conducted each part of the duplicate safety inspection were distracted and did not

[1] The control that changes the pitch angle of the rotor blades individually during a cycle of revolution, and as a result tilts the main rotor disc to control the direction and velocity of flight.

[2] The helicopter rolled about the longitudinal axis without conscious or deliberate control input from the pilot.

[3] An emergency locator transmitter transmits a distress signal to the Cospas-Sarsat search and rescue satellite system.

[4] A servo is a hydraulic actuator that assists the movement of a mechanism.

[5] Designed to verify that a critical maintenance task has been done correctly, and identify and capture any errors that may have occurred during the conduct of the maintenance task. It is not simply a process of confirming the work has been carried out, but a detailed review of the maintenance actions, *see* Advisory Circular (AC) 43-1, 3.3.

adequately verify that the left and right main rotor servo swap had been completed correctly.

1.9. It is **likely** that the engineer who certified the second part of the duplicate safety inspection was experiencing a level of cumulative fatigue[6] that contributed to the error.

What we can learn

1.10. A thorough handover and pre-flight inspection are important following any maintenance activity, especially when there has been any disturbance of the primary flight controls.

1.11. The duplicate safety inspection is an essential part of maintenance on critical flight controls and must be performed thoroughly and carefully.

1.12. Proper and timely record keeping is an important part of the maintenance of aircraft and should be completed as soon as practicable at the completion of each task.

1.13. Distractions, including interruptions, are an ever-present risk to aviation safety and need to be managed to ensure critical tasks are completed correctly.

1.14. A run-on landing[7] with minimal changes to the flight controls and power required will usually provide the safest method to approach and landing when the integrity of the primary flight controls of a helicopter is unknown.

1.15. On-board video recorders can provide valuable information for transport safety investigations to assist with determining the circumstances and causes of accidents and incidents, to avoid similar occurrences in the future.

Who may benefit

1.16. All pilots, operators, maintenance providers and their staff may benefit from the findings in this report.

[6] Characterised by a progressive state of exhaustion that builds up over time due to consistent physical or mental exertion without sufficient recovery. Unlike acute fatigue, which can be resolved with a good night's sleep or a short break, cumulative fatigue persists and often requires more structured intervention to address. It is fundamentally a state of incomplete recovery from recurring stressors, leading to an increasing deficit in energy and performance over time.

[7] A landing with significant forward motion, as opposed to a landing from a hover. After touchdown, forward motion is maintained until ground friction brings the helicopter to a halt. It is generally used when there is insufficient power to sustain a hover or to reduce the power required and control inputs required in some emergency situations where the integrity of the primary flight controls of a helicopter is unknown.

2 Factual information
Pārongo pono

Narrative

Accident flight

2.1. At 1347 on Saturday 20 July 2024, Airbus Helicopters AS 350 BA helicopter ZK-HJM (the helicopter), operated by Amuri Helicopters Limited (the operator), departed from the Salus Aviation (AW) Limited (the maintenance provider) hangar at Queenstown Aerodrome. It was a non-revenue repositioning flight to Franz Josef with two people on board.

2.2. The helicopter had been released to service after completing planned maintenance, (*see* paragraph 2.16). The pilot had also flown the helicopter the previous day for a series of operational flight checks. The passenger,[8] in their role as the operator's chief pilot, had also flown the helicopter earlier in the day as part of the post-maintenance acceptance process.

2.3. The accident flight was initially uneventful. The on-board video and audio recorder (on-board video) captured the pilot remarking how smoothly the helicopter was flying[9] after the maintenance work.[10]

2.4. About 52 minutes into the flight, the pilot reported feeling a slight jolt in the aircraft and commented to the passenger that the helicopter's main rotor blades appeared to go 'out of track'.[11] The pilot and passenger discussed the out-of-track condition and possible causes and initially chose to continue with the flight.

2.5. About seven minutes later, after further discussion, the pilot and passenger collectively decided to make a precautionary landing to check the helicopter, near a settlement close to the Paringa River mouth.

2.6. When the pilot lowered the collective to descend, the out-of-track and vertical vibration became more pronounced and they found that the cyclic control had become harder to move to the left. The pilot and passenger discussed the development, noting that it appeared to be consistent with a single hydraulic servo failure.[12]

2.7. The pilot and passenger discussed the likelihood of a single hydraulic servo failure. The pilot informed the Commission that at the time they did not consider that they could have had either a main rotor servo slide valve seizure or a hydraulic system pressure loss. They then chose to land on a grass area near the Paringa River mouth.

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[8] Although there were two pilots on board, only a single set of flight controls were fitted for the right-hand pilot position.

[9] Recorded on the installed Eye In The Sky™ cockpit video recorder that also recorded intercom and radio communications.

[10] There had been several maintenance actions to improve the flight characteristics of the aircraft, including repairing the bracket for one of the vibration dampening weights under the floor of the helicopter, resetting the main rotor blade trim tabs to zero, then tracking and balancing the main rotor blades.

[11] When the main rotor blade tips are not following the same path as seen from the cockpit.

[12] A single hydraulic servo failure refers to a failure of a single component within a hydraulic servo system. This failure can be due to various reasons such as contamination, wear or inadequate maintenance. It is characterised by a specific malfunction of the servo valve, which can lead to reduced control precision.

During interviews the pilot said that they intended to make a run-on landing to the flat grass area (*see* Figure 3).

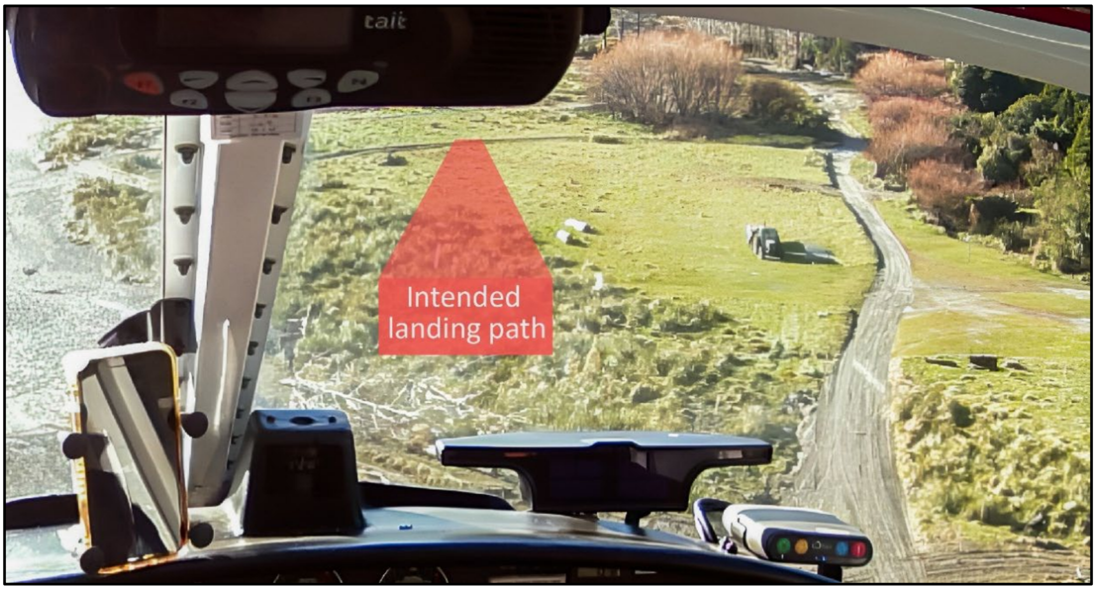

Figure 3: Landing Site
(Credit: On-board video camera)

2.8. Immediately prior to landing, when the helicopter was about 10 to 20 feet above the ground, the on-board video showed the torque[13] increasing through 40 to 60%, and the pilot stated that they were 'out of control'.

2.9. The helicopter then commenced an uncommanded roll to the left, resulting in it impacting the ground and coming to rest on its left-hand side, facing about 180 degrees from the approach direction (*see* Figure 4).

2.10. The passenger vacated the helicopter through the broken front left window. The pilot shut down the engine by closing the fuel lever, then also vacated via the same window.

2.11. The helicopter's emergency locator transmitter (ELT) was activated automatically on impact. The Rescue Coordination Centre (RCC) received an alert at 1451, and a search and rescue helicopter was dispatched.

2.12. The pilot and passenger inspected the helicopter after the accident. They discovered a bolt missing from the lower attachment point where the left main rotor hydraulic servo connects to the transmission housing (*see* Figure 5 and Appendix 1). After the accident, the pilot and passenger located the bolt on the helicopter transmission deck. However, the nut was unable to be located at the site.

2.13. The rescue helicopter arrived about 1600 and transported the pilot and passenger to Grey hospital in Greymouth with minor injuries.

[13] The amount of torque is directly related to the amount of engine power being used to turn the main rotor disk, and the cockpit display is shown as a percentage of the maximum engine torque as defined by the manufacturer.

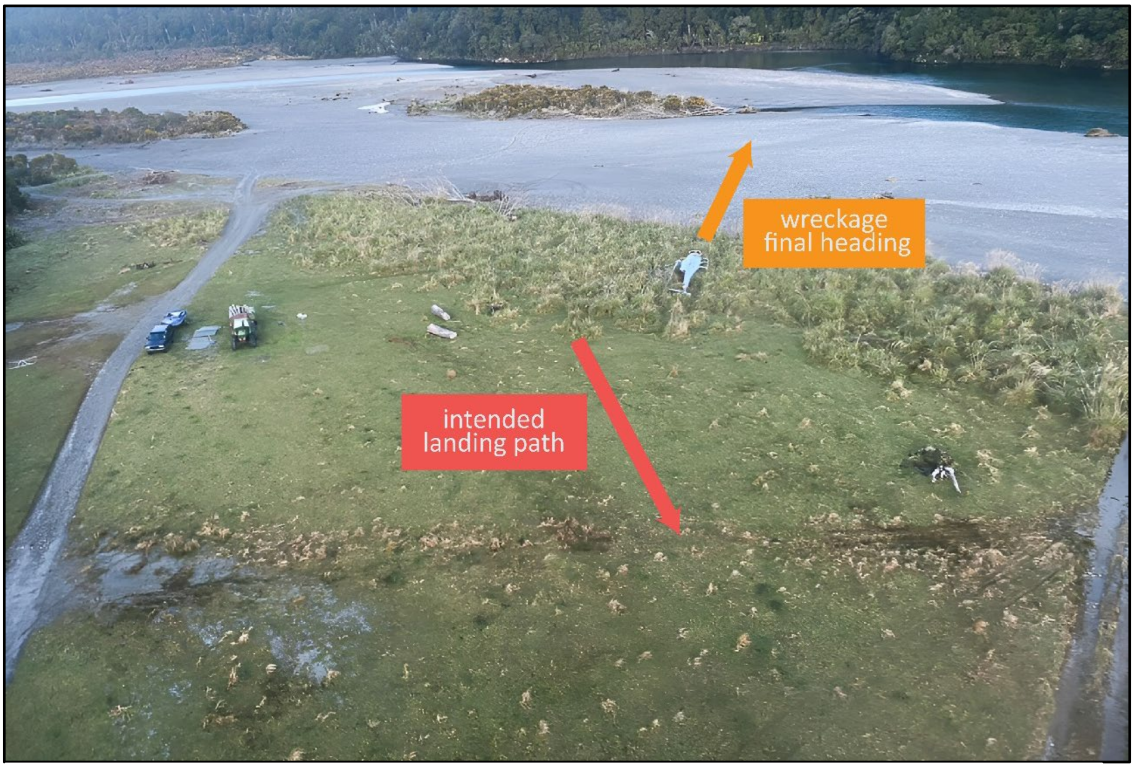

Figure 4: Final position of the helicopter
(Credit: TAIC)

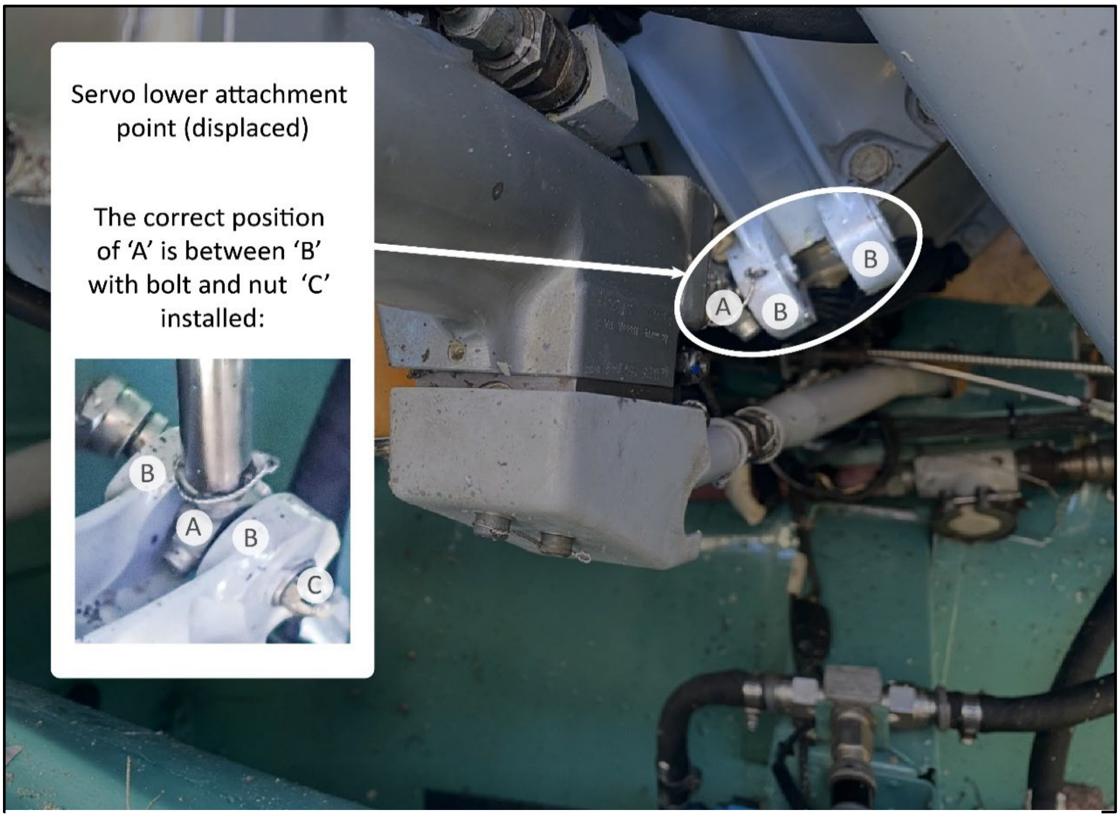

Figure 5: ZK-HJM left hydraulic lower attachment point bolt missing and hydraulic lower connection point no longer connected
(Credit: TAIC)

2.14. The maintenance records show that the left and right hydraulic servos had been swapped over during the maintenance activity prior to the accident. The swap was done at the request of the operator to balance wear on the components, and to improve the service life of the servo that is subject to higher workloads.

2.15. Impact damage shows that during the accident sequence all four main transmission mounts failed in instantaneous overload. The right-hand hydraulic servo input rod broke in overload just above the transmission deck, and the right-hand cyclic bellcrank pivot bolt[14] sheared off at the thread end below the transmission deck.

Prior maintenance activities

2.16. From 1 July to 20 July 2024, the helicopter underwent maintenance at the maintenance provider's hangar at Queenstown Airport. This involved a 150-hour airframe and 300-hour engine check consisting of 67 scheduled[15] and 16 unscheduled[16] additional maintenance tasks. These tasks were published in a workpack[17] and made available to the engineers who would be working on the helicopter.

2.17. The installation of the left hydraulic servo was certified as completed on 6 July 2024 in the workpack by Engineer A, who also certified the first part duplicate safety inspection for the same job on the same date.

2.18. A duplicate safety inspection was certified as completed by Engineer B on 15 July 2024.

2.19. On Friday 19 July 2024, at the completion of maintenance, a foreign object debris/damage[18] (FOD) check was completed prior to the helicopter being flown on a series of track and balance[19] flights, subject to the conditions of a limited release to service[20] (RTS).[21] The flights were undertaken locally in the Queenstown area, and were to adjust the main rotor flight characteristics following maintenance activity. This included a pre-flight inspection by the pilot that conducted these maintenance flights, who was also the pilot on the accident flight.

2.20. On the morning of 20 July 2024, Engineer B, who was the RTS Licenced Aircraft Maintenance Engineer (LAME), certified that the helicopter was in an airworthy condition following all maintenance activity.

2.21. The chief pilot for the operator conducted a formal post-maintenance acceptance of the helicopter, including a pilot pre-flight inspection and an acceptance flight in the local area. The helicopter was then formally released to the operator.

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[14] The pivot bolt serves as the rotation point for the pivot arm. The bellcrank converts the control input into a different direction to actuate another component.

[15] Based on calendar and/or airframe hours.

[16] To rectify a defect or at the operator's request.

[17] The repair, maintenance or overhaul instructions provided to the engineer for accomplishment of scheduled or unscheduled work. It can include work order/task cards.

[18] Any object found in an inappropriate location that, as a result of being in that location, can damage equipment or injure personnel.

[19] Rotor track and balance is a routine maintenance task that involves a calculated system of adjustments to pitch links, blade weights and trim tabs. These adjustments are designed to reduce vibrations at the fundamental (once-per-revolution) rotor frequency.

[20] Refers to the formal declaration that the maintenance tasks on an aircraft (or component) have been carried out correctly by an appropriately authorised person, as per the requirements of CAR Part 43 Subpart C – Release to Service

[21] For the purpose of operational flight checks.

2.22. A minimum of four trained and qualified individuals inspected the helicopter for airworthiness prior to the accident flight. All were aware that during maintenance the left and right servos had been swapped over. They all had the opportunity to inspect the helicopter, and all certified that they had done so.

General Maintenance Rules

2.23. The New Zealand Civil Aviation Rules (CARs) Part 43 General Maintenance Rules prescribes the requirements for the maintenance and RTS after maintenance of aircraft, and components to be fitted to aircraft, that are required by Part 91[22] to have an airworthiness certificate issued under Part 21.[23]

2.24. Maintenance records must be completed in accordance with CAR 43.69. CAR 43.69(d) requires that a person performing maintenance on an aircraft or a component must, after recording the details required by paragraphs (a) to (c) of CAR 43.69, include the following information as part of the maintenance record:

(1) the person's name:

(2) the person's signature except if the maintenance logbook or worksheet is in electronic format:

(3) if applicable, the person's licence, approval or authorisation number:

(4) the date of the completion of the maintenance.

2.25. Duplicate safety inspections are required for components of the flight control system[24] as they are critical to the safe operation of the aircraft.[25] CAR Part 43.113 requires that no certification for RTS of aircraft/components is permitted after initial assembly, disturbance or adjustment of any control system part unless:

(a) the applicable requirements of Subpart C have been complied with; and

(b) a duplicate safety inspection has been carried out by an appropriately qualified person,[26] to ensure that –

(i) the control system of the aircraft or the component functions correctly; and

(ii) in respect of the maintenance performed, the control system assembled correctly and every required locking mechanism is in place; and

(c) the certification and signatures required are complete.

2.26. Following the completion of a duplication safety inspection, CAR 43.113(c)(3) prescribes the statement that must be entered in the appropriate maintenance logbook or worksheet by the person who carried out the inspection:

> We certify that a duplicate safety inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in

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[22] CAR Part 91, General Operating and Flight Rules.

[23] CAR Part 21, Certification of Products and Parts.

[24] A system that has the ability to directly change the flight path, attitude, or propulsive force of an aircraft, and includes the flight controls, the engine and propeller controls, the related system controls, and the associated operating mechanisms: CAR Part 1, General Definitions.

[25] CAR Part 43.113.

[26] As specified in CAR 43.113(b)(1)-(2).

respect of the maintenance performed, the control system is assembled and locked correctly.

2.27. CAR 43.113(d) outlines the details that must be entered in the maintenance logbook or worksheet adjacent to the statement required above, once the duplicate safety inspection has been carried out:

(1) the name of the person; and

(2) the signature of the person except if the maintenance logbook or worksheet is in electronic format; and

(3) the licence number, approval number, or authorisation number for the person; and

(4) the date of entry.

Personnel information

Pilot

2.28. The pilot had been issued with a Commercial Pilot Licence (Helicopter) in November 1984, with the last renewal conducted in January 2023.

2.29. The pilot's last company check[27] with the operator had been conducted in November 2021.

2.30. At the time of the accident the pilot had a total flight time of 3981 hours, of which about 2857 had been on the AS350-type helicopter.

2.31. The pilot was also a Licenced Aircraft Maintenance Engineer with 53 years' experience. They had over 45 years' experience on the AS350-type helicopter.

Passenger

2.32. The passenger was the operator's chief pilot and had been issued with a Commercial Pilot Licence (Helicopter) in July 2011.

2.33. Their last company flight crew competency check with the operator had been conducted in August 2023.

2.34. At the time of the accident the chief pilot had a total flight time of 5180 hours, of which 2500 had been on the AS350-type helicopter.

Maintenance personnel

Engineer A

2.35. Engineer A was employed by the maintenance provider in June 2019. They initially joined as a trainee, and then in October 2021 they gained their aircraft engineer's licence.

2.36. Engineer A held several ratings, including a Group 2 rotorcraft rating. In November 2022 they were appointed as the maintenance provider's Queenstown hangar

[27] A standard flight crew competency check was not required as the pilot performed CAR Part 91 General Operating and Flight Rules operations only and was not employed on a commercial basis.

foreman. Engineer A was authorised to release to service and to undertake first and second part duplicate safety inspections.

Engineer B

2.37. Engineer B was employed by the maintenance provider in January 2019.

2.38. Between January 2019 and November 2020, they were the helicopter maintenance manager for Queenstown. From November 2020 until the time of the accident, they had been working as the maintenance provider's Queenstown chief engineer. Engineer B was a licensed aircraft engineer and held multiple ratings, including Group 2 for rotorcraft. Engineer B was authorised to release to service and to undertake first and second part duplicate safety inspections.

2.39. They had over 45 years' maintenance experience, mostly in the rotorcraft field.

Aircraft information

2.40. ZK-HJM was manufactured as an Airbus AS 350 B helicopter, serial number 1671, constructed on 6 December 1982 by Eurocopter Helicopters in France under Type Certificate R008. The helicopter was converted to an AS 350 BA (FX2) in 2016, which included changing the single Safran Arriel 1B engine to the Honeywell International Inc LTS-101-700D-2 turboshaft engine.

2.41. The helicopter had accrued 13,043.2 total flying hours since new at the time of the accident.

2.42. A review of airworthiness was carried out on 28 December 2023, at 12,865.2 hours' total time in service. The next review was due on 17 December 2024.

2.43. Using the certified weight of the helicopter, and the weights and positions of the two occupants plus the calculated fuel load, the helicopter was calculated to be within its weight and balance limits at the time of the accident.

Recorded data

2.44. The helicopter was fitted with a Tracplus™ RockAIR tracking system that recorded the helicopter's flight path and provided a flight following and alerting service to the operator.

2.45. The helicopter was also fitted with an Eye In The Sky™ on-board video and audio recording system. This recorded the flight path, speed, heading and altitude, as well as instantaneous acceleration in all three axes of movement.

Medical information

2.46. Both the pilot and the passenger suffered minor injuries. The pilot was not wearing a helmet for this flight and was not required to do so. The passenger was wearing a helmet.

Tests and research

Hydraulic servos

2.47. As part of the investigation the three hydraulic servos were taken to an independent overhaul facility in Brisbane, Australia for expert evaluation under the supervision of a Commission investigator. The testing identified wear outside overhaul limits to the left main hydraulic[28] servo. The report stated:

> Servo-Actuators tested and evaluated using OEM CMM maintenance data 65-40-02 Rev 7 for P/N AC67246, and CMM 65-40-03 Rev 10 for P/N AC67244.
>
> • Servo S/N CC426, piston speed in retract and extend was found to be outside of the CMM limits during the Speed Test. This is a result of both the Link Pin and Hinge Pins having wear outside the CMM limits.
>
> • Internal leak in the retract position of the Servo Valve would be due to wear on the internal O-Rings.
>
> Regarding the identified issues on S/N CC426 with operational speeds outside limits in both directions, the CMM test is conducted over a full piston cycle. When in service, the effect may appear negligible due to the occurrence of piston movements on a much smaller scale.

The report concluded that the effect of the wear may appear negligible when in service.

Fuel tank

2.48. The fuel tank ruptured during the accident sequence. At the request of the Commission, three-axis acceleration data and photos of the wreckage were passed to Airbus Helicopters through the French Bureau d'Enquêtes et d'Analyses (BEA). Airbus undertook a review of the evidence and advised that:

> Given the impact conditions and structural deformations around the main fuel tank, it is not abnormal that it ruptured.

2.49. Airbus further advised that crash-resistant fuel systems are available as retrofit solutions for the entire AS350/EC130 fleet. These solutions are proposed under the helicopter Type Certificate[29] (TC) or a Supplemental Type Certificate[30] (STC).

Seats

2.50. The pilot seat attachment point separated during the accident sequence, causing the seat and pilot to fall onto the floor-mounted control quadrant. This bent the collective control and prevented the pilot from being able to stop fuel flow to the engine immediately after the accident.

2.51. The seats fitted to the helicopter were of the original design approved as part of the certification of the AS350 model helicopter. In 2000, the helicopter manufacturer offered owners the option to upgrade the installation of the current pilot and co-pilot

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[28] As it was at the time of the accident.

[29] A Type Certificate is issued by the National Aviation Authority (NAA) of the state of the operator, stating the airworthiness standard for the aircraft type, model, aircraft engine or aircraft propeller. The initial Type Certificate is likely to be obtained in the state of manufacture.

[30] An approval to carry out an aircraft type modification which is deemed by the Airworthiness Authority concerned to be a sufficient change to the original design of an aircraft type to require a specific validation.

bucket seats with a reinforced 'standard' seat attachment. Alternatively, the original seat could be replaced by a newer reinforced energy-absorbing design, and this was subsequently fitted to all new models of AS350/H125 helicopter from July 2008.

Organisational information

Salus Aviation (AW) Limited (the maintenance provider)

2.52. The Queenstown maintenance facility was part of a nationwide maintenance and repair provider certified under CAR Part 145, Aircraft Maintenance Organisations. The maintenance provider's exposition described how maintenance was to be organised and conducted, and how that maintenance was to be recorded. A local maintenance manager was responsible for oversight of the maintenance facility. They were supported by a certifying engineer and a hangar foreman.

2.53. The hangar foreman was responsible for managing resources and control of the workflow through the hangar. They would assign tasks to maintenance personnel and ensure that the standard of work met the organisation's expectations. They would also ensure that the appropriate quality control checks were carried out during the maintenance work.

2.54. The release to service engineer[31] was responsible for ensuring that aircraft left the hangar in an airworthy condition and that all associated documentation for its return to service had been completed. They were expected to personally inspect each aircraft to ensure that maintenance had been completed in conformance with technical data.

2.55. Maintenance engineers were responsible for performing allocated maintenance tasks within the scope of their company authorisations. They were to advise the certifying engineer if any control system had been disturbed so that the certifying engineer could initiate a duplicate safety inspection.

2.56. All staff were expected to be alert to safety hazards and raise a safety report if they identified a hazard.

2.57. The organisation's Safety Management System referenced the use of Standard Practice Instructions (SPI) including SPI105 – Workpack Compilation, Completion and Certification, which included the following instructions.

> **Progressive Detailing and Signing**
>
> All preformatted maintenance schedule worksheets must be signed as the tasks are completed. The following information shall be included when completing and recording tasks:
>
> - Date task carried out.
> - Certifying Engineer second inspection check and signature.
> - Referenced receiver numbers (batch numbers) for standard parts and consumables, not already recorded within the MRO IT system against a scheduled or unscheduled maintenance task.

[31] Certifies upon the completion of any maintenance carried out on an aircraft and its components that the ordered maintenance has been properly carried out in accordance with appropriate organisational procedures and regulatory requirements.

- Calibrated tooling used referencing tooling number and measurement (if required).
- Referencing when a Duplicate Safety Inspection or stage inspection is required.
- Authorised Release Certificate or Form One information as applicable.
- Signing the AME and Rated LAME column, this confirms that the information provided on the worksheet has been referenced appropriately and associated tasks have been carried out.
- If a maintenance task cannot be completed in its entirety, then the engineer must raise a work entry into the appropriate aircraft worksheet for the stage at which the relevant task is complete. A subsequent work entry shall be raised for the remaining steps that must be completed to complete the task in full and a verbal handover is to take place between the engineer carrying out the task and the release to service or certifying engineer as applicable.

2.58. SPI116 Duplicate Safety Inspection of Controls (*see* Appendix 2) also included the following instructions for duplicate safety inspections.

Carrying Out the First Part Duplicate Safety Inspection
This person shall ensure that:

1. They are appropriately rated and authorised to carry out the first part duplicate inspection
2. Current Technical Data was used for the work
3. All parts of the system which have been disturbed are free from defects; including:
   a. Incorrect rigging
   b. Incorrect locking
   c. Any possibility of fouling or jamming
   d. For the complete system, the controls function throughout their range of travel in each mode, and with each alternative means of actuation;
      i. Freely and in the correct sense
      ii. Without excessive backlash
      iii. With the correct static friction

Carrying Out the Second Part Duplicate Safety Inspection
This person shall ensure that:

1. That they are appropriately authorised to carry out a Second Part Duplicate Inspection
2. Current Technical Data was used for the work
3. All parts of the system which have been disturbed are free from defects; including:
   a. Incorrect rigging
   b. Incorrect locking
   c. Any possibility of fouling or jamming
   d. For the complete system, the controls function throughout their range of travel in each mode, and with each alternative means of actuation;
      i. Freely and in the correct sense
      ii. Without excessive backlash
      iii. With the correct static friction

Amuri Helicopters Limited (the operator)

2.59. Amuri Helicopters Limited was based at Hamner Springs. It had a fleet of three helicopters, comprised of two Airbus AS350 FX2s and one MD Helicopters MD520N. It operated nationwide to include a wide range of commercial operations.

Other occurrences

2.60. The Commission identified previous occurrences that involved the lower attachment point of a main rotor hydraulic servo becoming disconnected during flight.

2.61. One such occurrence[32] involved an AS365 N3 Dauphin helicopter, which the BEA reported was being operated by the French Military. Airbus Helicopters treated it as a major incident and produced an Emergency Alert Service Bulletin on 25 July 2019 (which was updated on 03 February 2025) that described the failure as a result of incorrect maintenance actions.

2.62. Another occurrence involving an AS 350 BA, where the left lateral flight control servo became disconnected in-flight at the transmission, occurred in Princeville, Hawaii, USA in March 2007 (National Transport Safety Board, 2009). This accident was investigated by the United States of America National Transportation Safety Board (NTSB). The NTSB determined the probable cause(s) to be:

> The failure of maintenance personnel to properly tighten (torque) the flight control servo lower attachment clevis, and reinstall a functioning lock washer, which resulted in a flight control disconnect and a complete loss of helicopter control. Contributing to the accident was the operator's failure to ensure its maintenance program was being executed in accordance with Federal regulations.

2.63. The Commission also identified other instances where the duplicate safety inspection process had failed to capture incomplete or inaccurate maintenance activities. The Civil Aviation Authority of New Zealand (CAA) published an educational article titled *The life-saving importance of the duplicate inspection* in the Autumn 2025 issue of Vector.[33] The article stated that there were four[34] known instances in the second half of 2024 where ineffective duplicate safety inspections were carried out. It reported that:

> In all cases it was not an instance of the duplicate inspections not being done – they all were. It's that the inspection failed to identify issues in one or more of the critical elements required to be checked during the duplicate inspection.

2.64. The article referenced an earlier article published in the Winter 2022 issue of Vector that highlighted the importance of the duplicate safety inspection process,[35] reinforcing that this is a known and ongoing issue in the aviation industry.

2.65. On 19 February 2026, the maintenance provider notified the Commission of a related maintenance incident. On 12 January 2026, two engineers were tasked with connecting dual-control tail rotor pedals on two helicopters. The duplicate safety

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[32] Airbus Helicopters Alert Service Bulletin (ASB) 67-00-77 (AS 350 B3)

[33] https://www.aviation.govt.nz/safety/safety-education-and-advice/education/vector-magazine/vector-online/duplicate-inspection/.

[34] Including this accident.

[35] https://www.aviation.govt.nz/assets/publications/vector/vector-2022-2-winter-web.pdf.

inspections that were carried out on both helicopters did not identify that 'lock-out position' pins had not been installed in accordance with the relevant maintenance instruction, and the helicopters were not in an airworthy condition when released to service. The fault was detected during a pilot pre-flight inspection of one of the helicopters the next day.

2.66. The maintenance provider's internal investigation identified further safety improvements that the maintenance provider was in the process of implementing (*see* paragraph 5.3).

2.67. *TAIC inquiry AO-2001-009: Bell 206 ZK-HWI, engine power loss after take-off, Mount Pisa station Lowburn, 12 August 2001.* The Commission identified a safety issue with the need for the helicopter maintenance company, in conjunction with operators it provides services for, to establish a robust system that ensured any additional maintenance is recorded correctly, so additional maintenance is completed fully at the earliest opportunity.

2.68. The Commission recommended to Airwork NZ to establish a system, in conjunction with any operators for whom Airwork NZ provide maintenance services, that ensures any follow-up maintenance action necessary after any maintenance is correctly recorded and carried out at the appropriate time (013/02).

2.69. *TAIC inquiry AO-2002-003: Schweizer 269C helicopter, ZK-HIC, loss of tail rotor authority and emergency landing, Karaka Downs South Auckland, 15 March 2002*. The Commission identified a safety issue with the need for duplicate inspections of helicopter tail rotor drive trains.

2.70. The Commission recommended to the CAA to critically examine the requirements for duplicate inspections of aircraft control systems, with a view to including helicopter tail rotor drive trains as part of the duplicate inspection regime (037/02).

2.71. *TAIC inquiry AO-2005-007: Piper PA34-200T Seneca II, ZK-MSL, Wheels-up landing, Napier Aerodrome, 7 July 2005*. The nose gear had failed to extend because the centring spring attachment bolt had jammed against the nose gear door aft tube assembly. The bolt had been installed incorrectly nine weeks earlier during maintenance. Safety issues identified by the Commission included the need for aircraft maintenance engineers to refer to appropriate documentation when carrying out unfamiliar tasks, the ongoing compliance with an Airworthiness Directive concerning the attachment bolt, and the effectiveness of the associated Service Bulletin.

2.72. Safety recommendations were made to CAA and to the aircraft manufacturer regarding the Airworthiness Directive and Service Bulletin respectively (076/05) (104/05). The maintenance provider took action to improve staff maintenance practices, therefore no safety recommendation was made to that organisation.

2.73. *TAIC inquiry AO-2011-004: Piper PA31-350 Navajo Chieftain, ZK-MYS, landing without nose landing gear extended, Nelson Aerodrome, 11 May 2011*. The safety issue identified by the Commission was an inadequate standard of maintenance performed by a range of organisations and persons on the aeroplane, and the standard of maintenance for general aviation aircraft in New Zealand needed to be improved.

2.74. The Commission made two recommendations to the CAA.

1. That they widen the range of aircraft systems that require duplicate checks after specified maintenance, at least for those aircraft used in air transport operations, in order to reduce the likelihood of recurring defects and incidents (019/13).

   The Director of Civil Aviation replied:

   The CAA considers that widening the scope of aircraft systems requiring duplicate inspections [is] not sufficiently supported by the Commission's investigation. In this regard, the CAA prefers to remain in keeping with current world regulatory practice and therefore will not implement the recommendation.

2. That they take action, in concert with the aviation industry, to improve the level of compliance with Civil Aviation Rules and conformance with industry best practice throughout the general aviation maintenance sector (018/13).

   The Director of Civil Aviation replied:

   The CAA will not implement the recommendation as worded. However, the CAA will adopt the safety surveillance practices as described in our final draft report response letter 14 June 2013.

   The relevant portion of the CAA letter of 14 June 2013 stated:

   The CAA considers a recommendation that would address the relationship issues in terms of communications and record keeping between CAA Rule Part 43 maintenance providers and Part 135 AOC holders would be more effective. To this end, the CAA intends to profile Part 43 maintenance providers in order to identify poor performance or other risk issues. It is envisaged that increased surveillance and education programs would follow.

2.75. Australian Transport Safety Bureau (ATSB) AO-2017-078: Loss of cyclic control and in-flight break-up involving Robinson R22, VH-HGU, 7 km north-north-west of Cloncurry Airport, Queensland, on 2 August 2017. The safety issue identified by the ATSB was that Cloncurry Air Maintenance had adopted a number of practices, which included using abbreviated inspection checklists, not recording all flight control disturbances and not progressively certifying for every inspection item as the work was completed, which increased the risk of memory-related errors and the omission of tasks.

2.76. The Australian Civil Aviation Safety Authority issued Airworthiness Bulletin 67-005: Robinson Helicopter Flight Controls – Independent Inspections. The bulletin highlighted the need for independent inspections to be conducted and 'recorded consecutively with each adjustment made during rotor tracking and balancing' activities. The bulletin also identified several human-factor elements that could impact maintenance inspection performance, and highlighted the need for extra caution to be exercised during post-maintenance flights as per the guidance provided by Robinson.

2.77. Transportation Safety Board of Canada (TSB): Loss of control and collision with terrain Diamond Aircraft Sales USA Inc. Diamond Aircraft Industries GmbH DA 42 NG, N591ER London Airport, Ontario, 25 May 2022. TSB made the following findings as to risk.

- If maintenance personnel are not trained on company procedures and applicable regulatory requirements before being authorized to perform or certify maintenance, there is a risk that the aircraft will not be airworthy when it is returned to service.
- If procedures requiring the inspection of flight controls do not provide specific instructions regarding how to ensure the surface is moving in the correct direction, flight controls that have been rigged in reverse may not be recognized.
- If the person signing a maintenance release for work accomplished by another person does not observe the work to the extent necessary to ensure that it is performed in accordance with the applicable standards of airworthiness, there is a risk that the aircraft will not be airworthy when it is returned to service.

Summary

2.78. The Commission notes from the domestic occurrences there has been a pattern of maintenance errors, not captured by the duplicate safety inspection process, that have resulted in incidents and accidents. Recommendations consistently call for robust, mandatory double-checks for safety-critical work, improved maintenance record keeping and formal tracking of deferred actions to stop critical tasks being missed. The Commission has identified a related safety issue that is discussed further from paragraph 3.20.

2.79. The Commission identified the following themes in international occurrences.

- True independence/methodical dual inspection is essential – a second signature is not enough.
- Functional verification must supplement paperwork checks.
- Human factors (fatigue, rushed work, unclear roles and divided responsibilities) often defeat the intent of duplicate inspections.

2.80. International recommendations focused on making duplicate safety inspections mandatory for critical systems, including functional checks, documenting in detail and supplementing with training on human error/human factors.

3 Analysis
Tātaritanga

Introduction

3.1. The pilot lost control of the helicopter in the final stages of a precautionary landing, after noticing a change in the flight characteristics of the helicopter while flying straight and level on a repositioning flight.

3.2. The accident occurred after the helicopter had been released to service following maintenance, which included disturbing the primary flight controls. A bolt that was meant to be securing one of the critical flight controls was discovered to be missing from its correct location after the accident.

3.3. The following section analyses the circumstances surrounding the event to identify the factors that increased the likelihood of the event occurring or increased the severity of its outcome.

What happened

In-flight abnormalities and emergencies

3.4. The pilot reported feeling a slight jolt in the aircraft and then immediately noticed that the helicopter main rotor blades had started flying out of track about 52 minutes into the flight.

3.5. When the pilot lowered the collective to descend for a precautionary landing, about seven minutes after noting the blades going out of track, they found that the cyclic control became hard to move to the left. The pilot and passenger discussed these symptoms, including that it appeared to be consistent with a single hydraulic servo failure.

3.6. During interview, the pilot stated that they elected to keep the hydraulics on as they believed they did not have a total hydraulic failure, but possibly a single hydraulic servo failure. This was because the control response was not as severe as a hydraulics failure[36] and there was no HYD[37] warning light or horn. They stated that they did not want to make the situation worse by turning off the hydraulics.

3.7. The on-board video footage showed that the pilot made a shallow approach to land on a clear area that appeared suitable for a no-hover/slow run-on landing.

3.8. The footage also showed that during descent the torque was low, from 10 to 30%. However, on short finals the torque increased through 40 to 60% and the pilot stated they were out of control immediately before the helicopter rolled left and impacted the ground.

3.9. The bolt that connected the lower ball end fitting of the rotor actuator to the main gear box (MGB) was found on the transmission deck of the helicopter after the flight. It is **very likely** that the actuator bolt's movement from one side, where the lower ball

[36] Based on previous experience of turning off the hydraulics system during testing.
[37] The hydraulic system warning light is labelled as HYD on the helicopter annunciator panel.

end fitting connects to the MGB conical housing,[38] manifested through the main rotor controls as a slight jolt in the aircraft and then the initial out-of-track condition. As the bolt was still part-way through the connection, hydraulic assistance from the left servo was still being provided.

3.10. When the pilot lowered the collective to descend to the river for a precautionary landing, the torque reduced, which decreased the load through the main rotor control system. It is **very likely** that this allowed the loose bolt to fall completely free, thereby disconnecting the lower end of the hydraulic servo from the MGB conical housing.

3.11. Once disconnected, the hydraulic servo was still working normally. However, the lower end had nothing to push against to provide hydraulic assistance to the pilot on that control (*see* Figure 6).

3.12. The control rod that linked the pilot's controls to the main rotor was still connected to the non-rotating swashplate via the upper end of the hydraulic servo.

3.13. The flight manual stated that the AS350 helicopter was controllable with inoperative hydraulics, however the load feedback can be very heavy, especially at higher airspeeds. When a single hydraulic servo is no longer providing assistance on one of the three controls, in this case due to the disconnection of the lower attachment point from the MGB conical housing, the pilot is subject to those loads in one direction. This condition would exhibit symptoms as a heavy cyclic on one side.

3.14. When the collective is raised in this situation, all three control rods are raised; however only two are hydraulically assisted, while the third is not. This will manifest as the cyclic pushing towards the unassisted side and requires the pilot to be able to match the force exerted by the hydraulic system on the still-connected servos.

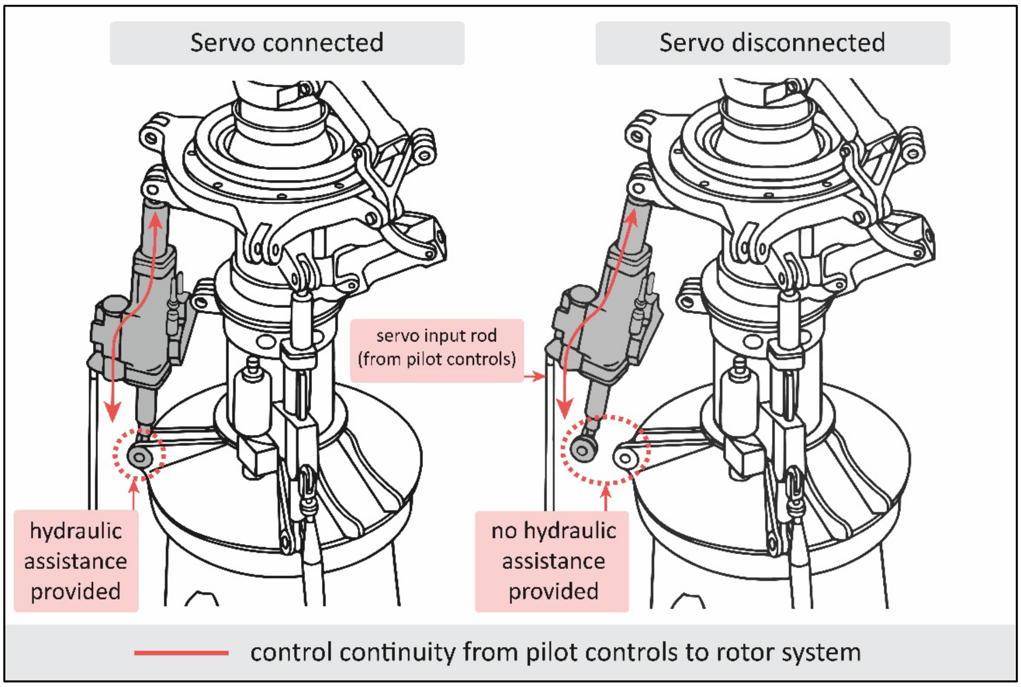

Figure 6: Hydraulic servo lower end disconnection

[38] The MGB conical housing is the cone-shaped enclosure containing the helicopter's main gearbox.

3.15. The pilot intended to make a run-on landing with minimal power changes close to the ground. The helicopter began rolling to the left following an increase in torque at about the point the collective would usually be raised to counter the loss of translational lift[39] during a normal approach.[40]

3.16. It is **virtually certain** that the increase in torque was due to the pilot raising the collective in response to a combination of the helicopter slowing and losing translational lift.

3.17. It is **very likely** that due to the lower end of the hydraulic servo not being attached, and the hydraulic system being active during the precautionary landing, there was an overwhelming load on the unassisted control. This led to the helicopter making an unintentional roll to the left as the collective was raised on short final.

3.18. A bolt securing the lower attachment point where the left main rotor hydraulic servo connects to the transmission housing was discovered to be missing after the accident. The bolt was found on the transmission deck; the nut was not found.

3.19. It is **virtually certain** that the bolt securing the lower end of the left-hand hydraulic servo became detached during flight, resulting in a change in the control characteristics of the helicopter and influencing the outcome of the landing.

Quality assurance of maintenance activity

Safety issue: The maintenance provider did not have a robust quality assurance process to ensure maintenance activities were being completed and documented in accordance with their approved maintenance procedures. This increased the risk of maintenance errors not being identified and rectified.

Installation of the main rotor hydraulic servos

3.20. The helicopter was flown to the maintenance provider's facility in Queenstown on 30 June 2024. From 1 July to 20 July 2024, the helicopter underwent maintenance.

3.21. The LAMEs involved stated during interviews that the operator made it clear to the maintenance provider that there was no time pressure for the release of the helicopter back into service.

3.22. The maintenance on the helicopter involved a 150-hour airframe and 300-hour engine check consisting of 67 scheduled and 16 unscheduled additional maintenance tasks. These tasks were published in a workpack and made available to the engineers who would be working on the helicopter. Engineer A initially took responsibility as the release to service engineer, meaning they would assume responsibility for oversight of the work being done on the helicopter.

3.23. Part of the unscheduled additional maintenance tasks that the operator had requested was to swap the left and right main rotor control hydraulic servos with each other. As this involved disturbance of the flight controls, a duplicate safety inspection was required following the completion of the task.

3.24. On the morning of 6 July 2024, Engineer A (who was not rostered to be working that day) arrived at the hangar to carry out some maintenance on their personal road

[39] Translational lift refers to the increased efficiency of a helicopter's rotor system as it transitions from a hover to forward flight, resulting in improved lift and performance.

[40] A normal approach and landing involves an approach to a hover, then vertical descent to skid touchdown.

vehicle. Two other engineers who were rostered on were at the hangar, working on another aircraft.

3.25. After approximately four hours, Engineer A packed up their tools and was preparing to go home when they decided to paint the helicopter's main rotor mast. Engineer A reasoned that if they did that task while they were at the hangar, the paint would be dry for their next rostered workday, 8 July 2024.

3.26. At the completion of painting, Engineer A decided to do some additional work on the helicopter.[41] This included:

- reinstalling the hydraulic tank
- swapping the left and right main rotor hydraulic servos
- cleaning the tail rotor gearbox sight glass
- charging the hydraulic accumulators with nitrogen.

3.27. Engineer A used a sonic cleaning bath to clean the sight glass. This involved periodically leaving the helicopter, where they were fitting the servos, to check how that task was progressing. Following installation of the right servo[42] Engineer A continued with the same task on the left-hand side. While they were working, a customer approached the hangar which interrupted Engineer A's work for about 10 minutes.

3.28. When Engineer A returned to the helicopter, they noticed that hydraulic fluid was dripping from two of the hydraulic hoses that had yet to be connected. They cleaned up the fluid spillage and set about connecting the two hoses. Engineer A later recalled that sorting out the leak had taken 'quite a while'.

3.29. The last task Engineer A worked on that day was charging the hydraulic accumulators with nitrogen. They then packed up and left the hangar at around 1600. Many of the tasks that Engineer A performed that day were disrupted, either by having to shift focus between different maintenance activities or by unplanned interruptions.

3.30. On 9 July 2024, Engineer A took a photograph of another part of the hydraulic system, which also happened to show the lower attachment bolt on the left hydraulic servo with the nut only partially done up (*see* Figure 8[43] There is no evidence of work being done on the left-hand hydraulic servo between the time the photo in Figure 8 was taken on 9 July 2024 and the helicopter departing on the accident flight.

3.31. On Friday 12 July 2024, Engineer A completed the paperwork that related to the maintenance activity they had undertaken on the helicopter the previous weekend. This was inconsistent with CAR 43.69(d) which required that on completion of the maintenance, a person performing maintenance on an aircraft or a component must include the date of completion of the maintenance as part of the maintenance record.

3.32. Additionally, the maintenance provider's procedures (SPI105) required that the maintenance schedule worksheets be signed as the tasks are completed; and if a maintenance task cannot be completed in its entirety, then the engineer must raise a

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[41] At this point they booked themselves onto the company system to officially record their work hours.
[42] This was the servo that had previously been on the left-hand side of the helicopter prior to the swap.
[43]This photograph was taken on 9 July 2024 and shows the state of the bolt and nut at that time.

work entry into the appropriate aircraft worksheet for the stage at which the relevant task is complete (*see* 2.57).

3.33. Advisory Circular (AC) 43-1, 2.16 provides guidance on CAR 43.69(b)[44] and emphasises that worksheets should be kept up to date during maintenance. It states:

> Worksheets provide the operator and maintenance provider with a valuable record of maintenance undertaken. They should be compiled in a way that is easily understandable for anyone not associated with the maintenance task.
>
> Worksheets should be kept up to date during maintenance so that they accurately reflect the aircraft status. Various accidents have been attributed to incomplete maintenance where maintenance providers have initiated a maintenance action without making a record in an appropriate document. Accurate work records assist the certifying engineer in ensuring that all necessary maintenance, including work arising during the check, is complete and that the aircraft is in an airworthy condition prior to release to service. They also support the operator in making an assessment that all necessary maintenance has been completed prior to returning the aircraft to operation.
>
> ...
>
> All worksheets and associated documentation should be complete prior to the certifying engineer issuing the release to service.

3.34. During inspection of the helicopter, Commission investigators found the upper attachment on the same hydraulic servo had the bolt in place with the nut attached to the bolt (*see* Figure 8). However, the nut was not tightened fully and did not have a locking pin installed. This was not in accordance with the manufacturer's instructions, which required the nut to be tightened to a specific torque and then secured with a locking pin.

3.35. It is **virtually certain** the nut was not tightened to the correct torque, and the locking pin that was meant to prevent the nut from coming loose was not installed, or not installed correctly, prior to the helicopter's departure from Queenstown.

3.36. Engineer A informed Commission investigators that while they had some memory of working on the right-side servo, they could not recall any details about work on the left-side servo. It is **virtually certain** that Engineer A did not complete the task of installing the left hydraulic servo.

[44] CAR 43.69 (b) A person performing maintenance on an aircraft or a component may use associated worksheets to record the details of the maintenance performed if (1) a summary of maintenance performed is recorded in the appropriate maintenance logbook; and (2) the worksheets are referenced in the summary of maintenance required under paragraph (b)(1).

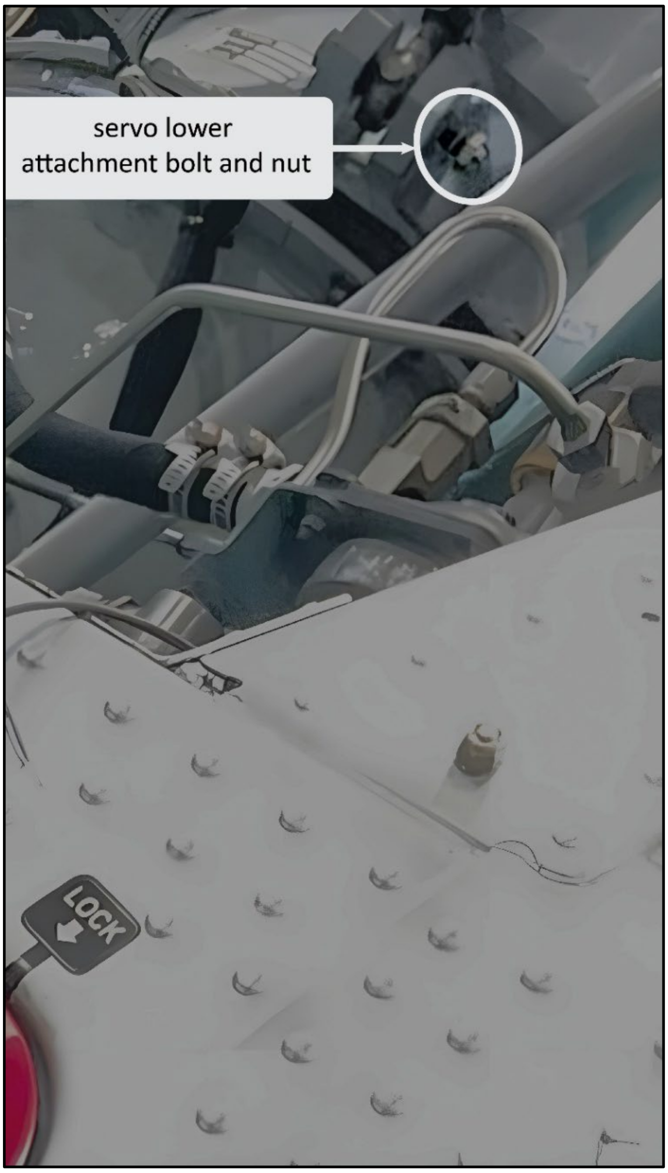

Figure 7: ZK-HJM lower attachment bolt and nut during maintenance
(Credit: Engineer A, marked up by TAIC)

Figure 8: Left hydraulic servo upper attachment point, taken post-accident
(Credit: TAIC)

First stage of the duplicate safety inspection and handover to the return to service engineer

3.37. Engineer A returned to work on 8 July 2024. Due to a change in priorities from the operator, they spent the following four days working on the operator's MD 500 while another engineer, Engineer B, conducted repair work on the helicopter.

3.38. Following the MD 500's release to service on 11 July 2024, Engineer A focused on preparing to hand over the responsibility as the helicopter RTS engineer to Engineer B. This was necessary as Engineer A was going on holiday and would not be available to release the helicopter to service at the planned completion of work.

3.39. Engineer A recalled spending the afternoon of 12 July 2024 completing paperwork for the helicopter. This included ensuring that all the task items scheduled for the helicopter were showing in the workplan that had been generated for the engineers. As some items were not showing, Engineer A added them manually and marked off what had been completed and what work remained.

3.40. Engineer A dated their certifying signature for the first part of the duplicate safety inspection for the items completed earlier in the week to match when they thought the inspection was completed, rather than the date the paperwork was completed.[45]

3.41. The handover briefing was conducted on Friday 12 July 2024, at a computer station adjacent to where the helicopter was positioned in the hangar. During Commission interviews, both engineers stated that they did not physically inspect the helicopter at any stage of the briefing. Engineer B recalled that the handover briefing took place at the end of the workday and lasted around 20 to 30 minutes. Engineer B recalled leaving for the weekend immediately after the briefing, at around 1700.

3.42. As a critical flight control component, a duplicate safety inspection of the servo installation was required. During the handover, Engineer A advised Engineer B that they would have to do the second part of the duplicate safety inspection. Duplicate safety inspections were required for certain tasks, including the removal and reinstallation of the hydraulic servos, which were classified as critical flight controls due to their potential to adversely affect the controllability of the helicopter if not installed correctly.

3.43. As a qualified LAME, Engineer A was authorised to sign off on the first part of the duplicate safety inspection for the installation of the servos, in accordance with CAR Part 43.113(c)(3):

> We certify that a duplicate safety inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in respect of the maintenance performed, the control system is assembled and locked correctly.

3.44. It is **very likely** that Engineer A was distracted in their work and under time pressure as they were going on leave, and that they did not adequately verify the left and right main rotor servo swap had been completed correctly at the time they signed the first part of the duplicate safety inspection certificate.

[45] CAR 43.113(d) requires the date of entry to be included in the appropriate maintenance logbook or worksheet adjacent to the statement required by CAR 43.113(c)(3).

Second stage of the duplicate safety inspection and release to service

3.45. Engineer B returned to work on Monday 15 July 2024. The pilot[46] who was going to fly the helicopter following its release to service later in the week, was at the hangar to undertake some maintenance work for the maintenance provider. Engineer B briefed the pilot on how the maintenance was progressing before the pilot began working on another aircraft.

3.46. Engineer B then refamiliarised themselves with the helicopter's workpack. Up until that point of the maintenance check, they had been engaged in repair under the helicopter's fuselage. Once they had reviewed the workpack, Engineer B elected to conduct the second part of the duplicate safety inspection that had been discussed with Engineer A during the handover briefing. This included the inspection of the left and right main rotor hydraulic servos that Engineer A had swapped.

3.47. During interview, Engineer B stated that they remembered inspecting the servo on the right-hand side of the helicopter. They also recalled looking through to the left-side servo but, as they could not inspect all the necessary components from their viewing position, they were aware that they would have to move to the left side of the helicopter to complete the inspection. However, they did not have any distinct memories of inspecting the left servo.

3.48. During their shift on Monday 15 July 2024, Engineer B undertook several duplicate safety inspections on the helicopter, including signing for the second part of the duplicate safety inspection for the left and right hydraulic servo swap. In doing so they were certifying that they had checked that the identified control system functioned correctly and, in respect of the maintenance performed, the control system was assembled and locked correctly.

3.49. On Tuesday 16 July 2024, Engineer B undertook work to connect the left and right hydraulic servo input rods. These had deliberately been left undone by Engineer A to facilitate the underfloor connection to the flight controls, and they communicated this to Engineer B during the handover. The position of the left input rod is in close proximity to the lower left servo connection (*see* Figure 9). However Engineer B noticed nothing untoward while they were connecting the input rod.

3.50. Another opportunity arose to notice the incorrectly installed servo on Thursday 18 July 2024. Engineer B tasked the pilot with carrying out the second part of the duplicate safety inspection for the connection of the hydraulic servo input rods they had completed two days earlier. During Commission interviews, the pilot recalled that despite the input rod connection being in close proximity to the lower hydraulic servo connection, they were focused on inspecting the input rods and noticed nothing untoward.

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[46] The pilot was also a LAME employed by the maintenance organisation on a casual employment basis.

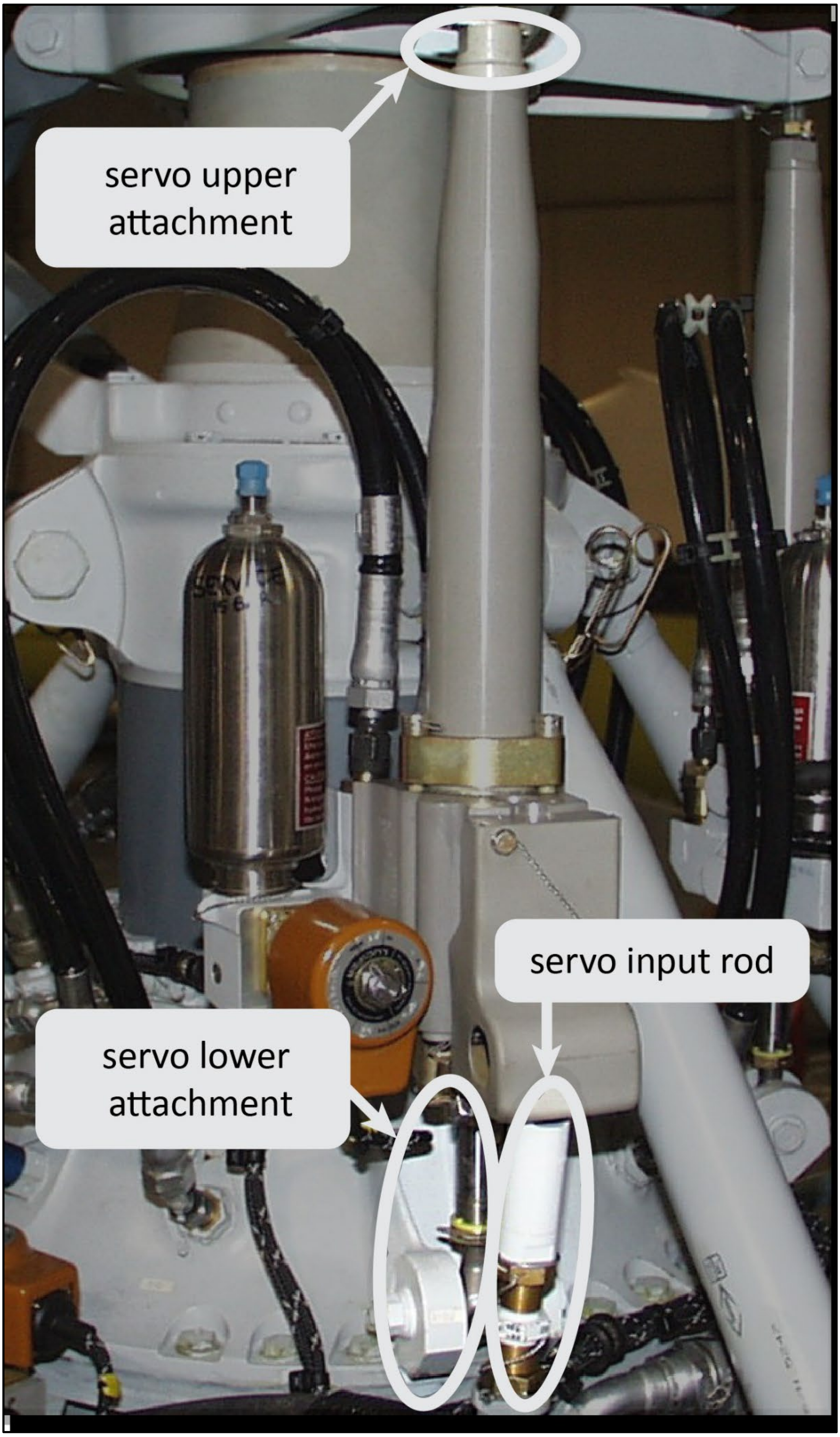

Figure 9: Example of AS350 hydraulic servo attachment points

Human error in maintenance

3.51. Humans are known to make errors (slips, lapses or mistakes) when working, which is why sociotechnical systems[47] must be designed to be resilient to any human errors that occur.

3.52. The aviation maintenance system requires a duplicate safety inspection of any flight-critical systems. A flight-critical system is any system that could affect the safety of flight of the helicopter if it is not functioning in accordance with the manufacturers specifications.

3.53. A duplicate safety inspection, as detailed in CAR 43.113, is designed to verify that a critical maintenance task has been done correctly and identify any errors that may have been made during the conduct of the maintenance task. To minimise the risk of an error not being identified, an inspection is completed by another engineer who was not involved in doing the maintenance task. The effectiveness of duplicate inspections has been debated at length within the industry; while they can be fallible, they are generally considered an effective mechanism for trapping errors. Best practice techniques include conducting the independent inspection as soon as possible following the original inspection (United Kingdom Civil Aviation Authority, 2003).

3.54. Despite the requirement for duplicate safety inspections, maintenance error remains a contributing cause to aviation accidents both within New Zealand and globally. Analysis of a 10-year data set of United States helicopter accidents between 2005 and 2015 found a significant clustering of accidents immediately following release from maintenance (Saleh, Tikayat, Zhang, & Churchwell, 2019). Errors during installation and errors associated with visual inspection are amongst the most frequent type of maintenance error (Rashid, Place, & Braithwaite, 2013) (United Kingdom Civil Aviation Authority, 2016). In relation to the 10-year US data set, Saleh et al. (2019) found improper or incomplete (re)assembly or installation of a part accounted for 57% of maintenance errors, followed by 35% failure to perform a required preventative maintenance and inspection task.

3.55. The leading cause of failure to follow maintenance procedures is unintentional error. This includes errors relating to attention and memory, including distractions and interruptions (Key, et al., 2022). During their work on the left hydraulic servo, Engineer A was exposed to at least three distractions, including the interruption by the customer arriving at the hangar, the clean-up of the leaking hydraulic fluid and the trips back and forth to the sonic bath whilst cleaning the sight glass. The maintenance provider had a system in place to manage distraction,[48] however Engineer A considered this only applicable for extended time away from a task (such as taking a lunch break or at the end of the shift). While it is possible the initial distraction of the customer may not have interfered with Engineer A’s ability to return and complete the installation, the additional distraction of the leaking hydraulic fluid increased the

[47] Relates to an interconnectedness between humans and technology within a system. Complex systems have multiple individual, but inter-related, components that interact. Within complex systems, safety is considered to be an emergent property of the system as a whole, not the result of individual components acting in isolation.

[48] This was by the use of a red ribbon that would be hung on the appropriate aircraft location to provide a visible reminder of any unfinished work.

amount of interruption time and therefore increased the likelihood that an omission error could be made.

3.56. Despite not completing the installation of the left servo, Engineer A had an opportunity to become aware of this during their write-up of the first part of the duplicate safety inspection. During interviews, Engineer A informed Commission investigators that best practice would be to write up the duplicate safety inspection paperwork immediately after finishing the job. Further best practice would be to include the torque value for the bolts installed during the task in the write-up.

3.57. Another type of unintentional error relates to visual perception, which can contribute to errors in inspection tasks. Engineer B should have discovered that the left-hand servo installation was incomplete as part of the duplicate inspection they performed on Monday 15 July 2024. During Commission interviews, Engineer B was unable to offer any explanation as to why they did not notice the nuts had not been fully tightened to the correct torque or that the missing locking pins had not been installed. Information they were able to provide to Commission investigators indicates that it was possible they became distracted at some point during their walk-around of the left-hand side of the helicopter and never inspected the servo. Alternatively, they did inspect the left-hand side but failed to notice the incomplete installation, effectively looking but not seeing (inattentional blindness).

3.58. Engineer B also informed the Commission that due to personal circumstances they were managing at the time of the event, their normal sleep pattern had become broken. It is therefore **likely** they were experiencing a level of cumulative fatigue that contributed to the error. While Engineer B had considered themselves fit for duty, in hindsight they considered it possible that their personal circumstances may have led to a degree of preoccupation that increased the likelihood of making an error.

3.59. It is **very likely** that the engineers who conducted each part of the duplicate safety inspection were distracted and did not verify that the left servo had been correctly installed.

Post-maintenance acceptance checks

3.60. The AS 350 BA helicopter flight manual details the checks the pilot is required to undertake prior to flight. The first point in the first section, Exterior Checks, states:

> Make sure that all flightworthiness-required corrective maintenance operations have been performed.

3.61. The helicopter flight manual[49] is the primary source of guidance for the pilot operating a helicopter, including the pre-flight checks to be completed.

3.62. While the helicopter flight manual had no specific requirement to check the condition and security of the flight control system, it detailed making sure all corrective maintenance operations had been performed.

3.63. In addition to these checks, as part of the return-to-service process, a check for FOD is completed by another independent engineer prior to the cowls being reinstalled on the helicopter.

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[49] Also known as the Pilot Operating Handbook (POH).

3.64. Prior to being released to service, the helicopter underwent operational flight checks under a limited release to service. This involved three flights to check the main rotor blade track and balance and verify the serviceability of other flight systems. The pilot flew the helicopter for the three main rotor blade track and balance flights.

3.65. On the morning of Saturday 20 July 2024, an operational check flight[50] was completed by the operator's chief pilot and Engineer B to ensure the aircraft was serviceable after the maintenance check.

3.66. The pilot conducted a pre-flight check of the helicopter and then departed with the operator's chief pilot as a passenger for the flight to Franz Josef.

3.67. Four appropriately trained and qualified individuals inspected the helicopter for airworthiness prior to the accident flight. All were aware that the left and right main rotor hydraulic servos had been swapped during maintenance. Each individual was required, and had the appropriate opportunity, to inspect the helicopter, and each certified that they had done so.

3.68. A thorough handover and pre-flight inspection are important following any maintenance activity, especially for any disturbance of the primary flight controls. They provide another opportunity to identify any maintenance errors and ensure they are rectified before the aircraft is flown.

[50] As required by CAR Part 43.103(c).

4 Findings
Ngā kitenga

4.1. It is **very likely** that the actuator bolt's movement from one side, where the lower ball end fitting connects to the main gear box conical housing, manifested through the main rotor controls as a slight jolt in the aircraft and then the initial out-of-track condition. As the bolt was still part-way through the connection, hydraulic assistance from the left servo was still being provided.

4.2. When the pilot lowered the collective to descend to the river for a precautionary landing, the torque reduced, which decreased the load through the main rotor control system. It is **very likely** that this allowed the loose bolt to fall completely free, thereby disconnecting the lower end of the hydraulic servo from the main gear box conical housing.

4.3. The control rod that linked the pilot's controls to the main rotor was still connected to the non-rotating swashplate via the upper end of the hydraulic servo.

4.4. It is **virtually certain** that the increase in torque was due to the pilot raising the collective in response to a combination of the helicopter slowing and losing translational lift.

4.5. It is **very likely** that due to the lower end of the hydraulic servo not being attached, and the hydraulic system being active during the precautionary landing, there was an overwhelming load on the unassisted control. This led to the helicopter making an unintentional roll to the left as the collective was raised on short final.

4.6. It is **virtually certain** that the bolt securing the lower end of the left-hand hydraulic servo became detached during flight, resulting in a change in the control characteristics of the helicopter and influencing the outcome of the landing.

4.7. It is **virtually certain** the nut was not tightened to the correct torque, and the locking pin that was meant to prevent the nut from coming loose was not installed, or not installed correctly, prior to the helicopter's departure from Queenstown.

4.8. It is **virtually certain** that Engineer A did not complete the task of installing the left hydraulic servo.

4.9. It is **very likely** that Engineer A was distracted in their work and under time pressure as they were going on leave, and that they did not adequately verify the left and right main rotor servo swap had been completed correctly at the time they signed the first part of the duplicate safety inspection certificate.

4.10. It is **likely** that Engineer B was experiencing a level of cumulative fatigue that contributed to the error.

4.11. It is **very likely** that the engineers that conducted each part of the duplicate safety inspection were distracted and did not verify that the left servo had been correctly installed.

5 Safety issues and remedial action
Ngā take haumaru me ngā mahi whakatika

General

5.1. Safety issues are an output from the Commission's analysis. They may not always relate to factors directly contributing to the accident or incident. They typically describe a system problem that has the potential to adversely affect future transport safety.

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.

Assurance process

Safety issue: The maintenance provider did not have a robust quality assurance process to ensure maintenance activities were being completed and documented in accordance with their approved maintenance procedures. This increased the risk of maintenance errors not being identified and rectified.

5.3. On 6 January 2026, the maintenance provider informed the Commission that they had taken the following safety action to address this issue.

> **Immediate Actions**
>
> 1. Salus removed the release to service privileges for both engineers while the internal investigation was underway. This was to protect both the individuals and the company while the facts were gathered. Both individuals were permitted to continue doing maintenance, but under supervision.
>
> 2. A physical check was carried out on three North Island and three South Island aircraft that had involved duplicate work carried out by Salus just prior to the ZK-HJM accident. All the duplicate checks, including the paperwork, had been completed correctly.
>
> 3. A one-day human factors course was run by the Safety Manager and the Engineering Manager / 145 Senior person for the two engineers involved in the ZK-HJM accident. This course formed part of their remedial training under the Salus Just Culture model. The training involved visual processing, information processing, attention and perception, complacency, situational awareness and distractions and interruptions.
>
> **Subsequent Actions**
>
> 4. The Salus Standard Practice Instruction (SPI) for Duplicate Inspections was rewritten to include the human factors considerations associated with the duplication inspection process. The human factor elements identified and used in the SPI were distractions, situational awareness, visual processing and complacency.
>
> 5. An online electronic learning package was developed on the human factor aspects of the duplicate process and second stage inspections. The content was based on the human factors published in the SPI. This learning package was delivered to all Salus engineering staff.
>
> 6. The Salus engineering work pack duplicate form was amended to include separate areas for the signing of the assembly, locking and function aspects for

each first and second part duplicate inspection. The Salus duplicate form also has a cross reference from the duplicate to the task number in the task sheets of the work pack. [*see* Appendix 3]

7. The Salus Work Pack initial and bi-annual classroom training was revised to place more emphasis on signing for work as it is completed. This included using the ZK-HJM accident as an example.

8. The entrance to the Salus Queenstown facility for all workers, contractors and visitors was through a door in the rear of the hangar. To remove any distractions for the engineers in the hangar, a new door was built into the administration Porta com (adjacent to the hangar) for contractors and visitors.

9. A daily assurance check was put in place at the Ardmore and Queenstown bases. This involved the Ardmore hangar manager and the Queenstown base manager physically checking that all maintenance work conducted was signed for at the end of the day and that all daily tool checks had been completed. The assurance check was then sent (daily) through to the CEO and the Executive General Manager MRO.

10. A weekly assurance work pack review was put in place to ensure that all the daily assurance checks had been completed and that items for improvement had been discussed and initiated. This was complemented by a monthly desk top audit of the daily and weekly assurance checks.

11. A revised maintenance process and a post maintenance inspection form was introduced at the end of any maintenance activity by Salus. The post maintenance inspection form is a checklist of items to be checked, and it includes a physical check (where accessible) by an independent certifying engineer of components disturbed during maintenance that required duplicate inspections.

12. An updated engineering authorisation process was introduced. When engineers are due for their bi-annual authorisation renewal, they now also have to complete a competency assessment interview conducted by two of Salus's Senior Persons.

13. Following a Quarter 1 2025 restructure, Salus introduced a Head of Engineering role. Despite a global talent shortage that extended recruitment to six months, an external candidate with significant international helicopter maintenance experience joined the company in November 2025. Since their arrival, they have focused on updating maintenance procedures, introducing new initiatives and securing CAANZ Senior Person approval for Part 145. Additionally, the former Engineering Manager role was replaced by a newly filled Technical Support Manager role.

14. The restructure also introduced a Base Manager position in Queenstown, reporting directly to the Head of Engineering. Following a six-month recruitment process, which included a three-month period under a temporary manager to maintain operational oversight and assurance, an internal candidate was appointed and commenced the role in September 2025.

5.4. Despite these actions, another incident involving the duplicate safety inspection process occurred on 12 January 2026 (*see* paragraph 2.65).

5.5. On 14 May 2026, the maintenance provider informed the Commission that they were implementing further safety actions.

When the incident occurred on 12 January 2026, the Head of Engineering had been in the role for approximately 30 working days and was actively transitioning from existing protocols to introducing new safety initiatives.

To elevate Salus above industry standards and best practice, the Company is now implementing a series of initiatives based on the International Association of Oil and Gas Producers (IOGP) Offshore Helicopter Recommended Practices. These initiatives will also focus on ensuring all maintenance is performed and documented strictly according to Salus procedures. Consequently, an expanded assurance action plan based on these IOGP standards and practices has been launched across the organization.

The following actions have been implemented or are in progress to be completed;

1. A more robust task card has been deployed into the maintenance documentation. The format is more aligned with industry best practise, and the layout encompasses the duplicate inspections and release certification sequentially on the same page. This is a more error tolerant design that will reduce ambiguity during completion and review prior to release to service.

2. Maintenance Line Operations Safety Assessment (M-LOSA). M-LOSA is a Threat and Error Management (TEM) program that proactively identifies and manages risks. The program works by training observers who are already subject matter experts, (licensed or unlicensed engineers, rather than auditors) to follow and capture issues observed through normal maintenance procedures. The observers are trained to carry out peer to peer assessments, with a focus on looking for any non-compliant issues or peripheral hazards. The observer's data is captured and reviewed regularly to ensure maintenance personnel are identifying and managing threats, and for system improvements. There have been nine LOSA observations undertaken with observations planned to take place regularly (monthly) within the Salus operation.

3. Duplicate Inspection definitions. The Salus definition list has been expanded to include a wider range of aircraft systems to help reduce the likelihood of recurring defects and incidents. This is in relation to Section 2.74 of the report. The Salus Standard Practice Instruction for Duplicate Inspections has been updated, and the expanded list is in place (attached).

4. A Senior Base Engineer for Queenstown. This position has been put into the engineering structure to help support the Queenstown base operation. An external candidate has been recruited and will be in place with effect from 25 May 2026. The recruitment and selection process focused on identifying the right candidate with a strong bias towards safety and compliance over production.

5. Complex Staged Worksheets will be used in addition to the task cards where there are critical or complex tasks to be undertaken. These staged worksheets are another error tolerant design to provide a detailed and sequential method of documenting the disassembly and reassembly of critical tasks and recording duplicate inspections at the appropriate critical stages (e.g. main / tail rotor and gearbox removal and refitment). The Complex Staged Worksheets also serve as an effective system of handing over semi completed critical tasks from one shift to another. These are being currently developed and deployed with associated training.

6. Authorisation Management. Before an engineer is provided with an authorisation by the Senior Persons Authorisations, the Senior Person Part 145 will carry out a detailed competence assessment to identify and rectify any skills

or competence gaps and ensure the key roles, functions and responsibilities associated with the authorisation are evaluated and recorded. Once complete, the engineer will undertake an interview with the Senior Person 145 and the Senior Person Authorisations as a final verification prior to the issue of a company release to service authorisation.

7. Learning from errors. A rolling programme reviewing the current "Top Ten" paperwork errors is now in place. Typical errors are identified and ranked in a review by the Engineering Administration team with actions to mitigate through process change or further training and standards development. The current work bi-annual Work pack and Safety training package will be updated to include specific and targeted training against these types of error.

8. Increased self-reporting. A campaign around increased self-reporting of errors is underway. This is being driven through toolbox talks and internal publications. This aspect provides confidence that personnel within the business will self-declare any issues proactively, this is in addition to the company focus on occurrence and hazard reporting.

9. Threat and Error Management (TEM) programme. The Engineering and Safety teams will collaborate more closely on an overarching TEM and review historical data on maintenance errors, mis-installations and hazards from the Safety Management System (SMS) and going forward using both SMS and M-LOSA data to identify individual and trending issues where further improvements are needed to mitigate risk. Many of the aforementioned initiatives fall under this overarching TEM programme but have been extracted individually in order to prioritise actions.

10. An Engineering Standards manual. This manual will supplement specific Salus operating procedures. The Standards manual will detail how Salus carries out engineering services including managing key risks. Topics within the Standards manual will include an improved shift handover process, paperwork standards and a sterile environment process (and Policy) to manage a distraction free environment, The Standards manual will support both the Engineering and Overhaul departments and collaboratively, best practises from each area will be assessed, cross-pollenated and defined into Salus standards.

11. The Salus Fatigue Management Policy is currently being reviewed and modified to include improved clarity around duty limits and rest periods to enhance planning and monitoring in order to reduce fatigue including cumulative fatigue.

12. To address Section 3.64 of the report and the management of personal circumstances resulting in cumulative fatigue and stress; Salus has undertaken St Johns Mental Health First Aid Training. St Johns have conducted two 8-hour training sessions for 25 personnel including the CEO and the Executive team. This provides key Salus staff with the necessary skills and knowledge to recognise and respond to personnel within the company that could be experiencing mental distress.

5.6. The Commission considers this safety action has addressed the safety issue. Therefore, the Commission has not made a recommendation.

6 Recommendations
Ngā tūtohutanga

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 recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

New recommendations

6.3. The Commission considers the safety action taken has addressed the safety issues. Therefore, the Commission has not made any recommendations.

7 Other safety lessons
Ngā akoranga matua

7.1. Proper and timely record keeping is an important part of the maintenance of aircraft and should be completed as soon as practicable at the completion of each task.

7.2. Distractions, including interruptions, are an ever-present risk to aviation safety and need to be managed to ensure critical tasks are completed correctly.

7.3. A thorough handover and pre-flight inspection are important following any maintenance activity, especially for any disturbance of the primary flight controls.

7.4. A run-on landing with minimal changes to the flight controls and power required will usually provide the safest method to approach and land when the integrity of the primary flight controls of a helicopter is unknown.

7.5. On-board video recorders can provide valuable information for transport safety investigations to assist with determining the circumstances and causes of accidents and incidents, to avoid similar occurrences in the future.

8 Data summary
Whakarāpopoto raraunga

Aircraft particulars

Aircraft registration:	ZK-HJM
Type and serial number:	Airbus Helicopters AS 350 BA, s/n 1671
Number, type of engines and serial number:	1x Honeywell LTS101-700D-2, s/n LE47013C
Year of manufacture:	1982
Operator:	Amuri Helicopters Limited
Type of flight:	Transport Passenger A to B
Persons on board:	2

Crew particulars

Pilot's licence:	Commercial Pilots Licence (Helicopter)
Pilot's age:	68 years
Pilot's total flying experience:	3981 hours

Date and time	20 July 2024, 1451
Location	Paringa River latitude: 43° 38.7´ south longitude: 169° 26.0´ east
Injuries	minor
Damage	substantial

9 Conduct of the inquiry
Te whakahaere i te pakirehua

9.1. On 20 July 2024, CAA notified the Commission of the occurrence. The Commission opened an inquiry on the 21 July 2024 under section 13(1) of the Transport Accident Investigation Commission Act 1990 and appointed an investigator in charge.

9.2. A protection order was issued covering the wreckage and surrounding areas.

9.3. From 21 to 24 July 2024, two Commission investigators conducted a site examination. The helicopter wreckage was then removed from the accident site and transported to the Commission's technical facility in Wellington for further detailed examination.

9.4. On 31 July and 1 August 2024, Commission investigators interviewed the pilot and passenger.

9.5. On 2 August 2024, the Commission made a safety interest disclosure and advised the maintenance provider about the missing bolt on the hydraulic system.

9.6. On 2 and 3 August 2024, Commission investigators visited the party that provided the maintenance of the helicopter, gathered the relevant maintenance records and interviewed the maintenance personnel in Queenstown.

9.7. On 6 August 2024, the Commission notified the Bureau d'Enquêtes et d'Analyses (BEA), the French Bureau of Enquiry and Analysis for Civil Aviation Safety, as the representative for the state of manufacturer (France) where the AS350 helicopter was manufactured. On 7 August 2024, the BEA appointed a non-travelling accredited representative to the investigation in accordance with Annex 13 to the Convention on International Civil Aviation. The accredited representative was assisted by a technical advisor from Airbus Helicopters.

9.8. On 14 August 2024, Commission investigators interviewed further maintenance personnel.

9.9. On 1 November 2024, the hydraulic servos were taken to a specialist overhaul facility in Brisbane, Australia for testing.

9.10. On 6 March 2025, Commission investigators interviewed management personnel from the maintenance provider in Auckland.

9.11. On 5 June 2025, Commission investigators visited the maintenance facility in Queenstown and conducted further interviews.

9.12. On 24 March 2026, the Commission approved a draft report for circulation to 10 interested parties for their comment.

9.13. Six interested parties provided detailed submissions and three interested parties replied that they had no comment. One interested party did not respond despite efforts to contact them. Any changes as a result of the submissions have been included in the final report.

9.14. On 8 June 2026, the Commission approved the final report for publication.

Abbreviations
Whakapotonga

ATSB	Australian Transport Safety Bureau
BEA	Bureau d'Enquêtes et d'Analyses
CAA	Civil Aviation Authority
CARs	New Zealand Civil Aviation Rules
ELT	emergency locator transmitter
FOD	foreign object debris
LAME	Licenced Aircraft Maintenance Engineer
MGB	main gear box
NAA	National Aviation Authority
NTSB	United States of America National Transportation Safety Board
POH	Pilot Operating Handbook
RCC	Rescue Coordination Centre
RTS	return to service
SPI	Standard Practice Instruction
STC	Supplemental Type Certificate
TC	Type Certificate
TSB	Transportation Safety Board of Canada

Glossary
Kuputaka

acceptance flight	a flight by the customer to confirm the handling and performance of the helicopter are satisfactory prior to receiving the helicopter back from the maintenance provider
actuator	transforms energy, typically in the form of electricity, hydraulics or pneumatics, into regulated motion or force
collective	one of the flight controls used by a helicopter pilot to 'collectively' adjust the pitch angle of all main rotor blades, and at the same time to alter the amount of thrust/lift being produced
cumulative fatigue	characterised by a progressive state of exhaustion that builds up over time due to consistent physical or mental exertion without sufficient recovery. Unlike acute fatigue, which can be resolved with a good night's sleep or a short break, cumulative fatigue persists and often requires more structured intervention to address. It is fundamentally a state of incomplete recovery from recurring stressors, leading to an increasing deficit in energy and performance over time
cyclic	the control which changes the pitch angle of the rotor blades individually during a cycle of revolution and as a result tilts the main rotor disc to control the direction and velocity of flight
duplicate safety inspection	designed to verify that a critical maintenance task has been done correctly and identify any errors that may have been made during the conduct of the maintenance task
emergency locator transmitter	transmits a distress signal to the Cospas-Sarsat search and rescue satellite system
foreign object debris	any object found in an inappropriate location that, as a result of being in that location, can damage equipment or injure personnel

helicopter transmission deck	the structural components that support the helicopter's transmission system, which transfer power from the engine to the main rotor and tail rotor during flight
MGB conical housing	the cone-shaped enclosure containing the helicopter’s main gearbox
on-board video	on-board video and audio recording system
release to service	the formal declaration that the maintenance tasks on an aircraft (or component) have been carried out correctly by an appropriately authorised person, as per the requirements of CAR Part 43 Subpart C – Release to Service
review of airworthiness	an assessment and inspection of the aircraft’s conformity to its type certificated or properly modified state, and its maintenance records and its condition
run-on landing	a landing with significant forward motion, as opposed to a landing from a hover. After touchdown, forward motion is maintained until ground friction brings the helicopter to a halt. It is generally used when there is insufficient power to sustain a hover or to reduce the power required and control inputs required in some emergency situations where the integrity of the primary flight controls of a helicopter is unknown
servo	a servo is a hydraulic actuator that assists the movement of a mechanism
sociotechnical systems	relates to an interconnectedness between humans and technology within a system. Complex systems have multiple individual, but interrelated, components that interact. Within complex systems, safety is considered to be an emergent property of the system as a whole, not the result of individual components acting in isolation
translational lift	the increased efficiency of a helicopter's rotor system as it transitions from a hover to forward flight, resulting in improved lift and performance

workpack	the repair, maintenance or overhaul instructions provided to the engineer for accomplishment of scheduled or unscheduled work. It can include work order/task cards

Citations
Ngā tohutoru

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Appendix 1 AS350 Hydraulic System

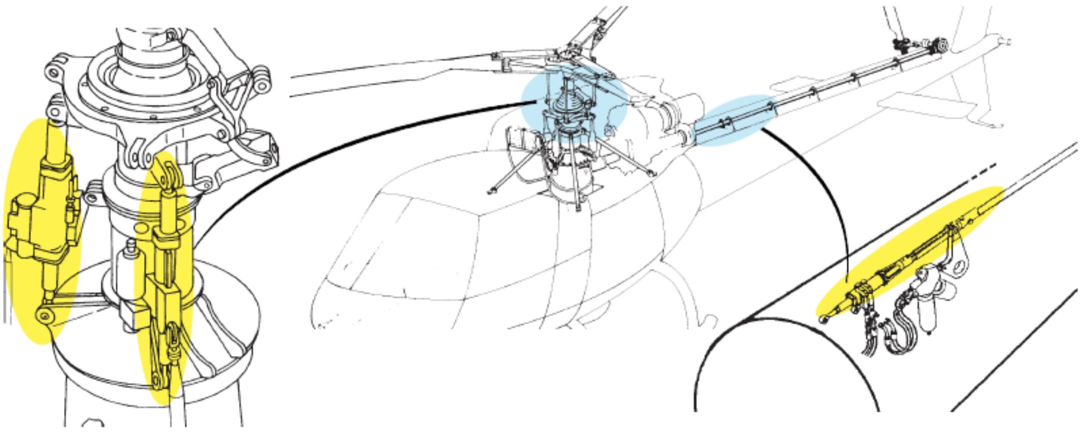
THM

eurocopter
an EADS Company

8.1 SERVO ACTUATORS

The helicopter can be controlled without servo actuators but this requires the pilot to apply non-negligible forces that are difficult to gauge. These control loads are absorbed by hydraulic servo actuators so that the pilot can fly the helicopter PRECISELY and EFFORTLESSLY.

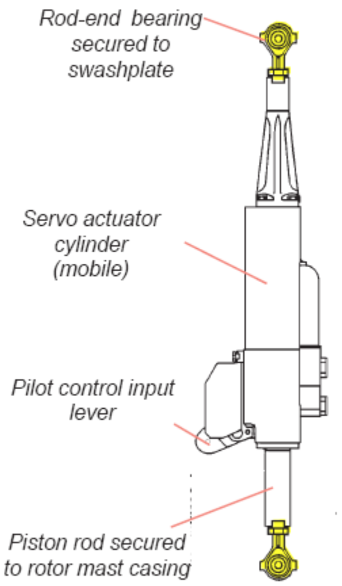
N.B. In case of loss of hydraulic pressure, accumulators in the main rotor servo actuators provide a small energy reserve, giving the pilot time to reconfigure in the safety configuration. The B1 and B2 versions are fitted with a yaw load compensator.



3 main rotor servo actuators

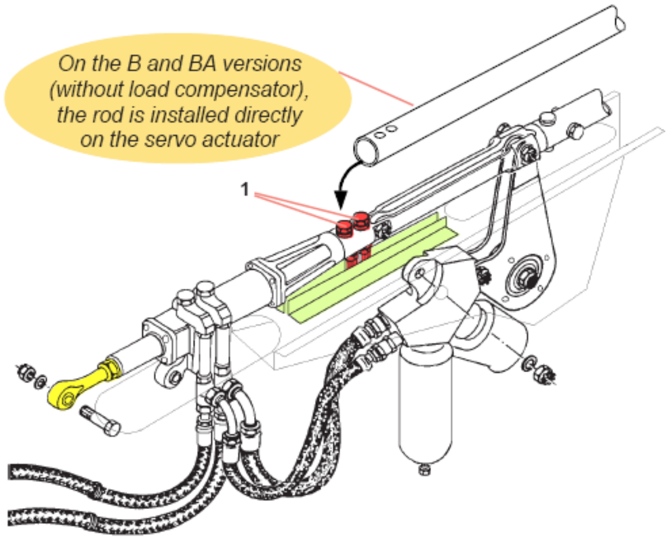
Apart from mounting differences, the 4 servo actuators on the control linkages are identical. The 3 main rotor servo actuators are secured via rod-end bearings to the rotor mast casing (fixed point) and to the swashplate.

MAIN ROTOR SERVO ACTUATOR



TAIL ROTOR SERVO ACTUATOR

The tail rotor servo actuator is secured via a rod-end bearing to the airframe. The tail rotor control rod is attached to the output adapter casing. Attaching bolts (1) act as guides.



Rev.
27-2005

8.3

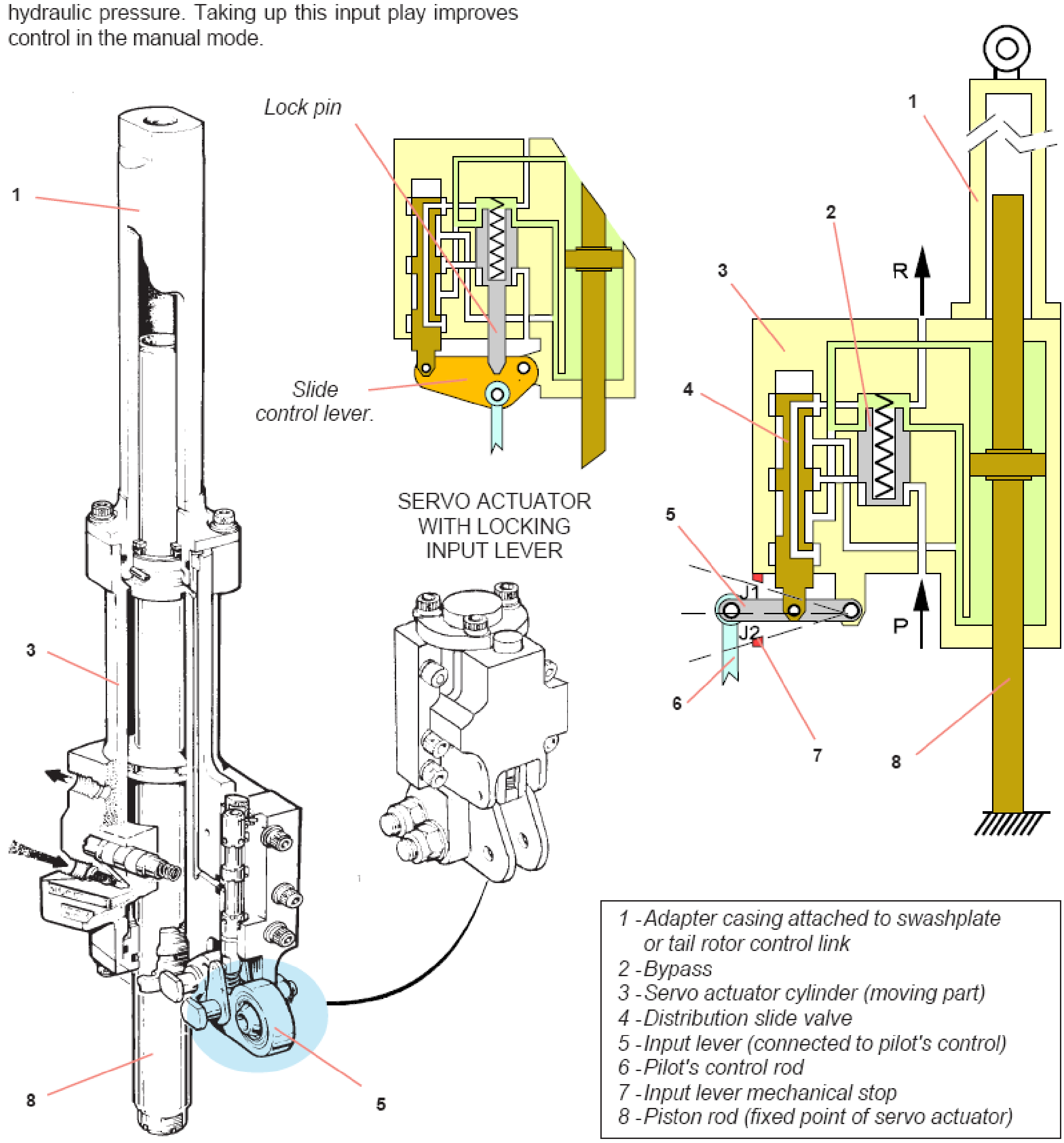
8.1.2 "DUNLOP" SERVO ACTUATORS

(1) Characteristics

The *Samm* and *Dunlop* servo actuators are interchangeable: their functional characteristics are identical or very similar and their mounting identical. Moreover, the design of the *Dunlop* servo actuator (sliding distributor valve with equal actuator areas) in no way affects the functional explanation.

Nonetheless it should be noted that the *Dunlop* servo actuator on the "longitudinal" channel is fitted with a system to eliminate the input lever play in case of loss of hydraulic pressure. Taking up this input play improves control in the manual mode.

Weight	1.9 kg
Operating pressure	40 bar
Piston cross-section	4.5 cm2
Input force	≤ 0.3 daN
Force at operating pressure (40 bar)	180 daN
Maximum working travel	110 mm
Bypass opening pressure ↓	≤ 14 bar
Bypass closing pressure ↑	≥ 6 bar



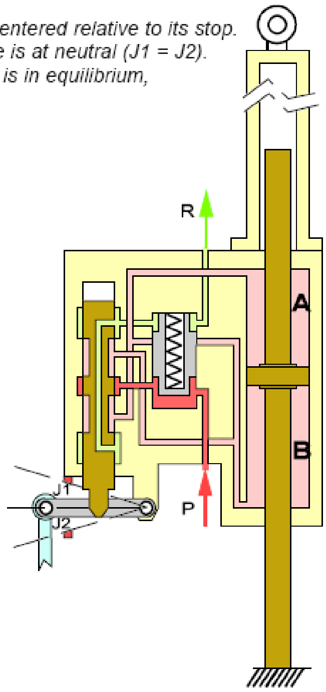
1 - *Adapter casing attached to swashplate or tail rotor control link*
2 - *Bypass*
3 - *Servo actuator cylinder (moving part)*
4 - *Distribution slide valve*
5 - *Input lever (connected to pilot's control)*
6 - *Pilot's control rod*
7 - *Input lever mechanical stop*
8 - *Piston rod (fixed point of servo actuator)*

8.1.2 "DUNLOP" SERVO ACTUATOR (Cont'd)

(2) Operation

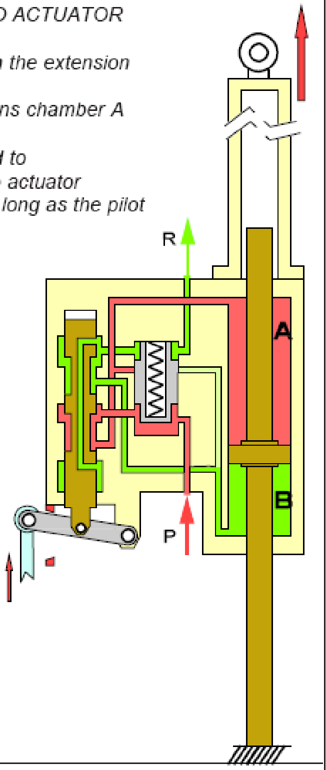
PILOT'S CONTROL STATIONARY

- *The input lever is centered relative to its stop.*
- *The distributor slide is at neutral (J1 = J2).*
- *The servo actuator is in equilibrium, i.e. stationary.*



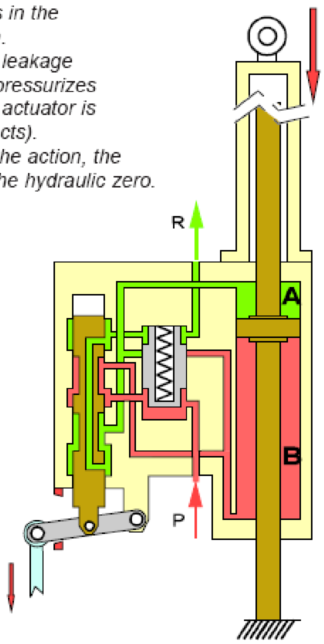
EXTENSION OF SERVO ACTUATOR

The input lever moves in the extension direction.
The distributor slide opens chamber A to the pressure flow.
Chamber B is connected to the return line: the servo actuator remains EXTENDED as long as the pilot maintains his action.
When the pilot stops the action, the distributor returns to the hydraulic zero.



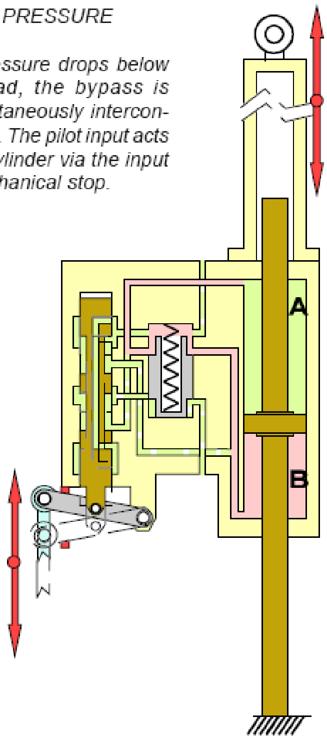
RETRACTION OF SERVO ACTUATOR

The input lever moves in the compression direction.
The distributor allows leakage from chamber A and pressurizes chamber B: the servo actuator is COMPRESSED (retracts).
When the pilot stops the action, the distributor returns to the hydraulic zero.

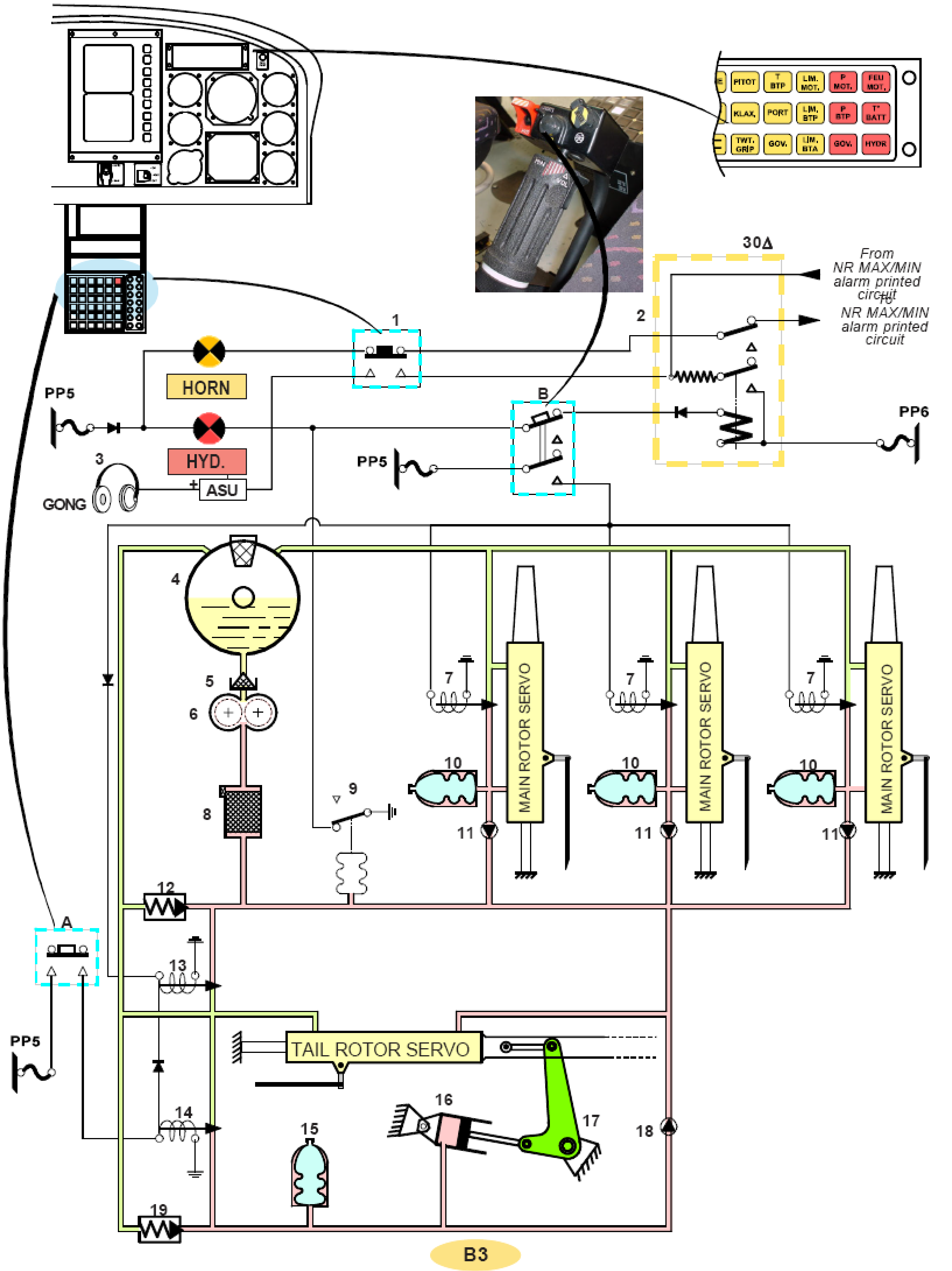


LOSS OF HYDRAULIC PRESSURE

When the hydraulic pressure drops below the bypass spring load, the bypass is pushed back and simultaneously interconnects chambers A and B. The pilot input acts on the servo actuator cylinder via the input lever seated on its mechanical stop.



8.2.2 HYDRAULIC SYSTEM COMPONENTS AND THEIR FUNCTIONS
Aft Mod 073263

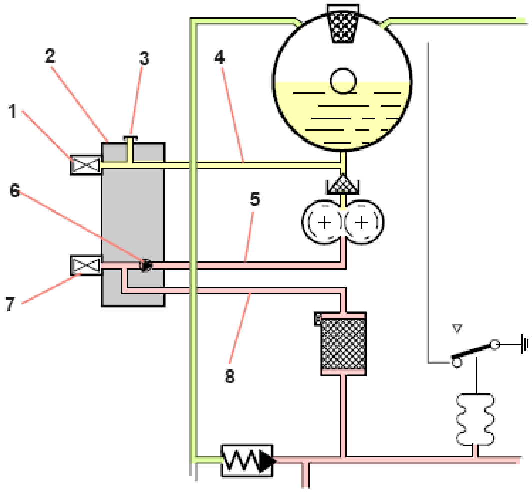


8.2.2 HYDRAULIC SYSTEM COMPONENTS AND THEIR FUNCTIONS (Cont'd)

1 **HORN pushbutton** on control pedestal. Used to disable the horn.
2 **Control relay**, energized in case of hydraulic pressure drop or loss of NR.
3 **HORN** providing aural alarm in case of loss of hydraulic pressure or drop in NR.
4 **Hydraulic fluid reservoir**
5 **Strainer** (mesh size = 0.8-1 mm) on pump inlet.
6 **Gear pump** driven by MGB, with flowrate = 6 l/min.
7 **Main rotor servo actuator solenoid valves,** controlled by pushbutton B. Used in case of hydraulic failure or seizure of a servo actuator distributor to route the servo pressure inlet line back into the reservoir; this eliminates back pressure in manual control and hence reduces the control loads.
8 **Filter unit** with clogging indicator. Filtering capacity = 3µ.
9 **Pressure switch,** which closes the "HYD" light circuit when P < 30 bar.
10 **Backup accumulators** on main rotor servo actuators. Used in case of hydraulic failure to provide a small energy reserve so that the pilot can attain a "least load" fallback speed for manual control.
11 **Main rotor servos non-return valves**, which are closed in case of hydraulic failure by the accumulators' pressure (the flow from the accumulators is only used by the servo actuator).
12 **Regulator valve,** which keeps the system pressure at 40 bar.
13 **"Hydraulic Test" solenoid valve,** controlled by pushbutton A. When energized it opens to route the servo actuator supply circuit back into the reservoir. This depressurizes the system and allows the backup accumulators (10) to be tested on the main rotor servo actuators.
14 **Solenoid valve** for discharging accumulator (15). When open, the valve allows the pedals to be operated with the rotor stopped.
15 **Accumulator,** which provides a power reserve for load compensator actuator (16).
16 **Hydraulic actuator,** which together with lever (17) facilitates tail rotor pitch changes in case of loss of hydraulic power.
17 **Multiplying lever**, which magnifies a small displacement of the actuator piston into a large movement of the servo actuator rod connecting point.
18 **Non-return valve,** which keeps accumulator (15) charged in case of loss of hydraulic pressure.
19 **Pressure relief valve,** which partially bleeds off the hydraulic fluid when the compensator piston returns from the extreme extended position; this eliminates hydraulic locking when the system is pressurized.
A **"HYDRAULIC TEST" pushbutton** (on control pedestal) which activates solenoid valves (13) and (14).
B **"Hydraulic cutoff" pushbutton** (on collective lever) which activates solenoid valves (7).

OPTION

INSTALLATION OF GROUND POWER CONNECTION



1 - Self-sealing suction ground connection
2 - Manifold on RH side of transmission deck
3 - Drain plug
4 - Suction pipe
5 - Helicopter pump delivery pipe
6 - Non-return valve
7 - Ground pressure quick release coupling
8 - Ground or pump delivery pipe

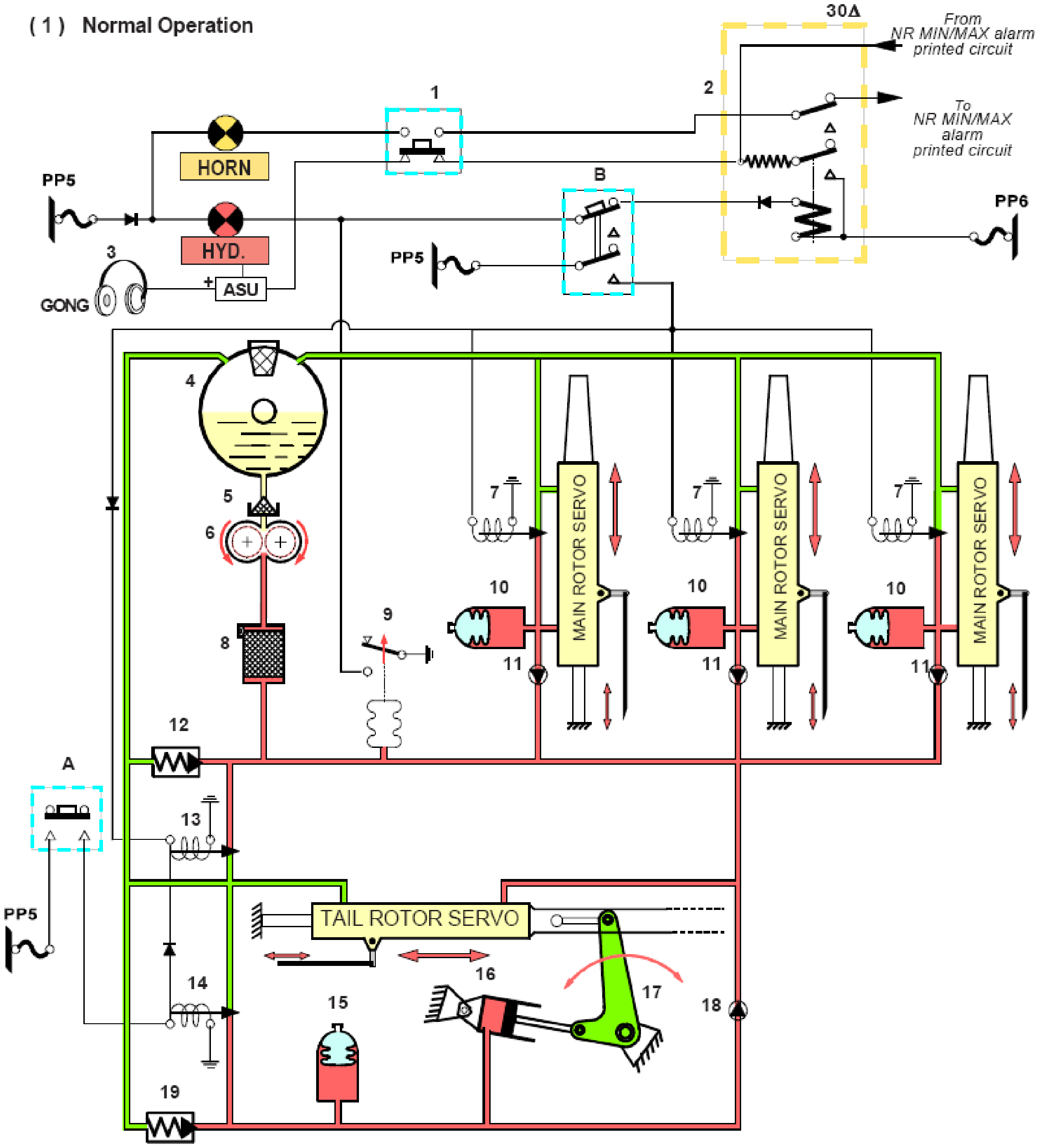
HORN — "HORN" light; when lit indicates the aural alarm pushbutton is not in working position

HYD. — "Hydraulic pressure drop" warning light

8.2.3 HYDRAULIC SYSTEM OPERATION

Aft Mod 073263

(1) Normal Operation



- When pusbuttons A and B are released:
  De-energized solenoid valves (7, 13, 14) are closed.
- Hydraulic pump (6) is running (rotor spinning).
- Regulator valve (12) holds the pressure at 40 bar:
  HYD light is off and horn is silent.
- Servo actuators are pressurized normally.
- Hydraulic fluid compresses the nitrogen in the accumulators.

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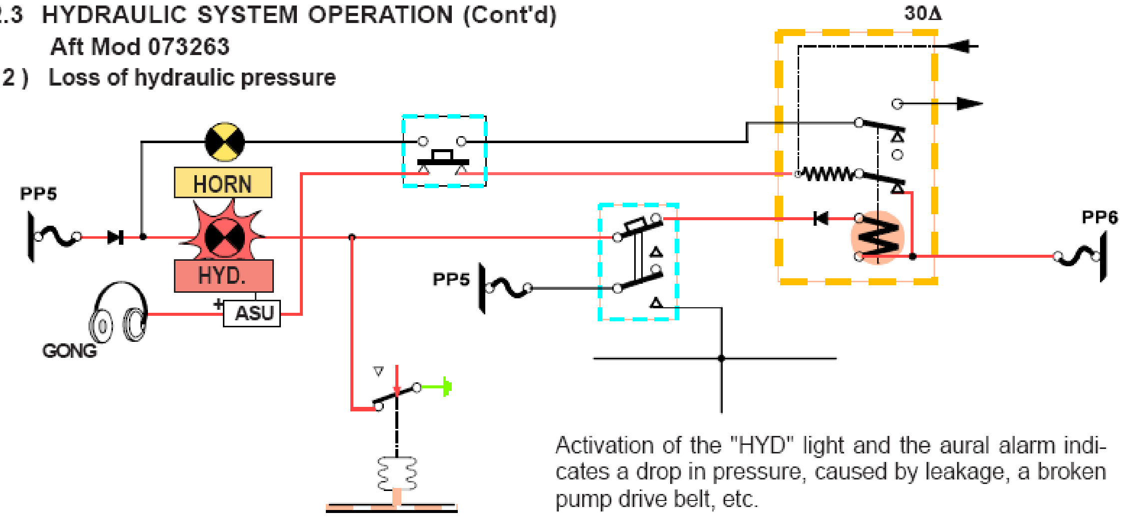
8.2.3 HYDRAULIC SYSTEM OPERATION (Cont'd)

Aft Mod 073263

(2) Loss of hydraulic pressure



Activation of the "HYD" light and the aural alarm indicates a drop in pressure, caused by leakage, a broken pump drive belt, etc.

This informs the pilot that manual control is necessary.

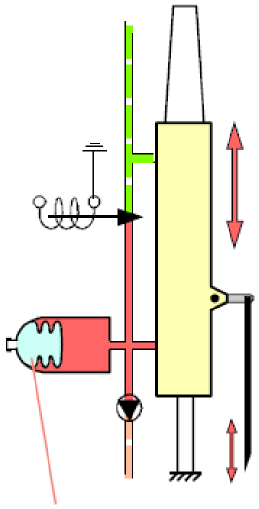
PURPOSE OF MAIN ROTOR SERVO ACTUATORS BACKUP SYSTEM

The main rotor control forces vary with the helicopter's airspeed. Above a certain speed, they increase as the helicopter flies faster. In case of hydraulic pressure loss the pilot should therefore decrease the airspeed by reducing collective pitch so that the control loads are acceptable for manual piloting.

OPERATION OF BACKUP SYSTEM

As soon as the system pressure drops, the accumulators release their stored pressure as the nitrogen expands. The non-return valves are closed and the servo actuators are kept pressurized until the accumulators are fully discharged.

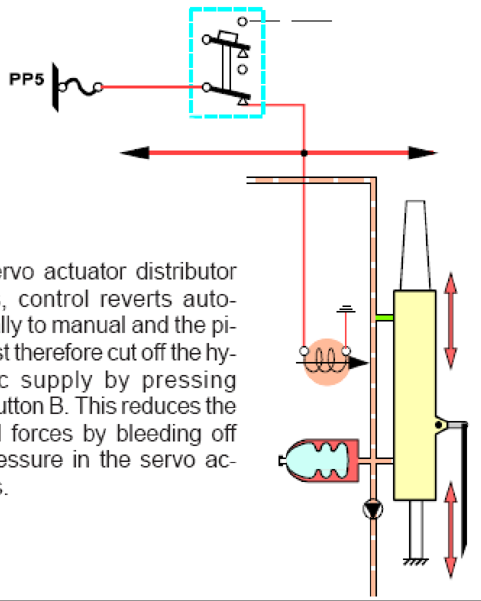
THE PILOT MUST REDUCE THE COLLECTIVE PITCH BEFORE THE ACCUMULATORS HAVE FULLY DISCHARGED.



Once the safe fallback speed is reached, the pilot is in manual model (accumulators discharged). The pilot opens solenoid valves (7) via "Hydraulic Cutoff" pushbutton (B) to eliminate any residual and back pressure on both sides of the servo actuator piston (this reduces the forces required to move the servo actuators).
NOTE: When pushbutton B is pressed, the horn stops (the horn circuit is wired through a pushbutton stage).

(3) Seizure of a servo actuator distributor

If a servo actuator distributor seizes, control reverts automatically to manual and the pilot must therefore cut off the hydraulic supply by pressing pushbutton B. This reduces the control forces by bleeding off the pressure in the servo actuators.



B3

Appendix 2 Standard Practice Instruction SPI116 – Duplicate Safety Inspection of Controls

1 Policy

It is company policy and a regulatory requirement that a Duplicate Safety Inspection of the control system is carried out after the initial assembly or adjustment of any part of an aircraft control system or component control system prior to certifying a Release to Service of an aircraft or control system component.

2 Objective/Purpose

The objective/purpose is to ensure:

- Compliance with the applicable regulatory requirements
- Each aircraft is airworthy for flight operations following maintenance.

3 Application

This SPI is for application on all aircraft maintained by Salus Aviation AW.

4 Responsibility and Authority

The Engineering Manager is responsible for:

- Ensuring qualified and competent personnel are assigned to carry out Duplicate Safety Inspections.

The Department Managers are responsible for:

- Ensuring staff comply with this SPI.

Certifying Engineers are responsible for:

- "A person must not certify an aircraft or component for release to service after the initial assembly, subsequent disturbance, or adjustment of any part of the control system of the aircraft or the control system of the component" without duplicate inspections being carried out.

The persons carrying out the Duplicate Safety Inspection are responsible for:

- Ensuring they hold a current Company Authorisation in accordance with SPI 004 – Issuing and use of a Company Authorisation
- Having adequate training, knowledge and experience to carry out the Duplicate Safety Inspection.

Engineers are responsible for:

- Notifying the Certifying Engineer when a control system is disturbed.

Note: In the event a person holding Company Authorisation Function 5 is not available, the Certifying Engineer may nominate a pilot to carry out the second inspection provided that the pilot is type rated on the aircraft.

5 References

The following regulator references apply:

- NZCAR Part 43.113
- CAANZ Advisory Circular 43-1 Aircraft Maintenance
- FAA 145.213(a)(b)(1)
- CCAR-145-R3

The following Salus Aviation AW procedures apply:

- CAANZ Part 145 Exposition
- SPI002, SPI004, SPI017, SPI116, SPI105

6 Definitions

Department Managers also means Foreman or Supervisor.

Duplicate Safety Inspection means a first and second part certified inspection, by appropriately qualified and authorised Engineers, of "the control system of the aircraft or the component, as the case may be, functions correctly; and in respect of the maintenance that has been performed, the control system is assembled correctly and every required locking mechanism is in place".

Control Systems means a system by which the attitude, direction of flight, or aerodynamic characteristics of the aircraft may be changed. A control system includes all associated units, whether mechanical, electrical, electronic, hydraulic or pneumatic. For rotorcraft the system includes but not limited to:

- the attachments of all rotary control surfaces or
- the means of operating collective pitch, cyclic pitch, and yaw control.

For engines the systems include all associated units – mechanical, hydraulic, electrical, electronic or pneumatic – that control:

- Power output
- Power absorption
- Emergency operation.

7 Process

7.1 Initiating a Duplicate Safety Inspection

When an engineer disturbs the controls systems on an aircraft the engineer will record this activity in the Maintenance and Recertification Record (Form Number 3622) or a Task Card (Form Number AM/GEN/341) generated through the MRO IT System and detail in this form a Duplicate Safety Inspection is required. The engineer will notify the authorised engineer who will initiate a Duplicate Safety Inspection.

7.2 Carrying Out the First Part Duplicate Safety Inspection

This person shall ensure that:

1. They are appropriately rated and authorised to carry out the first part duplicate inspection
2. Current Technical Data was used for the work
3. All parts of the system which have been disturbed are free from defects; including:
   a. Incorrect rigging
   b. Incorrect locking
   c. Any possibility of fouling or jamming
   d. For the complete system, the controls function throughout their range of travel in each mode, and with each alternative means of actuation;
      i. Freely and in the correct sense
      ii. Without excessive backlash
      iii. With the correct static friction

7.3 Carrying Out the Second Part Duplicate Safety Inspection

This person shall ensure that:-

1. That they are appropriately authorised to carry out a Second Part Duplicate Inspection
2. Current Technical Data was used for the work
3. All parts of the system which have been disturbed are free from defects; including:
   e. Incorrect rigging
   f. Incorrect locking
   g. Any possibility of fouling or jamming
   h. For the complete system, the controls function throughout their range of travel in each mode, and with each alternative means of actuation;
      i. Freely and in the correct sense
      ii. Without excessive backlash
      iii. With the correct static friction

7.4 Recording the Duplicate Safety Inspection Statement in the Workpack

The Engineers certifying the Duplicate Safety Inspection shall complete the Duplicate Safety Inspection Form (Form Number 3066), or Task Card (Form Number AM/GEN/341) as applicable that will include the following statement:

We certify that a Duplicate Safety Inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in respect of the maintenance performed, the control system is assembled and locked correctly.

The Engineers who have made the Duplicate Safety Inspection shall enter the following on the Duplicate Safety Inspection (Form Number 3066) or Task Card (Form Number AM/GEN/341) as applicable:

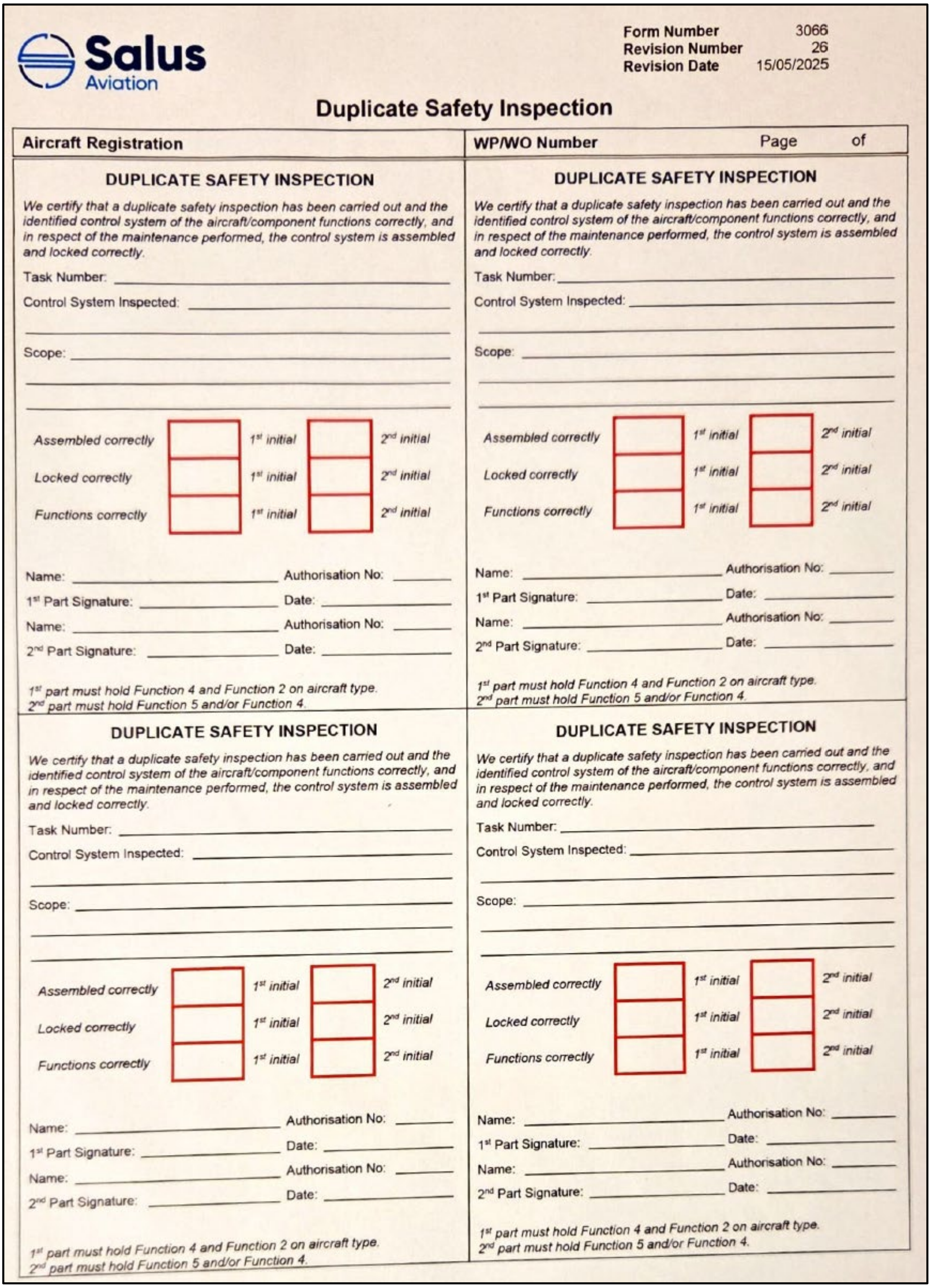
The person's name, signature, authorisation number and the date.

8 Records

Records shall be maintained in accordance with SPI 017 – Maintaining Records

1.

Appendix 3 Duplicate Safety Inspection Form



Salus Aviation

Form Number 3066
Revision Number 26
Revision Date 15/05/2025

Duplicate Safety Inspection

Aircraft Registration	**WP/WO Number** Page of

DUPLICATE SAFETY INSPECTION

We certify that a duplicate safety inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in respect of the maintenance performed, the control system is assembled and locked correctly.

Task Number: ____________________

Control System Inspected: ____________________

____

Scope: ____________________

____

____

Assembled correctly		*1st initial*		*2nd initial*
Locked correctly		*1st initial*		*2nd initial*
Functions correctly		*1st initial*		*2nd initial*

Name: ____________ Authorisation No: ________

1st Part Signature: ____________ Date: ________

Name: ____________ Authorisation No: ________

2nd Part Signature: ____________ Date: ________

1st part must hold Function 4 and Function 2 on aircraft type.
2nd part must hold Function 5 and/or Function 4.

DUPLICATE SAFETY INSPECTION

We certify that a duplicate safety inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in respect of the maintenance performed, the control system is assembled and locked correctly.

Task Number: ____________________

Control System Inspected: ____________________

____

Scope: ____________________

____

____

Assembled correctly		*1st initial*		*2nd initial*
Locked correctly		*1st initial*		*2nd initial*
Functions correctly		*1st initial*		*2nd initial*

Name: ____________ Authorisation No: ________

1st Part Signature: ____________ Date: ________

Name: ____________ Authorisation No: ________

2nd Part Signature: ____________ Date: ________

1st part must hold Function 4 and Function 2 on aircraft type.
2nd part must hold Function 5 and/or Function 4.

DUPLICATE SAFETY INSPECTION

We certify that a duplicate safety inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in respect of the maintenance performed, the control system is assembled and locked correctly.

Task Number: ____________________

Control System Inspected: ____________________

____

Scope: ____________________

____

____

Assembled correctly		*1st initial*		*2nd initial*
Locked correctly		*1st initial*		*2nd initial*
Functions correctly		*1st initial*		*2nd initial*

Name: ____________ Authorisation No: ________

1st Part Signature: ____________ Date: ________

Name: ____________ Authorisation No: ________

2nd Part Signature: ____________ Date: ________

1st part must hold Function 4 and Function 2 on aircraft type.
2nd part must hold Function 5 and/or Function 4.

DUPLICATE SAFETY INSPECTION

We certify that a duplicate safety inspection has been carried out and the identified control system of the aircraft/component functions correctly, and in respect of the maintenance performed, the control system is assembled and locked correctly.

Task Number: ____________________

Control System Inspected: ____________________

____

Scope: ____________________

____

____

Assembled correctly		*1st initial*		*2nd initial*
Locked correctly		*1st initial*		*2nd initial*
Functions correctly		*1st initial*		*2nd initial*

Name: ____________ Authorisation No: ________

1st Part Signature: ____________ Date: ________

Name: ____________ Authorisation No: ________

2nd Part Signature: ____________ Date: ________

1st part must hold Function 4 and Function 2 on aircraft type.
2nd part must hold Function 5 and/or Function 4.

Kōwhaiwhai - Māori scroll designs

TAIC commissioned its four kōwhaiwhai, Māori scroll designs, from artist Sandy Rodgers (Ngāti Raukawa, Tūwharetoa, MacDougal). Sandy began from thinking of the Commission as a vehicle or vessel for seeking knowledge to understand transport accident tragedies and how to avoid them. A 'waka whai mārama' (i te ara haumaru) is 'a vessel/vehicle in pursuit of understanding'. Waka is a 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 represents 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 a 'Aviation'.

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

Maritime: 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 'Maritime.

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-2024-001	Bombardier DHC-8-311, ZK-NEF, Runway excursion (overrun), Timaru Aerodrome, 7 February 2024
AO-2024-004	Airbus A320, registration VH-VFF, Loss of control – ground (LOC-G), Christchurch, 31 May 2024
AO-2023-008	Q-300, ZK-NES and Beech 76 Duchess, ZK-JED, air proximity occurrence, near Brynderwyn, 28 August 2023
AO-2025-001	AS350 helicopter, hard landing, Mount Madeline, 12 January 2025
AO-2024-003	Airbus A320-232, ZK-OXJ and drone, Air proximity incident over South Auckland, 7 NM east of Auckland International Airport, 02 April 2024
AO-2023-003	Runway excursion (veer-off), Boeing 777-319ER ZK-OKN, Auckland International Airport, 27 January 2023
AO-2023-011	ZK-JED BE76 / ZK-WFS C172, near mid-air collision, Ardmore Aerodrome, 3 October 2023
AO-2023-010	Kawasaki BK117 B-2, ZK-HHJ, collision with terrain, Mount Pirongia, 19 September 2023
AO-2022-005	Boeing 737-484SF, ZK-TLL, Incorrect fuel configuration, Sydney to Auckland, 7 June 2022
AO-2023-001	Airbus Helicopters AS350B2 (ZK-IDB) and EC130B4 (ZK-IUP), reported close air proximity, Queenstown Aerodrome, 27 December 2022
AO-2018-009	MD Helicopters 500D, ZK-HOJ, In-flight breakup, near Wānaka Aerodrome, 18 October 2018

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