Transportation Safety Board of Canada
Bureau de la sécurité des transports du Canada

AIR TRANSPORTATION SAFETY INVESTIGATION REPORT A23P0040

LOSS OF CONTROL ON GROUND

Mustang Helicopters Inc.
Airbus Helicopters AS 350 B3 (helicopter), C-GUXR
Smithers Airport (CYYD), British Columbia
06 May 2023

Canada

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Summary

On 06 May 2023, the Mustang Helicopters Inc. Airbus Helicopters AS 350 B3 (registration C-GUXR, serial number 3475) was undergoing maintenance ground run operations at Smithers Airport (CYYD), British Columbia, with 1 pilot on board and 2 maintenance staff members standing on the ground near the helicopter's left cargo door. During the 3rd maintenance ground run operation, as in the previous 2 maintenance ground run operations, the pilot increased the aircraft engine power from IDLE to FLT (flight idle) while monitoring the instruments. At approximately 0910 Pacific Daylight Time, once the helicopter had reached flight idle, it suddenly began an uncommanded rotation to the right. Upon recognition of the rotation, the pilot moved the engine control to IDLE, turned off the fuel, and applied the rotor brake. The helicopter came to rest after having completed approximately 540° of rotation. Both maintenance staff members were struck multiple times by the tail rotor; one of them sustained serious injuries, and the other was fatally injured. The pilot was uninjured. The helicopter received minor damage.

1.0 FACTUAL INFORMATION

1.1 History of the flight

On 06 May 2023, the Mustang Helicopters Inc. (Mustang) occurrence pilot and 2 company maintenance staff members (an aircraft maintenance engineer [AME] and an apprentice AME) were at the company hangar at Smithers Airport (CYYD), British Columbia (BC). They were working on the occurrence helicopter, Mustang's Airbus Helicopters AS 350 B3.

The helicopter was pushed out of the hangar and placed nose into the wind. The maintenance staff members were planning to balance the short shaft section of the tail rotor drive shaft.[1] The previous day, the same team of 3 had done maintenance ground run operations to balance the tail rotor, which requires the helicopter to be operated at flight idle[2] for a few minutes.

Balancing equipment was set up on the helicopter, and a battery power cart was placed near the airframe and plugged into the helicopter to supply electrical power for the multiple starts required for the balancing. The pilot completed a pre-flight inspection and detected the abnormal position of one of the skid gear springs. The anomaly was brought to the attention of the AME; however, it was decided that the issue would not hinder the continuation of the maintenance ground run operations as planned.

The pilot expressed to the maintenance staff members that he was interested in following a live sporting event using his cellphone, which he brought into the cockpit. He was wearing a Bluetooth earbud in his left ear and listening to music playing through the earpiece.

For the maintenance ground run operations, the pilot was in the pilot's seat on the right side of the aircraft. Because there was no intention for flight, he did not secure his safety belt before starting the engine, as required in the pre-start section of Mustang's checklist for the AS 350 B3.[3] His feet rested either on the floor of the helicopter or lightly on the bottom of the anti-torque pedals. The collective[4] remained in the down and locked position as intended by the manufacturer.

Both maintenance staff members stood outside the helicopter, on the left side near the cargo door, monitoring the balancing equipment. Because of the noise produced when the helicopter was running, the maintenance staff members were required to move forward along the left side of the helicopter and communicate to the pilot using hand signals when

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1 This action is part of the 600-hour routine aircraft inspection for the AS 350 B3 helicopter and is aimed at minimizing the vibrations of the helicopter.

2 Flight idle is a common term referring to the engine setting at which the rotor system is at full rpm (around 100%) but the collective is in the full-down position, preventing vertical lift.

3 Mustang Helicopters Inc., *AS 350 B3 2B Checklist* (08 June 2022), p. 1.

4 A helicopter's collective is on the left side of the pilot's seat and is used to manually make changes to the pitch angle of the main rotor blades and to the engine power.

an increase in engine power or a shutdown was needed. Both maintenance staff members were wearing double hearing protection.[5]

The pilot started the helicopter for the 1st maintenance ground run operation, completing the steps in the pre-start and start sections of Mustang's checklist, along with the checklist's hydraulic accumulator check and the hydraulic pressure isolation check.[6,7] The maintenance ground run operation lasted a few minutes, and toward the end of it, a maintenance staff member gave the pilot a hand signal to shut down the helicopter. The helicopter was shut down using the entire post-landing and shutdown section of the checklist. During this maintenance ground run operation, the pilot noticed that the helicopter had a pronounced bouncing sensation. Adjustments were made to the tail rotor drive shaft by the AME and apprentice AME, per the aircraft maintenance manual,[8] while the pilot remained in the helicopter.

Approximately 5 minutes after the initial shutdown, the pilot started the helicopter a 2nd time after completing, from memory, an abbreviated version of the steps in the pre-start and start sections of Mustang's checklist. The pilot omitted the fasten safety belt step and the freedom of travel controls check from the pre-start section of the checklist. He also omitted the hydraulic accumulator check and the hydraulic pressure isolation check.

The 2nd maintenance ground run operation lasted a few minutes, and toward the end, a maintenance staff member gave the pilot a hand signal to shut down the helicopter. At that time, the pilot's cellphone was observed sitting on the front left seat illuminated and containing images or text in active motion. The pilot began to conduct the shutdown, during which he was observed holding and interacting with his cellphone while the main rotor blades were spooling down. The helicopter was shut down using the post-landing and shutdown section of the checklist from memory, but the pilot forgot to complete the yaw load compensator check. During this 2nd maintenance ground run operation, the pilot sensed that the pronounced bouncing was still present; however, the helicopter vibration was less than during the 1st maintenance ground run operation. The pilot remained inside the helicopter after the 2nd maintenance ground run operation.

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5 Double hearing protection refers to the use of earplugs combined with over-ear hearing protection.

6 In the documents published by the company and the manufacturer, the terminology used for these 2 checks varies. Airbus Helicopters' *Flight Manual AS 350 B3,* Revision 15 (25 July 2023), section 4.1: Operating Procedures, subsection 4: Starting, 4.1 Starting Procedures, p. 5 refers to the accumulator check and the hydraulic pressure isolation check. In Airbus Helicopters' *Complementary Flight Manual AS 350 B3*, normal revision 15 (25 July 2023) section 7.8: Hydraulic System, subsection 3: Normal Operations, p. 6, the same checks are referred to as the hydraulic accumulator test and the hydraulic pressure cut-off test. In addition, Mustang Helicopters Inc.'s *AS 350 B3 2B Checklist* (08 June 2022), p. 2 refers to these as the hydraulic accumulator check and the hydraulic pressure isolation check. In the interest of consistency, the terms hydraulic accumulator check and hydraulic pressure isolation check are used throughout this report, except in quoted material.

7 The hydraulic accumulator check and the hydraulic pressure isolation check must be completed while the helicopter is at the IDLE engine power setting.

8 Airbus Helicopters, *A350 Aircraft Maintenance Manual*, Task 65-11-00 5-1A: Adjustment – Balancing of the Tail Rotor Drive Shaft – Tail rotor drive line (31 July 2022).

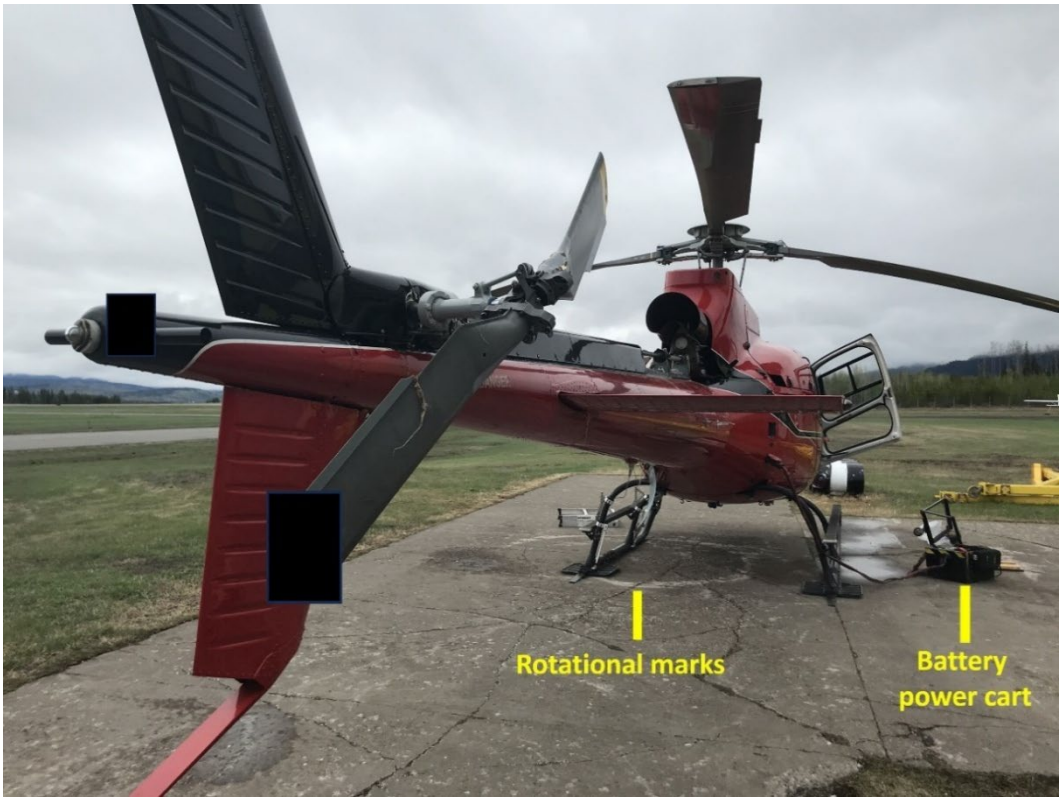
At this point, the balancing equipment indicated that the short shaft section of the tail rotor drive shaft was sufficiently balanced within the manufacturer's parameters. However, wanting to reduce the vibrations further, the maintenance staff members made a further adjustment. At approximately 0907,[9] the pilot started the helicopter for a 3rd time, completing, from memory, the same abbreviated version of the steps in the pre-start and start sections of the checklist that he had performed during the 2nd start.

The pilot adjusted the aircraft engine power from IDLE to FLT (flight idle), as in the previous maintenance ground run operations, while he monitored the engine instruments. Once the helicopter had reached flight idle, at approximately 0910, the helicopter suddenly lifted slightly and began to rotate to the right. The pilot had his head down at the time, and when he looked up, he realized the helicopter was rotating. The pilot immediately moved the engine control to IDLE, turned off the fuel, and applied the overhead rotor brake. It could not be determined if he had tried to counteract the rotation with the anti-torque pedals.

The helicopter came to rest after having rotated approximately 540° (Figure 1). During the rotation, both maintenance staff members had attempted to distance themselves from the spinning helicopter, but they were struck multiple times by the tail rotor.

9 All times are Pacific Daylight Time (Coordinated Universal Time minus 7 hours).

Figure 1. The occurrence helicopter shortly after the loss of control (Source: Smithers Royal Canadian Mounted Police [RCMP], with TSB annotations)



A 4th Mustang employee, a ground support staff member who had been in the hangar at the time of the accident, came out to offer assistance when he heard a commotion. 911 was called, and first aid was provided to both injured maintenance staff members. The apprentice AME was fatally injured. The AME received serious injuries and was transported by helicopter to a hospital in Prince George, BC.

1.2 Injuries to persons

The pilot was alone on board. Two company maintenance staff members were standing near the helicopter. Table 1 outlines the degree of injuries received.

Table 1. Injuries to persons

Degree of injury	Crew	Passengers	Persons not on board the aircraft	Total by injury
Fatal	0	–	1	1
Serious	0	–	1	1
Minor	0	–	0	0
Total injured	0	–	2	2

1.3 Damage to aircraft

The helicopter sustained damage to the tail rotor, the vertical stabilizer, the tail cone skins, the tail rotor gearbox (including the mounting components), the tail rotor drive shaft, and the tail rotor drive shaft cover.

1.4 Other damage

The battery power cart that was plugged into the helicopter at the time of the occurrence was destroyed.

1.5 Personnel information

1.5.1 Pilot

Table 2. Personnel information

Pilot licence	Commercial pilot licence - helicopter
Medical expiry date	01 December 2023
Total flying hours	approximately 2800
Flight hours on type	230.3
Flight hours in the 24 hours before the occurrence	0
Flight hours in the 7 days before the occurrence	0
Flight hours in the 30 days before the occurrence	0
Flight hours in the 90 days before the occurrence	2.7
Flight hours on type in the 90 days before the occurrence	2.7
Hours on duty before the occurrence	1.5
Hours off duty before the work period	14

The pilot had been employed by Mustang since January 2022. He held a commercial pilot licence - helicopter with a valid Category 1 medical certificate. He had accumulated approximately 2800 total flight hours, of which approximately 223.8 were on the AS 350 B2 helicopter and 6.5 were on the AS 350 B3, including 1.1 hours on the occurrence helicopter.

The pilot held the appropriate licence and rating to operate the AS 350 B3 in accordance with existing regulations.

The occurrence pilot held a current and valid first aid certificate at the time of the accident.

1.5.2 Aircraft maintenance and ground support staff members

The AME had been employed by Mustang since December 2022. He held an AME licence with an M2 rating issued by Transport Canada in July 2016. He had completed an AS 350 aircraft maintenance course in April 2016 and an AS 350 B3 differences course in January 2022. Additionally, the AME held a current and valid first aid certificate at the time of the accident, having been initially trained in first aid as a member of the Canadian Armed Forces in 2004.

The apprentice AME had been employed by Mustang since September 2022. He had graduated from an approved aircraft maintenance training course in April 2022.

The ground support staff member had held first aid certification for approximately 9 years.

1.6 Aircraft information

1.6.1 General

Table 3. Aircraft information

Manufacturer	Eurocopter*
Type, model, and registration	AS 350 B3, C-GUXR
Year of manufacture	2001
Serial number	3475
Certificate of airworthiness / flight permit issue date	23 April 2021
Total airframe time	10 012.7 hours
Engine type (number of engines)	Turboshaft Safran Arriel 2B (1)
Rotor type (number of rotor blades)	Starflex semi-rigid (3)
Maximum allowable take-off weight	5225 lb (2370 kg)
Recommended fuel types	Jet A, Jet A-1, Jet B
Fuel type used	Jet A

* Airbus Helicopters currently holds the type certificate for the aircraft type.

The Airbus Helicopters AS 350 B3 is a 6-seat, single-pilot, single-turbine-powered helicopter with a 3-bladed main rotor. The pilot flies from the right seat. The occurrence helicopter was manufactured in 2001 and imported into Canada in 2021. It was purchased by Mustang in June 2022.

The AS 350 B3's main rotor rotates to the right when viewed from above, imparting a force on the helicopter that will normally make the helicopter yaw to the left. This force is normally counteracted via the use of the tail rotor in flight.

There were no recorded defects outstanding at the time of the occurrence.

1.6.2 Aircraft weight

The helicopter's weight and centre of gravity were within the prescribed limits.

The helicopter's empty weight was 2958 pounds. The investigation calculated the total weight of the helicopter to be approximately 3505 pounds when it began to rotate.

1.6.3 Hydraulic system

To reduce a pilot's workload, the helicopter was designed with hydraulically boosted flight controls. The hydraulic boost results in a light control load on the cyclic, collective, and anti-torque pedals. When the engine is started, the hydraulic pressure is nil, but the hydraulic pump begins operating as soon as the rotor is turning.

There are 2 hydraulic system checks that form part of the starting procedures in Airbus Helicopters' *Flight Manual AS 350 B3* and are included in Mustang's *AS 350 B3 2B Checklist*: the hydraulic accumulator check and the hydraulic pressure isolation check. At shutdown, the hydraulic system check consists of the yaw load compensator check.

1.6.4 Manufacturer's guidance

1.6.4.1 Flight manual

Each certified aircraft has a published flight manual. The content of the manual is researched and vetted by the manufacturer before publishing to ensure that important operational information is supplied to the operators of the aircraft. This content is typically closely connected to the systems found in the aircraft and is configured accordingly in the manual.

The manufacturer of the AS 350 B3 developed a flight manual that contains guidance for the safe operation of the helicopter, as well as routine operational procedures and emergency procedures.

In the flight manual, warnings, cautions, and notes are used to emphasize important and critical instructions. The manual explains the specific usage of each of these messages:

> - WARNING: AN OPERATING PROCEDURE, PRACTICE, ETC., WHICH, IF NOT CORRECTLY FOLLOWED, COULD RESULT IN PERSONAL INJURY OR LOSS OF LIFE [emphasis in original].
> - CAUTION: AN OPERATING PROCEDURE, PRACTICE, ETC., WHICH, IF NOT STRICTLY OBSERVED, COULD RESULT IN DAMAGE TO, OR DESTRUCTION OF HELICOPTER PARTS OR EQUIPMENT [emphasis in original].
> - NOTE: An operating procedure, condition, etc., which is essential to highlight.[10]

Section 4.1 Operating Procedures does not contain any such warnings, cautions, or notes that express concern related to the omission of steps in the flight manual's starting or shutdown procedures. It is the expectation of the manufacturer that these procedures will be followed. In the flight manual, there are no separate procedures for maintenance ground run operations that do not involve the intention for flight.

1.6.4.2 Checks before starting the engine

Section 4.1 of the AS 350 B3 flight manual details the operating procedures and checks required before starting the engine. Among the checks required are 2 items that may assist pilots in recognizing the correct position of the anti-torque pedals before starting the helicopter. The checks are:

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10 Airbus Helicopters, *Flight Manual AS 350 B3,* Revision 15 (25 July 2023), section 1.4: Terminology, subsection 1: General, p. 1.

> - Press the "HYD TEST" (TEST HYDR) push-button for approx. 2 seconds to depressurize the yaw hydraulic accumulator.
> - Pedals----------Free travel, then LH [left-hand] pedal approx. 2 cm (0.8 in) forward.[11]

1.6.4.3 Starting procedures

Section 4.1 of the AS 350 B3 flight manual contains the starting procedures for the helicopter, which include the hydraulic accumulator check (also known as the accumulator check and the hydraulic accumulator test) and the hydraulic pressure isolation check.

In the complementary flight manual, the function of the hydraulic accumulator check is described as follows:

> The hydraulic accumulator test (HYD TEST pushbutton depressed) enables the pilot to check that the accumulators still provide hydraulic assistance should the hydraulic power system fail (i.e. checks that there are no significant leaks in the accumulators) and that HYDR warning light (flashes post MOD 07-3317) and the Gong [aural warning] operate to indicate a loss of hydraulic pressure.[12]

It is conducted as follows:

> Accumulator check:
>
> - Collective pitch - - - - - - - - - - - - - - - - - - - Checked correctly locked.
> - "HYD TEST" (TEST HYDR) pushbutton - - Press on center console.
> - Warning panel - - - - - - - - - - - - - - - - - - - Check "HYDR" light blinks.
> - Collective and cyclic controls - - - - - - - - - Hands on.
> - Move the cyclic control 2 or 3 times on each axes (+/- 10% of travel) and check for accumulator hydraulic assistance on pitch and roll (no control loads).
> - "HYD TEST" (TEST HYDR) pushbutton - - Set back in up position.
> - Warning panel - - - - - - - - - - - - - - - - - - - Check "HYDR" light goes off.[13]

The complementary flight manual also describes the function of the hydraulic pressure isolation check (also known as the hydraulic pressure cut-off test) as follows:

> The hydraulic pressure cut-off test (hydraulic cut-off switch on collective set to OFF) enables the pilot to check the electrovalves (dump valves) of the main servos for correct operation. These electrovalves are used to cut off the hydraulic power system in accordance with the AS 350 flight manual emergency procedures, in the event of a hydraulic power system failure or other flight control malfunctions.[14]

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11 Ibid., section 4.1: Operating Procedures, subsection 3: Checks Before Starting the Engine, p. 3.

12 Airbus Helicopters, *Complementary Flight Manual AS 350 B3*, normal revision 15 (25 July 2023), section 7.8: Hydraulic System, subsection 3: Normal Operations, p. 6.

13 Airbus Helicopters, *Flight Manual AS 350 B3*, Revision 15 (25 July 2023), section 4.1: Operating Procedures, subsection 4: Starting, 4.1 Starting Procedures, p. 5.

14 Airbus Helicopters, *Complementary Flight Manual AS 350 B3*, normal revision 15 (25 July 2023), section 7.8: Hydraulic System, subsection 3: Normal Operations, p. 6.

Section 4.1 of the flight manual explains how it is conducted:

> Hydraulic pressure isolation check:
> - Collective pitch - - - - - - - - - - - - - - - - - - Checked correctly locked.
> - Hydraulic cut-off switch - - - - - - - - - - - - - Set to OFF on collective pitch. (collective pitch)
> - Warning panel - Check "HYDR" light on.
> - Check that forces are felt immediately and that cyclic can be displaced in pitch and roll with normal feedback force.
> - Hydraulic cut-off switch - - - - - - - - - - - - - Set to ON. (collective pitch)
> - Warning panel - Check "HYDR" light goes off in 3 to 4 sec. Maintenance action must be performed prior to flight if this time is reduced to 1 sec. or greater than 4 sec. (at least one of the accumulators is faulty).[15]

The same section of the flight manual also contains the following note:

> NOTE 1: On the ground, to obtain zero thrust at the tail rotor, it is necessary to push the LH pedal over 2 cm approx. (0.8 in) from neutral position.[16]

1.6.4.4 After-landing procedures

During the shutdown of the helicopter, the right anti-torque pedal moves forward as the result of a natural effect of the load compensator.

In the after-landing procedures outlined in the AS 350 B3 flight manual, the steps for engine and rotor shutdown include the yaw load compensator check. The yaw load compensator check is done to ensure that the yaw load compensator is operating as designed and to remove torsion stress in the tail rotor blade spar. The check is completed by using the "HYD TEST" button to deplete the stored hydraulic pressure in the tail rotor accumulator and load compensator. This returns the hydraulic pressure to nil at the conclusion of the flight. The yaw load compensator check includes a step where anti-torque pedals are manually re-centred, creating an opportunity for the anti-torque pedals to be placed in the correct position for the next pre-start.

The yaw load compensator check is conducted as follows:

> - Check that right pedal moves forward without pilot input, or right pedal can be moved forward with low force.
> - press [*sic*] the "HYD TEST" (TEST HYDR) push-button for 1 or 2 second then release.
> - Check that pedals can be re-centered and remain centered.[17]

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15 Airbus Helicopters, *Flight Manual AS 350 B3,* Revision 15 (25 July 2023), section 4.1: Operating Procedures, subsection 4: Starting, 4.1 Starting Procedures, p. 5.

16 Ibid., p. 4.

17 Ibid., subsection 10: After Landing, p. 8.

Without completing the yaw load compensator check, the pedals will hydraulically lock with the right anti-torque pedal fully forward; the hydraulic pressure diminishes over time, releasing the pedals. When consecutive maintenance runs are conducted with minimal time between them, the hydraulic pressure may not fully diminish.

When the helicopter is restarted, the hydraulic boost will once again be available, and the anti-torque pedals can be manually moved back to the centred position. However, if the pedals are not returned to centre before power is increased to flight idle, uncommanded rotation can occur.

1.6.5 Air operator's guidance

An air operator's company operations manual (COM) is approved by Transport Canada. The COM outlines how that air operator will maintain operational control. There is no guidance in Mustang's COM related to maintenance ground run operations, nor is there required to be by regulation. Each air operator is able to generate its own checklist based on the manufacturer's guidance.

1.7 Meteorological information

The aerodrome routine meteorological report (METAR) for CYYD issued at 0900 indicated the following:

- Winds from 320° true at 8 knots
- Visibility of 15 statute miles (SM)
- Few clouds at 600 feet above ground level (AGL) and broken ceiling at 2000 feet AGL
- Temperature 8 °C and dew point 7 °C
- Altimeter setting 29.86 inches of mercury

Weather was not considered to be a factor in this occurrence.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

Not applicable.

1.11 Flight recorders

The helicopter was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was either required by regulation.

1.12 Wreckage and impact information

The helicopter remained upright throughout the uncommanded rotation to the right. The left skid tube remained in contact with the ground during the rotation, creating circular markings on the dry concrete pad (Figure 1 in Section 1.1 *History of the flight*). The right skid tube was not in contact with the ground during the rotation.

The stinger, at the rear of the helicopter, showed signs of contact with the ground.

The anti-torque pedals were found locked with the right pedal in a fully-forward position. The collective was found unlocked; however, this may have occurred during the rotation as the pilot was trying to regain control.

The battery power cart that was plugged into the helicopter was destroyed. It remained plugged in during the entire accident sequence.

1.13 Medical and pathological information

There was no indication that the pilot's performance was negatively affected by medical or physiological factors, including fatigue.

1.14 Fire

There was no indication of fire either before or after the occurrence.

1.15 Survival aspects

The pilot was not wearing a flight helmet, nor was he required to be by regulation.

The AME and apprentice AME were standing beside the helicopter when it began the uncommanded rotation. They tried to distance themselves from the helicopter; however, they were able to take only a few steps away before being struck by the tail rotor.

The AME began applying first aid to himself immediately utilizing his first aid training. He yelled for help near the hangar door, and, at 0911, the ground support staff member called 911.

The ground support staff member, who was trained in first aid, supplied first aid to the apprentice AME as directed by the 911 operator. The pilot assisted the AME while they waited for emergency services to arrive. The fire department was the 1st to arrive, 15 minutes after the 911 call had been initiated.

The AME was prepared for medical transport and airlifted to the hospital in Prince George, BC. He underwent multiple surgeries for his injuries.

1.15.1 Safety belt usage

There is no *Canadian Aviation Regulations* (CARs) requirement for a pilot to fasten their safety belt before starting an aircraft.

The manufacturer's checks before starting the engine contain the requirement to fasten safety belts. The pre-start section of Mustang's checklist also includes this instruction. Therefore, there is an expectation that while a person occupies the pilot seat with the engine running, that person would be wearing a safety belt.

The investigation determined that on the day of the occurrence, at no point during the maintenance ground run operations did the pilot secure his safety belt.

1.16 Tests and research

1.16.1 Transportation Safety Board

The tail rotor drive shaft system was mechanically examined, and the aircraft hydraulic circuit was tested by TSB investigators, in consultation with Airbus Helicopters. No anomalies were found during the testing.

The tail rotor servo was removed from the helicopter and tested separately at a third-party aircraft maintenance organization, under the supervision of the TSB. No anomalies were found during the testing.

The occurrence helicopter is equipped with a vehicle and engine multifunction display, which enables pilots to monitor the main vehicle and engine parameters. After the accident, the display was checked: it did not show any exceedances or anomalies for the maintenance ground run operations.

1.16.2 Airbus Helicopters

Using data and occurrence information supplied by the TSB, Airbus Helicopters conducted testing on an AS 350 helicopter[18] at its facility in Marignane, France. The goal of the testing was to recreate the helicopter's movement to the right. The helicopter was started and run for a short period of time. It was then shut down without depleting the tail rotor accumulator or completing the yaw load compensator check. The helicopter was then restarted without the completion of the 2 pre-flight hydraulic checks (the hydraulic accumulator check and the hydraulic pressure isolation check) from the starting procedure described in Airbus Helicopters' flight manual. When the Airbus Helicopters pilot set the aircraft engine power to IDLE, the helicopter remained stable. When the pilot adjusted the engine power from IDLE to FLT (flight idle), the helicopter began an uncommanded rotation to the right, and the test pilot quickly reacted to counter the movement by using the anti-torque pedals.

1.16.3 Mustang Helicopters Inc.

Using occurrence information, the company's chief pilot used an AS 350 flight simulator to conduct testing at a training facility in Edmonton, Alberta. The goal of the testing was to

[18] The helicopter that was tested weighed approximately 3814 pounds. This was approximately 300 pounds heavier than the occurrence helicopter.

recreate the helicopter's movement to the right. When the engine was started in the simulator, the chief pilot pressed the right pedal to the fully-forward position. While the pilot adjusted the engine power from IDLE to FLT (flight idle), the simulated helicopter began to rotate to the right. The collective remained locked down during the testing.

1.17 Organizational and management information

1.17.1 Mustang Helicopters Inc.

Mustang has 9 bases across Canada, with the main office located in Blackfalds, Alberta. Mustang provides helicopter services to a broad range of customers in a variety of industries, including power line and utility, mining, oil and gas, forestry, heli-skiing, and government.

At the time of the occurrence, Mustang held an air operator certificate for operations under CARs Subpart 702 (Aerial Work) and Subpart 703 (Air Taxi Operations). The company was also the holder of a CARs Subpart 573 (Approved Maintenance Organizations) certificate.

The Mustang fleet of 30 helicopters includes light, intermediate, and medium helicopters, some of which are twin-engined.

1.18 Additional information

1.18.1 Portable electronic devices

In recent years, the use of portable electronic devices (PEDs) has been linked to numerous accidents across transportation modes worldwide. A PED is "any lightweight, electrically powered electronic device capable of transmitting or producing electromagnetic signals,"[19] such as smartphones, tablets, e-readers, music players, and electronic toys.

The TSB has previously identified risks associated with the use of cellphones in accidents in multiple transportation modes.[20] The risks of using PEDs highlighted in past investigation reports or studies are as follows:

- PEDs, as a form of private communication, may interfere with the development of shared mental models in operational teams.
- Interacting with PEDs requires a use of cognitive resources that can distract from teamwork during safety-critical work.
- The use of PEDs incurs head-down time that risks interrupting visual and instrument scans during normal and emergency operations.

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19 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 101.01.

20 TSB marine transportation safety investigation reports M20C0188 and M12L0147, TSB Railway Investigation Report R10V0038, and TSB air transportation safety investigation reports A19P0112 and A18A0088.

- The use of PEDs may reduce cognitive resources, which are required to detect critical cues related to system behaviour and to process relevant information or trends.

In this occurrence, throughout the maintenance ground run operations, the pilot occasionally interacted with his cellphone, which was connected to a Bluetooth earpiece. This interaction included skipping to a next song on a playlist. In between the maintenance ground run operations, he was monitoring the score of a live sporting event while sitting in the pilot's seat. It could not be determined whether the cellphone was being interacted with or viewed by the pilot immediately before the occurrence.

Mustang had not developed procedures or policies regarding the use of PEDs on the flight deck, nor were they required to.

The aviation regulations[21,22] and guidance[23] in Canada are written as they relate to concerns around electromagnetic interference and are not explicitly related to cockpit distraction.

In contrast, the U.S. Federal Aviation Administration issued section 121.542(d)[24] of the *Code of Federal Regulations*. This regulation prohibits the personal use of PEDs by flight crew members in airline operations while at their duty station on the flight deck and while the aircraft is being operated.

The U.S. National Transportation Safety Board (NTSB) issued a Safety Alert that discusses several accidents in which the non-operational use of PEDs by pilots played a role. The document describes how the use of PEDs "can divert attention from activities necessary for safe operations, both in the air and on the ground."[25]

1.18.2 Human factors issues

1.18.2.1 Routine tasks in safety-critical work

Single-pilot commercial aviation is a safety-critical domain subject to a range of variable factors that may include multiple or conflicting goals, hazardous weather, time constraints, and the required familiarity with the limitations of systems and equipment being operated.

Maintenance activities that involve the operation of an aircraft on the ground generally present a less challenging environment than flight operations and do not involve the same

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21 Transport Canada, SOR/96-433, *Canadian Aviation Regulations*, section 602.08.

22 Ibid., section 700.12.

23 Transport Canada, Advisory Circular (AC) 700-05: Use of Transmitting and Non-Transmitting Portable Electronic Devices, Issue 03 (15 April 2014).

24 U.S. *Code of Federal Regulations*, Title 14, Chapter I, Subchapter G, Part 121, Subpart T, section 121.542(d), at https://www.ecfr.gov/current/title-14/chapter-I/subchapter-G/part-121/subpart-T/section-121.542 (last accessed on 06 May 2026).

25 United States National Transportation Safety Board (NTSB), Safety Alert 025: Distracting Devices? Turn Them Off! (May 2013, Rev. December 2015), p. 1 at https://www.ntsb.gov/Advocacy/safety-alerts/Documents/SA-025.pdf (last accessed on 06 May 2026).

level of risk but are nonetheless safety critical. The preparations for maintenance ground run operations are typically simpler than preparations for a flight. However, the hazards related to running engines and spinning main and tail rotors, as well as the associated rotational forces, require added vigilance, especially when maintenance staff members are in close proximity to the aircraft.

Pilots who are involved in maintenance ground run operations are subject to tasks that can be both routine and repetitive. Familiarity with repetitive and routine tasks, coupled with past successes and the absence of system malfunctions or unexpected aircraft behaviour, may lower an individual's perception of the risks involved and lead to a lower level of vigilance. The investigation determined that the pilot's attention was not fully focused on conducting the maintenance ground run operations, given that they were viewed as routine and repetitive.

1.18.2.2 Perception of cues

The human sensory system (e.g., hearing, touch, and sound) builds comprehension of a particular environment through determining the meaning of the sensory signal or event based on experience.[26] In safety-critical systems, the combination of sensory input, attention, and comprehension assists in recognizing the configuration and change of system status.

People working in complex industries are served by 2 forms of recall that support decision making in the execution of tasks: long-term and working memory. A fundamental element of pilot decision making can entail selecting a plan of action based on previous experience stored in long-term memory.[27] Working memory is also used in the performance of detailed tasks because it represents a combination of people's experience, both in the long and short term. For safety-critical work, however, the addition of new conditions or unpractised tasks demands particular attention, beyond the use of recall, by those involved. Safety-critical maintenance activities that involve repetitive patterns of tasks may, in and of themselves, form a risk, in that familiarity with these tasks, along with a perception of these tasks as routine in nature, may affect a person's perception of risk. If familiarity with the work process is supported by previous success and the absence of system malfunctions or unexpected behaviour, this type of work, and the perception of it as routine, can influence human performance.

1.18.2.3 Safety briefings

A safety briefing is carried out before an activity is started and generally includes details on the work: the day's objective, equipment involved, people's roles and responsibilities, and

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26 C.D. Wickens, W.S. Helton, J.G. Hollands, and S. Banbury, *Engineering Psychology and Human Performance,* 5th Edition (Routledge, 2022), p. 4.

27 C.D. Wickens and J.G. Hollands, *Engineering Psychology and Human Performance*, 3rd Edition (Prentice Hall, 1999), pp. 294-296.

the criteria for either success or a halt to the activity. A safety briefing is helpful to outline, communicate, and mitigate risk for everyone involved in an activity.

In this occurrence, the maintenance staff members and the pilot were continuing the maintenance ground run operations that they had started the previous day to balance the tail rotor. On the day of the occurrence, they had completed 2 maintenance ground run operations before the loss of control occurred. To support the work, the pilot was operating the helicopter's engine by memory, utilizing an abbreviated version of the steps in Mustang's checklist. Basic hand signals were used for communicating between the pilot and the maintenance staff members outside the aircraft. Before beginning the work on either day, the team's pre-balancing discussion did not include limitations of using hand signals or what to do in the event of an emergency.

There was no requirement to conduct a safety briefing for this operation.

1.18.3 Similar occurrences

During the investigation, the TSB was informed by several industry pilots that the AS 350 series of helicopters does, occasionally, encounter control issues during ground run operations; however, the investigation was unable to find any such documented occurrences. This is likely due to the fact that those encounters did not result in significant consequences and were, therefore, not required to have been reported to investigative agencies.

On 01 October 2025, the TSB was informed by a Canadian air operator that one of its aircraft had suffered a similar control issue during a ground run operation on 28 September 2025. The non-reportable incident involved an AS 350 B3e that was being ground run after maintenance had been performed. Without warning, the helicopter rotated 30 to 45° to the right during the acceleration of the main rotor after start. The rotation resulted in the left forward portion of the tail boom contacting a ladder being used for the maintenance activities. There were no injuries and the helicopter received minor damage. It was reported that the pilot did not have his feet on the helicopter's anti-torque pedals at the time of the unanticipated yaw.[28]

[28] TSB Air Transportation Safety Occurrence A25W0126.

2.0 ANALYSIS

After the loss of control of the helicopter, the actions of the pilot, aircraft maintenance engineer (AME), and ground support staff member all ensured that first aid was administered without delay. The AME's first aid training assisted in his own survival.

Following the occurrence, the helicopter's tail rotor system, hydraulic circuit, and tail rotor servo were examined. No defects were identified that would have affected the normal functioning of the helicopter.

The analysis will, therefore, focus on factors surrounding the loss of control. In particular, it will examine the helicopter's hydraulic system, the maintenance ground run operations (including the use of a checklist), and the expectations of the team conducting the operation. The analysis will also discuss the risks associated with not using a safety belt.

2.1 Hydraulic system

The Airbus Helicopters AS 350 B3 helicopter was designed with a hydraulic system that helps reduce the pilot's workload when the pilot is manipulating the flight controls. The hydraulic pressure system is designed to be off when the helicopter is shut down and to build pressure when the helicopter is started.

Before the pilot starts the engine, the Mustang Helicopters Inc. (Mustang) *AS 350 B3 2B Checklist*, which the occurrence pilot was following, requires the depressurization of the yaw hydraulic accumulator and the freedom of travel controls check to be completed, followed by the centring of the anti-torque pedals with the left anti-torque pedal 2 cm forward once done. These steps ensure that the aircraft systems and controls are in a neutral position before the aircraft is started.

The starting procedure in the Mustang Helicopters Inc. *AS 350 B3 2B Checklist* includes a hydraulic accumulator check and a hydraulic pressure isolation check. These checks ensure that the hydraulic system is operating as designed. Additionally, they remove adverse hydraulic pressure from being applied to the tail rotor control system.

During the engine and rotor shutdown, the right anti-torque pedal naturally travels to the fully-forward position and remains there, locked in place until the hydraulic pressure depletes. The Mustang after-landing procedures include a yaw load compensator check. This check depletes the hydraulic pressure from the system, allowing the anti-torque pedals to be re-centred by the pilot.

In this occurrence, the yaw load compensator check was completed after the 1st maintenance ground run operation; however, it was not completed after the 2nd maintenance ground run operation. As a result, following the shutdown, the right anti-torque pedal remained fully forward because there was insufficient time between ground run operations for the hydraulic pressure to deplete. During the pre-start checks for the 3rd maintenance ground run operation, the freedom of travel controls check from the pre-start section of Mustang's *AS 350 B3 2B Checklist* was not completed, and the anti-torque pedals were not centred with the left pedal 2 cm forward of the right one. When the

helicopter was started for the 3rd maintenance ground run operation, the hydraulic accumulator check and the hydraulic pressure isolation check from the starting procedures were not completed.

Then, with the right anti-torque pedal fully forward, the helicopter began to yaw to the right when engine power was increased to flight idle. At that time, the pilot was in a relaxed position, and his feet, as they had been during the previous maintenance ground run operations, were either lightly resting on the bottom of the anti-torque pedals or not on them at all.

The collective was in the down and locked position. The helicopter was light at the time of the occurrence, with a relatively light wind present.

Finding as to causes and contributing factors

When the engine was started the 3rd time, the right anti-torque pedal was fully forward. Then, with the pilot's feet either lightly resting on the bottom of the anti-torque pedals or not on them at all, once engine power was increased to flight idle a significant yaw force was exerted on the helicopter. Given the position of the pilot's feet, the pilot's response to the yaw force was insufficient to prevent the helicopter from beginning to rotate quickly to the right.

2.2 Maintenance ground run operations

The occurrence helicopter was nearing the completion of a maintenance inspection that required maintenance ground run operations to balance the short shaft section of the tail rotor drive shaft. On the day of the occurrence, there was no intention for flight.

Mustang's checklist was used by the pilot for the 1st maintenance ground run operation. To expedite the subsequent starts and shutdowns, the pilot relied on his memory of the checklist and omitted items that he deemed not required for the completion of maintenance ground run operations.

For example, the pilot omitted the freedom of travel controls check from the pre-start section of the checklist after the 1st start of the day. From the start section of the checklist, after the 1st start, he omitted the hydraulic accumulator check and the hydraulic pressure isolation check, which require the helicopter to be operated at the IDLE engine power setting until they are completed. These checks, therefore, delay, albeit minimally, the maintenance ground run operations from reaching the required engine power setting.

At the completion of the 2nd maintenance ground run operation, the pilot did not complete the yaw load compensator check, which depletes the hydraulic pressure in the system and allows for the centring of the anti-torque pedals.

As a result of all of these omissions, the helicopter was started with a charged hydraulic accumulator and the right anti-torque pedal in the fully-forward position.

Finding as to causes and contributing factors

After the 1st maintenance ground run operation, the pilot abbreviated the pre-start, start, and post-landing and shutdown sections of the air operator's checklist to expedite the maintenance ground run operations. In doing so, important steps in the checklist were not completed, leaving the right anti-torque pedal in a fully forward position, which went undetected for the 3rd maintenance ground run operation.

2.3 Expectation and attention

The nature of the maintenance ground run operations had become routine for the pilot. As a result, the operation was perceived to be simple and to have a low level of risk. Such an operation can result in missing critical steps and misjudging risks. Previous successful iterations of the operation further shaped the team's expectations with respect to the level of complexity and risk. The operation, therefore, did not prompt a safety briefing addressing the potential associated hazards. Such a briefing is commonly used to increase the level of risk awareness for everyone involved in an operation.

The purpose of the tail rotor balancing operation was to apply engine power in successive cycles that would allow the maintenance staff members to balance the short shaft section of the tail rotor drive shaft. Given that there was no intention to conduct flight operations during these maintenance ground run operations, the pilot adapted the Mustang checklist by completing it from memory and selecting applicable items from it that would support the maintenance ground run operations. This meant executing partial elements of the helicopter's checklist for the purpose of expediency, forgoing the use of his safety belt, and keeping his feet either partially or completely off the anti-torque pedals.

When engine power is applied to an AS 350 B3 helicopter in flight, it will tend to yaw to the left. With the helicopter at flight idle, the pilot's attention was not fully focused on conducting the maintenance ground run operations, given that they were viewed as routine and repetitive. The pilot was looking down when the yaw began, and he had not been expecting any movement of the aircraft, especially a yaw to the right. Upon realizing that the aircraft was rotating, he reacted as quickly as he could to stop the yawing motion. The aircraft had completed 540° of rotation before it was stopped.

Finding as to causes and contributing factors

The pilot was not expecting the helicopter's rapid rotation to the right and was looking down when the rotation began. As a result, the rotation was not arrested until the helicopter had completed 540° of rotation.

When the helicopter began to rotate, the AME and apprentice AME attempted to distance themselves from it. Before the helicopter could be slowed to a stop, the tail rotor contacted both the AME and the apprentice AME, seriously injuring one and fatally injuring the other.

Finding as to causes and contributing factors

During the rotation, the tail rotor struck both maintenance staff members standing in close proximity to the helicopter, seriously injuring one and fatally injuring the other.

The TSB has previously identified risks associated with the use of cellphones in accidents. It is clear that portable electronic devices (PEDs) can divert attention from activities that are necessary for safe operations.

There are no regulations in Canada that prohibit the non-essential use of PEDs in the cockpit of an aircraft.

Given that the pilot perceived the risk associated with the maintenance ground run operations as low, he used his cellphone periodically, distracting him from the maintenance ground run operations. Although the pilot was looking down at the time of the helicopter rotation, it could not be determined whether the cellphone had distracted him at that moment.

Finding as to risk

If the non-essential use of a PED is not minimized during an operation, there is a risk that even momentary reductions in attention will result in important cues being missed.

2.4 Safety belt usage

There was no intention for flight while the maintenance ground run operations were being conducted. This being the case, the pilot did not secure his safety belt before starting the engine on any of the maintenance ground run operations, as required in the manufacturer's starting procedures and the pre-start section of the air operator's checklist.

In the event of a loss of aircraft control, whether the aircraft is on the ground or in the air, the person occupying a pilot's seat is expected to take action to regain control of the aircraft. If the aircraft begins an uncommanded movement, as in this occurrence, and the occupants on board are not wearing their safety belt, there is a risk that they could be thrown from their seat.

Finding as to risk

If available safety belts are not worn when an aircraft is running, and a loss of aircraft control occurs, there is a risk that occupants could be thrown from their seats, increasing the potential for injury.

3.0 FINDINGS

3.1 Findings as to causes and contributing factors

These are the factors that were found to have caused or contributed to the occurrence.

1. When the engine was started the 3rd time, the right anti-torque pedal was fully forward. Then, with the pilot's feet either lightly resting on the bottom of the anti-torque pedals or not on them at all, once engine power was increased to flight idle a significant yaw force was exerted on the helicopter. Given the position of the pilot's feet, the pilot's response to the yaw force was insufficient to prevent the helicopter from beginning to rotate quickly to the right.

2. After the 1st maintenance ground run operation, the pilot abbreviated the pre-start, start, and post-landing and shutdown sections of the air operator's checklist to expedite the maintenance ground run operations. In doing so, important steps in the checklist were not completed, leaving the right anti-torque pedal in a fully forward position, which went undetected for the 3rd maintenance ground run operation.

3. The pilot was not expecting the helicopter's rapid rotation to the right and was looking down when the rotation began. As a result, the rotation was not arrested until the helicopter had completed 540° of rotation.

4. During the rotation, the tail rotor struck both maintenance staff members standing in close proximity to the helicopter, seriously injuring one and fatally injuring the other.

3.2 Findings as to risk

These are the factors in the occurrence that were found to pose a risk to the transportation system. These factors may or may not have been causal or contributing to the occurrence but could pose a risk in the future.

1. If the non-essential use of a portable electronic device is not minimized during an operation, there is a risk that even momentary reductions in attention will result in important cues being missed.

2. If available safety belts are not worn when an aircraft is running, and a loss of aircraft control occurs, there is a risk that occupants could be thrown from their seats, increasing the potential for injury.

4.0 SAFETY ACTION

4.1 Safety action taken

4.1.1 Mustang Helicopters Inc.

After the occurrence, Mustang Helicopters Inc. took the following actions:

- Changed maintenance procedures to require that the aircraft maintenance engineer (AME) be inside the helicopter during maintenance ground run operations.
- Purchased wireless communication systems (1 for each of the company's bases) for the pilot and the AME to be able to communicate during maintenance procedures.
- Introduced a new distraction policy, which includes stowing electronic devices.
- Reviewed and revised the internal maintenance formal hazard assessment.
- Reviewed and revised the internal pilot formal hazard assessment.
- Implemented the initial helicopter safety briefing for all apprentices, ground support staff members, and operational support staff members.
- Created a new standard operating procedure (SOP) entitled *Maintenance Ground Runs and Flight Checks Procedures* and added direction in the company operations manual (COM) for pilots to abide by the manufacturer's recommended procedures and applicable company SOPs.

This report concludes the Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of this report on 15 April 2026. It was officially released on 27 May 2026.