



NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

June 29, 2020

AIRWORTHINESS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB No: CEN19FA185

A. ACCIDENT

Operator: North Memorial Healthcare
Aircraft: Leonardo A109S, Registration N11NM
Location: Brainerd, Minnesota
Date: June 28, 2019
Time: 0040 central daylight time

B. GROUP

Group Chairman:	Chihoon Shin National Transportation Safety Board Washington, District of Columbia
Member:	Scott Tyrrell Federal Aviation Administration Fort Worth, Texas
Member:	Terry Lutz North Memorial Healthcare Crystal, Minnesota
Member:	Mikael Amura Agenzia Nazionale per la Sicurezza del Volo Rome, Italy
Member:	Christopher Lemieux Leonardo Helicopter Division Philadelphia, Pennsylvania
Member:	Marc Hamilton Transportation Safety Board of Canada Quebec, Canada
Member:	Merryn Spielman Pratt and Whitney Canada Montreal, Canada

LIST OF ACRONYMS

AD	airworthiness directive
ATT	aircraft total time
BRD	Brainerd Lakes Regional Airport
CFR	Code of Federal Regulations
CP	collective position
DAU	data acquisition unit
DCU	data collection unit
FAA	Federal Aviation Administration
FADEC	full-authority digital engine control
ICA	Instructions for Continued Airworthiness
IFR	instrument flight rules
ILS	instrument landing system
MGT	engine measured gas temperature
MY77	North Memorial Heliport
Nf	engine power turbine speed
Ng	engine gas generator speed
Nr	helicopter rotor speed
NTSB	National Transportation Safety Board
PCL	pitch control lever
P/N	part number
PWC	Pratt & Whitney Canada
Q	engine torque
S/N	serial number
STC	supplemental type certificate
TCDS	type certificate data sheet
VFR	visual flight rules
UTC	coordinated universal time

C. SUMMARY

On June 28, 2019, about 0040 central daylight time, a Leonardo A109S helicopter, N11NM, impacted terrain while landing at Brainerd Lakes Regional Airport (BRD), Brainerd Lakes, Minnesota (MN). The pilot and flight nurse were fatally injured and the flight paramedic was seriously injured. The helicopter sustained substantial damage. The helicopter was registered to and operated by North Memorial Healthcare under the provisions of Title 14 *Code of Federal Regulations* (CFR) Part 135 as a helicopter air ambulance flight. Instrument meteorological conditions prevailed at BRD for the instrument flight rules (IFR) flight, which departed North Memorial Heliport (MY77), Robbinsdale, MN about 2348 local time.

The helicopter was returning to BRD after delivering a patient to MY77. Following the descent from a cruise altitude of 6,000 feet mean sea level, the pilot flew the instrument landing system (ILS) Runway 23 approach at BRD. According to the flight paramedic, who was seated in the cockpit left seat¹, the runway surface and lights were visible below a thin fog layer during the approach to landing. He noticed a few clouds to the side of the helicopter and recalled the pilot remarking that the weather conditions were foggy, and they would need to go around. He subsequently noticed the helicopter spin to the right and impact the ground.

On June 28, 2019, the Airworthiness Group Chairman arrived at BRD and performed an initial documentation of the helicopter and accident site. On June 29, 2019, representatives from Leonardo, Pratt & Whitney Canada (PWC), and the Federal Aviation Administration (FAA) arrived at Brainerd Lakes Regional Airport to document the helicopter accident site, after which the wreckage was recovered and transported to Wentworth Aircraft in Crystal, MN. On June 30, 2019, members of the Airworthiness Group continued documentation of the helicopter at Wentworth Aircraft and reviewed maintenance records at the operator's facility, also in Crystal, MN.

On July 19, 2019, the engine data collection units (DCU) were downloaded at PWC facilities in Longueuil, Quebec, Canada under oversight of the Transportation Safety Board of Canada.

On July 30, 2019, the Airworthiness Group Chairman and representatives from Leonardo and Ametek, the manufacturer of the helicopter's data acquisition unit (DAU), convened at Ametek facilities in Binghamton, New York, to download recorded data from the DAU.

D. DETAILS OF THE INVESTIGATION

1.0 HELICOPTER INFORMATION

1.1 HELICOPTER DESCRIPTION

The Leonardo A109S is normal-category helicopter type certificated under FAA type certificate data sheet (TCDS) No. H7EU. The A109S has a four-bladed, fully-articulated main rotor system that provides helicopter lift and thrust, and a two-bladed semi-rigid tail rotor system that provides thrust for directional control. The flight controls are hydraulically assisted with a dual hydraulic system and an automatic flight control system provides stabilization and autopilot functions. The helicopter is equipped with two PWC PW207C turboshaft engines, mounted behind

¹ The pilot was seated in the cockpit right seat and the flight nurse was seated in the cabin forward-facing seat located on the right side of the cabin.

the main gearbox. Both engines are controlled by a full-authority digital engine control (FADEC) system. The helicopter was equipped with a retractable tricycle-type landing gear. The A109S is certified for single-pilot day and night, visual flight rules (VFR) and IFR operations.

The terms “left”, “right”, “up”, and “down” are used when in the frame of reference of looking forward from the aft end of the helicopter, i.e. aft-looking-forward. All locations and directions will be viewed from aft-looking-forward unless otherwise specified. Additionally, clock positions are in the aft-looking-forward frame of reference unless otherwise specified.

1.3 HELICOPTER HISTORY

The accident helicopter, serial number (S/N) 22075, was manufactured in 2008. The No. 1 (left) engine installed was S/N PCE-BH0183 and the No. 2 (right) engine installed was S/N PCE-BH0182. In the last available aircraft maintenance log entry, dated June 27, 2019, the starting aircraft total time (ATT) was 2,721.8 hours, and the Nos. 1 and 2 engines each had accumulated 2,721.8 hours. The accident helicopter was acquired by North Memorial Healthcare in December 2016, at which point the airframe had an ATT of 983.4 hours. According to maintenance records, the Hobbs meter and ATT were synchronized.

2.0 ON-SCENE AND POST-RECOVERY WRECKAGE EXAMINATION

On June 28, 2019, the Airworthiness Group Chairman arrived at BRD and performed an initial documentation of the helicopter and accident site. On June 29, 2019, representatives from Leonardo, PWC, and the FAA arrived at Brainerd Lakes Regional Airport to document the helicopter accident site, after which the wreckage was recovered and transported to Wentworth Aircraft in Crystal, MN. On June 30, 2019, members of the Airworthiness Group continued documentation of the helicopter at Wentworth Aircraft and reviewed maintenance records at the operator’s facility, also in Crystal, MN.

2.1 STRUCTURES

2.1.1 OVERVIEW

The helicopter structure comprises the main fuselage and the tail boom with empennage. The main fuselage contains the cockpit, cabin, bladder-type fuel tanks, and baggage compartment. The main fuselage supports the engine, main rotor gearbox, and the main rotor and its controls. The tail boom and empennage contain the tail rotor drive system and the tail rotor and its controls. The left and right horizontal stabilizers are mounted near the aft end of the tail boom and the vertical stabilizer is mounted at the aft end of the tail boom.

2.1.2 AIRFRAME

The helicopter came to rest upright at a heading of about 74 degrees magnetic ([Figure 1](#)). The nose cone was separated and found about 73 feet to the northeast of the main wreckage. The tail boom was partially separated from the main fuselage. Both the main fuselage and the tail boom exhibited crushing damage consistent with a primarily vertical impact ([Figure 2](#)). The left and right horizontal stabilizer remained attached to the tail boom. The left horizontal stabilizer’s tip end (winglet) was fractured and found adjacent to the left horizontal stabilizer. The right horizontal stabilizer remained whole.

The upper vertical stabilizer remained attached to the tail boom and exhibited wrinkling of its skin. The tail stinger was found about 33 feet south of the main wreckage. The lower vertical fin, to which the stinger attaches, was crushed underneath the tail boom.



Figure 1. A view of the left side of the accident helicopter.



Figure 2. A view of the right side of the accident helicopter.

The nose landing gear was found near its normally installed location but was separated from the airframe and laying on its side with the wheel pointed to the left. The

left and right main landing gear were found adjacent to their normally installed location and were partially separated from the airframe.

On the cockpit structure, the structural posts, to which the cockpit doors normally attach, were cut by first responders in order to extricate both cockpit occupants. The left cockpit door and left windscreen were found forward of the main wreckage. The right windscreen remained in its normally installed location but was partially detached from the airframe.

The left sliding door of the cabin was resting against the airframe near its normally installed location, but was detached from its door tracks. The right sliding door of the cabin was found on the ground about 20 feet from its normally installed location.

2.1.3 SEATS AND RESTRAINTS

All seating positions had a 4-point rotary buckle restraint system. The inertia reels for all restraints exhibited normal functionality.

The cockpit left seat pan was deformed downward and the seat remained attached to the airframe seat rail. The lap belt anchors remained attached to the seat. The cockpit right seat pan was deformed downward and the seat remained attached to the airframe seat rail, but the seat rails were attached to partially separated airframe structure. The lap belt anchors remained attached to the seat.

The cabin forward-facing seat, located on the right side of the cabin, forward mounts remained attached to the airframe, but the seat pan's aft side was separated from the fractured aft bulkhead. The rear portion of the seat pan exhibited a rearward deformation. The cabin aft-facing seat, located on the right side of the cabin, remained attached to the airframe and did not exhibit signs of distortion.

The medical stretcher, located on the left side of the cabin, was found in its normally installed location.

2.2 MAIN ROTOR SYSTEM

2.2.1 SYSTEM OVERVIEW

Power from each engine is transmitted to the coupling (also known as combining) gearbox via engine-to-transmission driveshafts. The coupling gearbox, mounted behind the main [reduction] gearbox, combines the drive from both engines and transmits it to the main gearbox. Each input gear shaft of the coupling gearbox has a sprag clutch freewheeling unit that allows for the coupling gearbox to decouple from the engines. The main gearbox contains a single-stage planetary gearing system that drives the main rotor shaft. The main rotor hub is splined onto the main rotor shaft. The main rotor gearbox is attached to the airframe via four support linkages (two forward support tubes and two aft links) and an anti-torque plate.

The main rotor head is composed of a titanium hub, four composite tension link assemblies, and four dampers. The scissor attachment flange, to which the rotating scissors

attach, is installed on the bottom of the main rotor head along with a sliding ring to which the droop stop plate contacts. Each tension link assembly is attached to the hub via an elastomeric thrust bearing that allows for pitch, flap/droop, and lead/lag motions. A flap limiter support is attached to each tension link assembly. A droop stop bracket and plate are attached to the underside of each tension link. The main rotor blade and a pitch lever are connected to the outboard end of each tension link assembly. Each damper, which moderates their respective blade's lead/lag motion, is connected to the hub on one end and the pitch control lever on its other end. Each pitch change link (PCL) is connected to its respective pitch lever.

The four main rotor blades are identified by color, presented in the order of advancing rotation (when seated in the pilot seat and observing the blades pass from right to left): 'red', 'yellow', 'white', and 'blue'. The main rotor rotates counterclockwise when viewed from above. The main rotor blades are composite in construction, with a fiberglass spar, carbon fiber skin which enclose a Nomex honeycomb core, and tip cap that is bonded to the parent blade. The leading edge of each main rotor blade has an erosion shield constructed of stainless steel, with a nickel lap plate on the leading edge at the interface between the tip cap and the parent blade.

The swashplate assembly is installed below the main rotor head and is composed of the stationary swashplate, rotating swashplate, and both stationary and rotating scissor assemblies. Main rotor blade pitch control is achieved via movement of the PCLs, connected between each blade's pitch control lever and the rotating swashplate. Three main rotor hydraulic actuators transmit pitch, roll, and collective commands to the stationary swashplate.

2.2.2 MAIN ROTOR OBSERVATIONS

The main rotor head remained attached to the main rotor shaft. The primary main rotor head components, including the hub, dampers, thrust bearings, and pitch change links, were present. The droop stops for the 'red' and 'blue' main rotor blades were separated from the hub and found within the transmission deck. The droop stops for the 'yellow' and 'white' main rotor blades remained attached to their respective tension links.

All four main rotor blades remained attached to their respective tension links. The 'blue', 'white', and 'red' main rotor blades were whole but exhibited fracturing of the blade skin at various locations. One section of afterbody from the 'yellow' main rotor blade was found about 31 feet northwest of the main wreckage, and a second section of afterbody was found about 97 feet south of the main wreckage. The 'yellow' main rotor blade tip cap was separated and found about 74 feet southwest of the main wreckage. The 'yellow' main rotor blade outboard end, where the tip cap is normally installed, exhibited a broomstraw appearance.²

Ground scars were present on the left side of the helicopter, within the area of the main rotor disk (**Figure 3**). The ground scar was an arc that spanned about 90 degrees and was about 6 inches in depth at its deepest point.

² Fractures that exhibit a broomstraw appearance are consistent with high tension stress and overload.



Figure 3. Ground scars to the left of the accident helicopter.

2.2.3 MAIN ROTOR DRIVE SYSTEM OBSERVATIONS

The coupling and main gearboxes remained installed on the helicopter but was leaning to the left due to deformation of the transmission deck. The main gearbox forward left support tube was fractured about mid-length and the forward-right support tube remained intact. Both main gearbox aft links were deformed. The main gearbox anti-torque plate remained attached to the transmission deck but was deformed similar to the transmission deck itself. The main rotor rotated freely in the direction of normal rotation when moved by hand. The forward side of the diaphragm couplings, connected to the coupling gearbox, did not rotate when the main rotor was rotated. The rotor brake flange and belt rotated when the main rotor was turned. The upper and lower main gearbox chip detectors were removed and found to be clean of debris.

2.3 TAIL ROTOR SYSTEM

2.3.1 SYSTEM OVERVIEW

The tail rotor hub is composed of a steel yoke to which each tail rotor blade attaches and are retained via strap assemblies. A steel trunnion, installed within the yoke, is splined to the tail gearbox output shaft and accommodates flapping movement of the blades. The tail rotor blades are composite in construction, with a fiberglass spar and fiberglass skin that enclose a Nomex honeycomb core.

The tail rotor drive train, driven by the coupling gearbox, is composed of three tail rotor drive shafts that are connected via Thomas couplings and supported by hanger assemblies. All three tail rotor drive shafts are constructed of an aluminum alloy. The tail gearbox is mounted at the aft end of the tail boom and supports the tail rotor.

2.3.2 TAIL ROTOR OBSERVATIONS

The tail rotor hub remained attached to the tail gearbox (**Figure 4**). The tail rotor blade PCLs and the tail rotor control linkages remained connected. One of the two tail rotor blades was fractured at its root and found about 211 feet to the southwest of the main wreckage; this blade exhibited impact damage near its tip and a broomstraw appearance on its inboard end, but was otherwise whole (**Figure 5**). The second tail rotor blade was partially fractured at its root but remained attached to the tail rotor hub and resting on the ground. Ground scars were found adjacent to the tail rotor and was consistent with multiple tail rotor blade strikes. The ground scars were about 7 inches deep.



Figure 4. The tail rotor attached to the tail gearbox.



Figure 5. The separated tail rotor blade, found about 211 feet from the main wreckage.

2.3.3 TAIL ROTOR DRIVE SYSTEM OBSERVATIONS

The forward flange of the No. 1 tail rotor drive shaft was fractured and separated at its two attaching points. The attaching hardware remained connected to the Thomas coupling, which in turn remained connected to the rotor brake output flange. The tail rotor drive train was continuous along the tail boom up to the tail gearbox. All hanger bearings were present and exhibited no anomalous damage. The tail gearbox remained installed on the airframe and its output shaft was bent in the aft direction.

2.4 FLIGHT CONTROL SYSTEM

2.4.1 OVERVIEW

The cockpit flight control system is composed of cyclic, collective, and directional (pedal) controls. Additionally, the engine control levers and rotor brake handle are centrally located at the forward portion of the cockpit ceiling-mounted control panel. The cyclic controls are interconnected, between cockpit left and right seats, underneath the cockpit floor and routed up the right cockpit door post. The collective controls are similarly interconnected and routed up the left cockpit door post. Cyclic and collective inputs are transmitted, via a series of control tubes and bell cranks, to a mixing unit (also known as the mixing star). The mixing unit outputs cyclic and collective movements to the three main rotor hydraulic actuators, the latter of which are installed between the main gearbox housing and the stationary swashplate. Each main rotor hydraulic actuator (left, right, and aft) is composed of two redundant cylinders, mounted in tandem but sharing the same piston, that are each supplied by independent hydraulic systems (the Nos. 1 and 2 hydraulic systems). Collective inputs will result in all three main rotor hydraulic actuators moving in unison.

Pedal controls are interconnected between the cockpit left and right seats. Pedal inputs are transmitted, via a series of control tubes and bell cranks, to a single-cylinder tail rotor hydraulic actuator that is powered by the No. 1 hydraulic system, and subsequently to the tail rotor control bell crank. The tail rotor control bell crank moves a pitch change mechanism, which slides along the tail gearbox output shaft.

The A109S is equipped with an autoflight system that performs stabilization and trim functions. The stabilization system consists of four cyclic linear actuators, two for the lateral cyclic (roll) axis and two for the longitudinal cyclic (pitch) axis, and a single yaw linear actuator for the yaw axis, all of which are installed in series with the cyclic and pedal control system, respectively. Two trim motors (pitch and roll) are connected in parallel to the cyclic control system. Additionally, when a pitch or roll linear actuator exceeds 30% of its travel from its center position, the autotrim system re-centers the linear actuator, via movement of the trim motors, in order to restore the linear actuators to their full authority. Lastly, the autoflight system can perform two-axis autopilot functions via a flight director.

2.4.2 ROTOR FLIGHT CONTROL OBSERVATIONS

The three main rotor hydraulic actuators remained attached to the stationary swashplate and the main gearbox housing ([Figure 6](#)). The flight control linkages underneath the upper fairing, which included the pitch and roll linear actuators and the

mixing star, showed no evidence of fractures or disconnections with the exception of a fracture observed on the input linkage routing to the right main rotor hydraulic actuator. The rotating and stationary scissors remained connected to their respective swashplates.



Figure 6. A view of the flight controls from the mixing star to the main rotor hydraulic actuators (only the left and right actuators are visible).

The tail rotor hydraulic actuator and the yaw linear actuator remained installed within the tail boom. The bell crank underneath the forward [engine] firewall remained attached to the airframe, and the lower rod end was connected to the bell crank but was separated from its control tube.

Both hydraulic pumps remained attached to the main gearbox housing. No fluid level was visible on the fluid level indicator for both hydraulic reservoirs. No residual hydraulic fluid was visible on the transmission deck. The hydraulic filter bypass pop-out indicator remained inset. The hydraulic lines to the main and tail rotor hydraulic actuators remained installed.

2.4.3 COCKPIT FLIGHT CONTROL OBSERVATIONS

The right-seat cyclic and collective controls were installed, and the left-seat cyclic and collective controls were not installed. Movement of the cyclic control did not result in movement of the cyclic bell crank at the bottom of the right door post.

The collective control was fractured and separated from its base. The head of the collective control was fractured from the control, but remained connected via wiring. The base of the collective control, to which the collective control attaches, was at an angle consistent with a high collective position.

Both left and right-seat pedals were installed and present, but a pedal lockout kit was installed on the left-seat pedals.³ For the right-seat pedals, the right pedal was able to be moved slightly by hand but there was no corresponding movement of the left pedal.

Both engine control levers were found in the “flight” position and the rotor brake lever was stowed (**Figure 7**).



Figure 7. The engine control levers and rotor brake lever.

2.5 COCKPIT INSTRUMENTS AND AVIONICS

An Appareo Vision 1000 was installed on the cockpit roof between the two cockpit seats.⁴ The Vision 1000 sticker showed S/N VIS-FH4U. The Vision 1000 was removed and retained for further examination by the NTSB Recorders Laboratory. For additional information for the Appareo Vision 1000, see the Onboard Image, Audio, and Data Recorder Group Chairman’s Factual Report in the docket for this investigation.

A Sandel HeliTAWS⁵ (S/N 46-1025) and an Outerlink CP-3i⁶ (S/N 43009B) were also installed on the accident helicopter. According to the operator, the radar altimeter is shown on the HeliTAWS display and XM weather is displayed on the Garmin 530. An emergency location transmitter was not installed on the accident helicopter. The Hobbs meter showed 2723.7 [hours].

³ According to aircraft records, a tail rotor pedal lockout kit, manufactured by Dart Aerospace, was installed onto N11NM by MSP Aero on March 21, 2017 under the provisions of Supplemental Type Certificate (STC) No. SR02258E.

⁴ The Appareo Vision 1000 is a flight data monitoring system. According to aircraft records, the Appareo Vision 1000 was installed onto N11NM by MSP Aero on March 21, 2017 under the provisions of STC No. SR03055CH.

⁵ The Sandel HeliTAWS is a helicopter terrain awareness and warning system. According to aircraft records, the Sandel HeliTAWS was installed onto N11NM by MSP Aero on March 21, 2017 under the provisions of STC No. SR02314LA.

⁶ The CP-3i is an aircraft tracking system. According to aircraft records, the Outerlink CP-3i was installed onto N11NM by MSP Aero on March 21, 2017. This installation referenced MSP Aero Work Order No. MSP-160607; Outerlink manual No. CP3i-IOM-AC; MSP Aero Outerlink CP-3i wiring diagram MSP170107; AC43.13-2B; and AC27-1B.

The Sandel HeliTAWS and Outerlink CP-3i were removed and retained for further examination by the NTSB Recorders Laboratory. For additional information on the Sandel HeliTAWS and Outerlink CP-3i, see the Electronic Devices Specialist's Factual Report in the docket for this investigation.

The DAU remained installed onto the airframe and residual engine oil was found on its housing. The data plate for the DAU showed P/N 10705B01M02 and S/N 07030174. The DAU was removed for download. See Section 4.0 of this report for more information on the DAU.

2.6 ENGINE

2.6.1 ENGINE DESCRIPTION

The PWC PW207 is a turboshaft engine that is composed of a single-stage centrifugal compressor; an annular, reverse-flow combustor; a single-stage axial gas generator turbine; and a single-stage axial power turbine. The gas generator turbine and the power turbine are not mechanically connected and rotate independently of each other. The reduction gearbox, mounted on the forward side of the engine, reduces the drive speed between the power turbine to the main output shaft (which powers the helicopter rotor system). The gas generator turbine drives the centrifugal compressor as well as the engine accessories, such as the fuel and oil pumps, the fuel management module, and the alternator.

Each engine is equipped with a DCU, whose purpose is to serve as a repository for various engine trim parameters, accumulated operational times and part cycles, as well as exceedances. The electronic engine controls automatically store the data in the DCU in a "snapshot" format when triggered during certain events, such as engine operation in manual mode or operation in the one-engine-inoperative range.

2.6.2 NO. 1 ENGINE OBSERVATIONS

The No. 1 engine remained installed on the engine deck. The inlet screen showed no evidence of blockage. The inlet screen was removed and the compressor blades were visible. The compressor blades did not exhibit evidence of impact damage or debris ingestion. The compressor rotated in the direction opposite of normal rotation with no evidence of binding. Viewing the power turbine from the engine exhaust, there were no missing power turbine blades. The power turbine rotated freely when the power output flange was rotated by hand.

The gearbox chip detector was not able to be removed by hand and was ultimately not observed. The oil filter bypass pop-out indicator had popped out. The oil filter was removed and had no debris. No fluid level was visible on the oil level indicator, but a pool of oil was seen in the aft area of the engine bay.

A hose was connected to the fuel filter drain line and the drain was opened. No fuel exited the hose. The fuel filter bowl was removed and the filter element had no debris. The

left airframe fuel filter remained installed but the aft fuel line was fractured at the filter housing.

The No. 1 engine DCU, P/N 3054276-02 and S/N DP07-4862, was removed from the engine and retained for download. See Section 3.0 of this report for additional information on the engine DCUs.

2.6.3 NO. 2 ENGINE OBSERVATIONS

The No. 2 engine remained installed on the engine deck. At the accident site, a patch of grass to the aft of the engine exhaust exhibited a tan-colored discoloration consistent with exposure to hot engine exhaust (**Figure 8**). (A corresponding discoloration of the grass was not present on the No. 1 engine side.)



Figure 8. A red arrow points to discoloration observed on the grass to the aft-right of the No. 2 engine exhaust.

The inlet screen showed no evidence of blockage. The inlet screen was removed and the compressor blades were visible. The compressor blades did not exhibit evidence of impact damage or debris ingestion. The compressor rotated in the direction opposite of normal rotation with no evidence of binding. Viewing the power turbine from the engine exhaust, there were no missing power turbine blades. The power turbine rotated freely when the power output flange was rotated by hand.

The gearbox chip detector was removed and it was clean of debris. The oil filter bypass pop-out indicator remained inset. The oil filter was removed and had no debris. No fluid level was visible on the oil level indicator. A small pool of oil was seen in the aft area of the engine bay.

A hose was connected to the fuel filter drain line and the drain was opened. No fuel exited the hose. The fuel filter bowl was removed and the filter element had no debris. The right airframe fuel filter remained installed and the fuel lines were intact.

The No. 2 engine DCU, P/N 3054276-02 and S/N DP07-4860, was removed from the engine and retained for download. See Section 3.0 of this report for additional information on the engine DCUs.

3.0 DCU DOWNLOAD

On July 19, 2019, the DCUs were downloaded at PWC facilities in Longueuil, Quebec, Canada with oversight from the Transportation Safety Board of Canada.

The downloaded data from the Nos. 1 and 2 engine DCUs showed each had a total of 8 entries. For each DCU, 6 of the 8 entries were consistent with the time of the accident flight. **Table 1** shows the 6 entries from the No. 1 DCU and **Table 2** shows the 6 entries from the No. 2 DCU that are associated with the accident flight; each table contains the following selected parameters: engine gas generator speed (Ng); engine torque (Q); engine power turbine speed (Nf); measured gas temperature (MGT); collective position (CP); and helicopter rotor speed (Nr).⁷

Table 1. Selected parameters, from the downloaded DCU data from the No. 1 engine, at the time of the accident flight.

Time (hours)	Time (elapsed from previous entry, seconds)	%Ng	%Q	%Nf	MGT (°C)	%CP	%Nr	Description
3129.1832	N/A	97.2	142.0	97.9	838.3	81.0	97.8	Torque peak value
3129.1833	0.432	98.5	145.3	101.3	865.9	80.5	101.2	MGT peak value
3129.1833	0	98.5	145.3	101.3	865.9	80.5	101.2	Ng peak value
3129.1868	12.528	71.2	0.9	110.1	566.2	42.5	94.7	Nf peak value
3129.1871	1.08	64.9	0.6	106.0	530.6	13.1	88.2	Nr fault
3129.2022	54.504	33.4	-0.2	47.2	514.3	42.4	42.4	Unexpected flameout

Table 2. Selected parameters, from the downloaded DCU data from the No. 2 engine, at the time of the accident flight.

Time (hours)	Time (elapsed from previous entry, seconds)	%Ng	%Q	%Nf	MGT (°C)	%CP	%Nr	Description
3107.35571	N/A	97.3	144.1	97.9	859.8	81.0	98.8	Torque peak value
3107.35577	0.216	98.4	146.1	99.9	881.7	81.7	98.3	Ng peak value
3107.35583	0.216	98.5	143.3	101.3	885.3	80.5	97.1	MGT peak value
3107.35925	12.312	71.8	-0.4	110.6	583.8	41.9	70.3	Nf peak value
3107.35962	1.332	64.2	0.1	105.7	529.4	43.1	62.9	Nr fault
3107.69312	1200.6	31.0	-0.6	47.5	423.8	42.4	62.1	Unexpected flameout

⁷ The presented values for Ng, Q, Nf, MGT, CP, and Nr have been rounded to the nearest tenth.

4.0 DAU DOWNLOAD

On July 30, 2019, the Airworthiness Group chairman and representatives from Leonardo and Ametek (the manufacturer of the DAU) convened at Ametek facilities in Binghamton, New York, to download the data recorded onto DAU S/N 07030174. The DAU data reflected an airframe S/N of 22044.⁸ (The accident helicopter airframe S/N was 22075.)

The unit was connected to a bench and Channel A was powered. The unit drew about 150 milliamperes of power, indicating the unit had not short-circuited. Channel A was successfully downloaded using the bench computer, and two files were created: a data log and a status log.⁹ The Channel A dataset's last record was June 28, 2019 at 05:26:03 coordinated universal time (UTC). Channel B was powered and successfully downloaded using the bench computer. Two files were created: a data log and a status log. The Channel B dataset's last record was June 28, 2019 at 05:45:42 UTC.

Attachment 1 contains a graph showing a portion of the recovered DAU dataset, from N11NM, focused around the time of the accident.

5.0 MAINTENANCE

The accident helicopter was maintained under the aircraft manufacturer's recommended inspection program. A review of the maintenance records for the accident helicopter showed no overdue inspections or airworthiness directives (AD). The last available maintenance log entry, found in the accident helicopter, was dated June 27, 2019; the log entry showed that AD 2015-11-08, a tail rotor duplex bearing locknut daily inspection, was performed at an ATT of 2721.8 hours with no faults found. The previous maintenance log entry, dated June 26, 2019, showed that AD 2015-11-08 was completed with no faults found. Additionally, the Jun 26, 2019 record stated a main rotor track and balance was completed at the request of pilots. No additional entries followed.

The STC for the Appareo Vision 1000 included Instructions for Continued Airworthiness (ICA) Manual 20-0109-01ICA, Revision 2 dated April 14, 2014. The ICA included an initial system inspection as well as an annual system inspection to be performed every 12 months. The initial system inspection contained procedures to check the functionality of the Vision 1000 and to download the memory chip to verify audio, video, and position data is accurate. The annual inspection included a visual inspection of the wiring and connections for damage and security as well as the initial system inspection.

According to the operator, at the time of the accident, only the visual inspection of the Vision 1000 was performed due to the lack of software to access the recorded data, and the data recorded by the Vision 1000 was not downloaded periodically to verify functionality and an adequate field of view of the Vision 1000, or for use in a flight data monitoring program. Thus, firmware updates to the Vision 1000 unit installed on N11NM were available but not installed on the unit at the time of the accident. After the accident, the operator had made the following changes:

⁸ A109S S/N 22044 is currently registered as N90NM under North Memorial Health Care. It is likely that the installation information on board the DAU was not reset when the unit was moved from N90NM to N11NM, resulting in the unit reflecting the previous airframe S/N.

⁹ The data log contains the time history log of helicopter parameters, such as rotor speed and engine speed, as well as a fault log, exceedance log, and a cumulative log. The status log contained a snapshot of faults and exceedances. Data from both the data log and status log are recorded at a 1 hertz sampling rate.

- All Vision 1000 units installed in their fleet were inspected, [firmware] updated, and verified to be operational.
- The Appareo Transfer Utility was installed on their maintenance laptops to allow for remote uploading of the data.
- Maintenance staff was informed that the Vision 1000 memory cards were to be uploaded at a 50-hour/30-day interval, when possible.

Attachment 2 contains the maintenance log entries for N11NM dated June 26 and 27, 2019.

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