Aviation Investigation Final Report

Location:	Alexandria, Minnesota	**Accident Number:**	CEN16FA372
Date & Time:	September 17, 2016, 02:04 Local	**Registration:**	N91NM
Aircraft:	Agusta A109	**Aircraft Damage:**	Destroyed
Defining Event:	Loss of control in flight	**Injuries:**	3 Serious
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled - Air Medical (Medical emergency)		

Analysis

The pilot and two medical crewmembers were conducting a night instrument flight rules cross-country flight to pick up a patient. During the instrument approach to the destination airport, the weather conditions deteriorated. The pilot was using the helicopter's autopilot to fly the GPS approach to the airport, and the pilot and the medical crew reported normal helicopter operations. Upon reaching the GPS approach minimum descent altitude, the pilot was unable to see the airport and executed a go-around. The pilot reported that, after initiating the go-around, he attempted to counteract, with right cyclic input, an uncommanded sharp left 45° bank . Recorded flight data revealed that the helicopter climbed and made a progressive right bank that reached 50°. The helicopter descended as the right bank continued, and the airspeed increased until the helicopter impacted treetops. The helicopter then impacted terrain on it's right side and came to rest near a group of trees.

Postaccident examinations of the helicopter and flight control systems did not reveal any malfunctions or anomalies that would have precluded normal operation. The helicopter was equipped with a GPS roll steering modification that featured a switch that allowed the pilot to manually select the heading reference source. In case of a malfunction or an erroneous setting, the helicopter's automatic flight control system had at least two limiters in place to prevent excessive roll commands. Further testing revealed that the GPS roll steering modification could not compromise the flight director and autopilot functionalities to the point of upsetting the helicopter attitudes or moving beyond the systems limiters.

Recorded helicopter, engine, and flight track data were analyzed and used to conduct flight simulations. The simulations revealed that the helicopter was operated within the prescribed limits; no evidence of an uncommanded 45° left bank was found. The helicopter performed a constant right climbing turn with decreasing airspeed followed by a progressive right bank with the airspeed and descent rate increasing. In order to recover, the simulations required large collective inputs and a steep right bank; such maneuvers are difficult when performed in night conditions with no visual references, although less demanding in day conditions with clear visual references. The data are indicative of a descending

accelerated spiral, likely precipitated by the pilot inputting excessive right cyclic control during the missed approach go-around maneuver, which resulted in a loss of control.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's excessive cyclic input during a missed approach maneuver in night instrument meteorological conditions, which resulted in a loss of control and spiraling descent into terrain.

Findings

Aircraft	Altitude - Not attained/maintained
Aircraft	Lateral/bank control - Not attained/maintained
Personnel issues	Aircraft control - Pilot
Aircraft	(general) - Incorrect use/operation
Personnel issues	Incorrect action performance - Pilot
Environmental issues	Clouds - Effect on operation
Environmental issues	Low ceiling - Effect on operation
Environmental issues	Below approach minima - Effect on operation

Factual Information

History of Flight

Approach-IFR missed approach	Loss of control in flight (Defining event)
Approach-IFR missed approach	Collision with terr/obj (non-CFIT)

On September 17, 2016, at 0204 central daylight time, an Agusta (Leonardo) A109S helicopter, N91NM, impacted trees and terrain near Chandler Field Airport (AXN), Alexandria, Minnesota. The commercial rated pilot and two crew members sustained serious injuries and the helicopter was destroyed. The helicopter was registered to North Memorial Health Care and operated by North Memorial Air Care under the provisions of Title 14 *Code of Federal Regulations (CFR)* Part 135 as an air medical positioning flight. Night instrument meteorological conditions prevailed at the accident site and an instrument flight rules (IFR) flight plan had been filed. The helicopter departed Brainerd Lakes Regional Airport (BRD), Brainerd, Minnesota at 0137 and was destined for the Douglas County Hospital helipad, Alexandria, Minnesota, via AXN.

A review of the air traffic control (ATC) communications and radar data revealed that the pilot requested a clearance at 0135 and departed about two minutes later. Radar data indicated the helicopter climbed to 4,000 ft above ground level (agl) and flew southwest toward AXN. The radar data showed a generally straight and level flight with minimal altitude changes after the initial climb.

The pilot contacted ATC and requested to proceed direct to KILVE, the initial approach fix for the RNAV (GPS) approach to runway 22 at AXN. The controller cleared the pilot for the approach and instructed him to maintain 4,000 ft until established on the approach. One minute later ATC lost radar contact with the helicopter and instructed the pilot to report when established on the approach. Ten minutes later the pilot reported inbound on KILVE. Additional radar data later indicated that the helicopter made a slight left turn which corresponded to an extended line of the final approach course to runway 22. The controller, who was still not in radar contact with the helicopter, approved a frequency change and requested that the pilot report the cancellation of the IFR flight plan, to which the pilot acknowledged; no further communications from the pilot were recorded. Radar data later indicated that the helicopter remained on the final approach course while descending until the last radar target was recorded at 0201:06; 4.75 nautical miles from the runway about 2,050 ft agl. An onboard device recorded the accident flight coordinates; figure 1 shows the helicopter's final flight path.

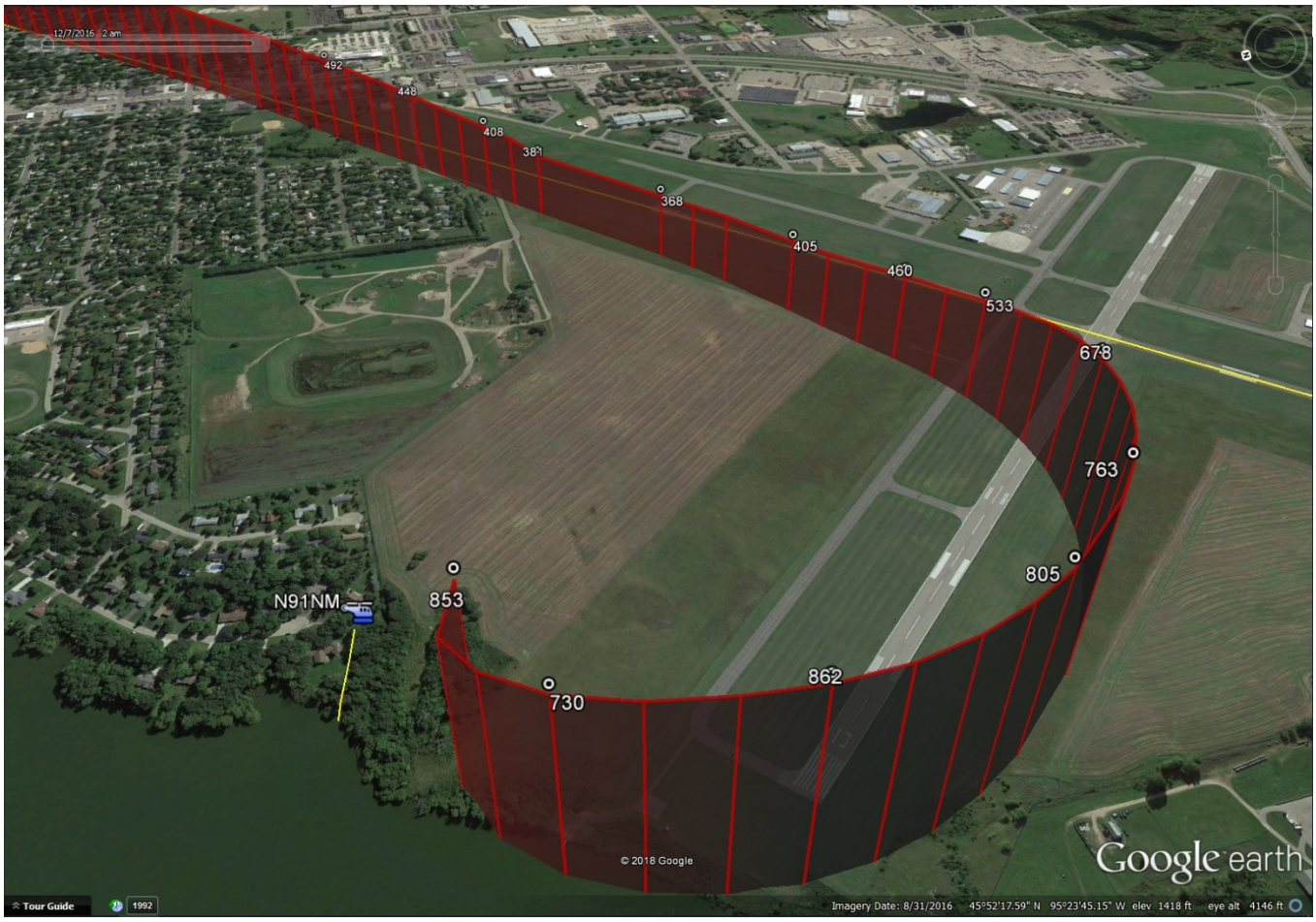

Figure 1 – Final Flight Path

In a postaccident statement the pilot stated that he received a call for a flight about 0100; after a review of the weather conditions he accepted the flight and then filed an IFR flight plan to AXN. He was in radio contact with ATC, but radar contact was lost about half way through the flight. About 20 miles from AXN he noticed clouds quickly forming underneath the helicopter. He stated that ATC cleared the flight for the RNAV (GPS) 22 approach to AXN as clouds were still forming beneath the helicopter. With the landing sight not visible, he initiated a missed approach by utilizing the go-around function of the helicopter's autopilot and had 100% engine power applied. He stated that during the missed approach the helicopter made a quick 45° left bank so he applied right cyclic. Then the helicopter banked sharply to the right.

The flight nurse who was seated in the middle cabin, stated that the IFR flight to AXN was uneventful until they were near the airport. When the helicopter descended near AXN and he could see the runway lights beneath the helicopter through the fog. He couldn't determine the altitude of the helicopter because they were in the fog. He added that the pilot stated to the crew that they weren't going to break out of the fog and they would go-around. He did not know exactly why they needed to go around. He added that the helicopter banked to the right, then shuddered when the alarms and bells sounded. The helicopter

shudder was "on the lighter side" of intensity, but he had never felt the helicopter shudder like that before. The engines sounded normal throughout the flight and he did not recall any unusual sounds or anomalies with the helicopter until the shudder. He did not remember if the helicopter entered a spin during the event.

The helicopter impacted the tops of several tall trees and the ground, then continued into a wooded area (figure 2). Several nearby residents were awake at the time of the accident and heard the helicopter's engines and then the sound of the impact.

Figure 2 – Accident Site

A review of the recorded flight data revealed that the flight path was in line with the GPS approach course and followed the respective waypoints. The helicopter intercepted the approach's last waypoint, WANBI, at 02:02:31 then the flight path started to deviate right of course (figure 3). The flight path continued toward AXN while maintaining the slight right deviation until 02:03:11 when the helicopter reached 1,840 ft, which is the approach's minimum descent altitude. Between 02:03:12 and 02:03:14 the collective position percentage increases, which is consistent with the reported go-around maneuver (figure 4). The helicopter descends to 1,740 ft until a climb began at 02:03:17. The helicopter climbed and turned right with a maximum bank angle of 50°. The flight path continued right as the helicopter then descended and the collective position continued to increase.

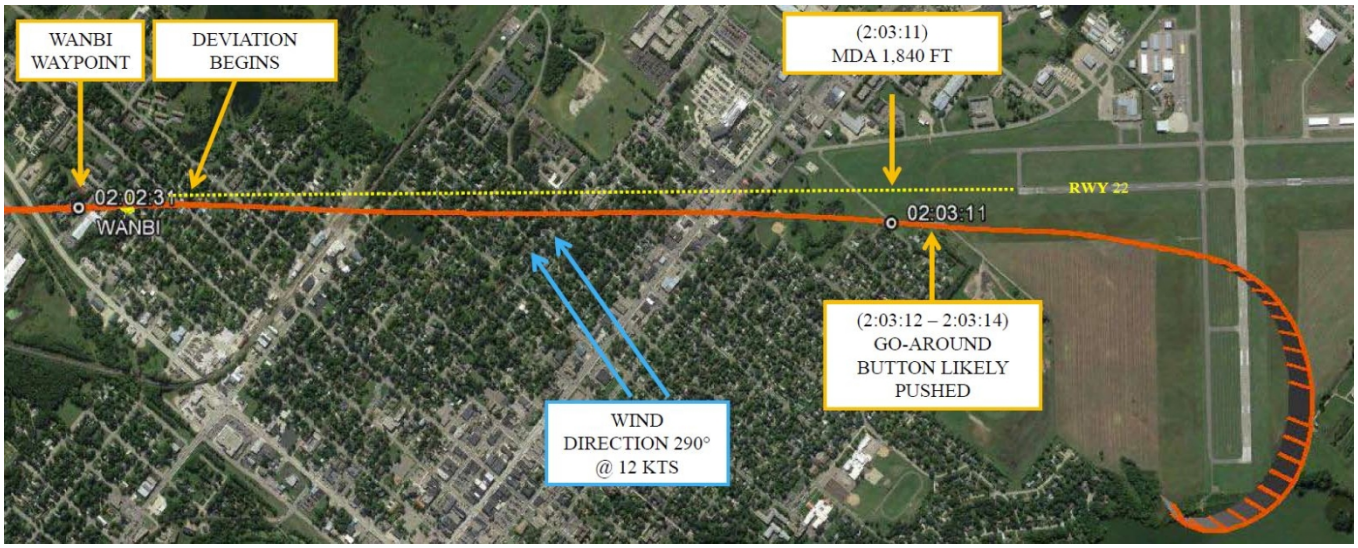

Figure 3 – Flight Path

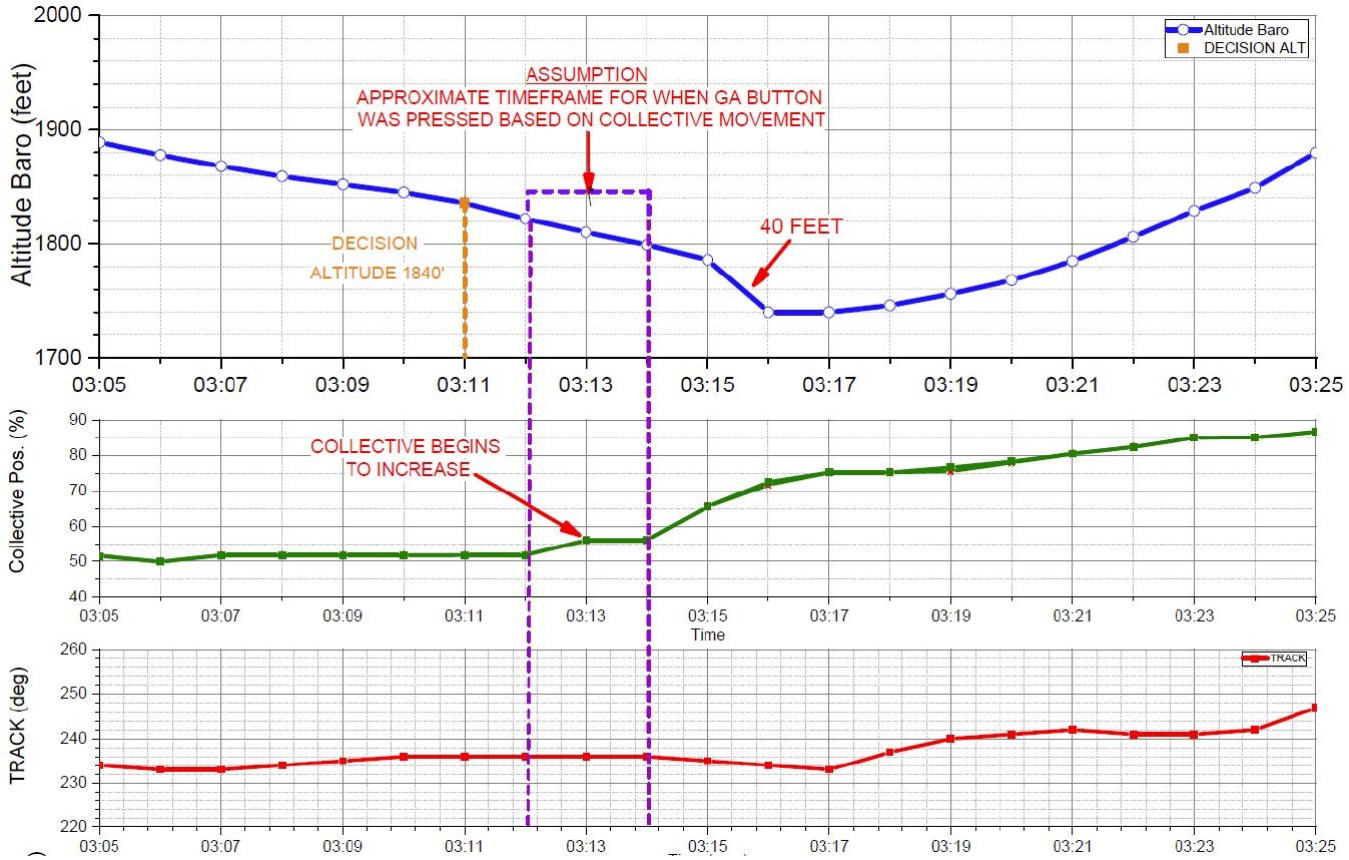

Figure 4 – Flight Data Graph

Pilot Information

Certificate:	Commercial; Flight instructor	**Age:**	47,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Helicopter; Instrument helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	May 10, 2016
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	June 21, 2016
Flight Time:	4057 hours (Total, all aircraft), 965 hours (Total, this make and model), 3167 hours (Pilot In Command, all aircraft), 1116 hours (Last 90 days, all aircraft), 5.5 hours (Last 30 days, all aircraft), 0 hours (Last 24 hours, all aircraft)		

The pilot was the Director of Operations for North Memorial Air Care.

In the preceding 6 months the pilot had accumulated 2.4 hours of flight time in actual instrument

conditions, logged 11 precision instrument approaches, and 6 landings at night.

The North Memorial Operation's Manual stated that for recent night flight experience, each pilot is to abide by the requirements of 14 *CFR* Part 135.247(a)(2), which required in the preceding 90 days, he pilot must complete 3 takeoffs and 3 landings as the sole manipulator of the flight controls in the same aircraft category and class. The pilot had logged 6 night takeoffs and landings in the preceding 90 days.

Aircraft and Owner/Operator Information

Aircraft Make:	Agusta	**Registration:**	N91NM
Model/Series:	A109 S	**Aircraft Category:**	Helicopter
Year of Manufacture:	2006	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	22014
Landing Gear Type:	Retractable - Tricycle	**Seats:**	5
Date/Type of Last Inspection:	September 13, 2016 AAIP	**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo shaft
Airframe Total Time:	1659.1 Hrs as of last inspection	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	Not installed	**Engine Model/Series:**	PW207C
Registered Owner:	North Memorial Health Care	**Rated Power:**	633 Horsepower
Operator:	North Memorial Air Care	**Operating Certificate(s) Held:**	On-demand air taxi (135)

On June 12, 2015, the helicopter was equipped with a Spectrum Aeromed Medical Conversion Kit, supplemental type certificate (STC) SR02974CH, consisting of a base assembly with pivot, a stretcher, a medical attendant seat, and other medical components.

The helicopter was equipped with a GPS roll steering modification that featured a HEADING/GPS STEER switch, per an STC. The switch allows the pilot to manually select the heading (HDG) reference source. When the switch is selected to 'HEADING', the flight director (FD) computer calculates the necessary roll commands to bank the helicopter to intercept and maintain the heading selected on the electronic horizontal situation indicator (EHSI). With the switch selected to 'GPS STEER', the FD computer receives the heading error signal as computed by a dedicated STC box which compares the requested GPS heading and the actual heading. The FD transmits the calculated roll commands to the helipilot computers, which would in turn drive the pitch and roll rotary trim actuators to achieve the target attitude, rate, and heading.

In case of a malfunction or erroneous setting of the system, the A109S automatic flight control system (AFCS) has two different limiters in place to prevent excessive roll commands: one in the Flight Director computer, which imposes a max roll command in HDG mode of ±20°, when coupled to the AFCS for hands-off flying, and one in the helipilot computers, which had a target maximum roll attitude of ±24° and a maximum commanded roll rate of ±8.2° per second for short term stabilization purposes.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Night
Observation Facility, Elevation:	KAXN,1431 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	02:09 Local	**Direction from Accident Site:**	157°
Lowest Cloud Condition:		**Visibility**	4 miles
Lowest Ceiling:	Broken / 300 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	12 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	290°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.87 inches Hg	**Temperature/Dew Point:**	14°C / 14°C
Precipitation and Obscuration:	Moderate - None - Mist		
Departure Point:	BRAINERD, MN (BRD)	**Type of Flight Plan Filed:**	IFR
Destination:	Alexandria, MN (AXN)	**Type of Clearance:**	IFR
Departure Time:	01:35 Local	**Type of Airspace:**	Class E

At 0201, the AXN automated surface observing system (ASOS) recorded wind from 290 degrees at 10 knots, 9 miles visibility, scattered clouds at 400 ft, broken clouds at 3,600 ft, temperature 57 degrees F, dew point 57 degrees F, and altimeter setting 29.87 inches of mercury.

At 0209, the AXN the ASOS recorded wind from 290 degrees at 12 knots, 4 miles visibility, mist, broken clouds at 300 ft, temperature 57 degrees F, dew point 57 degrees F, and altimeter setting 29.87 inches of mercury.

An AIRMET Sierra for IFR conditions due to mist and precipitation was issued on September 16 at 2145 and was valid at the accident time.

A search of official weather briefing sources indicated the pilot used the ForeFlight application on his iPad at 0119 and received Lockheed Martin Flight Service weather briefing information in both text and graphical format. The weather information contained all valid AIRMETs, weather observations, and forecasts valid between the departure and destination airports; the pilot viewed the graphical images on his iPad. There is no record of the pilot receiving or retrieving any other weather information before the flight.

Airport Information

Airport:	CHANDLER FIELD AXN	**Runway Surface Type:**	Asphalt
Airport Elevation:	1425 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:	22	**IFR Approach:**	Global positioning system;RNAV
Runway Length/Width:	4098 ft / 75 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	3 Serious	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Serious	**Latitude, Longitude:**	45.874721,-95.398056

The accident site was located in a residential area surrounded by trees about 1,000 yards northwest of the approach end of AXN's runway 22 (figure 5). The debris path was about 130 yards long and began with lopped tree tops (95 to 100 ft tall) and ended about 30 yards beyond the main wreckage. The middle of the debris path was in a back yard of a residence and consisted of lopped tree tranches, fragmented main rotor blades, and pieces of the helicopter. The initial impact marks were several parallel ground scars followed by the helicopter's tail skid in an impact crater. The debris path continued with a large ground impact area that contained helicopter pieces, followed by the main wreckage. The fuselage came to rest on its left side, was separated aft of the engines, and wrapped around two trees. The right side of the fuselage exhibited ground impact damage and mud smearing. The tail and aft portion of the rear fuselage were pointing in an opposite direction from the fuselage. The bottom of the tail contained mud smearing and splatter marks near the tail rotor. The right pilot seat and one passenger seat pan had separated from their respective mounts.

Figure 5 – Wreckage Diagram

A postaccident examination of the helicopter and related systems was conducted by the NTSB with assistance provided by technical representatives from the helicopter manufacturer and system component manufacturers. The flight control and autopilot system, which included mechanical, hydraulic and electronic components, revealed no malfunctions or anomalies that would have precluded normal operations. The HEADING/GPS STEER pushbutton was found in the HEADING position and electrical continuity was confirmed. To confirm switch functionality of the GPS STEER position, the pushbutton was depressed. Electrical continuity was confirmed to the GPS STEER position and the HEADING position was no longer active.

Tests and Research

Computed Tomography (CT) Scans

The helicopter's control system actuators were subjected to CT scans to confirm internal component configuration and integrity without disassembly. The following actuators were scanned: roll trim actuator, both left and right roll linear actuators, and both left and right pitch linear actuators. The scans did not reveal any preimpact anomalies that would have precluded normal operation. The NTSB CT Specialist Factual Report is included in the public docket for this accident report.

Actuator and Computer Testing

The roll artificial feel and trim actuator were examined at the manufacturers facility under the supervision of the Agenzia Nazionale per la Sicurezza del Volo (ANSV) of Italy. Results of the examination showed that there were no mechanical or electrical malfunctions with the actuator and the unit passed its acceptance testing.

The two helipilot computers and the FD computer were examined at the manufacturers facility under the supervision of the ANSV. The first helipilot computer sustained minor external damage, but there was no evidence of internal mechanical damage, or electrical/burn failures of the components located on the circuit boards or the circuit boards. All internal circuits were within specification. Control of the servo amplifiers output signal was confirmed with no anomalies noted. The test confirmed that the computer provided the correct command signal to position the linear actuators; the tests performed were successful and each pitch, roll, and yaw channel worked properly. Based on the results of the testing, no functional anomalies were found. The second helipilot computer sustained significant external damage and internal damage to the motherboard; the yaw, pitch, and roll cards were found separated from the motherboard due to the mechanical deformation of the chassis. The gain card was undamaged. Due to the internal damage, functional testing was limited to the roll and gain cards by using an exemplar chassis assembly. All internal circuits were within specification. Control of the servo amplifiers output signal was confirmed with no anomalies noted. The tests performed were successful and each pitch, roll, and yaw channel worked properly. Based on the results of the testing, no functional anomalies were found with the roll channel.

The FD computer sustained significant external damage and the internal circuit cards were impact damaged but did not show signs of electrical/burn damage. A functional test of the FD computer could not be performed.

The three main rotor actuators, identified as red, yellow, and blue, were examined at the manufacturers facility under the supervision of the ANSV. The red and yellow actuators attachments were fractured under overload. The actuators were subjected to the manufacturer's functional tests procedures; each actuator passed the functional tests and disassembly of the units was not performed. The results of the functional testing are provided in the NTSB Systems Factual Report included in the public docket for this accident report.

Leonardo Helicopters (Agusta) Flight Simulation and Testing

Leonardo Helicopters completed extensive flight simulations and testing based on the accident data. The simulator session was performed with an Agusta A109E level D full flight simulator (FFS) at the

Leonardo Helicopter Training Academy, to reproduce the accident Flight and identify anomalies or contributing factors. An A109S FFS was not available, but the functionally of the A109E FD and helipilot computers are identical among the two simulator types. The testing revealed that the helicopter was operated within the prescribed limits and there was no evidence of a mechanical malfunction. The data revealed that the helicopter performed a constant right climbing turn with decreasing airspeed followed by a progressive right bank with airspeed and descent rate increasing. The simulator testing did not find evidence of an uncommanded 45° bank as reported by the pilot. The simulation required large collective inputs and steep right bank, which were the most critical conditions in the simulations, especially when performed in night conditions with no visual references. The simulation recovery maneuver was less demanding in day conditions with clear visual references. Further testing revealed that the GPS roll steering modification on an A109S cannot compromise the FD and AFCS functionalities up to the point of upsetting the helicopter attitudes.

Additional Information

Data Collection Unit (DCU)

Each engine is equipped with a DCU and both units were downloaded by the engine manufacturer under the supervision of the Transportation Safety Board of Canada. The purpose of the DCU is to serve as a repository for various engine parameters, accumulated operation time, accumulated part cycles, and specific operational exceedance data. The electronic engine controls automatically store the data in the DCU in snapshot format when there is a triggering event. Engine data stored during the last 100 hours of operating time was analyzed. Both engines were producing power at the moment of impact and no preimpact engine anomalies were recorded.

Data Acquisition Unit (DAU)

The DAU was examined and downloaded by the manufacturer under the supervision of the Federal Aviation Administration (FAA). The unit did not exhibit any significant impact damage and the download of both channels A and B was successful. The data was redundant from both channels and did not reveal any recorded faults or exceedances.

Sandel ST3400

The Sandel ST3400 is an integrated Terrain Awareness and Warning System (TAWS). The device is capable of recording GPS coordinates, track, barometric altitude, vertical velocity, and radar altitude. The data retrieved from the device revealed an operating time from 01:25:54 to 02:03:42 CDT. On approach to AXN the device produced no voice callouts since the input from the radar altimeter never met the mandatory call-out threshold of 300 ft AGL. Additionally, there were no forward-looking terrain avoidance or ground proximity warning system alerts recorded in the flight data during the approach phase of the accident flight as the alerting buffer never indicated terrain and/or obstacle clearance issues.

Appareo Stratus 2S

The Appareo Stratus 2S is a battery-operated automatic dependent surveillance-broadcast (ADS-B) receiver with GPS capability designed to interface with an iPad, iPhone, or iPod Touch running the ForeFlight Mobile application. The device did not have any recorded data from the accident flight.

Apple iPad Air 2

The iPad was found in the wreckage and displayed a map page within the ForeFlight application. The device was given to the operator and later sent to the NTSB Recorders Lab for download since the device was capable of storing non-volatile memory. When a download was attempted by the NTSB, the device had been manually reset and no data was retrieved.

Garmin GNS 530 Data Card

The data card was inserted into a surrogate Garmin GNS 530W unit at the NTSB Recorders Laboratory. When the device is powered using the docking station, the GPS is automatically put into a "simulator" mode; therefore, the map location shown on the screen was not indicative of any accident information. The map database was version 4.00 and the aviation database expiration date as October 13, 2016. When powered on, the device's communication (COM) frequency was set to 123.000 megahertz MHz and the localizer (LOC) frequency was set to 109.70 MHz. These frequencies corresponded to the pilot's statement that the last LOC frequency would have been selected for BRD instrument landing system (ILS) RWY 34 approach, which utilizes 109.7 MHz.

Administrative Information

Investigator In Charge (IIC):	Lindberg, Joshua
Additional Participating Persons:	Allan Thilmany; FAA; Minneapolis, MN David Nelson; FAA; Minneapolis, MN John Eller; Honeywell; Phoenix, AZ Chelsea Jensen; Honeywell; Phoenix, AZ Chris Lemieux; Leonardo Helicopters; Philadelphia, PA Giorgio Dossena; Leonardo Helicopters Claude Beaudry; Pratt & Whitney Canada
Original Publish Date:	September 4, 2018
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=94022