Aviation Investigation Final Report

Location:	Superior, Arizona	**Accident Number:**	WPR16FA040
Date & Time:	December 15, 2015, 17:23 Local	**Registration:**	N74317
Aircraft:	AIRBUS Helicopters AS350	**Aircraft Damage:**	Substantial
Defining Event:	Low altitude operation/event	**Injuries:**	2 Fatal, 1 Serious
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled - Air Medical (Discretionary)		

Analysis

The commercial pilot was repositioning the helicopter (with a flight nurse and flight paramedic on board) to its base following an air ambulance flight. The paramedic, who survived the accident, reported that after refueling, they departed and headed east towards mountainous terrain; peak elevations were 5,700 to 6,000 ft. About 10 minutes after takeoff, the helicopter entered the mountainous terrain, and the height of the helicopter above the terrain began to vary as the terrain elevation rose and fell. During the final few minutes of the flight, the helicopter's altitude above the ground varied between 30 ft and 770 ft.

About 30 seconds before impact, the helicopter flew east over a north-south canyon and continued through a saddle on the canyon's east wall, clearing the terrain by about 30 ft. As the helicopter passed over the eastern ridgeline, it banked to the right and reached a ground speed of about 120 knots. After the helicopter cleared the ridge, it started to descend and accelerate. The ground speed reached a maximum of 148 knots, and about 10 seconds later, there was an abrupt increase in the helicopter's pitch and right roll rates, consistent with right and aft cyclic inputs. According to the paramedic, around this time, the pilot said an expletive in a panicked voice. The paramedic looked up and saw a ridgeline immediately in their flight path and terrain filling up the view. The paramedic described the subsequent motions of the helicopter as a violent hard right bank, and he stated that the pilot did not say anything else but was making jerky, fast hand movements. The flight characteristics seconds before impact, as described by the paramedic and shown in flight data, were consistent with a rapid onset of servo transparency. The helicopter impacted terrain on the northwest facing slope of a ridgeline, near a saddle, at an elevation of about 5,035 ft.

Servo Transparency begins when the aerodynamic forces acting to change the pitch of the rotor blades exceed the hydraulic servo actuators' capability to resist those forces and maintain the commanded blade pitch angles. The force deficit is then transmitted back to the pilot's cyclic and collective controls. On clockwise turning main rotor systems such as the AS350B3, the right servo receives the highest load when maneuvering (retreating blade), resulting in an uncommanded right and aft cyclic motion accompanied by down collective movement. The NTSB's Servo Transparency Study for accident No. LAX03MA292 notes that the pilot's control force required to counter this aerodynamically-induced phenomena "tends to be progressive" and is "proportional to the severity of the maneuver," and "may give a pilot who is not aware of this phenomenon an impression that the controls are jammed." If the pilot does not reduce the maneuver, the aircraft will roll right and pitch-up, but the phenomenon normally lasts less than 2 seconds.

The general load on the main rotor increases under the following conditions: high speed, high torque (increase in collective pitch), high g-load, and increase in density altitude. Although the helicopter will self-correct and recover from the servo transparency, the potential exists for a significant flight path deviation. The onset of servo transparency is rapid and could conceivably lead to a helicopter in a right turn exceeding 90º of bank before the pilot was able to recognize what was happening and react accordingly. The associated transition from light and responsive controls to heavy controls that require considerable force to counter the uncommanded maneuver, could cause an unsuspecting pilot to believe that he was experiencing a malfunction, rather than a known characteristic of the helicopter when maneuvered at the published performance limits.

The Operation Control Center mistakenly lost tracking of the helicopter about 2 hours and 10 minutes after the accident occurred. Another company helicopter was then sent to search for the accident helicopter and located the wreckage about 50 minutes later. Due to the mountainous terrain and limited access to the accident site, another helicopter responded to the area about 4 hours after the accident and was capable of hoisting medics to the accident site.

The emergency locator transmitter (ELT) did not activate during the accident sequence, resulting in the delayed response of the search and rescue teams. Examination of the ELT revealed that the G-switches in the unit failed to activate due to a powdery residue from internal wear.

The pilot's autopsy identified a lesion in his brain consistent with a cavernous hemangioma. No bleeding or other acute finding around the cavernous hemangioma was described by the autopsy report, and no other natural disease was identified. Given the paramedic's description of the flight indicating that the pilot was actively flying, it is unlikely that the cavernous hemangioma contributed to the accident.

According to the paramedic, the flight nurse survived the impact and was initially awake and alert, but over time, he became increasingly short of breath and eventually stopped talking and breathing. An injury study was completed on the flight nurse to evaluate whether improved communication regarding the timing and location of the crash, such as through a functioning ELT, could have allowed him to survive. Given the flight nurse's injury severity, particularly to the chest, the amount of internal bleeding, and the fact that he was wet and exposed with minimal clothing in 20°F temperature, it is unlikely that he would have survived until help arrived even if the initial notification of the crash had occurred more rapidly.

No evidence was found of any preimpact mechanical malfunctions or failures of the airframe or engine that would have precluded normal operation. Examination of the accident site and wreckage revealed that the helicopter impacted terrain in a right bank and level attitude.

Probable Cause and Findings

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

The pilot's loss of helicopter control in mountainous terrain as the result of operating the helicopter outside the performance envelope of its hydraulic system and encountering the servo transparency phenomenon. Contributing to the accident was the pilot's decision to perform low-level, high-speed maneuvers through mountainous terrain.

Findings

Personnel issues	Aircraft control - Pilot
Personnel issues	Incorrect action performance - Pilot
Aircraft	(general) - Capability exceeded
Aircraft	Climb capability - Attain/maintain not possible
Personnel issues	Decision making/judgment - Pilot
Environmental issues	Mountainous/hilly terrain - Decision related to condition
Aircraft	Airspeed - Incorrect use/operation
Aircraft	Altitude - Incorrect use/operation

Factual Information

History of Flight

Maneuvering-low-alt flying	Low altitude operation/event (Defining event)
Maneuvering-low-alt flying	Collision with terr/obj (non-CFIT)

HISTORY OF FLIGHT

On December 15, 2015, about 1723 mountain standard time, an Airbus, AS350 B3 helicopter, N74317, was substantially damaged when it impacted terrain while maneuvering near Superior, Arizona. The helicopter was registered to and operated by Air Methods Corporation, doing business as Native Air Ambulance, under the provisions of Title 14 *Code of Federal Regulations* (CFR) Part 135. The commercial pilot and the flight nurse sustained fatal injuries, and the flight paramedic sustained serious injuries. Visual meteorological conditions prevailed, and a company visual flight rules (VFR) flight plan was filed for the repositioning flight. The cross-country flight originated about 1708 from the Phoenix-Mesa Gateway Airport (IWA), Mesa, Arizona, with an intended destination of Globe, Arizona.

According to the operator, the helicopter was based in Globe and had transported a patient from the Cobre Valley Community Hospital in Globe to the Baywood Heart Hospital in Mesa. After transporting the patient, the pilot flew the helicopter to IWA for refueling before the return flight to Globe. (See figure 1)

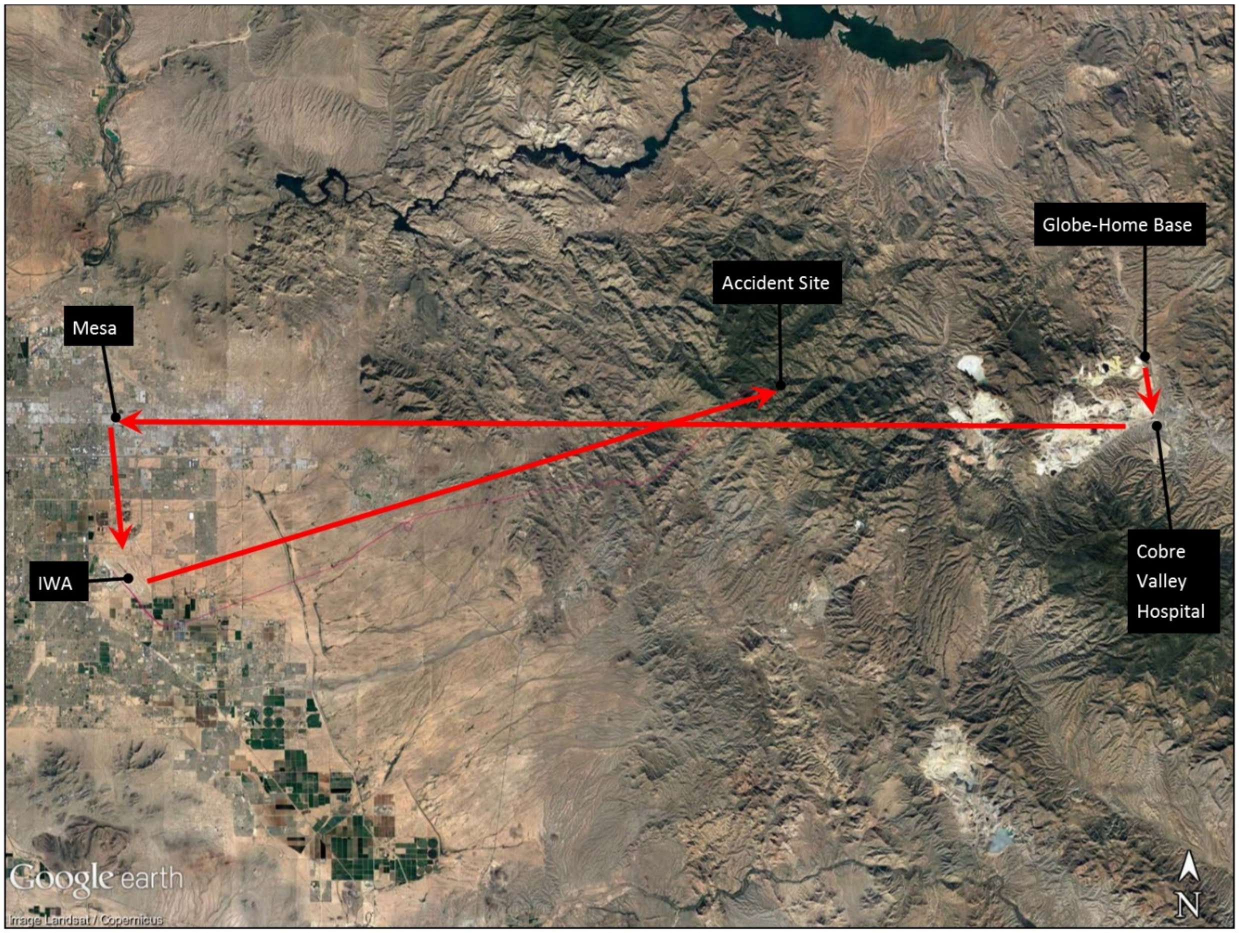

Figure 1-Overview of Flights

The flight paramedic stated that after refueling, they departed IWA and headed east toward the Superstition Mountains. Local radar and flight data obtained from an onboard Appareo GAU2000 "data logger" device showed that the helicopter departed IWA about 1708 and headed east-northeast maintaining an altitude of about 500 ft above ground level (agl). The helicopter made a 360° right hand turn over the small community of Gold Canyon at 1715. According to the flight paramedic, the flight nurse's daughter was outside her house in the small community, waving as they flew by at 400-500 ft agl. Over the next 4 minutes, the flight track continued east along the south side of the Superstition Mountains at or below 500 ft agl.

About 1719, the helicopter entered mountainous terrain, and the height of the helicopter above the terrain began to vary as the terrain elevation rose and fell. Between 1718 and 1720, the altitude varied between 240 ft agl and 1,150 ft agl. Between 1720 and the end of the flight, the altitude varied between 30 ft agl and 770 ft agl. About 1721, the helicopter turned from a heading of about 80° to a heading of about 45° and followed a canyon beneath its ridgelines. (See figure 2)

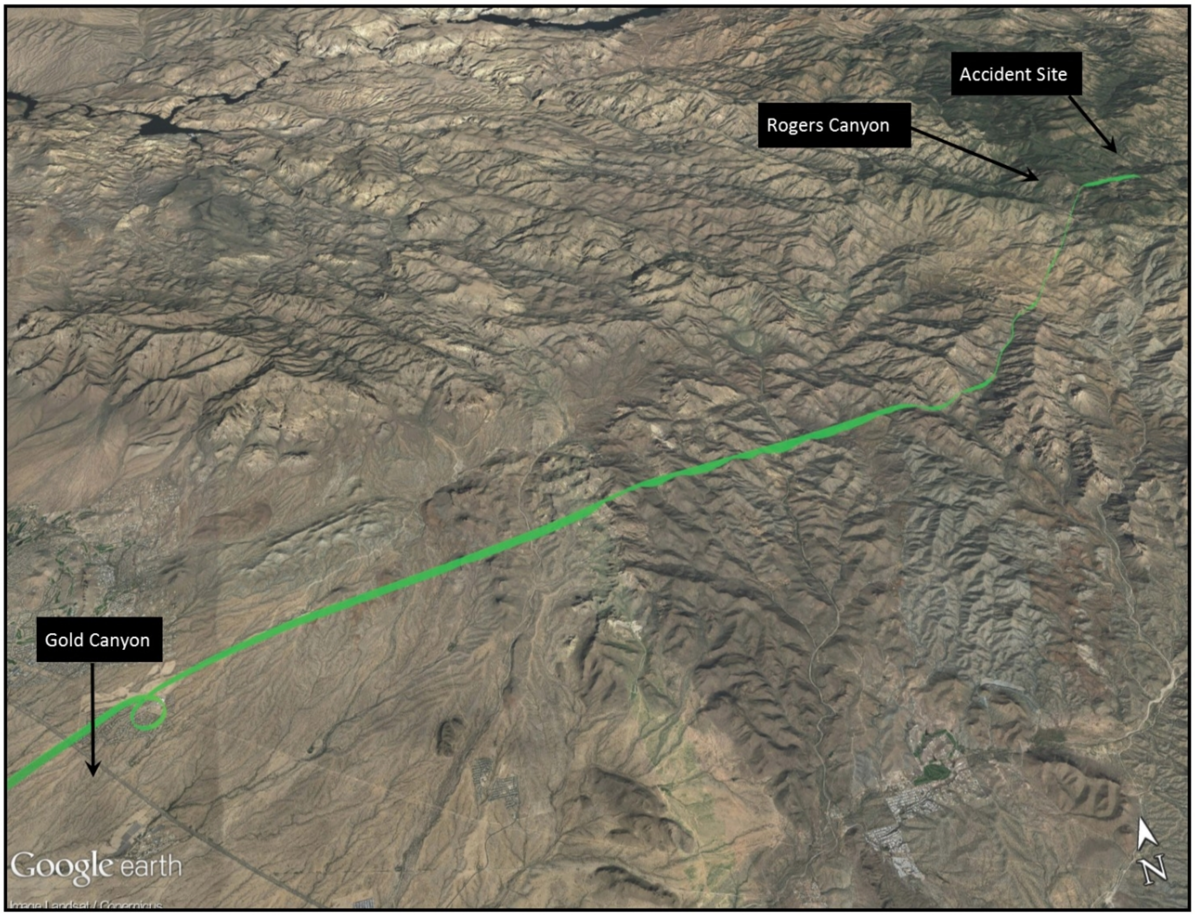

Figure 2-Aerial View of Accident Flight

The helicopter flew nearly perpendicularly over the north-south oriented Rogers Canyon, and at 1723:07, it continued through a saddle on the canyon's east wall, clearing the terrain by about 30 ft. As it passed over the eastern ridgeline, the helicopter banked to the right, changing from a ground track of about 43° to 76°, and reached a ground speed of about 120 knots. After the helicopter cleared the ridge, it started to descend and accelerate. The ground speed reached a maximum of 148 knots at 1723:21. The helicopter banked right (about 5° to 10° of roll), and its heading changed from 76° at 1723:18 to about 90° at 1723:32. (See figure 3)

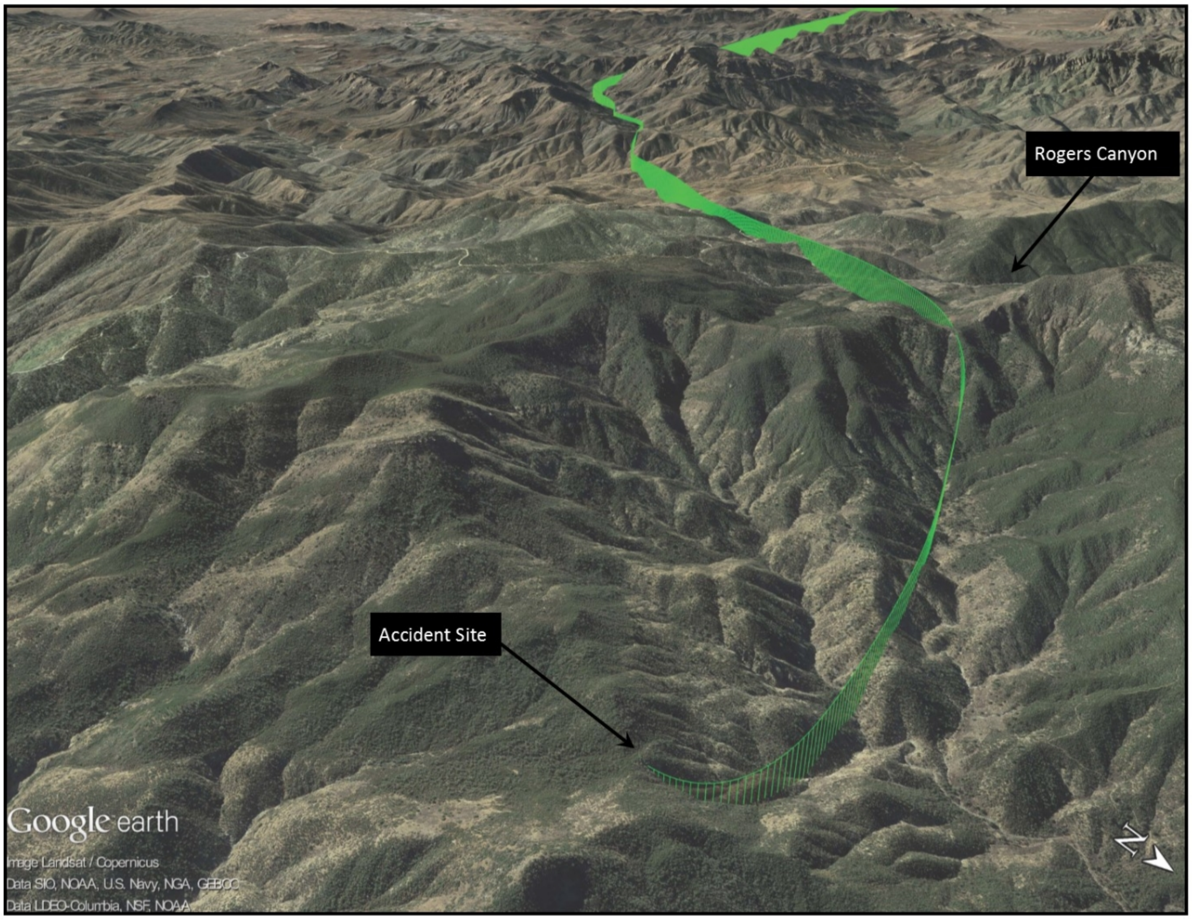

Figure 3-Aerial View of the Accident Flight and Accident Flight

At 1723:32, the GAU2000 recorded an abrupt increase in the helicopter's pitch rate and right roll rate, consistent with right and aft cyclic inputs. According to the paramedic, around this time, the pilot said an expletive in a panicked voice. The paramedic looked up and saw a ridgeline immediately in their flight path and terrain filling up the view. The paramedic described the subsequent motions of the helicopter as a violent hard right bank, and he stated that the pilot did not say anything else but was making jerky fast hand movements. The helicopter impacted terrain on the northwest facing slope of a ridgeline, near a saddle, at an elevation of about 5,035 ft mean sea level.

PERSONAL INFORMATION

The pilot, age 51, held commercial pilot and flight instructor certificates, both with a rotorcraft-helicopter rating. His most recent Federal Aviation Administration (FAA) second-class airman medical certificate was issued on December 8, 2015, with the limitation that he must have available glasses for near vision.

A review of company documentation revealed that he had accumulated about 5,670 hours of flight experience of which about 2,117 hours were in the same make and model as the accident helicopter.

The pilot completed his initial company training in September 2014. He received his most recent annual 14 *CFR* 135.293 and 135.299 airman competency/proficiency check on August 22, 2015.

The paramedic stated that the pilot was the safety officer at the Globe base and took the job very seriously. He stated that the pilot flew lower than the other pilots but was never dangerously low. The pilot was one of his favorites to fly with because he was very helpful and would aid the medical crew with duties such as cleaning out the stretchers. He did not think that the pilot took risks or operated dangerously.

AIRCRAFT INFORMATION

The helicopter, serial number 4317, was manufactured in March 2007. At the time of the accident, the helicopter had accumulated about 4,236 flight hours. The helicopter was equipped with a Turbomeca Arriel 2B1 turboshaft engine, which had accumulated about 2,491 hours. The helicopter's weight at the time of the accident was about 4,801 pounds, which was less than the maximum gross weight of 4,961 pounds.

According to the operator, the helicopter was maintained under an FAA-approved aircraft inspection program. Helicopter logbook records showed the following maintenance events during the days before the accident:

• December 15, 2015: daily check of the tail rotor laminated half bearings for deterioration
• December 14, 2015: 10-hour inspection
• December 10, 2015: 10-, 15-hour/7-day, 25- and 30-hour inspections

The helicopter was equipped with an Artex Aircraft Supplies, INC., (now ACR Electronics Inc.), C406-N HM Emergency Locator Transmitter (ELT), part number 453-5061 (serial number 04326). According to the manufacturer's original documents for that serial number, the ELT was manufactured in October 2007. The helicopter records indicated that the ELT was installed in May 2008 by Texas Aviation Services. The ELT battery, part number 452-0133 (serial number 359028-018), was recorded as being installed in May 2015. The last maintenance that occurred was recorded as consisting of a check per 14 *CFR* 91.207 (d) on October 29, 2015.

The Airbus AS350 B3 is equipped with a single hydraulic system, which provides 600-psi hydraulic boost to the cyclic, collective, and tail rotor controls. The main rotor control system consists of a series of rigid rods interconnected by bell cranks and reversing levers. The respective control linkages interface with the swash plate through three hydraulic servo actuators, which are designed to exert the necessary control force. If the required control force exceeds the maximum force that can be provided by the available servo pressure, the hydraulic system reaches its limitation, and the remaining required force must be supplied by the pilot via the flight controls. This can be felt by an apparent stiffening of the controls, which become gradually heavier to operate. The phenomenon that then arises is called servo transparency. Servo transparency is also known as hydraulic transparency, servo reversibility, and jack stall. In short, servo transparency begins when the aerodynamic forces acting to change the pitch of the rotor blades exceed the hydraulic servo actuators' capability to resist those forces and maintain the commanded blade pitch angles. The NTSB has examined the servo transparency phenomenon before, during the investigation of a September 30, 2003 accident involving an Aerospatiale (Eurocopter, now Airbus Helicopters) AS350BA helicopter in the Grand Canyon (NTSB # LAX03MA292), and produced a "Servo Transparency Study." That Study located in the public docket for LAX03MA292, describes servo transparency as follows:

According to [Airbus], servo transparency is a condition when the forces exerted from the rotor system overcome the force handling capability (output) of the flight control hydraulic actuators. The condition manifests itself when the aerodynamic forces of the main rotor system in flight are higher than that of the hydraulic servo control force. The main rotor system forces are transmitted (feedback) back through the flight control pushrod/bellcrank system through all three main servos of the AS350 helicopter to the pilot's controls. The feedback forces usually occur only during extreme maneuvering. The servo transparency is also known as hydraulic transparency, servo reversibility, and jack stall. ...

According to [Airbus], servo transparency begins when the aerodynamic forces generated by the main rotor system exceed the hydraulic forces from the control system and the difference between the forces is transmitted back to the pilot's cyclic and collective controls. On clockwise turning main rotor systems, the right servo receives the highest load when maneuvering, so when servo transparency condition occurs, it results in an uncommanded right and aft cyclic motion accompanied by down collective movement. The force transmitted through the controls tends to be progressive and the feed back forces through the controls could give an unaware pilot the impression that the controls are very hard to move or are jammed. The amplitude of the induced control feedback loads is proportional to the severity of the maneuver, but the phenomenon normally lasts less than 2 seconds when the pilot is aware of the condition and relaxes the pressure on the flight controls. ...

On December 4, 2003, Eurocopter published Service Letter No. 1648-29-03 concerning servo transparency. In the service letter, pilots were advised about the servo transparency phenomenon, what happens during the event, how it manifests itself, factors that increase the likelihood of encountering the condition, what to do in the event it is encountered, and the best way to avoid the condition. According to Eurocopter, servo transparency occurs smoothly and is not dangerous, if properly anticipated by a pilot during an abrupt or excessive high load maneuver, such as high positive g turn or pull-up. ...

The FAA issued a Special Airworthiness Information Bulletin (SAIB) on January 23, 2004, concerning servo transparency in the AS350 and EC120 series helicopters.... The SAIB referenced Eurocopter's Service Bulletin and advised helicopter pilots of these helicopters that they (the pilot) should follow (not fight) the control movement. Pilots should allow the collective pitch to decrease to reduce the overall load. The pilot should be aware that as the load is reduced, hydraulic assistance will be restored and force being applied to the controls could result in undesired opposite control movement. The SAIB advises pilots to follow the aircraft limitations in accordance with the Aircraft Flight Manual.

6 Maneuvering Limitations

- *Continued operation in servo transparency (where load feedback is felt in the controls) is prohibited.*
- *Maximum load factor is a combination of TAS, Hσ and gross weight. Avoid such combinations at high values associated with high collective pitch.*
- *Transparency may be reached during maneuvers, steep turns, hard pull-up or when maneuvering near Vne. Self-correcting, the phenomenon will induce an uncommanded right cyclic load and*

an associated collective down reaction. However, even if the transparency feedback loads are fully controllable, immediate action is required to relieve the feed back loads: reduce the severity of the maneuver, follow the aircraft's natural reaction, let the collective pitch decrease naturally (avoid low pitch) and smoothly counteract the right cyclic motion.

- *Transparency will disappear as soon as excessive loads are relieved.*

The SAIB states that pilots should understand that servo transparency is a natural phenomenon for any flyable helicopter. Basic airmanship should prevent encountering this phenomenon by avoiding combinations of high speed, high gross weight, high-density altitude, and aggressive maneuvers, which exceed the aircraft's approved flight limitations.

The LAX03MA092 Servo Transparency Study also notes that "the AS350 helicopter was flight tested during its original certification process in 1985. During the flight tests the servo transparency condition was noted versus changes in gross weight, altitude, and airspeed." Furthermore:

The AS350 helicopter was tested again during December 2003 for the effects of servo transparency by Eurocopter's Chief test pilot and an FAA test pilot.... According to the flight test results, servo transparency was impossible to encounter if the collective is less than 50% raised. With a speed of less than 100 knots, servo transparency was very difficult to enter. According to the flight test results, all of the entries and sustainment in the servo transparency region were accomplished with deliberate high g-forces, at high gross weights, at very high entry airspeeds, and were very difficult to sustain. All of the servo transparency conditions were exited immediately when the collective was reduced.

After the Superior, AZ accident, Airbus Helicopters issued two Safety Information Notices (SINs) that are relevant to the circumstances of the accident, and to the servo transparency phenomenon in particular. SIN 3093-S-00, issued on October 25, 2016, discusses safety items to be considered during flight close to or at V_{NE}; and SIN 3287-S-67, issued on November 20, 2018, discusses servo transparency.

SIN 3093 provides the following "Operational precautions at VNE:"

- avoid continuous flight at VNE as much as possible,

- flight close to VNE should be conducted with smooth inputs on the controls,

- the time spent close to VNE should be limited, with a return to normal cruise airspeeds as soon as possible, in

order to ensure operational margins if maneuvering is required,

- VNE at low altitude should be avoided,

- high pitch changes should be avoided close to VNE,

- high bank angles should be avoided close to VNE.

The precaution that "VNE at low altitude should be avoided" is particularly relevant to the circumstances of the Superior, AZ accident.

SIN 3287 reminds operators that the servo-transparency phenomenon is described and explained in the Eurocopter Service letter and FAA SAIB cited above. In addition, the SIN states that

If nothing is done by the pilot to decrease the maneuver force and counter the gradual increase of the control load (tendency for nose-up and RH roll), this phenomenon can cause risks if it occurs while the aircraft is operated close to the ground.

Airbus Helicopters insists on the importance to comply with the limitations of the Flight Manual/RFM and prevent forceful or excessive maneuvers at all times moreover with a heavy aircraft at high speed and high density altitude; even more when aircraft is operated close to the ground.

METEOROLOGICAL INFORMATION

At 1715 the automated weather observation station at the Coolidge Municipal Airport (P08), Coolidge, Arizona, located about 38 miles south southwest of the accident site, reported wind was from 310° at 5 knots, sky clear, temperature 9° C, dew point -4° C, and an altimeter setting of 29.99 inches of mercury. Using the reported weather conditions and the accident site elevation (5,037 ft), the calculated density altitude was about 5,089 ft.

At 1647 the automated weather observation station and the Phoenix-Mesa Gateway Airport, Mesa, Arizona, located about 30 miles west-southwest of the accident site, reported wind from 300° at 5 knots, visibility 45 statute miles, few clouds at 7,000 ft msl, temperature 11° C, dew point -5° C, and an altimeter setting of 30.00 inches of mercury.

According to the Astronomical Applications Department at the United States Naval Observatory, sunset was at 1718; the end of civil twilight was at 1746; and moonset was at 2152. At 1730, the sun was -3.0° below the horizon at an azimuth of 243.9°. The moon was 40.5° above the horizon and visible as a waxing crescent with 20% of the moon's visible disk illuminated.

WRECKAGE AND IMPACT INFORMATION

The accident site was in mountainous terrain about 18 miles west of the Globe base, and the surrounding peaks, about 1 to 1.5 miles from the accident site, ranged in height from about 5,700 to 6,000 ft. Examination of the accident site revealed a debris field that was about 330 ft in length on a magnetic heading of about 230°.

The first identified points of contact were multiple cuts through two bushes that were about 2 ft apart. The bushes were evenly cut at an angle of about 45° to the horizon. Downhill of the two bushes, four divots were cut from the soil that were, each about 18 inches long, 12 inches wide and 3 inches deep; the divots spanned a length of about 20 ft. The multiple cuts in the bushes and the divots were consistent with main rotor blade strikes. Two bushes with broken branches and the red lens cover from the beacon located on the lower side of the helicopter's fuselage were located about 12 ft uphill from the divots. Surrounding this area were fragments of rotor blade material.

About 62 ft from the main rotor strikes, along the debris field, was a small clearing containing a shallow elongated crater that measured about 1 ft wide and 3 ft long. In this clearing were large broken branches and the helicopter's right step and forward right toe skid. The debris path continued level along the slope for 64 ft to the tail rotor assembly. About midway between the crater and the tail rotor assembly, the helicopter doors, right side engine cowling, broken interior paneling, gurney, and medic bag were found. About 5 ft further were two helmets identified as belonging to the flight nurse and flight paramedic. About 10 ft from the helmets were the helicopter's left step and forward left toe skid.

The fuselage was located about 40 ft downslope from the tail rotor assembly. The fuselage came to rest on its right side, and the cabin roof was found in sections near the fuselage. The forward cabin floor had separated, and the remaining fuselage forward of the forward skid mounting legs was bent upward about 30°. The pilot's seat remained attached to the fuselage. The floor structure and the pilot's seat rails were buckled and distorted.

The rear cabin modular seating system consisted of a single seat on the left and two seats on the right separated by a medical equipment console. The modular seating system separated from the rear cabin wall and was located on the ground below the fuselage. The two right seats remained attached to the lower horizontal support bracket and were found near the right skid. The seat bottoms separated from the seat backs near the hinge locations. Both seat belt buckles were unlatched. The single left seat separated from the rear support brackets. The single left seat bottom was found near the main rotor hub. The left seat belt was unbuckled, and the belt webbing was taut around a portion the main rotor head. The single left seat back was found near the main rotor head and remained attached to the seat belts.

The engine was exposed and was separated from the main and tail rotor drive shafts. The engine remained attached to the fuselage and was crushed and distorted at the exhaust. The main rotor hub and blades remained attached and were located below the fuselage. The blades had deformation and delamination from the mid-sections to the tips. The yellow main rotor blade was frayed at the tip. The tail boom, forward of the horizontal stabilizer, was partially attached to the fuselage. The fuel tank's right side was visible and intact. Fuel leaked from the right rear access panel during the onsite examination. The ground, downslope of the main wreckage, was saturated in fuel. The instrument console separated from the cabin area and was found in the top of a tree about 200 ft down the debris field from the tail rotor assembly.

The tail rotor blades had minor damage. The tail rotor system rotated freely when turned through by hand at the tail rotor drive shaft. The tail rotor drive shaft was still attached to the tail rotor gear box input shaft flex coupling.

The ELT did not activate during the accident sequence. The ELT remained attached to its mount and antenna and was undamaged. When the wreckage was positioned on a flatbed trailer during recovery, the ELT activated and was subsequently shut off.

MEDICAL AND PATHOLOGICAL INFORMATION

At the time of his most recent medical certification examination, the pilot reported using the drug metoprolol. Metoprolol is a prescription medication used to treat high blood pressure and to prevent recurrent heart attacks; it is not generally considered to be impairing.

The Pinal County Sheriff's Office, Pinal County, Arizona performed an autopsy of the pilot. The cause of death for the pilot was reported as multiple blunt force injuries. In addition to his injuries, the autopsy identified a 3- by 2.5- by 2.5-centimeter spongiform red lesion within the white matter of the left temporal/occipital lobe of brain; the lesion was consistent with a cavernous hemangioma. These lesions may be congenital or acquired, and if they are asymptomatic, the treatment is benign observation. Only if the person develops seizures or other neurologic symptoms are more invasive treatments indicated. No bleeding or other acute finding in the area of the cavernous hemangioma was described by the autopsy report, and no other natural disease was identified.

The FAA's Bioaeronautical Sciences Research Laboratory, Oklahoma City, Oklahoma, performed forensic toxicology on specimens from the pilot. The tests were negative for carbon monoxide and ethanol. Metoprolol was detected during tests for drugs.

The flight nurse's injuries included multiple rib fractures with a left-sided flail chest as well as intraabdominal injuries with significant associated bleeding into both the thoracic and abdominal cavities (total of 1300 cc of blood in the cavities). The flight nurse's Injury Severity Score (ISS) was 22.

The injuries were coded using the abbreviated injury scale (AIS) system that applies a severity score of 1 (minimal) to 6 (maximal) to each injury; these are grouped into 9 body regions. The ISS predicts the likelihood of survival among traumatically injured individuals and can be used to compare the severity of injury among individuals. To calculate the ISS, the squares of the maximum AIS scores for each of the three highest scoring body regions are added together. ISSs are routinely divided into four groups: minor (ISS 1-8), moderate (ISS 9-15), severe (ISS 16-24), and very severe (ISS >25). See the Injury Factual Report in the docket for further information.

SURVIVAL ASPECTS

The paramedic stated that he never lost consciousness during the impact sequence, and the helicopter came to rest with him hanging off the left side of the fuselage suspended by the straps of his seatbelt harness. His helmet and glasses had come off, and he cut himself out of the harness and slid down to the snow. The paramedic recalled hearing the pilot take his last breaths, but he never heard him say anything. The flight nurse began to talk to him and said that he was pinned under the helicopter's right skid. He asked the paramedic for help, but the paramedic was unable to move due to his injuries. The paramedic had become soaked in fuel and was worried that the wreckage was going to catch on fire. The fuel continued to pour out of the wreckage in a continuous steady stream.

According to the paramedic, he and the flight nurse tried to use their cell phones but did not have any reception. The nurse told the paramedic that he was having difficulty breathing and believed his lung had collapsed. Once the sun went down, they became very cold, and the nurse's breathing became very labored. Shortly thereafter, the nurse passed away. Sometime later, the paramedic heard a helicopter in the distance, and because of the darkness, he turned his cell phone light on to signal the helicopter as to his location (assuming that they would likely be wearing night vision goggles and would be able to see the light). A helicopter orbited over him, and then another helicopter came shortly thereafter.

The flight was being tracked by satellite at the operator's national communication center, AIRCOM, in Omaha, Nebraska. The company's operations control center (OCC), located in Denver, Colorado, was monitoring the flight on their Flight Management System. At 1723, satellite tracking of the helicopter was lost, but was not noticed by personnel until about 2 hours and 10 minutes later. AIRCOM notified the OCC, and a search was conducted by a company aircraft. The wreckage was located about 50 minutes later as a result of an aerial search. Due to the mountainous terrain and limited access to the accident site, another helicopter responded to the area and at 2154 hoisted medics to the accident site.

According to first responders, the pilot was found in his seat with his helmet on and his seat belt fastened. Both the flight nurse and the paramedic were found outside the fuselage and unsecured from their restraints. The flight nurse lay parallel to the right skid and was pinned underneath the forward right skid leg, which crossed over the top of his neck and jaw. The paramedic was downhill from the main wreckage and lay parallel to a main rotor blade.

TEST AND RESEARCH

Appareo Data

Following recovery of the helicopter, the on-board recording devices consisting of Appareo RMS 2000 was removed and sent to the NTSB's Vehicle Recorder Division for read-out. The data imaging process was successful, and the accident flight was downloaded to the SD card. A report of the component examination from the NTSB Vehicle Recorder Laboratory is contained in the NTSB public docket.

Digital Engine Electronic Control Unit Data

The digital engine electronic control unit (DECU), and the vehicle and engine multi-function display (VEMD) were removed from the helicopter and shipped to the helicopter manufacturer. Under the supervision of the NTSB, the components were downloaded, and the data showed that the engine was providing power at the time of terrain impact.

ELT Testing

The ELT was sent to the manufacturer for testing. During the G-switch centrifuge test, the primary 2.3G-switch did not activate nor did the 5-axis 12.5G-switch assembly, a small circuit board that has 5 individual switches wired in parallel. Both G-switches were removed from the ELT and x-rayed at the NTSB materials laboratory. The x-rays revealed that the primary G-switch's acceleration spring was bent to one side of the switch housing, resulting in the spring not sitting centered on the ball. Also, one of the individual switches in the 5-axis switch assembly showed an improper resting position of the piston; the piston was about halfway through the housing and compressed the spring.

Both G-switches were sent to the switch manufacturer for further testing and examination. During the testing, the primary G-switch activated 1 time out of about 30 tests. The 5-axis G-switch assembly remained intact for the testing; during the testing, one of the individual switches activated normally; and the other four did not activate. The primary G-switch and the 5 individual switches of the 5-axis G-switch assembly were opened. Internal examination of the primary G-switch revealed a black powder residue on the spring, ball, contact area and the housing internal surface areas. Internal examination of the 5-axis G-switches revealed wear signatures on the outer circumference of the pistons.

Detailed reports of the ELT examinations are contained in the NTSB public docket.

Performance Calculations

Given load factor, density altitude, and helicopter gross weight, a servo transparency parameter (STP) can be calculated that defines the helicopter's proximity to flight conditions susceptible to the servo transparency phenomenon. Estimates of the STP were calculated using information recorded on and derived from the GAU2000 data. At 1723:32, as the helicopter started a relatively abrupt right roll, the STP was well below the threshold for the servo transparency condition and of similar magnitude to its values during the previous 21 seconds. However, as the load factor increased along with the roll angle to the right, the STP quickly climbed toward values consistent with the onset of the servo transparency condition. The STP value crossed the threshold for the servo transparency condition at 1723:34 and continued to increase until about 1723:39 (about a second before the end of the recorded data). See the Helicopter Performance Memorandum in the public docket for further information about servo transparency and the calculation of the servo transparency parameter.

Pilot Information

Certificate:	Commercial; Flight instructor	**Age:**	51,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	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	December 8, 2015
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	2117 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	AIRBUS Helicopters	**Registration:**	N74317
Model/Series:	AS350 B3	**Aircraft Category:**	Helicopter
Year of Manufacture:	2007	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	4317
Landing Gear Type:	Skid	**Seats:**	4
Date/Type of Last Inspection:	Condition	**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo shaft
Airframe Total Time:		**Engine Manufacturer:**	
ELT:	Installed	**Engine Model/Series:**	
Registered Owner:	AIR METHODS CORP	**Rated Power:**	
Operator:	AIR METHODS CORP	**Operating Certificate(s) Held:**	On-demand air taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KP08,1574 ft msl	**Distance from Accident Site:**	32 Nautical Miles
Observation Time:	00:15 Local	**Direction from Accident Site:**	205°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	310°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.98 inches Hg	**Temperature/Dew Point:**	9°C / -4°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	PHOENIX, AZ (IWA)	**Type of Flight Plan Filed:**	Company VFR
Destination:	GLOBE, AZ (P13)	**Type of Clearance:**	VFR
Departure Time:		**Type of Airspace:**	Class D

Wreckage and Impact Information

Crew Injuries:	2 Fatal, 1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Fatal, 1 Serious	**Latitude, Longitude:**	33.425277,-111.154724(est)

Administrative Information

Investigator In Charge (IIC):	Swick, Andrew
Additional Participating Persons:	Kenneth E Nettles; FAA-FSDO; Scottsdale, AZ Kevin Flynn; Air Methods; Phoenix, AZ Michael Binder; Sikorsky Aircraft; Quantico, VA
Original Publish Date:	March 18, 2019
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=92454