Aviation Investigation Final Report (

Location:	Albuquerque, New Mexico	**Accident Number:**	CEN14FA193
Date & Time:	April 9, 2014, 17:43 Local	**Registration:**	N395P
Aircraft:	Airbus AS350 B3E	**Aircraft Damage:**	Substantial
Defining Event:	Loss of control in flight	**Injuries:**	3 Minor
Flight Conducted Under:	Part 91: General aviation - Positioning		

Analysis

The commercial rated pilot planned to depart on a repositioning flight from a medical helipad located on a hospital rooftop with two medical technicians on board. The pilot reported that he completed all of the pretakeoff hydraulic checks and did not note any abnormities with the pedal movement. As the helicopter lifted from the helipad, the pilot expected a slight left turn; however, the helicopter kept turning. The pilot tried to stop the turn without success, and the helicopter then entered a left spin. The pilot reported that the (antitorque) pedals felt jammed or locked in the neutral position. The pilot added that, during the spin, he looked for a light but that he did not recall seeing any (warning) lights. Video footage from a security camera captured the helicopter completing several rotations before it impacted the rooftop and then came to rest adjacent to the helipad.

The helicopter was equipped with a dual (upper and lower) hydraulic system, and the lower system was used to power the single-servo tail rotor servo control and the yaw load compensator. Testing and examination of the lower hydraulic system did not reveal any abnormalities. Data from the helicopter's quick access recorder (QAR) and nonvolatile memory (NVM) from the engine controls were also downloaded; no abnormities were noted.

An examination of the cockpit found the yaw servo hydraulic switch on the collective in the "on" (flight) position, the correct position for the flight. The "ACCU TEST" switch, which controls the accumulator for the tail rotor, was also found in the normal (flight) position. The NVM does not record the positioning of the switches, and analysis of the recorded data provided no indication that the switches were activated during flight.

The investigation tried to determine a reason for the development of the helicopter's spin. Given the pilot's statement that the wind was "relatively calm," which was corroborated by the security camera video footage that showed the wind effect on the nearby smoke and water, a loss of tail rotor effectiveness likely did not occur. Drive continuity of the tail rotor and control continuity from the pedals to the tail rotor were established. No evidence of foreign object debris (FOD), including any

witness marks that could be associated with the presence of FOD, was observed in the pedal control system, and there was no evidence indicating that a pedal had jammed.

During takeoff, it is likely that there was an absence of hydraulic boost to the tail rotor pedals, either from a misconfiguration of the yaw hydraulic isolation switch or a failure in the lower hydraulic system that was not evident during postaccident testing. Although the specific cause of the absence of hydraulic boost to the pedals could not be identified, there was no evidence of either abnormal functionality of the lower hydraulic system or a tail rotor hydraulic circuit misconfiguration. Additionally, by design, the helicopter's caution panel does not provide a warning indication when the yaw hydraulic isolation switch is activated.

The manufacturer had originally equipped the helicopter with a cockpit imaging system; however, the operator had removed the system. The removal of this system precluded a determination of the configuration of the hydraulic control switches before takeoff. Further, due to the lack of available cockpit images, the investigation was unable to verify the pilot's actions before takeoff, including whether he moved the hydraulic isolation to "off" before the 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 loss of yaw control during takeoff due to the absence of hydraulic boost to the tail rotor pedals for reasons that could not be determined based on the available information. A finding in the accident was the lack of a caution indicator to alert the pilot of the lower hydraulic system configuration.

Findings (

Not determined	(general) - Unknown/Not determined
Aircraft	Instrument panel - Not installed/available

Factual Information

History of Flight

Takeoff	Unknown or undetermined
Takeoff	Loss of control in flight (Defining event)
Takeoff	Collision during takeoff/land
Post-impact	Fire/smoke (post-impact)

On April 9, 2014, about 1743 mountain daylight time, an Airbus H125 (Eurocopter AS350 B3e) helicopter, N395P, impacted a hospital rooftop following a departure from the New Mexico Heliport (NM11), Albuquerque, New Mexico. The helicopter was registered to PHI, Inc., Lafayette, Louisiana, and operated by PHI Air Medical, LLC, under the provisions of Title 14 Code of Federal Regulations Part 91 as local repositioning flight. The commercial rated pilot and two medical technicians received minor injuries, and the helicopter was substantially damaged. Visual meteorological conditions prevailed, and a company flight plan was filed for the local repositioning flight that was originating at the time of the accident.

The pilot reported that he completed all of the pre-takeoff hydraulic checks and did not note any abnormities with the pedal movement. During the takeoff from the helipad, the pilot expected a slight left turn to clear the platform and hospital for departure; however, the helicopter kept turning. The pilot applied pedal to stop the turn without success, and the helicopter entered a spin. The pilot stated that the pedals felt jammed or locked in the neutral position. The pilot added that, during the spin, he looked for a light but that he did not recall seeing any (warning) lights.

Video from a security camera mounted on the hospital showed the helicopter facing in a slightly northwest direction prior to takeoff. As the helicopter lifted from the platform, it entered a left turn, and as it continued to a hover height, the turn continued into a spin. The helicopter completed several rotations before it impacted the rooftop and came to rest adjacent to the helipad. A small post-crash fire started but was extinguished shortly after the helipad's fire suppression system was manually activated.

Pilot Information

Certificate:	Commercial	**Age:**	60
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	March 13, 2014
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time: (	7930 hours (Total, all aircraft), 1644 hours (Total, this make and model), 6645 hours (Pilot In Command, all aircraft), 26 hours (Last 90 days, all aircraft), 13 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus	**Registration:**	N395P
Model/Series:	AS350 B3E	**Aircraft Category:**	Helicopter
Year of Manufacture:	2013	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	7698
Landing Gear Type:	High skid	**Seats:**	
Date/Type of Last Inspection:	April 8, 2014 AAIP	**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	1 Turbo shaft
Airframe Total Time:	24 Hrs	**Engine Manufacturer:**	Turbomeca
ELT:	C126 installed	**Engine Model/Series:**	Arriel 2D
Registered Owner:		**Rated Power:**	
Operator:		**Operating Certificate(s) Held:**	On-demand air taxi (135)

The helicopter was a Eurocopter AS350 B3e model (its current designation is "Airbus H125"), manufactured in 2013, with an elastomeric (Starflex) three-bladed main rotor system that rotates in a clockwise direction. The helicopter had accumulated 24.4 total flight hours. The helicopter had been modified by Metro Aviation for emergency medical services (EMS) operations. The helicopter was equipped with a North Flight Data system quick access recorder (QAR). The helicopter was originally factory-equipped with an Appareo Vision 1000 cockpit image and flight data monitoring system; however, the Appareo unit had been removed by the operator, and as installed, the North Flight Data system did not include cockpit imaging.

Hydraulic system

As delivered from the manufacturer, the helicopter was fitted with a dual hydraulic system, which

provides hydraulic assistance to the main and tail rotor flight controls. The dual hydraulic system consists of two independent hydraulic circuits (an upper and a lower hydraulic circuit); each circuit has separate reservoirs, pumps, and filters. Each hydraulic circuit powers independent servos on each of the three main rotor servo controls (fore-aft, right roll, and left roll). However, only the lower hydraulic circuit powers the single-servo tail rotor servo control and the yaw load compensator.
The yaw load compensator contains an accumulator that is used as a hydraulic power reserve in the event of a depressurization of the lower hydraulic circuit.

A tail rotor servo control electrovalve is installed on the transmission deck and provides hydraulic fluid cut-off from the lower hydraulic circuit to the tail rotor servo control and yaw load compensator in the event of a tail rotor servo control malfunction or tail rotor control failure. Activation of this electrovalve is controlled with the hydraulic (tail rotor) isolation control switch located on the collective lever. During normal operation, the tail rotor servo control electrovalve is in the "on" (flight) position.

The yaw load compensator assembly contains an accumulator test electrovalve that allows hydraulic pressure to discharge from the yaw load compensator hydraulic circuit when the "ACCU TEST" push-button switch, which is located on the cockpit center console, is depressed. When the button is activated, the switch, which has an internal light, will illuminate "ACCU TEST." The "ACCU TEST" function is used during start-up checks to check the functionality of the yaw load compensator accumulator electrovalve, and is used in conjunction with an emergency procedure for a tail rotor control failure. During normal operation, the "ACCU TEST" electrovalve is in the "closed" position.

Once battery power has been applied to the helicopter, and during the prestart test, a "HYDR" light on the caution panel will illuminate when pressure in either of the hydraulic systems is below 20 bar ± 2bar (290 pounds per square inch [psi] ± 29 psi).

As part of the helicopter manufacturer's prestart checklist, the pilot is to check the tail rotor pedals (for freedom of movement), verify that the yaw hydraulic isolation switch is in the "on" (normal or flight) position, and activate the "ACCU Test" switch, (from "off" to "on" and then move the pedals, to center the tail rotor pedals, and then move the test switch back to "off").

After engine start, the "HYDR" light on the caution panel will extinguish (indicating normal hydraulic system pressure). The pilot is then required to perform the following hydraulic system checks are required as part of the pre-takeoff checklist:

• Hydraulic isolation switch switched off; anti-torque pedal loads should remain low. The activation of this switch isolates the tail rotor servo control, but the yaw load compensator should remain boosted by the remaining hydraulic pressure. This check is performed to verify correct operation of the solenoid valve, which closes the tail rotor hydraulic circuit when the hydraulic switch is activated.

• "ACCU TEST" is switched on, and then check that loads are felt on the anti-torque pedals. The purpose of this check is to verify correct operation of the solenoid valve when the push button is activated. When activated, the hydraulic pressure inside the yaw load compensator is released, and the yaw load compensator will no longer provide load assistance. The "ACCU TEST" push- button light will illuminate.

• "ACCU TEST" is then reset to the "off" position, which closes the solenoid valve but does not recharge the yaw load compensator as the yaw servo hydraulic switch is still in the "off" position. The "ACCU TEST" push-button light will extinguish.

• Hydraulic isolation switch is then reset to the "on" position, and a check of the anti-torque pedals is done to verify no loads are felt. Setting the yaw servo hydraulic switch to the "on" position restores hydraulic pressure within the yaw hydraulic circuit.

Other than the position of the yaw servo hydraulic switch, the helicopter's caution panel does not provide a warning light to indicate that the lower (tail rotor) hydraulic system has been turned off. Additionally, failure to restore the hydraulic isolation switch to the "on" position could result in a perceived tail rotor control failure (jamming) as described in Airbus Helicopter Safety Information Notice No. 2776-S-29 (see the section titled "TESTS and RESEARCH," for more information about the notice).

With the aid of the hydraulics, only a light amount of pedal force would normally be required to counter yaw. Based on the conditions for the accident helicopter, the amount of pedal force the pilot had exert, without the aid of both the lower hydraulic system pressure and yaw load compensator pressure, was calculated to be approximately115 ft.-lbs.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KABQ	**Distance from Accident Site:**	2 Nautical Miles
Observation Time:	17:52 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Scattered / 13000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	13 knots / 21 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	260°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.04 inches Hg	**Temperature/Dew Point:**	27°C / -13°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Albuquerque, NM (NM11)	**Type of Flight Plan Filed:**	Company VFR
Destination:	Rio Rancho, NM	**Type of Clearance:**	None
Departure Time:		**Type of Airspace:**	

At 1752, the automated weather reporting station located at the Albuquerque International airport, about 2 miles south of the helipad, recorded wind from 260 degrees at 13 knots gusting to 21 knots. During an interview with the pilot, he reported that the wind was "relatively calm" for the departure.

Airport Information (

Airport:	New Mexico Heliport NM11	**Runway Surface Type:**	
Airport Elevation:	5273 ft msl	**Runway Surface Condition:**	Dry
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

The New Mexico Heliport (NM11) is a 28 foot by 28 ft raised platform located on the rooftop of a six-floor hospital building at the University of New Mexico, Albuquerque, New Mexico. It is a private-use helipad used for EMS operations. The helicopter previously landed at the helipad to deliver a transfer patient and remained on the helipad for about 20 minutes before taking off for the accident flight.

Wreckage and Impact Information

Crew Injuries:	3 Minor	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Minor	**Latitude, Longitude:**	35.087776,-106.618614

Examination of the accident site revealed that the helicopter came to rest on its right side. Several cuts/scars on the rooftop, consistent with impact from the main rotor blades or skids, were observed. Continuity of the drive train was confirmed throughout the tail rotor system. All major structural components of the helicopter were accounted for on scene.
During examination of the cockpit, the yaw hydraulic isolation switch was found in the "on" (flight) position. The "ACCU TEST" switch was found in the normal (flight) position. During the accident, the aft tailboom section was bent and distorted to a 45-degree angle, which prevented the tail rotor pitch control tube from being able to move. For recovery of the helicopter, the aft section of the tailboom was removed. After the aft section of the tailboom was removed, the tail rotor pitch control moved freely. The anti-torque pedals also moved freely. No witness marks or evidence was found to indicate that an object had jammed the pedals.

Additional Information

Rotorcraft Flying Handbook, FAA-H-8083-21

Pinnacle and Ridgeline Operations

FAA-H-8083-21 states the following:

A pinnacle is an area from which the surface drops away steeply on all sides. A ridgeline is a long area

from which the surface drops away steeply on one or two sides, such as a bluff or precipice. The absence of obstacles does not necessarily decrease the difficulty of pinnacle or ridgeline operations. Updrafts, downdrafts, and turbulence, together with unsuitable terrain in which to make a forced landing, may still present extreme hazards.

Vertical Takeoff to a Hover

FAA-H-8083-21 also states the following:

A vertical takeoff to a hover involves flying the helicopter from the ground vertically to a skid height of two to three feet, while maintaining a constant heading. Once the desired skid height is achieved, the helicopter should remain nearly motionless over a reference point at a constant altitude and on a constant heading.

Further, Helicopter Flying Handbook, FAA-H-8083-21A states,

..... Very slowly increase the collective until the helicopter becomes light on the skids or wheels. At the same time apply pressure and counter pressure on the pedals to ensure the heading remains constant. Continue to apply pedals as necessary to maintain heading and coordinate the cyclic for a vertical ascent. As the helicopter slowly leaves the ground, check for proper attitude control response and helicopter center of gravity. A slow ascent will allow stopping if responses are outside the normal parameters indicating hung or entangled landing gear, center of gravity problems, or control issues.

Tests and Research

The helicopter was removed from the hospital's rooftop and transported to Air Salvage of Dallas, Texas, (ASOD) for further examination. The examination of the helicopter was conducted by representatives from the National Transportation Safety Board, Federal Aviation Administration (FAA), Bureau d'Enquêtes et d'Analyses (BEA), the operator, and technical advisors from the engine and airframe manufacturers.

Investigators tried to determine if the pilot had departed with the yaw hydraulic isolation switch in the "off" position, if a malfunction occurred in the tail rotor drive system, or if a malfunction in the tail rotor controls allowed the helicopter to spin.
A visual examination of the hydraulic system was conducted followed by an examination of the nitrogen charge on the yaw load compensator accumulator with a pressure gauge. A hydraulic pump rig was used to drive the helicopter's lower hydraulic system. Several test scenarios were evaluated, including using the ACCU TEST and yaw hydraulic isolation switches. Additionally, return hydraulic fluid was captured to determine if there were any contaminants in the fluid. No abnormalities were noted during the tests.

The tail rotor servo, yaw load compensator/accumulator, isolation valve, engine data recorder (EDR), digital engine electronic control unit (DECU), and the vehicle and engine multi-function display

(VEMD) were removed from the helicopter and shipped to the airframe manufacturer in France.

Under the supervision of the NTSB and BEA, the tail rotor servo was bench tested and then partially disassembled; no evidence of abnormities was found. The yaw load compensator/accumulator and isolation valve were also bench tested with no abnormities noted.

Under BEA supervision, data from the EDR and DECU were downloaded; no abnormalities were noted with the units; and failure flags in the units were attributed to the helicopter's impact with the rooftop.

Data from the QAR were also downloaded, and no abnormalities were noted. The nonvolatile memory (NVM) does not record the position of the yaw servo hydraulic isolation switch or the "ACCU Test" switch.

The examination of the tail rotor drive system and lower hydraulic system did not reveal any abnormalities in the components that would have resulted in a loss of tail rotor thrust or pitch control. The pitch on the tail rotor blades is not a recorded parameter on the QAR. However, the QAR does record data from various sources, including the DECU. When an additional flight load is added by the main and/or the tail rotor system, the engine's DECU would sense the additional power requirement and respond with additional fuel to the engine. A potentiometer located in the tailboom is used by the engine control to signal when additional power is required from the engine as a result of increased pitch on the tail rotor blades. The potentiometer parameter (XPA) is recorded by both the QAR and DECU. A limitation of the XPA value is that it is an indication of power requirement, but is not directly an indication of pitch on the tail rotor blades. Additionally, the value for XPA needs to exceed 70 percent before additional power is required from the engine; thus, changes in engine power (and corresponding tail rotor pitch changes) below 70 percent would not have been recorded. In reviewing the data, the XPA value did not exceed 70 percent until the end of the data, consistent with the tail rotor striking the rooftop during the accident. Additionally, the data were absent a "normal" XPA spike during the takeoff, which was expected to be present due to the additional power requirement at takeoff.
The investigation was unable to verify the pilot's pre-take off actions due to the lack of a cockpit recording system with the ability to capture image data.

During the course of the investigation, investigators learned of two events in which a pilot initiated the takeoff with the yaw hydraulic isolation switch in the "off" (cutoff) position. The events did not result in an accident and were not reported (nor was a report required). The actual number of similar occurrences is unknown because pilots/operators are not required to report such events.

Airbus Helicopters issued Safety Information Notice No. 2776-S-29, "Hydraulic Power – Information about the Dual Hydraulic System," dated August 21, 2014, to operators.
The air safety notice, noted that if the pilot fails to move the yaw servo hydraulic switch back to the "on" position before takeoff, there will be a complete lack of hydraulic boost to the tail rotor system. Before switch activation, the yaw load compensator would have been discharged to verify proper operation of the hydraulic accumulator test switch and valve. This situation could be perceived by the pilot as a tail rotor control failure due to the increased load required to move the control pedals. If not quickly identified and corrected, this situation could lead to a loss of helicopter control.

The notice also identified two modifications that would help prevent departures in the helicopter without

the hydraulic systems properly configured: (1) new production helicopters have been fitted with a flashing "HYDR 2" light on the caution panel, which will illuminate when the yaw hydraulic isolation switch is in the "off" position, (2) a future modification will also change the "ACCU TEST" button from an "on-off" push-button to a momentary push-button switch.

On February 25, 2015, Airbus Helicopters issued Service Bulletin (SB) No. AS350-67.00.64, "Rotor Flight Controls – Double Hydraulic Servo Controls." The SB recommends modifying the hydraulic indications to the pilot, on helicopters equipped with the dual hydraulic system. The recommended modifications would provide an indicator light on the caution and warning panel, when the yaw hydraulic isolation switch is activated and a second light to indicate the status of the two systems.

Administrative Information

Investigator In Charge (IIC):	Hatch, Craig
Additional Participating Persons:	Dick Stone; FAA FSDO; Albuquerque, NM Lindsay Cunningham; Airbus Helicopters; Grand Prairie, TX Bryan Larimore; Turbomeca Bernard Boudaille; BEA; Paris Kevin McChord; PHI Air Medical; Albuquerque, NM Chihoon Shin; NTSB, Aviation Engineering; Washington, DC
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