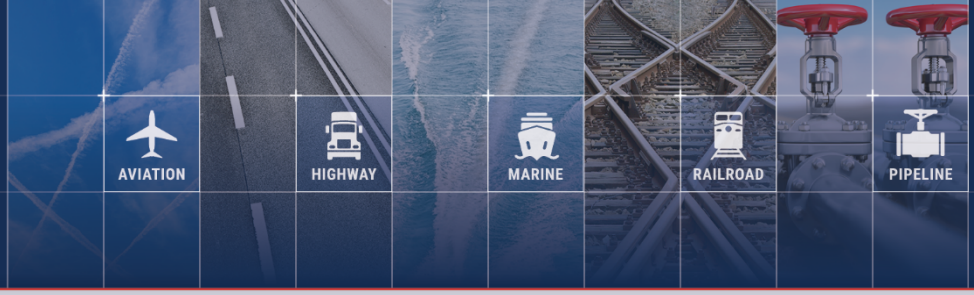

Aviation Investigation Final Report

Location:	Drexel Hill, Pennsylvania	**Accident Number:**	ERA22FA105
Date & Time:	January 11, 2022, 12:55 Local	**Registration:**	N531LN
Aircraft:	EUROCOPTER DEUTSCHLAND GMBH EC135 P2+	**Aircraft Damage:**	Substantial
Defining Event:	Unknown or undetermined	**Injuries:**	1 Serious, 3 None
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled - Air Medical (Medical emergency)		

Analysis

Flight track data from the helicopter air ambulance flight indicated that, while in cruise flight at an altitude of about 1,500 ft mean sea level (msl), the helicopter departed normal cruise flight with an abrupt increase in altitude, followed by a dive. The recovered data from various sources onboard the helicopter did not contain information as to whether the helicopter rolled inverted during this altitude excursion, as recalled by the crewmembers. Surveillance video showed the helicopter in a near-vertical, nose-down, spiraling descent. The pilot arrested the rotation and recovered the helicopter from the dive but was unable to climb or hover due to insufficient engine power, thereby resulting in a hard landing to a city street and substantial damage to the helicopter. Examination of the helicopter revealed no evidence of malfunction that would result in an abrupt departure from cruise flight.

Because of the limited control authority of the Stability Augmentation System (SAS) actuators, it is unlikely that a malfunction of a SAS actuator would have resulted in an inflight upset before the pilot could react to the malfunction. Additionally, a malfunction of a trim actuator would not result in an inflight upset as the pilot would notice an attitude deviation before the trim actuator, whose rate of movement is limited by design, would be able to move the helicopter into an unusual attitude.

Data indicated that a main rotor system overspeed, which likely occurred during the dive maneuver, resulted in the overspeed of both engine power turbines due to the sudden reduction in load from the main rotor. As a result of the power turbine overspeed, both engine control systems, independent of each other, functioned as designed and reverted to manual mode while at a minimum fuel flow rate. Both engines continued to run at low power without

automatic governing, resulting in insufficient power to continue normal flight as the engine twist grips remained in the normal fly position for the duration of the flight.

Probable Cause and Findings

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

An inflight attitude upset for undetermined reasons that resulted in a rotor system overspeed, a reduction of power from both engines, and a subsequent hard landing.

Findings

Not determined	(general) - Unknown/Not determined
Aircraft	Powerplant parameters - Capability exceeded
Personnel issues	Aircraft control - Unknown/Not determined
Aircraft	Main rotor mast/swashplate - Capability exceeded

Factual Information

History of Flight

Enroute	Unknown or undetermined (Defining event)
Enroute	Inflight upset
Landing	Hard landing

On January 11, 2022, about 1255 eastern standard time, a Eurocopter EC135 P2+, N531LN, was substantially damaged when it was involved in an accident in Drexel Hill, Pennsylvania. The airline transport pilot was seriously injured. The two medical crewmembers and the patient were not injured. The helicopter was operated by Air Methods Corporation as a Title *Code of Federal Regulations* Part 135 air ambulance flight.

Automatic dependent surveillance - broadcast (ADS-B) data revealed that the helicopter departed Chambersburg Hospital Heliport (PA60) about 1205 and was destined for Children's Hospital of Philadelphia Heliport (9PN2), Philadelphia, Pennsylvania. The track showed the helicopter in a cruise profile on an easterly track about 3,500 ft mean sea level (msl). About 1243, the helicopter descended and leveled about 2,800 ft msl, and then descended and leveled at 1,500 ft msl, tracking directly toward 9PN2. At 1253:11, the helicopter track depicted a series of heading and altitude excursions. The plots depicted altitudes between 1,700 ft msl and 1,250 ft msl before the target disappeared at 1253:17.

In a written statement, a witness whose home was directly beneath the helicopter's flight path said that he was an aviation enthusiast and was familiar with the many helicopters flying to and from area hospitals. He said that his attention was drawn to the accident helicopter because it was, "very low and louder than normal" and that the "tone" of the rotors was unfamiliar. According to the witness, the helicopter was "in a nose down attitude… far less than 1,000 ft above the ground… [and] rotating around its longitudinal axis."

A doorbell camera about 1 mile from the accident site, and approximately beneath the helicopter's flight path, captured both audio and video of the helicopter's initial descent from its cruise altitude. The sound could be heard before the helicopter entered the frame. The helicopter's departure from controlled flight was not captured, as it was blocked by a porch awning on the front of the house. A high-pitched whine was heard, increasing in volume and pitch before the helicopter appeared beneath the awning above the camera in a near-vertical, nose-down descent. The helicopter's angle of descent shallowed as it disappeared behind a tree line. The volume and pitch of the sound continued to increase for a time after the helicopter disappeared and before the sound ultimately faded.

A second witness nearby said that he saw a helicopter, “very low…very loud…banked right and left out of control, then appeared to straighten…” before it disappeared from view.

Brief video clips from open-source media outlets showed the helicopter upright, in a steep descent, exhibiting small but rapid changes in each axis (pitch, roll, yaw). Another home doorbell camera captured the last second of flight as the helicopter appeared level in the frame, in a slight nose-up attitude, as it impacted the ground, separating the tailboom, then disappeared from view.

The pilot made himself available for interview, but the interview was postponed due to his medical condition. Subsequent conversations between the pilot and the Investigator-In-Charge over the months following the accident revealed that the pilot had no memory of the accident flight.

In an interview with the operator during September 2023, the pilot recalled details of planning the flight, as he had not flown to 9PN2 “in a while.” He said that he was in cruise flight at 5,000 ft, then initiated a descent to “clear the first shelf of the airspace” surrounding Philadelphia.

The pilot further stated, “I have no recollection of the initial incident. I remember being on the controls and fighting the aircraft in a dive…I realized the collective was fully up when the aircraft finally leveled off but the aircraft was still descending.”
The pilot described assessing and rejecting multiple forced landing sites before selecting the point of touchdown. He said, “Since I didn’t think I had any collective left, I pointed towards the landing area and pulled aft cyclic during landing. This all happened in 15 seconds or less.”

The flight nurse and flight medic were interviewed by a Federal Aviation Administration (FAA) aviation safety inspector. According to the flight medic, the flight was routine, and they were within 10 minutes of landing at 9PN2. He and the flight nurse were out of their seats treating the patient when a loud “bang” was heard, and the helicopter banked sharply right and continued into a right roll. The medic said that the helicopter rolled inverted, perhaps multiple times, and that he and the nurse were “pinned to the ceiling” and internal communication was lost. The helicopter was leveled, the patient was secured, the crewmembers secured themselves in their seats, and they braced for landing.

Following the accident, the flight nurse evacuated the patient, and then evacuated the pilot while the medic shut down both engines. The nurse travelled with the patient while the medic travelled with the pilot to area hospitals.

Pilot Information

Certificate:	Airline transport; Private	**Age:**	51,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	August 26, 2021
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	August 5, 2021
Flight Time:	(Estimated) 4123 hours (Total, all aircraft), 185 hours (Total, this make and model), 3650 hours (Pilot In Command, all aircraft), 53 hours (Last 90 days, all aircraft), 11 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

The pilot held an airline transport pilot certificate with ratings for airplane multiengine land and rotorcraft-helicopter, with private pilot privileges for airplane single engine land. The pilot's most recent second-class FAA medical certificate was issued on August 26, 2021.

The operator reported that the pilot had accrued 4,123 total hours of flight experience, of which 3,400 hours were in helicopters and 185 hours were in the accident helicopter make and model.

Aircraft and Owner/Operator Information

Aircraft Make:	EUROCOPTER DEUTSCHLAND GMBH	**Registration:**	N531LN
Model/Series:	EC135 P2+	**Aircraft Category:**	Helicopter
Year of Manufacture:	2006	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	0474
Landing Gear Type:	Skid	**Seats:**	7
Date/Type of Last Inspection:	January 11, 2022 AAIP	**Certified Max Gross Wt.:**	6400 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo shaft
Airframe Total Time:	9163.2 Hrs as of last inspection	**Engine Manufacturer:**	Pratt & Whitney
ELT:	C126 installed, not activated	**Engine Model/Series:**	206B2
Registered Owner:	AIR METHODS CORP	**Rated Power:**	734
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:	PHL,10 ft msl	**Distance from Accident Site:**	6 Nautical Miles
Observation Time:	12:54 Local	**Direction from Accident Site:**	142°
Lowest Cloud Condition:	Few / 6000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots / 17 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	310°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.53 inches Hg	**Temperature/Dew Point:**	-4°C / -19°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Chambersburg, PA (PA60)	**Type of Flight Plan Filed:**	VFR
Destination:	Philadelphia, PA (9PN2)	**Type of Clearance:**	VFR
Departure Time:	12:05 Local	**Type of Airspace:**	Class E

Wreckage and Impact Information

Crew Injuries:	1 Serious, 2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 None	**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Serious, 3 None	**Latitude, Longitude:**	39.947563,-75.30347(est)

Examination of the accident site revealed that the helicopter initially impacted the ground upright and came to rest on its left side next to a building on a heading of about 220°. All components of the helicopter were accounted for at the accident site. Examination of the main rotor, tail rotor, and their drive systems revealed no preimpact failures. Both freewheeling units exhibited normal functionality when manually moved in both drive and freewheeling directions. Both engines remained installed and their exhaust pipes exhibited impact deformation as well as thermal damage to the drain lines and cowlings adjacent to the exhaust pipes. Examination of both engines revealed no anomalous damage on all first stage compressor blades and all power turbine blades. Examination of the flight control system, including the automatic flight control system (AFCS), found no evidence of preimpact fractures, disconnections, or restrictions in their freedom of movement. Both collective-mounted engine twist grips remained in the normal fly position. Testing and disassembly examination of the main rotor actuators, fenestron actuator, and the hydraulic supply systems found no functional anomalies that precluded their normal operation. A piece of black-colored debris was observed captured within the No. 1 hydraulic filter (pre-filtration) and black-colored foreign material was adhered to the installation orifice for the No. 1 hydraulic filter (post-filtration). Spectroscopy of the black-colored debris and foreign material revealed peaks in carbon and oxygen. Similar debris and foreign material were not present elsewhere in the No. 1 hydraulic system or in the main rotor actuators. Testing of the smart electromechanical actuators (SEMA), the pitch and roll trim actuators, and various AFCS sensors resulted in no anomalous findings that would have precluded their normal operation.

Fault and exceedance data were downloaded from the engine data collection units (DCU), the cockpit warning unit, the vehicle and engine multifunction display (VEMD), the caution and advisory display (CAD), and the two flight control display modules (FCDM). The No. 1 FCDM recorded no faults while the No. 2 FCDM recorded 11 faults for the accident flight. These faults all occurred between 48 minutes and 7.5 seconds to 48 minutes and 10 seconds into the accident flight and included various air data and flight display discrepancies, including a failure indicating that the No. 1 FCDM was not operating. The VEMD data showed the accident flight had a duration of about 50 minutes with 12 associated failure entries. Within the VEMD data, at 48 minutes and 8 seconds into the accident flight, there were exceedances in mast moment, rotor speed (Nr), and engine power turbine speed (Nf) while engine torque was at 0%.

Additionally, at 49 minutes and 45 seconds into the accident flight, main transmission oil pressure was at 1.45 psi (0.1 bar). The warning unit data, which does not have timestamped data entries like the VEMD and DCU data, revealed three separate Nr excursions from normal (100%) to above 112%. Autopilot failure warnings were also recorded in the warning unit data. The recovered DCU data recorded engine time versus flight time, thus the DCU data entries could not be synchronized to the VEMD and FCDM data. The DCU data for each engine showed that during the accident flight, their respective Nf values recorded a peak of 126.79% at near-zero torque values. As a result of the Nf overspeeds, the DCU data showed that both engine control systems had, for their respective engine, reduced fuel flow to a minimum and subsequently reverted the engine control to manual mode. When an engine fuel control is in manual mode, the pilot is required to manipulate the respective engine twist grip, mounted on the collective control, to manually control fuel flow to that engine. If the engine twist grip remains in the normal fly position while the engine is in manual mode, the engine will continue to run at the last known fuel flow rate until the pilot intervenes by manipulating the engine twist grip. The last recorded parametric data line from the DCUs showed that, nearly 2 minutes after the Nf overspeed occurred, the engine gas generator speed (Ng) was between 23-29%, torque was at 0%, and Nf was at 0%.

For additional details on the examination of the helicopter and its various components, see the Airworthiness Group Chair's Factual Report in the docket.

Tests and Research

An EC135 P2+ simulator was used to determine the helicopter response to various scenarios involving abrupt disconnection of the AFCS during high-speed cruise flight without hands on the flight controls. These scenarios included disconnection of the autopilot, specifically the altitude hold and heading hold upper modes, as well as disconnection of the entirety of the AFCS, including all stabilization systems, using the "SAS/AP CUT" button on the cyclic grip. In all scenarios except those involving the SAS/AP CUT button, the helicopter remained stabilized. In scenarios involving the SAS/AP CUT button, the helicopter became unstabilized and required high pilot workload to regain control of the helicopter. When a dual engine control failure was introduced to these scenarios involving disconnection of the AFCS, the pilot workload to land the helicopter increased. The most difficult scenario for the simulator pilot involved a dual engine control failure coupled with a complete disconnection of the entirety of the AFCS using the SAS/AP CUT button.

Additional Information

For the helicopter's AFCS, SAS actuators provide short-term attitude hold and rate damping (stabilization) in the pitch, roll, and yaw axes. The SAS actuators have limited control authority of about 12% in the pitch axis, 14% in the roll axis, and 18.5% in the yaw axis, but can reach their control limit within seconds. The inputs by the SAS actuators are not transmitted to the cockpit cyclic control and pedals.

The AFCS pitch and roll trim actuators provide long-term attitude hold in their respective axes as well as control of the helicopter when the autopilot upper modes are active. In contrast to the SAS actuators, the trim actuators have full control authority of the cockpit cyclic control in the pitch and roll axes, but their rate of movement is limited. A pilot can temporarily override the trim actuators by using the cyclic-mounted force trim release button or by forcefully pushing against the cyclic control. Lastly, the cyclic-mounted SAS/AP CUT button, which is inset to prevent unintended activation, will immediately disengage all AFCS functions, resulting in an unstabilized helicopter necessitating constant control inputs by the pilot to maintain attitude.

Administrative Information

Investigator In Charge (IIC):	Rayner, Brian
Additional Participating Persons:	Michael Bauer; FAA/FSDO; Philadelphia, PA Seth Buttner; Airbus Helicopters; Grand Prairie, TX Kevin Drew; Air Methods; Greenwood Village, CO Axel Rokohl; German Federal Bureau of Aircraft Accident Investigation; Braunschweig Nora Vallée; Transportation Safety Board of Canada; Gatineau, OF
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Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=104517