Aviation Investigation Final Report

Location:	Chicago, Illinois	**Accident Number:**	CEN18FA259
Date & Time:	July 7, 2018, 21:23 Local	**Registration:**	N312SA
Aircraft:	EUROCOPTER DEUTSCHLAND GMBH EC135 P1	**Aircraft Damage:**	Substantial
Defining Event:	Miscellaneous/other	**Injuries:**	3 Serious, 1 None
Flight Conducted Under:	Part 135: Air taxi & commuter - Non-scheduled - Air Medical (Medical emergency)		

Analysis

While en route during night visual conditions to a hospital helipad with two crewmembers and a patient, the commercial pilot noticed a twist grip caution indication on the left engine (No. 1) cockpit display system (CDS) panel. The pilot also noticed a second indication but could not recall the specific caution message. He stated that he then grabbed each engine throttle twist grip individually to gently verify if he could feel they were in or out of position (neutral detent) but did not notice any significant changes to the throttle position. The pilot decided to divert to a nearby airport, and, as he executed a turn toward the airport, he noticed the No. 2 engine indication no longer matched the No. 1 engine indication; he stated that "it was lower and oscillating." Within about 1 minute of the turn, the pilot "heard the low rotor [rpm] horn," and he lowered the collective to maintain rotor speed. The pilot located a "dark spot" on the ground, which he determined would give him the best opportunity to complete a full autorotation. As he started a turn toward his intended landing location, he felt the tail oscillate to the right and back and heard an increase and decrease in engine speed. When the helicopter was about 200 ft above ground level, he thought he may land short of the intended location and adjusted the collective and cyclic to maintain rotor rpm and airspeed. The helicopter impacted terrain, rotated 180°, and came to rest upright. Surveillance video from a rail platform near the accident site showed a fire near the right (No. 2) engine during the autorotation and a flame burst after the impact with terrain.

Examination of the throttles, throttle linkages, engines, control systems, CDS, and the electronic engine control (EEC) units revealed no evidence of preimpact mechanical malfunctions or failures that would have precluded normal operation. Analysis of data retrieved from the CDS and EEC units revealed that, about 4 minutes after takeoff, the No. 1 engine was placed in manual mode and out of EEC control, which indicates that the pilot had likely inadvertently moved the No. 1 engine throttle out of its neutral detent. The No. 1 engine was in manual mode for about 7 minutes before the pilot noted the CDS twist grip caution indication. The data showed that as the pilot continued to manually control the No. 1 engine, the No. 2 engine was also placed in manual mode and out of EEC control, which indicates that the pilot moved the No. 2 throttle out of its neutral detent. The pilot attempted to maintain rotor and engine rpms while controlling both engines manually; it is not likely that he fully understood the nature of the problem. The pilot misinterpreted an aural alert (low rotor rpm as opposed to high rotor rpm) when high rotor rpm existed and then lowered the collective, which created a rotor overspeed condition. This configuration resulted in a high-workload scenario in which it would be particularly challenging for the pilot to control the helicopter while maneuvering in low altitude and night visual conditions.

The pilot had accumulated about 300 hours of flight experience in EC135s, with about 11 hours in the accident make and model EC135 P1. The accident helicopter was the only EC135 P1 variant in the operator's fleet. Its engines, displays, and throttle controls differed from the EC135 P2+ variant in which the pilot was formally trained. The investigation revealed the pilot completed a basic online (self-study) differences training presentation and some informal familiarization training with other company pilots. No formal flight training was part of the differences training curriculum. Because the throttle (twist grip) differs between the P1 and P2+ variants, it is likely that the pilot moved it into manual mode without realizing it; he likely did not recognize this issue because he did not have as much experience or formal training in the P1 variant. Because the displays also differed between the variants, it could have been more difficult for the pilot to recognize and understand the indications he was receiving. Given the differences among the two variants regarding the displays and throttle controls, additional familiarization training, such as a familiarization flight with a company check pilot, would have provided the pilot with a better understanding of the key differences. The helicopter manufacturer issued a service bulletin about 10 years before the accident regarding collective throttle controls with grips that had an increased mechanical protection against unintentional adjustment; however, that modification was not mandatory.

Probable Cause and Findings

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

The pilot's inadvertent disabling of the No. 1 and No. 2 engines' electronic engine control systems, which resulted in engine and rotor overspeed conditions, a subsequent autorotation, and a hard landing. Contributing to the accident were the pilot's inexperience with the helicopter variant and the operator's lack of a more robust helicopter differences training program.

Findings

Aircraft	(general) - Unintentional use/operation
Personnel issues	Use of equip/system - Pilot
Personnel issues	Knowledge of equipment - Pilot
Organizational issues	(general) - Operator
Environmental issues	Dark - Ability to respond/compensate

Factual Information

History of Flight

Enroute	Miscellaneous/other (Defining event)
Maneuvering	Uncontained engine failure
Autorotation	Hard landing
Autorotation	Fire/smoke (non-impact)

On July 7, 2018, about 2123 central daylight time, a Eurocopter Deutschland GMBH EC135 P1 helicopter, N312SA, impacted terrain during an autorotation near Chicago, Illinois. The pilot, flight paramedic, and flight nurse sustained serious injuries, and the patient was not injured during the accident. The helicopter sustained substantial damage to the fuselage, tailboom, and main rotor blades. The helicopter was registered to Bennett Aviation, LLC, Elmhurst, Illinois, and operated by Pentastar Aviation Charter under the provisions of Title 14 *Code of Federal Regulations (CFR)* Part 135 as an air ambulance flight. Night visual meteorological conditions prevailed at the time of the accident, and the flight was operated under a visual flight rules flight plan. The flight departed St. Mary Medical Center, Hobart, Indiana, at 2110, and was destined for Advocate Christ Medical Center, Oak Lawn, Illinois.

Helicopter satellite tracking data and air traffic control information revealed the helicopter was traveling northwest from the St. Mary Medical Center on a direct route to Advocate Christ Medical Center about 1,000 ft above ground level (agl). About 5 miles southeast of Advocate Christ Medical Center, the helicopter turned to the right after the pilot requested to divert to the Gary International Airport (GYY), Gary, Indiana. About a minute later, the pilot declared a "mayday" and stated the helicopter was going down into a field. The helicopter came to rest upright in a grass area between the Interstate Highway 94 and Interstate Highway 57 interchange (see Figures 1, 2, and 3).

Figure 1. Flight Track Map

Figure 2. Main Wreckage

Figure 3. Main Wreckage

Surveillance video from a Chicago Transit Authority rail platform, located adjacent to the accident site, depicted the helicopter during the final phase of the autorotation and impact with terrain. The video showed a fire near the No. 2 (right) engine during the autorotation. A flame burst was observed after the impact with terrain.

The pilot was able to recall portions of the flight and recounted them during interviews with National Transportation Safety Board (NTSB) investigators and also provided a written statement. On the evening of the accident, the pilot received a flight request, checked the weather, and performed a preflight inspection for the planned 12 to 13-minute flight. After departure, the pilot climbed to 1,700 ft mean sea level, or about 1,000 ft agl. About 5 miles west of GYY, he contacted Chicago Midway International Airport (MDW), Chicago, Illinois, requesting entry into the airspace, and noticed a "Twist Grip" warning on the left engine 1 side warning panel. The pilot noticed a second indication but could not recall the specific warning. He grabbed each engine throttle twist grip individually to gently verify if he could feel they were in or out of position, and he did not notice any significant changes to the throttle position.

The pilot decided he did not have enough time to trouble shoot the emergency procedure before landing at the intended hospital destination, and he would not land at the hospital with a warning indication. He informed the medical crew they would divert to GYY and handed them the helicopter emergency checklist book to assist with locating the emergency checklist procedure(s).

As the pilot executed the turn to GYY, he noticed the No. 2 engine indication (N1 gas producer) no longer matched with the No. 1 engine; "it was lower and oscillating." Within about 1 minute of the turn toward GYY, the pilot "heard the low rotor RPM horn", and he lowered the collective to maintain rotor speed. The pilot located a "dark spot" which would give him the best opportunity to complete a full autorotation with a flare to cushion the landing. The pilot determined he no longer could troubleshoot the problem and was doing his best to fly the helicopter. As he started a turn toward his intended landing location, he felt the tail oscillate to the right and back and heard increase and decrease in engine speed. About 200 ft agl, he thought he may land short of the intended location, and he made adjustments to the collective and cyclic to maintain rotor RPM and airspeed. The pilot then initiated a flare and landing. After the helicopter came to rest, the flight paramedic mentioned the helicopter was on fire, and the pilot noticed a fire near the No. 2 engine.

Pilot Information

Certificate:	Commercial	**Age:**	46,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 1 With waivers/limitations	**Last FAA Medical Exam:**	October 31, 2017
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	March 31, 2018
Flight Time:	3334 hours (Total, all aircraft), 11 hours (Total, this make and model), 3291 hours (Pilot In Command, all aircraft), 22 hours (Last 90 days, all aircraft), 8 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

A review of the pilot's records and telephone interviews revealed the pilot was hired by Pentastar in August 2016 and primarily flew the EC135 P2+ helicopter. His most recent Federal Aviation Regulations Part 135 competency check was completed March 31, 2018, in the EC135 P2+ helicopter, which was equipped with a different cockpit display than the EC135 P1 accident helicopter. At the time of the accident, the pilot had accumulated about 319 flight hours in the EC135 P2+, with about 11 total hours in the EC135 P1.

The pilot completed the Pentastar "RW EC-135P1 Differences Training", which was an online self-study course, on February 18, 2018. The online course included, but was not limited to, the following differences: Cockpit Display System (CDS) versus Center Panel Display System (CPDS) (P2+), analogue versus first limit indicator (FLI) all engines operative and one engine inoperative limits, and twist grip controls. In addition, the pilot stated he completed some "hands-on" EC135 P1 training with other company pilots, and familiarization flights. The pilot had not received any simulator training for the EC135 P1 helicopter as there was no EC135 P1 simulator available at any worldwide training facility.

Aircraft and Owner/Operator Information

Aircraft Make:	EUROCOPTER DEUTSCHLAND GMBH	**Registration:**	N312SA
Model/Series:	EC135 P1	**Aircraft Category:**	Helicopter
Year of Manufacture:	1998	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	0054
Landing Gear Type:	Skid	**Seats:**	6
Date/Type of Last Inspection:	April 2, 2018 Continuous airworthiness	**Certified Max Gross Wt.:**	6250 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo shaft
Airframe Total Time:	6555.4 Hrs at time of accident	**Engine Manufacturer:**	Pratt & Whitney Canada
ELT:	C126 installed, activated, did not aid in locating accident	**Engine Model/Series:**	PW206B
Registered Owner:	BENNETT AVIATION LLC	**Rated Power:**	431 Horsepower
Operator:	Pentastar Aviation Charter, Inc	**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:		**Operator Designator Code:**	UG8A

According to Pentastar, the helicopter was maintained according to the manufacturer's inspection program, and the most recent inspection was completed on April 2, 2018. At the time of the accident, the helicopter had accrued 6,555.4 flight hours. The helicopter was not equipped or certified for instrument flight rules operations.

The engines were equipped with Electronic Engine Control (EEC). The engine throttles (twist grips) were mounted on the collective. The forward throttle was for the No. 1 (left position) engine, and the aft throttle was for the No. 2 (right position) engine. For the throttles to be in the neutral position, a white line and the letter "N" on each throttle need to be aligned with a white arrow on the collective. There was a detent when the throttle was rolled across the neutral position, which matched the painted positions that were mid-way between the full open and minimum idle positions. Normal flight was conducted with the throttles in the neutral position, allowing the EECs to control the engines. The EECs provided several functions, which included the scheduling of fuel and maintaining engine operation within predetermined limits.

The airframe manufacturer refers to the engine EECs as Full Authority Digital Engine Controls (FADECs) in the cockpit indications.

The operator's helicopter fleet consisted of two EC135 P2+ helicopters, and one EC135 P1 helicopter.

Manual Engine Control

According to the EC135 P1 CDS flight manual, if either throttle were rolled out of the neutral position, two annunciator lights would illuminate on the CDS; ENG MANUAL (engine manual) and TWIST GRIP, and a yellow master caution light in the pilot's field of view on the instrument panel. The ENG MANUAL light indicated that the FADEC no longer controlled that engine, and the movements of the collective up or down would not automatically result in engine power changes to maintain constant rotor speed. The TWIST GRIP light indicated that the throttle was not in the neutral position but was unaffected by whether the engine was in manual or under FADEC control. The rotorcraft flight manual (RFM) page 3-16, indicated the following warning about operating the engine in the manual mode: "OPERATE THE TWIST GRIP WITH GREAT CARE AND AVOID QUICK TWIST GRIP ROTATIONS. HOLD MIN. 10% TORQUE ON THE NORMAL ENGINE TO MAINTAIN AUTOMATIC CONTROL OF [Rotor Speed]."

The RFM page 3-34, effective after alert service bulletin (ASB) EC135-76A-002 had been completed, also noted that if a throttle were rolled out of the neutral position and if the residual torque on the engine in MANUAL mode was greater than 10%, the respective engine twist grip should be moved to the neutral position. If the residual torque on the engine in MANUAL mode was less than 10%, the respective guarded ENG MODE SEL switch on the overhead panel must be switched to MANUAL then to NORM, followed by verification of ENG MANUAL caution light extinguished, the respective engine twist grip moved to the neutral position, and verification of correct operation in NORM mode through small collective movements. In either case, if the TWIST GRIP caution indication remained on, LAND AS SOON AS PRACTICAL.

Once the throttle was returned to the neutral position, the TWIST GRIP light would extinguish; however, if the throttle were rotated from the neutral position again, in either direction, the engine would revert to manual control, and the process would have to be repeated.

According to the helicopter manufacturer, with one engine in manual mode, and the other under EEC control, a reduction in power (using the twist grip to reduce fuel flow) on the manual engine would result in a power increase on the engine under EEC control (in an effort to maintain the rotor speed), up to the predetermined limits. If power was increased on the engine in manual mode (using the twist grip), then the power could increase to the engine fuel control limits, and there would be a corresponding decrease in power on the engine under EEC control.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night
Observation Facility, Elevation:	MDW,619 ft msl	**Distance from Accident Site:**	7 Nautical Miles
Observation Time:	21:53 Local	**Direction from Accident Site:**	306°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	100°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.27 inches Hg	**Temperature/Dew Point:**	22°C / 13°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Hobart, IN	**Type of Flight Plan Filed:**	Company VFR
Destination:	Oak Lawn, IL	**Type of Clearance:**	VFR
Departure Time:	21:10 Local	**Type of Airspace:**	Air traffic control;Class B

Wreckage and Impact Information

Crew Injuries:	3 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 None	**Aircraft Fire:**	In-flight
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 Serious, 1 None	**Latitude, Longitude:**	41.715278,-87.624443

Examination of the accident site revealed the initial impact was consistent with the tail bumper contacting the terrain, followed by the landing gear skids and fuselage. The left landing gear skid was separated and came to rest near the ground scar that was consistent with the fuselage impact. The fuselage was crushed upward, and the fenestron structure was separated near the tailboom attachment location. The helicopter had rotated 180° from the direction of impact and came to rest upright. Three main rotor blades displayed fractures near the root, and one blade was relatively undamaged. The pilot seat (right front) and paramedic seat (left aft, aft-face) were found fully attenuated. The flight nurse seat (right aft, forward-face) two floor legs were fractured, and the seat back was separated from the aft wall brackets.

The ENG 1 twist grip (forward) was in the "Max" position, and the ENG 2 twist grip (aft) was in the near "Max" position. Both engines ENG MOD SEL switches were in the "normal" position, and the switch guard in place. The ENG CONTROL switches were unguarded and in the "off" position. The FADEC switches were in the "on" position. The rotor brake was engaged.

Thermal damage was noted on the No. 2 engine and main transmission cowling. Both engines power turbine wheel blades were missing the outer halves of the blades. Multiple impact dents, consistent with the fractured turbine blades, were noted inside the exhaust stubs of both engines. The No. 1 engine had a 1/2" by 1/2" hole in the exhaust stub at the 1 o'clock position forward of the aft firewall, and the No. 2 engine had a 2" by 1" hole in the exhaust stub at the 10 o'clock position forward of the aft firewall. The engines and FADEC components (Electronic Engine Controls (EECs) and Data Collection Units (DCUs)) were removed and shipped to Pratt & Whitney Canada (PWC) for further examination.

Control continuity was established from the cyclic and collective controls to the rotor head. Tail rotor control continuity was established from the anti-torque pedals to the breaks in the tailboom, and then from the breaks to the fenestron. The main transmission was intact and secure in its mounts. Continuity was established through the transmission to its accessories.

Communications

The following transcription excerpts were noted with the recording beginning at 2108:16.3. The communications include intra-cockpit and air to ground communications. The complete audio transcript is located in the NTSB public accident docket.

2109:41.2 Pilot: Alright. Flight guarded - cautions -warnings - all good.

2110:13. 5 Medical Crew 1 (MCR 1): Caution warning lights?

2110:15.7 Pilot: Everything is out.

2110:34.9 Cockpit Area Microphone (CAM): [sound similar to helicopter transitioning to hover]

2114:25.0 Pilot: Unintelligible word/expletive [spoken under breath]

2114:50.0 CAM: [sound of increasing engine power]

2121:57.0 Pilot: Hey guys.

2122:03.2 Pilot: We gotta re-return to uh Gary you guys are gunna have to go by ground I got a manual twist grip here.

2122:10.3 Pilot: So I also - might need you guys to look - look it up.

2122:25.3 Pilot Radio: Yeah, I'd like to return to uh Gary airspace um medivac two sierra alpha.

2122:41.1 Pilot: I'mma hand this back to you.

2122:58.5 MC1?: Okay - what are we looking up?

2123:00.9 Pilot: Engine manual twist grip.

2123:20.9 CAM: [sound of electronic warning gong]

2123:26.0 CAM: [start of sound similar to high rotor RPM alarm begins and lasts until 2124:01.5]

2123:29.6 CAM: [sound similar to increase of rotor RPM]

2123:31.3 Pilot Radio: Mayday, mayday, mayday

2123:50.1 CAM: [sound similar to brief increase in engine or rotor RPM]

2123:51.1 CAM: [sound similar to decrease engine or rotor RPM]

2124:01.5 CAM: [sound of electronic warning gong]

2124:06.3 CAM: [sound similar to low rotor RPM alarm, continues until 2124:28.4]

2124:08.4 CAM: [sound similar to decrease in engine or rotor RPM noise]

2124:16.6 CAM: [sound of impact]

2124:58.0 Pilot Radio: Mayday, mayday, mayday - we're on the ground - uhhh had an accident - three one two sierra alpha

Flight recorders

The helicopter was equipped with an Outerlink IRIS lightweight flight data monitoring (FDM) device. The system provided two-way communication between the flight crew and any equipped ground operator via a global satellite network, an internal Attitude Heading Reference System (AHRS), and recorded voice and video data. The intercom system (ICS) is configured to interface with the IRIS device. The pilot's headset hot mic and ear cups are recorded to the IRIS through the ICS system. Additionally, a lipstick style video camera interfaces with the system and is set to record a view over the pilot's shoulder of the helicopter's cockpit, including the pilot's control stick inputs as well as portions of the instrument panel and windscreen.

The IRIS system components were sent to the NTSB Vehicle Recorder Laboratory, Washington, DC, for data extraction. The unit was undamaged; data and audio information were extracted from the system's processor unit normally.

Data

The accident flight was recorded starting about 2108:00 and valid data ceased about 2124:18. The dataset was limited to only parameters that could be validated in the context of the investigation.

Video

Video information associated with the accident flight was determined to not be useful to the investigation. The video imagery appeared blurred and out of focus. Focal length and focus were set via two external set screws. Upon arrival at the laboratory, these set screws could be moved without tools or excessive force.

On May 25, 2018, Outerlink issued a service bulletin (SB) titled: N00-5300 Camera. The purpose of the service bulletin was listed as "to provide better retention of the focus ring allowing the camera to remain in focus." The service bulletin provides instructions to modify the camera's focus ring assembly by adding holes for two additional set screws which are used to retain the focus ring from moving. For the accident camera, only one set screw was in place on the camera's focus ring which indicated the service bulletin was not applied to the accident helicopter camera.

At the time of the accident, the operator had not been notified or received the Outerlink service bulletin.

Audio

An audio transcription group was convened to document the audio data. Timing on the transcript was established by correlating an audio event to a corresponding recorded data event from the FDM. The recording began as the helicopter was powered and idling on the ground at 2108:16.3. The transcription began at the recording's start as the medical crew were discussing the patient injuries, and the recording lasted the entire duration of the flight, through impact and continued recording until 2126:10.3.

Survival Aspects

The pilot's seat lower composite structure was fractured and shoulder harness inertial reel was separated. The pilot's injuries included a laceration to his head and spinal fractures. No evidence of contact by other structure was noted on the composite seat.

Tests and Research

The helicopter was reexamined in Poplar Grove, Illinois, on November 13, 2018, under the supervision of the NTSB. Examination of the twist-grip throttles confirmed continuity from each throttle to the respective engines. The No. 1 engine twist grip throttle was unable to move, and the No. 2 engine twist grip throttle was free to rotate. Impact related damage was noted from the co-pilot collective control gearbox (collective/throttle not installed during accident) and cable interconnect to the pilot collective control. Throttle break force measurements were conducted; however, due to damage, the measurements were considered unreliable. The collective control assembly was removed for further examination.

The master caution light was removed from the instrument panel. Electrical connection was verified from the master caution light to the CDS. Electrical power was applied to the master caution light and the bottom two light bulbs illuminated. The top two light bulbs displayed broken filaments.

The collective assembly was examined at Airbus, Grand Prairie, Texas, under the supervision of the NTSB. Impact damage was noted to fittings on both collective gearboxes which prohibited throttle movement. The fittings were straightened with tooling to accommodate a friction test. The pilot collective twist grip was accomplished with cockpit to engine cables attached. The following results were noted:

Throttle No. 1 - Neutral to Max: 12 ft. lbs.; Neutral to Idle: 10 ft. lbs.

Throttle No. 2 - Neutral to Max 11 ft. lbs.; Neutral to Idle: 8 ft. lbs.

All examination participants manipulated the No. 1 and No. 2 throttles to feel the neutral detent. No anomalies were noted in the detents during the manipulation of the throttles. The collective gearboxes were disassembled and no anomalies were noted.

Cockpit Display System

The CDS was examined at the Honeywell facility, Urbana, Ohio, under the supervision of the Federal Aviation Administration. According to Honeywell, the CDS stores two types of non-volatile memory (NVM) for later retrieval and analysis. Neither data type will be erased unless N1 I or N1 II increases above 20%. When one of these two signals increase over that level, the NVM device is erased of any previous stored codes and new recording is allowed. The CDS records all the caution signals that were activated in the previous one minute in an NVM device. The order the cautions appear on the screen is chronological from top to bottom, with the oldest caution on the top and the most recent caution on the bottom.

For the No. 1 engine, the top light illuminated was ENG MANUAL, followed by TWIST GRIP, FADEC FAIL, FADEC MINR, HYD PRESS, GEN DISCON, and BUSTIE OPN.

For the No. 2 engine, the top light illuminated was ENG MANUAL, followed by TWIST GRIP, FADEC FAIL, FADEC MINR, ENG FAIL, ENG CHIP, HYD PRESS, and BUSTIE OPN.

FADEC FAIL indicated a loss of automatic acceleration and deceleration during power (collective) changes, and the system reverts to manual mode. FADEC MINR indicated a change or loss of a number of governing functions. ENG FAIL indicated respective N1 RPM below the threshold value. ENG CHIP indicated metal particles detected in engine oil. GEN DISCON indicated the respective generator has failed or disconnected from the power distribution system. HYD PRESS indicated a loss of hydraulic pressure. BUSTIE OPN indicated that the electrical systems were separated, and the high load bus was disconnected.

PWC PW206B Engines No. 1 (s/n: BB0049) and No. 2 (s/n: BB0045)

The engines were reexamined at PWC, St. Hubert, Quebec, Canada, on September 17 to 21, 2018. Both engines were not mechanically capable of further operation. The No. 2 engine displayed evidence of a nacelle fire, and metal spray was found in the compressor turbine vanes. Both engines' power turbine (PT) blades were all fractured at 1/3 span consistent with tensile overload in an overspeed condition. According to PWC, the PT blades were designed to release at the dimpled area at a speed of approximately 150% power turbine speed (NPT) in order to preserve the integrity of the PT disc. The diameter of both engines' PT discs had grown beyond factory limits, which was also consistent with an overspeed condition.

The No. 1 engine displayed a partially separated and dislodged metal shroud, a component of the PT duct, deformed and covering the air flow path of the exhaust duct. The exhaust duct exhibited multiple pock marks consistent with high speed impact from small internal parts. There was one penetration hole about the 1 o'clock location (aft looking forward (ALF)), exhibiting petalling consistent with an inside-to-outside particle direction. There were no findings with any of the accessories that would have precluded normal operation.

The No. 2 engine displayed a partially separated and dislodged metal shroud, a component of the PT duct, deformed and covering the air flow path of the exhaust duct. The exhaust duct exhibited multiple pock marks consistent with high speed impact from small internal parts. There was one penetration hole about the 10 o'clock location ALF, exhibiting petalling consistent with an inside-to-outside particle direction. The PT retaining ring and the No. 5 bearing carbon seal were separated into multiple pieces. The forward cavity of the No. 5 bearing surfaces was coated with an oily soot, consistent with an oil fire. The No. 2 engine displayed evidence of an internal fire near the exhaust area. There were no findings with any of the accessories that would have precluded normal operation.

EECs No. 1 and No. 2

The EECs were downloaded in the presence of a Transportation Safety Board of Canada representative. Due to the basic nature of the fault recording in the EEC, there was no time stamp which precluded a sequence of events/faults. The following sensors are recorded when the faults are detected by the EEC.

1. Torque (Q) sensor: provides the primary torque signal (QA) and power turbine speed (NPT) signal to the EEC

2. NPT sensor: provides the backup torque signal (QB) and the backup NPT signal to the EEC. It provides the primary NPT signal to the cockpit.

3. Gas Generator Speed (NG): provides the NG speed to the cockpit and EEC.

The No. 1 engine detected an "NF (Power turbine speed) out of range fault" on both its Q and NPT sensors, both with NG values of above 96%. This fault was triggered when the NPT speed exceeds 127%. Both sensors detected the NPT speed exceeding 127%.

The No. 2 engine detected "NF (Power turbine speed) out of range fault" on both its Q and NPT sensors, both with NG values of above 97%. Both sensors detected the NPT speed exceeding 127%.

DCUs No. 1 and No. 2

Both engines DCUs were successfully downloaded and the data contained their respective trims and cycles.

PWC Flight Data Review

The flight data recorded during the accident flight was provided by the NTSB to PWC for review. The data from the last flight was plotted with the following engine parameters: Filtered Torque 1 (%), Filtered Torque 2 (%), Ground Speeds (knots), Radio Height (ft), Time and Collective Angle 1 (%).

Flight conditions prevailing at the time of the accident flight were such that the main rotor speed (NR) and power turbine speeds should have been governing at 100% during the entire flight. At 2114:29.5, the No. 1 engine entered manual mode following a collective (CLP) input, and the engine remained in manual mode for the remainder of the flight. The No. 1 engine no longer responded to CLP inputs and appeared to increase in torque while the CLP was being lowered which can be explained by a rotation of the twist grip.

The No. 2 engine was operating in automatic mode up to time 2123:17.1, at which point the torque increased with a steady-state CLP (in automatic mode the torque should remain constant with a constant CLP), and the engine operated in manual mode.

As the torque was increased with the CLP decreasing, the engines' NPT speeds and main rotor speeds increased.

Both engines show a flatline torque in the data. A flatline will occur because both the NPT and Q were picked up from the same probe and as NP increased above its range (127%) two faults were flagged and the Q will no longer be calculated but instead will hold the last good value (LGV), thus flatlining. Once the NPT was back within range, the Q was again calculated and decreased towards 0% within approximately 1 second.

The NPT had a maximum range of 127% and to attain a fault, the true NPT value would have to have exceeded 127%, however, the maximum value attained could not be determined. Data showed the No. 2 engine was above 127% for about 2 seconds before suddenly decreasing, which was consistent with PT blade release or potentially the pilot commanded the engine to 0% torque. Physical evidence was consistent with a blade release due to an overspeed condition. The loss of engine No. 2 torque would reduce the total torque on the main rotor system and reduced the total NR.

The engine No. 1 torque was stable and unchanging (flatlined) about 51% for 23 seconds. As previously explained, this flatline was consistent with the NPT above 127% for about 23 seconds and the peak % could not be determined. As the CLP decreased toward 0% and the fuel flow remained fixed, the No. 1 engine would continue to overspeed. A sudden decrease in torque to 0% was consistent with PT blade release.

Additional Information

Per Federal Regulation 14 *CFR* 135.607, helicopters in air ambulance operations must be equipped with an approved flight data monitoring (FDM) system capable of recording flight performance data. This rule went into effect on April 23, 2018. The rule does not include a requirement that the helicopter air ambulance operators perform periodic reviews of the flight data to ensure the data is valid or use the flight data in any kind of flight operations quality assurance program. Additionally, there is no requirement that the FDM devices be certified to any crashworthiness standard. The Outerlink IRIS FDM installed on the accident helicopter qualified as an approved FDM for the rule.

According to Eurocopter Service Bulletin EC135-67-013 - Rotor Flight Control - Collective Control - Replacement of collective levers and introduction of a weight compensation, dated July 28, 2008, Eurocopter (Airbus) offers collective levers with grips ENG 1/ENG 2 that offer an increased mechanical protection against unintentional adjustment. In addition, the surface structure of the grips ENG 1/ENG 2 differs decisively so that they can be distinguished by tactual sensation.

According to Airbus, as of the end of 2018, the total number of EC135 P1 helicopters in service in the U.S. was 17, and the total number of SB EC135-67-013 kits sold in the U.S. was 2.

An NTSB review of available records found one previous investigation involving similar facts and circumstances. See NTSB accident NYC06MA131.

Administrative Information

Investigator In Charge (IIC):	Sauer, Aaron
Additional Participating Persons:	Eric West; Federal Aviation Administration; Washington , DC Michael Baker; Pentastar Aviation; Pontiac, MI
Original Publish Date:	April 13, 2020
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=97706