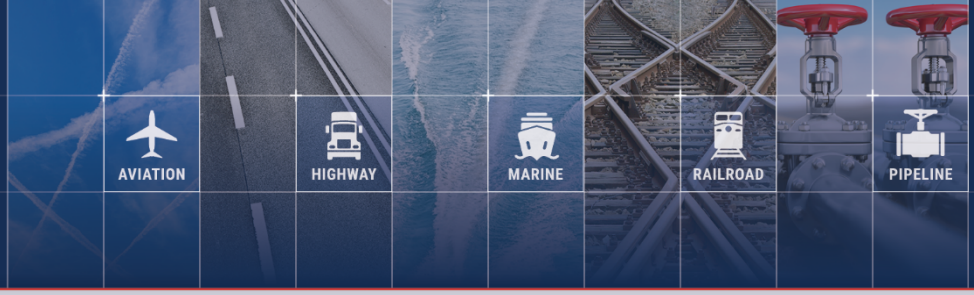

Aviation Investigation Final Report

Location:	Arlington, Indiana	**Accident Number:**	CEN18FA258
Date & Time:	July 6, 2018, 17:20 Local	**Registration:**	N96195
Aircraft:	Bell 47G	**Aircraft Damage:**	Substantial
Defining Event:	Part(s) separation from AC	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 137: Agricultural		

Analysis

The commercial helicopter pilot was conducting aerial applications work on a corn field. The helicopter did not return to the loading platform when expected, and a subsequent search for the helicopter ensued. The wreckage of the helicopter was located near the south edge of a field being sprayed. The upper transmission, mast, and main rotor separated from the helicopter and were located about 75 ft north of the main wreckage. Ground scars, damage to the crop, and damage to the helicopter was consistent with an inflight separation of the upper transmission, mast, and main rotor. A postimpact fire ensued and damaged the cabin and engine of the helicopter.

Postaccident examination of the lower transmission housing found elongation of four of the bolt holes and tearing of two of the bolt holes; two of the bolt holes were unremarkable.

The upper main rotor transmission housing pieces and gears separated from the lower transmission housing due to shear fractures of the threads in six of the eight bolts attaching the housing pieces. The fractures likely occurred due to the fracture of threads on the two bolts that were weakened by thread damage from a prior installation using those bolts as discussed below.

Specifically, these bolts showed damage on intact threads adjacent to the sheared threads. The damage had circumferential markings and a profile matching the nut threads with deformation to the remaining thread, consistent with an over-torque installation of a nut on the bolt. However, because the nuts likely did not back off from their installed position, the thread damage would have occurred during a prior installation. Thus, these two bolts were likely installed on the accident helicopter with damaged threads that were not detected at the time of installation.

Additionally, one of the bolts had thread profile anomalies indicating that the bolt was likely manufactured with an incompletely formed thread. The deviations from the standard thread profile could have contributed to an improper fit with the installed nut and might have contributed to the thread damage on that bolt during a prior installation.

For the other six bolts, the fit between the nut and the bolt might have contributed to threads shearing. The major diameter of threads on one of these six bolts was below minimum specification, which would limit the thread engagement to produce a shear fracture of the thread, and the major diameter of another of these bolts was close to the lower limit. No evidence of prior thread damage was observed on either of these bolts, indicating the failures were likely secondary to the failure of bolts Nos. 2 and 3.

The housing assembly attachments showed evidence of poor maintenance practice. Deviations from the assembly drawing included the use of bolts with an incorrect number of washers and incorrect length. Furthermore, the damage to bolts 2 and 3 from a prior installation was not detected when the bolts were installed on the accident helicopter.

Limited maintenance records were available for the helicopter. According to the available records, the main rotor transmission was replaced in 2009, and the transmission bolts were retorqued in 2014, about 73.6 flight hours before the accident. The investigation was unable to determine if any other maintenance was conducted on the transmission fasteners, when the maintenance was performed that initially damaged the threads of the two of the bolts, or when the damaged bolts were installed on the helicopter.

No other mechanical anomalies were noted that would have precluded normal operation. The inflight separation of the upper transmission was due to the weakened bolt threads as a result of damage during a prior installation which caused the threads on those bolts as well as the threads on other bolts to fracture. However, the prior installation damage could not be associated to any particular maintenance action.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The inflight separation of the upper transmission due to the thread failure of transmission housing attachment bolts, which were installed on the helicopter with thread damage from a prior installation.

Findings

Aircraft	(general) - Incorrect service/maintenance
Aircraft	Fasteners - Incorrect service/maintenance

Factual Information

History of Flight

Maneuvering-low-alt flying	Part(s) separation from AC (Defining event)
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On July 6, 2018, about 1720 eastern daylight time, a Bell 47G-2 helicopter, N96195, was substantially damaged when it impacted a corn field near Arlington, Indiana. A postimpact fire ensued. The commercial pilot was fatally injured. The helicopter was owned and operated by Central Indiana Ag Services, LLC as a Title 14 *Code of Federal Regulations* Part 137 aerial application flight. Visual meteorological conditions prevailed and no Federal Aviation Administration (FAA) flight plan had been filed for the flight. The local flight departed about 1655 from a loading platform at a farm located 1 mile northwest of the accident location.

According to the co-owner of the helicopter, the pilot had been flying since 0945 that morning and had completed between 10 and 15 spray runs. The pilot was applying a fungicide to corn crops and each run was averaging 20 minutes. When the pilot did not return after 30 minutes, they initiated search operations. The wreckage was located later that evening.

Figure 1 shows the flight track for the accident flight based on GPS latitude and longitude data recovered from a Lowrance AIRMAP 2000c device installed on the helicopter. The device contained data from three flight tracks; one of which was the accident flight. The data did not contain altitude or time data, so the time lengths of the track are not known. The last data point of the final flight recorded was consistent with the wreckage location.

There were no witnesses to the accident.

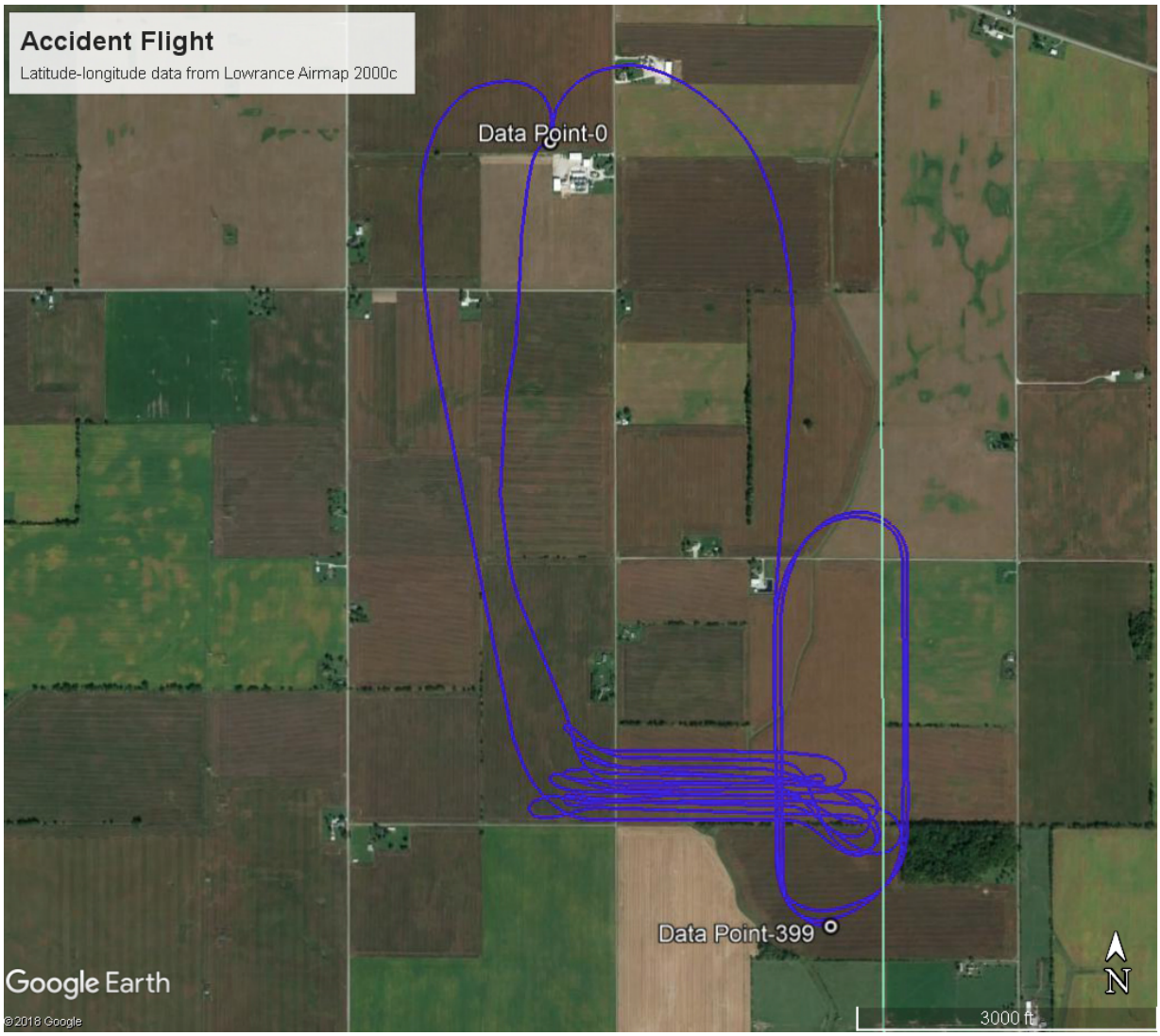

Figure 1. Accident Flight Track from Lowrance Airmap

Pilot Information

Certificate:	Commercial	**Age:**	52,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Single
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	None	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	April 24, 2018
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	February 26, 2018
Flight Time:	1865 hours (Total, all aircraft), 27 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N96195
Model/Series:	47G 2	**Aircraft Category:**	Helicopter
Year of Manufacture:	1953	**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	681
Landing Gear Type:	Skid	**Seats:**	1
Date/Type of Last Inspection:	February 15, 2018 Annual	**Certified Max Gross Wt.:**	
Time Since Last Inspection:	27 Hrs	**Engines:**	1 Reciprocating
Airframe Total Time:	13948.8 Hrs at time of accident	**Engine Manufacturer:**	Lycoming Engines
ELT:		**Engine Model/Series:**	VO-435-A1F
Registered Owner:	Central Indiana AG Services, LLC	**Rated Power:**	250 Horsepower
Operator:	Central Indiana AG Services, LLC	**Operating Certificate(s) Held:**	None

Limited maintenance records were provided to FAA inspectors and subsequently, National Transportation Safety Board (NTSB) investigators. A review of the available maintenance records indicated that an annual inspection had been completed on February 15, 2018, at an airframe total time of 13,922 hours. The Hobbs Meter on scene read 323.8. The helicopter flew approximately 26.8 hours between the last inspection and the accident and had a total airframe time of 13,948.8 hours.

On July 9, 2009, the main rotor transmission was replaced with another transmission. A maintenance release card for the main rotor transmission, dated June 24, 2009, revealed that the fan drive quill and the clutch assembly were repaired with serviceable parts in accordance with Bell 47G-2 maintenance procedures. The transmission was tested and reinstalled "in accordance with the manufacturers publications and FAR part 43." The work orders associated with this replacement confirmed this information.

The maintenance records contained only two entries indicating routine annual/100-hour inspections between July 2009 and January 2014. A maintenance log entry dated November 1, 2014, stated in part "retorqued transmission T adapter plat bolts." This maintenance was performed during a 100-hour inspection at an airframe total time of 13,875.2 hours. The mechanic that performed this work was no longer available to speak to investigators. No other entries in the available maintenance records noted work on the main rotor transmission.

According to the co-owner of the helicopter, on the day before the accident, he and the pilot performed general maintenance on the helicopter. The co-owner's description of the maintenance performed did not include any reference to work on the main rotor transmission.

According to the Illustrated Parts Breakdown (IPB) document for the Bell 47G-2 helicopter as provided

by a representative of Scott's Bell, Inc., the attachment bolts holding pieces of the main rotor transmission housing together consist of 6 AN5-37A bolts, 1 AN5-41A bolt, and 1 AN5-44A bolt. The AN5-41A and AN5-44A bolts are located next to each other. Each of the bolts in the IPB has a NAS679A5 nut. The 6 AN5-37A bolts are each installed with 1 AN960-516 washer under the head and 1 AN960-516L washer under the nut. The AN5-41A and AN5-44A bolts are each installed with 1 AN960-516 washer under the head and another AN960-516 washer under the nut.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KGEZ,802 ft msl	**Distance from Accident Site:**	8 Nautical Miles
Observation Time:	21:53 Local	**Direction from Accident Site:**	250°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots /	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:	40°	**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	30.23 inches Hg	**Temperature/Dew Point:**	28°C / 15°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Arlington, IN	**Type of Flight Plan Filed:**	None
Destination:	Arlington, IN	**Type of Clearance:**	None
Departure Time:	16:55 Local	**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	39.633056,-85.635833

The wreckage was located at the south end of a corn field at an elevation of 850 ft. The initial impact point was characterized by damage to the crop, just north of the edge of the field. The initial damage swath/scar was 20 ft long and 6 ft at its widest point. The helicopter impacted on an approximate bearing of 002° and the wreckage came to rest inverted about 20 ft from the initial impact point.

The main wreckage of the helicopter included the fuselage, landing skids, engine and lower transmission assembly, tail rotor, and tail boom. A postimpact fire damaged the left side of the fuselage and engine.

The upper portion of the helicopter, to include both main rotor blades, the mast, collective and cyclic

controls, swash plate, and upper portion of the transmission were located about 75 ft north of the main wreckage. The components remained together as an assembly.

The lower portion of the transmission assembly remained attached to the engine. The internal gears of the transmission rotated freely when actuated at the engine and the tail rotor spline. A large scar/witness mark was observed on the inside well of the transmission. The mounting holes on the lower housing of the transmission were labeled Nos. 1 through 8 for identification purposes (Figure 2). The Nos. 1 and 7 holes were torn and partially separated. The Nos. 2 and 3 holes were unremarkable. The Nos. 4 and 5 holes were elongated. The Nos. 6 and 8 holes were elongated, and the hole material exhibited tearing on the outer edge. No fasteners remained in any of the holes.

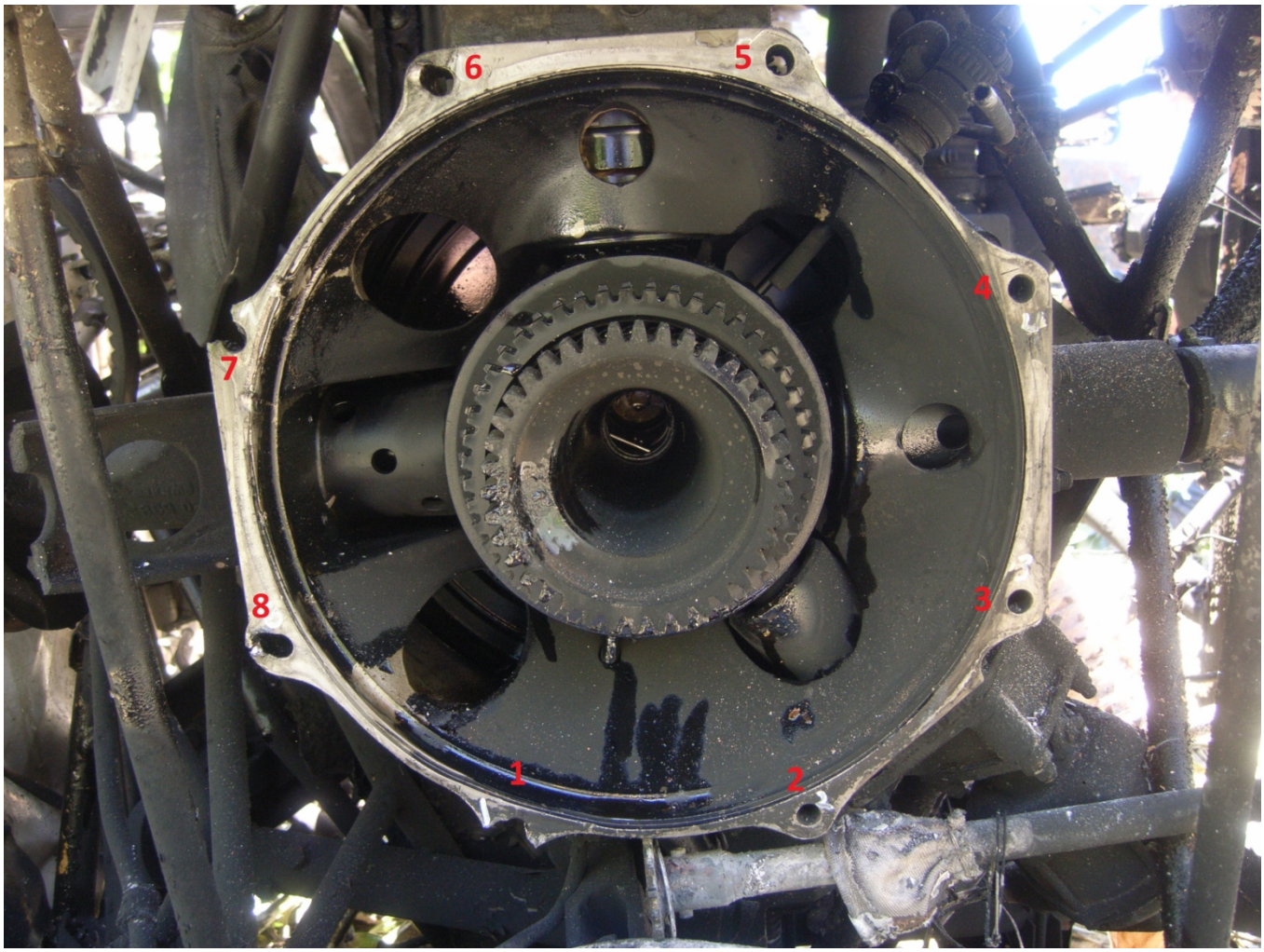

Figure 2. Lower Transmission With Labels 1 through 8

The upper portion of the transmission assembly remained attached to the main rotor assembly. The attachment locations where the upper portion separated from the lower portion were labeled Nos. 1 through 8 for identification purposes and corresponded with the lower portion of the transmission. Bolt

Nos. 1 and 7 remained inserted and both the metal from the adjacent mounting surface and the nut remained attached. Bolts Nos. 2 and 3 remained inserted and neither bolt remained attached to a nut. Bolts Nos. 4, 5, and 6 remained partially inserted and neither bolt remained attached to a nut. Bolt No. 8 remained inserted and was bent at the thread end and no nut was attached.

The upper portion of the main rotor transmission assembly and the eight attachment bolts were sent to the NTSB Materials Laboratory in Washington, DC, for further examination.

A washer was observed under the head of each of the attachment bolts Nos. 1, 2, 7, and 8. A washer was also included with attachment bolt No. 4, but not with bolt Nos. 3 and 5. Bolts Nos. 1 and 7 had nuts remaining in place on the threaded end of the bolt, and 2 washers were observed under the nut on each bolt. The thickness of all remaining washers except for the one under the head of attachment bolt No. 7 was approximately 0.060 inch, consistent with an AN960-516 washer. The washer under the head of attachment bolt No. 7 was about one-half the thickness of the other washers, consistent with an AN960-516L washer.

On the lower surface of the freewheeling gear where it mated to the lower transmission housing, areas of slight fretting damage and material transfer were observed near attachment bolt holes Nos. 3 through 8. The lower edge of attachment bolt hole No. 5 was deformed inward consistent with contact with the attachment bolt grip.

The attachment bolts had varying numbers of intact and sheared threads. On bolts Nos. 1 and 7, all threads were intact. Bolts Nos. 2 through 6 and 8 had between one and five intact threads adjacent to the bolt grip, but the thread peaks were at least partially flattened and smeared, consistent with contact with the corresponding lower housing attachment hole bore. The remainder of the threads in bolts Nos. 2 through 6 and 8 were fractured near the thread roots, and the fracture surfaces were smeared, consistent with shear fracture from contact with the corresponding threads of the nut. Sheared bolt threads remained trapped within the separated nut.

Closer views of the threaded ends of bolts Nos. 2 and 3 illustrated intact but damaged threads between the shank and the completely sheared threads. The pressure flanks of some of the mostly intact threads were deformed and missing with a profile shape corresponding to the nut thread peak profile. Circumferential sliding contact marks were observed in the contact surfaces of the damaged pressure flanks where the deformed and missing bolt thread was observed.

The pressure flanks on several intact threads on bolt No. 5 had circumferential contact marks but appeared without substantial deformation or missing material. The pressure flanks of the intact threads on bolt No. 4 had no circumferential contact marks or circumferential contact damage.

Dimensional measurements on the intact portions of threads for attachment bolts Nos. 2 through 5 found that the major diameters of threads in bolts Nos. 2, 3, and 5 were less than the minimum specified diameter for a new bolt and the major diameter of the threads for bolt No. 4 was close to the lower limit.

Bolts Nos. 3 through 5 had thread profile measurements that were generally comparable to the thread specification. Measured values for bolt No. 2 showed larger deviations from the specified thread profile. The average flank angle for bolt No. 2 was about 11° less than the specified angle of 60° and the average

thread depth for bolt No. 2 was 0.0055 inch less than the specified value of 0.02481 inch. The average width of the thread peaks in bolt No. 2 was about double the maximum thread peak width calculated from the thread form at the minimum major diameter of 0.3053 inch. The thread peaks for bolt No. 2 had a gold hue consistent with the original plating, indicating variations in thread depth and peak width were not due to wear or damage to the thread peak.

Medical and Pathological Information

The Central Indiana Forensic Associates, LLC, performed the autopsy on the pilot on December 12, 2008, as requested by the Shelby County Coroner's Office. The cause of death was "positional asphyxia and left-sided rib fractures" and the manner of death was ruled an accident.

The FAA Forensic Sciences Laboratory, Oklahoma City, Oklahoma, performed toxicological tests on specimens that were collected during the autopsy. Results were negative for all tests conducted.

Tests and Research

A performance study was conducted by the NTSB Office of Research and Engineering using the data recovered from the two onboard recording devices to understand the pilot's flying technique on previous flights. During the five flights, the helicopter stayed between 100 and 150 ft above ground level and the groundspeeds varied between 40 and 60 knots. The calculated load factors for these flights varied from about 1.20 g's to 1.45 g's, which were within the normal flight load factors of between 2 and 2.5 g's for most helicopters.

Administrative Information

Investigator In Charge (IIC):	Rodi, Jennifer
Additional Participating Persons:	David Shaul; Federal Aviation Administration; Indianapolis, IN Leslie Thompson; Federal Aviation Administration; Indianapolis, IN J. Mike Childers; Lycoming Engines; Williamsport, PA
Original Publish Date:	April 20, 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=97704