Aviation Investigation Final Report

Location:	Hanalei, Hawaii	**Accident Number:**	WPR16FA055
Date & Time:	January 17, 2016, 14:32 Local	**Registration:**	N11VQ
Aircraft:	Airbus EC130	**Aircraft Damage:**	Substantial
Defining Event:	Loss of engine power (total)	**Injuries:**	7 Serious
Flight Conducted Under:	Part 135: Air taxi & commuter - Scheduled - Sightseeing		

Analysis

During an air tour flight, the helicopter was about 1/4 mile offshore at 1,450 ft mean sea level (msl) when the pilot heard the low rotor rpm warning horn. He immediately entered an autorotation and turned toward the beach. As he approached the shoreline at 374 ft msl, he made a sharp right turn to avoid large boulders in his intended landing area. The helicopter subsequently landed hard on the beach, bounced, and came to rest.

Examination of the engine revealed that the main fuel injection pipe between the fuel valve assembly and the injection union was cracked and broken at the injection union B-nut connection. Subsequent engine test runs revealed that the starter-generator imparted a vibration into the engine that excited the fuel pipe to vibrate in resonance and ultimately fracture due to reverse bending fatigue at the flared end. The crack or fracture of the fuel pipe allowed pressurized fuel to escape, reducing fuel flow and pressure to the injection manifold below that which was required to sustain combustion, and resulted in the loss of engine power. The vibration imparted into the engine by the starter-generator remained below the global vibration limit for the entire engine, but was sufficient to excite the fuel pipe.

Examination of the starter-generator revealed that the front bearing outer race and support exhibited signatures consistent with fretting and pronounced wear. This observed wear of the front bearing support allowed the armature to oscillate and impart a vibration into the engine frame. Further, the investigation was unable to determine when the vibration began and if the fatigue crack had already started at the time of the last inspection. Without a requirement to look at the front bearing and the shaft play, the operator would have no way to identify the vibration issue.

Onboard video imagery recorded during the accident flight confirmed that the pilot's harness lap belt was positioned properly, low and tight across his hips. Of the six passengers onboard, four passengers' lap belt positioning were visible in recorded cabin imagery, and depicted that the lap belts were not tight across their hips and that the buckle was at or above their waists. Examination of the pilot's seat revealed vertical displacement consistent with a significant amount of vertical energy being absorbed by the seat during the hard landing. Two of the passenger seats displayed some vertical displacement, two displayed minimal vertical displacement, and two seats showed no vertical displacement. The seat displacement was directly related to the amount of vertical energy absorbed by the seat and to the severity of the occupant's injuries. The loose and out-of-position seatbelts most likely allowed the passengers' bodies to shift out of position on the seat before and during the hard landing and did not restrain the occupants in the proper position for the seat to absorb the vertical landing loads for which it was designed.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be:
The fatigue failure of the engine fuel pipe as a result of vibration caused by a worn starter-generator front bearing support, which excited the fuel pipe and caused it to oscillate at a resonant frequency, and a subsequent loss of engine power due to fuel starvation. Contributing to the severity of passenger injuries was the improper positioning of the passengers' seat belts.

Findings

Aircraft	Fuel distribution - Fatigue/wear/corrosion
Aircraft	Starter-generator - Damaged/degraded
Aircraft	Passenger compartment equip - Incorrect use/operation

Factual Information

History of Flight

Enroute-cruise	Loss of engine power (total) (Defining event)
Autorotation	Hard landing

HISTORY OF FLIGHT

On January 17, 2016, about 1432 Hawaii standard time (HST), an Airbus EC130 T2, N11VQ, was substantially damaged when it was involved in an accident near Hanalei, Hawaii. The commercial pilot and six passengers were seriously injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 135 air tour flight.

The pilot reported that, about 25 minutes after departure for the sightseeing flight, the helicopter was about 1/4-mile offshore northwest of the Honopu Sea Arch between 1,300 ft and 1,400 ft mean sea level (msl) when he heard the low rotor rpm aural warning horn. He immediately entered an autorotation, turned toward the beach, and transmitted over the radio that he had an engine failure. As the helicopter approached the shoreline, he made a sharp, low-level right turn to the south to avoid large boulders in his intended landing area and subsequently landed hard on the beach. He applied the rotor brake to slow the rotor and noted that the engine was not running. The passengers began to exit the helicopter and he pulled the engine fuel cutoff.

The first indication of an inflight loss of power was an uncommanded right yaw that occurred at 14:31:31. The first limit indicator (FLI) on the instrument console started to drop rapidly, followed by the GENE (generator) annunciator light illumination. The helicopter entered a 20° right turn toward the coastline. Five seconds later, the ENG P (engine oil pressure) annunciator light illuminated, followed by the FUEL P (fuel pressure) light and the helicopter returned to a nearly-level flight attitude. About 10 seconds later, the helicopter was passing through 600 ft at 85 knots. Rotor rpm had increased to 430. After about 11 seconds, the coastline became discernable and revealed a rocky, unsuitable landing area. The helicopter's altitude was about 350 ft and the rotor speed was 364 rpm. At 14:32:08, the helicopter had entered a 45° right bank, altitude was 275 ft, airspeed was zero, and the helicopter was maneuvering toward a sandy beach area. About 3 seconds later, the LIMIT (servo limit) light illuminated, the helicopter entered a near-level pitch attitude, airspeed was near zero, and rotor speed was around 200 rpm. Initial ground impact was at 14:32:13 and the rotorcraft was at rest at 14:32:15.

AIRCRAFT INFORMATION

The single-engine helicopter was configured for air tours with 6 passenger seats and a single pilot seat, and equipped with a skid mounted emergency flotation system. The pilot occupied the left front seat. Review of maintenance records showed that the helicopter was maintained in accordance with an FAA-approved aircraft inspection program (AAIP) which can differ from the maintenance program recommended by the manufacturer. The Hobbs meter read 692.7 hours immediately after the accident. The helicopter was equipped with an Appareo Vision 1000 flight data recorder and a Datatoys AirKnight HD4s video recorder system that had hard-mounted internal and external cameras for recording the tour for the customer.

The rotorcraft flight manual listed the maximum gross weight of the helicopter as 5,512 lbs. Information provided by the operator indicated that the helicopter departed on the accident flight with a takeoff weight of 5,284 lbs. The helicopter would have consumed about 170 lbs (26 gal) of fuel during the flight.

FLIGHT RECORDERS

The helicopter had two flight recorder systems installed, an Appareo Vision 1000 small self-contained image, audio, and data recorder, and a Datatoys AirKnight HD4s airborne video recorder designed for helicopter tour applications.

Data from both systems was recovered and reviewed by the NTSB Vehicle Recorders Laboratory.

WRECKAGE AND IMPACT INFORMATION

The helicopter landed hard onto Kalalau Beach, along the north shore of Kauai. While on the beach, sea water washed over the landing skids and cabin deck of the helicopter. The operator transported the helicopter from the landing site to their maintenance hangar in Lihue, Kauai. On January 25, 2016, technical representatives from Safran Helicopter Engines (Safran HE) and Airbus Helicopters under the oversight of an FAA inspector examined the helicopter at the hangar. During the examination, the engine's main fuel injection pipe between the fuel valve assembly and the injection union was found cracked and broken at the B-nut connection. A black, oily substance was observed around the interface between the engine magnetic seal and the starter-generator. The airframe sustained structural damage to the tail boom and cockpit floor. The engine, starter-generator, vehicle and engine management display (VEMD), digital engine condrol unit (DECU), and engine data recorder (EDR) were removed for further examination at the manufacturer's facility. The fractured fuel pipe was sent to the NTSB Materials Laboratory.

On May 11, 2016, the NTSB investigator-in-charge (IIC) and technical representatives from Blue Hawaiian Helicopters, Air Methods Corporation (DBA Blue Hawaiian Helicopters), Airbus Helicopter and Zodiac Aerospace, examined the helicopter wreckage at the Lihue hangar. The tail skid was bent up into bottom of the fenestron and the bottom of the fairing displayed a 20-inch crack in the longitudinal direction. The tail boom was symmetrically buckled on the left and right sides at the intermediate structure attach point and had significant buckling at the bottom. The rear fenestron drive shaft support bracket displayed a slight buckle. The engine deck was slightly buckled aft of the rear engine support. Plastic deformation of the engine support in the aft direction was observed. The right transmission bay, transmission support rod, and lower rod end rivets had sheared along the support tube axis. The main gear box (MGB) right support rod was deflected 24 mm at the largest point (mid span). The right cargo bay had no noticeable buckling of the X-wall. The crashworthy fuel tank displayed no deformation or leaking of fuel. The cockpit center console's forward upper mount plate was buckled on the right side. The left MGB support rod rivet heads were sheared. The left cargo bay displayed buckling of the X-wall at the lower aft corner. The left firewall had buckled along the lower edge. There were two areas of slightly buckled skin indentations on the fuselage transition area. The helicopter sat with a 5° list to the right.

The seats were documented and then removed from the helicopter. The seats were manufactured by Zodiac Seats France (ZSFR), part numbers 19820-02-00 (front, referred to as T198) and 28410-0400 (rear, referred to as T284). The helicopter cabin was scanned using a 3D handheld laser, and all the seats were laser scanned. Pitch & roll angles were similar for all the seats. Seat foam and upholstery had manufacturing labels from Aero Comfort Company, the seat labels did not display a technical standard order (TSO) compliance number. No external impacts to any of the seats was observed. All seat equipment was installed correctly, according to Airbus and Zodiac technical representatives.

The following table documents the postaccident configuration of each seat. The stroke is the measured downward displacement of the seat as a result of vertical accelerations, and the fuses are metal links that release once a specified amount vertical force is experienced allowing the seat to stroke downwards (Note: Seat No. 3 is used in some configurations, but was not installed in the accident helicopter).

Seat	**Left Side Stroke**	**Right Side Stroke**	**Left Fuse**	**Right Fuse**	**Forward Deformation**
Pilot	15.3 cm	15.3 cm	Broken	Broken	6.2mm
1	0 cm	0 cm	Broken	Not broken	8.1 mm
2	3.7 cm	3.2 cm	Broken	Broken	2.3 mm
4	3.8 cm	3.7 cm	Broken	Broken	0.5 mm
5	6.5 cm	6.6 cm	Broken	Broken	0.5 mm
6	7.2 cm	6.8 cm	Broken	Broken	1.0 mm
7	0 cm	0 cm	Not broken	Not broken	4.0 mm

Table 1 - Seat displacement measurements.

SURVIVAL FACTORS

Injuries

Six of the seven helicopter occupants were diagnosed on the day of the accident with thoracolumbar compression fractures. The seventh was diagnosed several weeks later. With the exception of the occupant of seat No. 1 (who became paraplegic), the occupants remained neurologically intact. The occupants in seat Nos. 2 and 7 had fractures at multiple vertebral levels. The occupants in seat Nos. 1 and 2 both had sternal fractures.

Helicopter Seat Design

Both T198 and T284 seats consisted of a composite bucket affixed to a structural frame composing both the seat legs and seatback supports. The seatback supports contained energy absorbing features in order to meet the requirements referred to in 14 CFR sections 27.785, 27.561, and 27.562. Corrugated absorption devices and fuses were built into either side of seatback supports (total of two in each seat) to absorb energy in event of high vertical loading. The composite seat bucket was affixed to the seat frame on a set of tracks via two "bucket fixings" and plastic bushings (rollers). When subjected to high vertical loads, these features allowed the bucket to move downwards while the absorption devices deformed (i.e. stretched) and absorbed vertical energy. The undeformed dimension of the absorption devices was 10.7cm. Additionally, the seat foam and upholstery are considered part of the seat design and certification (SFR ETSO C127a).

Zodiac Seats France reported to the BEA (Bureau d'Enquetes et d'Analyses pour la securitie de l'aviation civile) that the two models of seats installed in the helicopter were certified to Europe TSO C127a for dynamic conditions of a 30g downward test with the seat pitched upwards at 60°, and an 18.4g forward dynamic test both using a 170-pound anthropomorphic test device .

Immediately before takeoff, the internal camera video recorded the passengers' seating position and the visible harness buckle location on those individuals. The helicopter seat designated numbers are as follows; the pilot seat in the front left, seat Nos. 1 and 2 were front center and right, respectively; seat Nos. 4, 5, 6, and 7 were the rear seats numbered right to left, sequentially. The pilot's harness lap belt was positioned below his waist and low across his hips. The harness buckle position on the passenger in seat No. 1 was positioned about mid abdomen. The seat No. 2 passenger's harness buckle was in the vicinity of his mid abdomen. The seat No. 4 passenger's left shoulder harness was visible, but all other harness features were obstructed. The seat No. 5 passenger's harness buckle appeared to rest slightly below mid abdomen. View of the seat No. 6 passenger's harness configuration was obstructed. The seat No. 7 passenger's harness buckle was above their mid abdomen.

About 2 minutes before the beginning of the accident sequence, the AirKnight camera showed the passenger cabin view. The seat No. 1 passenger was leaning forward, her right shoulder harness was secured over the right shoulder, her left shoulder harness was not seen over the left shoulder but moved in concert with the right shoulder harness at the Y strap. The shoulder harness was moving consistent with the passenger's body movement, which was slightly leaned forward. The pilot's shoulder harness was in place. The pilot's left hand was forward and resting on an undetermined cockpit object. The seat

No. 2 passenger was seated normally and wearing their shoulder harness. The seat No. 4 passenger was seen with the left shoulder harness clearly visible; their right shoulder harness was obstructed. The seat No. 5 passenger was seated normally and seen wearing both shoulder harnesses. The seat No. 6 passenger was taking a photograph at head level and had his body oriented to the right in the helicopter. The view of his harness position was obstructed. The seat No. 7 passenger was seated normally and was looking out the left side of the helicopter; both shoulder harnesses were visible.

Immediately prior to initial ground impact, passenger 1 had moved her left hand off her left knee and neither of her hands were visible in the field of view. Her feet appeared to be flat against the rotorcraft's floor. The other passengers were not in the field of view of the camera, and therefore their body positions were not documented.

Hard Landing Impact Analysis

Airbus Helicopters used GPS, helicopter flight data recorded by the on-board Vision 1000 Flight Data Monitoring hardware, post-accident helicopter structural measurements, on-scene photos, and landing terrain plasticity (sand) to estimate landing attitude and impact forces experienced by the helicopter during the accident. The on-site documentation and the flight data were consistent in showing that the helicopter experienced two landing events, an initial landing followed by a bounce and a second landing. Data showed that immediately before ground impact the helicopter was in a 10° right bank, 3.6° nose up, forward velocity was 13.2 m/s and vertical velocity was 12.2 m/s. A Mecano simulation was created modeling these conditions. The results of the simulation estimated that the initial landing impact was 24g in the vertical axis, 9g in the horizontal axis, and 4g in the lateral axis. The second landing forces were estimated as 19g vertically, 7g horizontally, and 1 g laterally. Based on the low level of rotational acceleration of the center of gravity, all occupants experienced about the same level of impact forces.

Harness / Seat Belt Positioning on Occupant

Section 4.3 of the EC 130 B4 Flight Manual is the Start Up Checklist. Under the subtitle 4.3.1 Engine Prestart Check is:

"- Seats and control pedals…………..ADJUSTED"

"- Seat belts ……………………………FASTENED"

There is no information in the flight manual describing the proper use or positioning of the seat belt on occupants.

Blue Hawaiian Helicopters provided a 6-minute instructional and safety video for the passengers to watch before flight . The seat belt instruction portion of the video simply states to pull the waist straps until snug and showed a passenger with the buckle positioned over her navel. The operator had an employee escort the passengers to the helicopter. They then would assist the passengers in entering the helicopter and fastening the four-point harness.

FAA Medical Facts for Pilots, publication AM-400-90/2, Seat Belts and Shoulder Harnesses (2004), states:

"The restraint should be adjusted as tightly as your comfort will permit to minimize potential injuries. The safety belt should be placed low on your hipbones so that belt loads will be taken by the strong skeleton of your body. If the safety belt is improperly positioned on your abdomen, it can cause internal injuries." "...When it is tight about your hips, the safety belt should be positioned so that it makes about 55 degrees with the center of the airplane. This allows it to resist the upward pull of the shoulder belts, reducing the risk of internal injury."

TESTS & RESEARCH

Blue Hawaiian Fleet Survey of Fuel Pipe

The Air Methods Director of Engineering and Reliability issued a Fleet Campaign Directive, Inspection of fuel pipe B-nut checking for torques and leakage. Air Methods Corporation owns and operates Blue Hawaiian Helicopters. The survey of the Blue Hawaiian fleet of EC-130 helicopters did not identify any loose fuel pipe B-nuts or leakage of the fuel pipe.

Engine Exams and Tests

On February 4, 2016, the NTSB IIC with technical representatives from the FAA, Safran Helicopter Engines, Airbus Helicopters, and party representative from Blue Hawaiian Helicopters examined the engine and associated components at the Safran Helicopter Engines facility in Grand Prairie, Texas. The engine was visually examined. No external damage was noted. The compressor and turbine turned freely by hand. Compressed air was passed through the engine to clear out any debris. A borescope examination of the compressor, combustion section and the high-pressure turbine, revealed no anomalies. The broken fuel pipe had been removed during the initial on-scene examination. A replacement fuel pipe was installed on the engine. The starter-generator was removed and a black oil/grease substance was observed on the starter-generator engine side mounting flange and on the forward face of the starter-generator. A sample of the oil/grease substance was taken for further examination. The starter-generator (Thales SN: 5493) was visually examined. The rotor's splined shaft rotated freely by hand and 1-mm of lateral movement was observed when a lateral force was applied by hand to the shaft. Maintenance records showed that the starter-generator was inspected on January 6, 2016, at an engine total time of 627.2 hours, in conjunction with a 150 hour and 600 hour inspection. The brush length was measured in the yellow range, and the unit was placed back into service.

The engine was equipped with a standard 6mm fuel injection pipe (PN: 0292737310, diameter 6 mm). Safran had also a larger 10mm fuel pipe (PN: 0292730350, diameter 10 mm) that was authorized for installation on the engine. Both fuel pipes were tested on the accident engine.

The engine was placed on a test stand and equipped with MicroVib accelerometers on the starter-generator and the fuel pipe injection union mount B-nut. Three engine test runs were performed to measure engine vibrations using an exemplar starter-generator and the accident starter-generator in combination with both a standard fuel pipe and the alternative larger diameter fuel pipe. Table 2 shows the results of the test runs.

Test No.	Starter-Gen	Fuel pipe (diameter)	Starter-Gen Peak Freq (cpm)& Vel (ips) at flight idle	Fuel Pipe peak freq (cpm) & Vel (ips) at flight idle
1	Exemplar	Standard (6 mm)	9,063 / 0.126	9,091 / 0.173
2	Accident	Standard (6 mm)	7,472 / 2.92	7,500 / 1.25
3	Accident	Large Dia (10 mm)	7,579 / 3.41	7,583 / 1.355

Table 2 – Vibration results of engine test runs, cpm=cycles per minute, ips=inches per second (velocity)

The engine tests revealed that the accident starter-generator imparted a vibration into the engine that excited both models of fuel pipes; however, the global vibration experienced by the engine and measured by the engine test stand remained below the criteria for unacceptable gas generator or power turbine unbalance.

Engine Tests at Marignane & Bordes, France

Further testing of the accident starter-generator was performed during ground runs on a EC130T2 helicopter at Airbus Helicopters, Marignane, France, and on an Arriel 2D engine placed on a test bench at Safran Helicopter Engines at Bordes, France. Representatives from the BEA attended the tests for the accident starter-generator and exemplar Arriel 2D along with the technical advisers from Airbus Helicopters, Safran Helicopter Engines and Thales. During those tests, the starter-generator was fitted with 3 axis-accelerometers and the fuel pipe was fitted with strain gauges. Vibration and stress recordings were made while the engine performed several running cycles on the ground (due to the installed measurement equipment, no flight tests were performed). During these ground tests, recordings were made with exemplar starter-generators and, for the tests in Bordes, recordings were also made with three test bench shuttle starter-generators of slightly different design (amendments G and H) which exhibited various levels of radial play on the input shaft.

When operating with the accident starter-generator, the tests showed the presence of an abnormal nonsynchronous vibration that was not visible with the exemplar starter-generators. The abnormal non-synchronous vibration exhibited erratic fluctuations and jumps (between runs and occasionally within some of the runs) between 110 Hz and 190 Hz (equivalent to 6,600 cpm to 11,400 cpm); appeared neither linked to the gas generator rotational speed nor to the electrical collection and was not a direct consequence of usual mass unbalance or misalignment; and came close at times to the 1st mode resonance frequency of the fuel pipes (about 130Hz for the standard pipe and about 175Hz for the larger diameter pipe which can vary slightly due to manufacturing and material tolerances and internal fuel flow during operation).

Despite the tests' limitations (no test flights and no test of the broken fuel pipe), the erratic abnormal non-synchronous vibration came close but did not exactly match the resonance frequency of the standard pipe. Nevertheless, during the Bordes tests, recordings with the accident starter-generator showed a maximum stress level on the standard diameter pipe at 128 Hz (7,680 cpm) that reached 87% of the maximum acceptable limit. Regarding the larger diameter pipe, the maximum stress level was obtained at 175 Hz (10,500 cpm) and reached 31% of the maximum acceptable limit with the accident starter-generator, and 132% of the maximum acceptable limit on a starter-generator of an amendment H design.

Engine Disassembly Examination

The NTSB IIC and technical representatives from Safran HE and Airbus Helicopters, and a party representative from Air Methods Corporation, convened at the Safran facility in Grand Prairie, Texas, to disassemble and examine the engine. No anomalies were identified during the visual examination of the engine equipment.

Fuel Pipe Fracture Examination

The fuel pipe fracture was examined by the NTSB Materials Laboratory. The tube was fractured at the flared end. A close view of the fracture surface on the tube portion revealed fractographic ratchet marks and crack arrest marks consistent with reverse bending fatigue fracture initiation at two diametrically opposite positions on the outside surface of the tube. There was no evidence of static loading due to installation of the pipe on the engine.

Safran HE, with the oversight of the BEA, performed a dimensional check of the accident fuel pipe. The pipe was installed on the control jig that was used to dimensionally check newly-manufactured fuel pipes. The fuel pipe was found to fit and remain in contact with the jig blocks except at the fractured end, where a 2-mm gap was observed. The maximum allowable gap for a newly-manufactured pipe is 1-mm. This measurement was performed after the end portion of the pipe was cut to allow for the deep examination of the fracture surfaces. Moreover, on-site photos taken on the wreckage showed that the pipe was still aligned with the union's port when the B-nut was removed. Safran engineers concluded that the dimensional checks of the pipe showed that its diameter and thickness were within specification; the flared end's radius was slightly above tolerance while remaining smaller than the contact surface with the sleeve; and no other significant discrepancies were noted. Safran engineers also created a finite element model of the pipe and determined that the crack initiation locations matched the maximum stress areas on the pipes's first vibration mode.

Safran HE provided fuel pipe reliablity information stating that the type of fuel pipe installed on this engine had been installed on 4,500 Arriel 2 engines and had accumulated 14.2 million flight hours. No instances of a similar type of failure had been documented for the entire history of this fuel pipe design.

Starter-Generator Examination

The BEA provided oversight for the examination of the accident starter-generator at the Thales (original equipment manufacturer) manufacturing plant in Meru, France. A visual examination of the starter-generator revealed play between the armature shaft and the flange. The brush wear was measured using a brush gauge; all the brushes were worn to the beginning of the yellow area. The starter-generator was placed on a test bench and fitted with accelerometers to measure vibration. Tests were performed at 8,000 rpm and 12,000 rpm, each with 0A load and 50A load. Peak vibration levels were identified at the 8,000-rpm speed, no load, with a vibration of 130 Hz and 88.01 m/s^2, and at 12,000 rpm, 50A load, vibration at 134 Hz and 112.17 m/s^2 acceleration. Additionally, lower vibrations were identified at the 2nd and 3rd harmonic frequencies. Displacement of the armature shaft laterally to the centerline was measured twice, revealing 0.98 mm and 0.81 mm displacement values. The front bearing of the starter-generator was found coated with a black oil/grease-like substance. The front bearing outer race exhibited signatures consistent with fretting. Measurement of the front bearing support revealed wear, with a difference between 0.650 and 0.680 mm from measured diameter to nominal diameter.

Thales provided service reliability information of similar starter-generators. Between January 1, 2010 and June 30, 2015, Thales received 881 starter-generators, 624 for scheduled repair, and 257 for unscheduled repair (all amendment variants). Thales focused on 2016-2017 time period for starter-generator removals of three operators: Blue Hawaiian Helicopters, Air Methods Corporation, and US Coast Guard. The total number of starter-generators for this grouping that Thales repaired was 111: 98 pre-amendment J, and 13 amendment J variants. Thales found drive flange out-of-tolerance conditions for 23 pre-amendment J, and 7 amendment J variants.

Thales reported to the BEA on February 23, 2017, that as of January 2016, a quality check of the front bearing diameter had been conducted for all starter-generator assemblies being produced. This check was not in place before January 2016.

Starter-Generator Magnetic Seal Examination

Safran HE, under the supervision of the BEA, examined the accident starter-generator magnetic seal, the interface between the starter-generator and the engine, which, had been found coated with a black oil-like substance. BEA analysis of the black-oil deposit identified the substance as a mixture of engine oil (O-156) and Loctite 8012 (lubricating moly paste for the bearing assembly). The magnetic seal graphite support ring was found in satisfactory condition, the friction ring was found properly installed, and the O-rings were in good condition. No discrepancies were identified that explained the magnetic seal leak, however, the magnetic seal had been subjected to abnormally high vibrations originating from the starter-generator during operation.

Starter-Generator Maintenance

The Airbus Helicopters maintenance manual for the EC130 T2 specifies the required inspections and maintenance for the installed starter-generator. For starter-generators with part numbers 524-030 and 524-031 periodic inspections were required at 600 and 1,200 flight hour intervals. The 600-hour inspection involved examination of the starter's general condition, electrical connections, and measuring brush wear in accordance with AMM 24-31-00 and CMM 80.19.02. The 1,200-hour inspection specified replacement of the brushes if the brushes are measured in the yellow range using the measuring tool. If any of the brushes were measured in the red range then the starter-generator was to be repaired. The operator's maintenance program did not require starter-generator brush replacement when brushes were in the yellow ranger, however, the operator monitored and measured brush wear much more frequently than what the manufacturer recommended.

Blue Hawaiian Helicopters maintains their EC-130's utilizing a FAA approved aircraft inspection program (AAIP). Specified under the Blue Hawaiian Helicopters AAIP the starter-generator was inspected every 150 flight hours. The starter-generator is removed from the engine and checked for its general condition, terminal lug covers, and security clamp. The brushes are inspected and measured in accordance with CMM 80.19.02. If brush length is in the red (higher wear than in the yellow range), when utilizing the measuring tool, the starter is to be replaced. Additionally, the electrical power system is inspected during the AAIP 600-hour inspection. The 600-hour inspection did not involve removal of the starter-generator or measurement of the brushes. However, normally the 600-hour inspection coincides with a 150-hour inspection.

The Safran Helicopter Engines maintenance manual for the Arriel 2D specifies to visually examine the engine and the engine floor for leakage every 15 flight hours or every 7 days (whichever comes first). The accident helicopter performed 15 flight hours in 2.5 days before the accident and no leaks were reported. In particular, no leaks were reported at the engine / starter-generator clamp interface which is not designed to be liquid-tight.

Blue Hawaiian Fleet Wide Survey of Starter-Generator Maintenance

The Blue Hawaiian Helicopters director of maintenance collected maintenance records for the 6 months preceding the accident that involved starter-generator (PN: 524-031 amendment J) replacement. Blue Hawaiian Helicopters and other Air Methods operations that flew EC-130T2 helicopters had removed 25 starter-generators for routine maintenance, three of which were identified as having lateral play of the splined armature shaft. As specific measurement of the play was not required before the accident, the extent of the reported play could not be determined.

ADDITIONAL INFORMATION

Airbus Information Notice and Service Bulletins

Airbus issued an Information Notice on April 13, 2017, reminding operators to inspect starter-generators for oil seepage, to remove the starter-generator when inspecting the brushes, and to examine for anomalies such as radial play of the drive shaft.

Airbus Helicopters issued 3 service bulletins on March 12, 2018, for the AS350, AS550, and EC130 model helicopters (SB N° AS350-24.00.32, SB N° AS550-24.00.11, SBN° EC130-24.00.08). The service bulletin directs the inspection of the starter-generator (PN: 524-030 & 524-031) before either 450 flight hours of the starter-generator or within 150 hours if the starter-generator had more than 300 total flight hours. The inspection involves measurement of armature radial play, and for an oil leak on the mechanical interface of the starter-generator and the engine and requests a return of information of the observation.

The results of the information gathered from these inspections regarding the concerned fleet resulted in the issuing of new service bulletins on December 24, 2018, (SB N° AS350- 05.00.95, SB N° AS550-05.00.71 and SB N° EC130-05-30) requesting a 300 hours periodic inspection of the starter-generator. These service bulletins have latterly been cancelled as this inspection is now incorporated in the Airbus Helicopters maintenance program.

Airbus Helicopters issued a Safety Information Notice in December 2019, reminding the operators of the correct use of seats and restraint systems to minimize the risk of injury.

Pilot Information

Certificate:	Commercial	**Age:**	56,Male
Airplane Rating(s):	None	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	November 30, 2015
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	November 13, 2015
Flight Time:	4550 hours (Total, all aircraft), 2500 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Airbus	**Registration:**	N11VQ
Model/Series:	EC130 T2	**Aircraft Category:**	Helicopter
Year of Manufacture:	2015	**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	8070
Landing Gear Type:	Skid	**Seats:**	7
Date/Type of Last Inspection:	January 6, 2016 AAIP	**Certified Max Gross Wt.:**	5512 lbs
Time Since Last Inspection:	66 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	692.7 Hrs at time of accident	**Engine Manufacturer:**	Safran Helicopter Engines
ELT:	C126 installed, activated	**Engine Model/Series:**	Arriel 2D
Registered Owner:	Nevada Helicopter Leasing LLC	**Rated Power:**	952 Horsepower
Operator:	Blue Hawaiian	**Operating Certificate(s) Held:**	On-demand air taxi (135), Commercial air tour (136)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	PHLI,152 ft msl	**Distance from Accident Site:**	24 Nautical Miles
Observation Time:	14:53 Local	**Direction from Accident Site:**	304°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	3 knots /	**Turbulence Type Forecast/Actual:**	/ None
Wind Direction:	330°	**Turbulence Severity Forecast/Actual:**	/ N/A
Altimeter Setting:	30.02 inches Hg	**Temperature/Dew Point:**	22°C / 17°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Lihue, HI (PHLI)	**Type of Flight Plan Filed:**	Company VFR
Destination:	Lihue, HI (PHLI)	**Type of Clearance:**	VFR
Departure Time:	14:00 Local	**Type of Airspace:**	Class G

Airport Information

Airport:	Lihue PHLI	**Runway Surface Type:**	
Airport Elevation:	153 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	Forced landing

Wreckage and Impact Information

Crew Injuries:	1 Serious	**Aircraft Damage:**	Substantial
Passenger Injuries:	6 Serious	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	7 Serious	**Latitude, Longitude:**	22.173055,-159.65805

Administrative Information

Investigator In Charge (IIC):	McKenny, Van
Additional Participating Persons:	Seth Buttner; Airbus Helicopters; Grand Prairie, TX Bryan Larimore; Safran Helicopter Engines; Gran Prairie, TX Eric Lincoln; Blue Hawaiian Helicopters; Kahului, HI Don Lambert; Air Methods; West Mifflin, PA Troy Atkinson; Blue Hawaiian Helicopter; Kahului, HI Scott Tyrrell; FAA; Fort Worth, TX Benoit Thubert; Thales; Toulouse Jeremy Castellani; Zodiac Aerospace; Issoudun
Original Publish Date:	August 25, 2020
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=92585