August 14, 2024 Aviation Investigation Report AIR-24-04

Collision with Powerlines and Terrain during Forced Landing MARPAT Aviation Bell Helicopter UH-1B, N98F

Amherstdale, West Virginia
June 22, 2022

Abstract: This report discusses the June 22, 2022, accident that occurred during an event at which attendees could pay to fly or ride in a former military turbine-powered UH-1B helicopter. About 15 minutes after the flight departed, the pilot attempted a forced landing, but the helicopter impacted two powerlines and a rock face about 3.5 nautical miles east of the airport. The helicopter came to rest partially inverted on its right side on an asphalt road, and a postcrash fire ensued. Postaccident examination of the helicopter engine found static damage in the compressor section; rotational damage in the gas-producer turbine; and additional damage to the exhaust diffuser, rear bearing cover, No. 2 bearing, and two power turbine blades. Safety issues discussed in this report include the Federal Aviation Administration's (FAA) inspection requirements for the UH-1B and other former military turbine-powered aircraft, the operator's maintenance of the accident helicopter, the operator's management of the helicopter's experimental airworthiness certificate, and the FAA's oversight of the certificate. As a result of this investigation, the National Transportation Safety Board issues six new safety recommendations to the FAA and reiterates one recommendation to the FAA.

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Acronyms and Abbreviations

AC	advisory circular
ADS-B	automatic dependent surveillance-broadcast
ATSB	Australian Transport Safety Board
CFR	*Code of Federal Regulations*
FAA	Federal Aviation Administration
FSDO	flight standards district office
LHFE	living history flight experience
NTSB	National Transportation Safety Board
PMI	principal maintenance inspector
TM	technical manual
6L4	Logan County Airport, Logan, West Virginia

Executive Summary

What Happened

This accident occurred during a flight offered as part of an annual event at Logan County Airport, Logan, West Virginia, that showcased a former military UH-1B helicopter. A volunteer pilot for the event (the pilot-in-command) was in the left front seat, a passenger was in the right front seat, and four other passengers were seated in the cabin. The right front-seat passenger made a required $250 donation to fly the helicopter for 30 minutes, and the other four passengers each made a smaller donation to ride in the helicopter. About 15 minutes after the flight departed, the helicopter impacted two powerlines and a rock face located about 3.5 nautical miles east of the airport during an attempted forced landing. The helicopter came to rest partially inverted on its right side on an asphalt road, and a postcrash fire ensued. The six helicopter occupants were fatally injured, and the helicopter was destroyed.

Postaccident examination of the engine found static damage in the compressor section; rotational damage in the gas-producer turbine; and other damage to the exhaust diffuser, rear bearing cover, the No. 2 bearing, and two power turbine blades. Postaccident examination of the helicopter's main rotor blades found no evidence indicating a powered impact; thus, a partial or total loss of engine power occurred before impact.

What We Found

The National Transportation Safety Board found that, at the time of the accident, the helicopter was being operated under a special airworthiness certificate in the experimental exhibition category. The certificate, which was dated December 2014, was issued by the Federal Aviation Administration's (FAA) Charleston, West Virginia, Flight Standards District Office (FSDO). The FSDO also issued operating limitations as part of the special airworthiness certificate. These operating limitations included specific inspection standards for the helicopter.

In August 2010, the FAA issued Order 8130.2, titled "Airworthiness Certification of Aircraft and Related Products," to establish policies and procedures for issuing airworthiness certificates for aircraft. In December 2011, the FAA issued a Memorandum of Deviation to Order 8130.2G, which revised the operating limitations for experimental airworthiness certificates that were issued for the purpose of exhibition. The Memorandum of Deviation allowed former military turbine-powered rotorcraft with an experimental exhibition certificate, including the accident helicopter, to be inspected under the provisions of Appendix D to Title 14 *Code of Federal Regulations* Part 43.

We found that the inspection standards in Part 43 Appendix D did not have sufficient scope and depth for inspecting former military turbine-powered rotorcraft because the standards comprised generic inspection criteria for aircraft systems and components undergoing annual and 100-hour inspections. We also found that the damage to the engine exhaust diffuser (cracking) and the rear bearing cover (outer flange separation) were significant long-term engine issues that could have been detected if the operator, MARPAT Aviation, had used more detailed inspection criteria and more frequent inspection intervals than those in Part 43 Appendix D. (The operator followed more stringent inspection requirements when the helicopter was operated under a restricted-category certificate; those requirements, which were derived from the helicopter's type certificate, were last in effect in 2014.)

Further, we found that an operating limitation to the helicopter's experimental airworthiness certificate required the owner/operator to submit annual program letters that included "a list of events at which the aircraft will be exhibited." The FAA used these program letters to plan its surveillance of experimental aircraft. However, the FAA did not have a program letter or other correspondence from MARPAT Aviation indicating that the helicopter would be flown at the June 2022 annual event. As a result, the Charleston FSDO was unaware that MARPAT Aviation was operating the accident helicopter at that event.

The Charleston FSDO was also unaware of the helicopter flights at the June 2022 annual event because the FSDO had not performed surveillance of the operator (separate from its Part 145 repair station certificate) before the accident. FAA Order 8900.1, Flight Standards Information Management System, did not include a requirement for inspectors to perform routine surveillance of operators with experimental exhibition airworthiness certificates.

In addition, we found that MARPAT Aviation advertised the opportunity to fly the accident helicopter for a required "donation" or ride in the helicopter for a "small donation." However, the operator did not hold a living history flight experience exemption for the helicopter, which would have allowed the helicopter to be operated for compensation.

The National Transportation Safety Board determined that the probable cause of this accident was the operator's failure to adequately inspect the former military turbine-powered helicopter, which allowed an engine issue to progress and result in a loss of engine power and a subsequent loss of control after the helicopter struck powerlines during a forced landing. Also causal to the accident were the following:

- the FAA's inadequate inspection and maintenance standards for former military turbine-powered aircraft operating with an experimental exhibition airworthiness certificate;

- the operator's use of those standards instead of more rigorous standards, which were readily available to the operator and previously used to inspect and maintain the helicopter; and
- the FAA's inadequate oversight of the operator, which did not detect the inherent risk associated with the operation.

What We Recommended

As a result of this investigation, we made six new recommendations to the FAA. We recommended that the FAA review all experimental exhibition airworthiness certificates issued to former military turbine-powered rotorcraft and ensure that their operating limitations meet the standards of the latest iteration of FAA Order 8130.2, which contain more stringent inspection standards than those in the Memorandum of Deviation. We also recommended that the FAA establish periodic reviews for experimental exhibition airworthiness certificates to ensure that those aircraft are being inspected and maintained according to the standards in the latest iteration of FAA Order 8130.2.

We recommended that the FAA require operators of aircraft equipped with the accident engine model to perform recurrent inspections of the rear bearing cover and the exhaust diffuser inner cone and inner struts with the exhaust diffuser cover removed.

We also recommended that the FAA remind operators of experimental exhibition aircraft about the requirement to submit program letters that list all events at which the aircraft will be exhibited. We further recommended that the FAA develop a method for ensuring that operators of experimental exhibition aircraft meet their annual obligation to submit program letters. In addition, we recommended that the FAA revise Order 8900.1 to include inspector guidance requiring routine surveillance of operators of aircraft with experimental exhibition airworthiness certificates.

We also reiterated Safety Recommendation A-21-9 to the FAA to develop national safety standards for Part 91 revenue passenger carrying operations, which include requirements for initial and recurrent training and maintenance and management policies and procedures.

1. Factual Information

1.1 History of Flight

On June 22, 2022, about 1645 eastern daylight time, a Bell Helicopter UH-1B helicopter, N98F, was destroyed when it was involved in an accident in Amherstdale, West Virginia. About 15 minutes after the flight departed, the helicopter impacted two powerlines and a rock face during a forced landing, and a postcrash fire ensued. The pilot and five passengers were fatally injured. The helicopter was operated by MARPAT Aviation under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 91.[1]

The flight was associated with the "7th Annual Huey Reunion" event at which the operator offered attendees the opportunity to either fly the former military helicopter with a "safety pilot" (who was the pilot-in-command) in the left front seat for a required "donation" ($250) or ride in the helicopter for a "small donation."[2] The accident flight was the last planned flight of the day on the second day of the 6-day event, which was held at Logan County Airport (6L4), Logan, West Virginia.[3]

According to witnesses, about 0800 on the day of the accident, the helicopter underwent a preflight inspection conducted by volunteer pilots and the MARPAT Aviation mechanic. The engine was started for the first flight of the day and ran continuously throughout the day.

For the accident flight, the pilot-in-command (the safety pilot) was in the left front seat of the helicopter, consistent with the operator's procedures. One of the passengers was in the right front seat, and the other four passengers were seated in

[1] Visit ntsb.gov to find additional information in the public docket for this NTSB accident investigation (case number ERA22FA279). Use the CAROL Query to search safety recommendations and investigations.

[2] UH-1-series helicopters (including the UH-1B) are referred to as "Huey" helicopters. See section 1.6.1 for information from the operator's website regarding the 2022 reunion event and the safety pilot's responsibilities.

[3] The helicopter made multiple flights on the day of the accident. These flights were not logged. The scheduling manager for the Huey reunion event stated that the helicopter flights operated daily during the reunion from 0800 to 1700.

the cabin.[4] The accident flight departed about 1630. No flight plan was required or filed for the local flight.[5]

About 15 minutes after departure, the helicopter impacted powerlines and a rock face located about 3.5 nautical miles east of the airport and came to rest partially inverted on its right side on an asphalt road. A postcrash fire ensued. The National Transportation Safety Board (NTSB) did not identify any witnesses who saw or heard the accident flight's final moments.

1.2 Personnel Information

1.2.1 Pilot-in-Command

The pilot-in-command, age 53, held a private pilot certificate with ratings for airplane single-engine land, rotorcraft helicopter, and rotorcraft gyroplane. He also held a second-class medical certificate that was issued on June 14, 2021, with the limitation that the pilot must have glasses available for near vision. The pilot's logbook indicated that he had a total of 493 hours of flight experience, including 21 hours in the UH-1B helicopter and 12.0, 6.5, and 3.4 hours in the 12 months, 90 days, and 30 days, respectively, before the accident. According to the pilot's stepson (who was a flight instructor), the pilot did not log all his flight time in his logbook, so a "big chunk of time" was not reflected in the logbook. The accident pilot's Federal Aviation Administration (FAA) medical application form, dated June 13, 2021, listed a total of 1,400 hours of flight experience, 20 hours of which were accumulated during the previous 6 months. A review of FAA records found no reports of previous accidents or incidents involving the accident pilot.

The pilot had volunteered for the Huey reunion event for 4 years, and the pilot's logbook showed that he flew the accident helicopter during the reunion events from 2020 to 2022. According to the MARPAT Aviation owner, the pilot did not have any UH-1B flight time before he began operating the accident helicopter. The pilot's

[4] The passenger in the right front seat, age 69, held a commercial pilot certificate, dated February 15, 1995, with ratings for rotorcraft helicopter and instrument helicopter. This passenger's last Federal Aviation Administration medical certification was a second-class medical certificate dated April 1996. (Certification information for the pilot-in-command appears in section 1.2.)

[5] The helicopter was not equipped, and was not required to be equipped, with a cockpit voice recorder or a flight data recorder. The helicopter was capable of transmitting automatic dependent surveillance-broadcast (ADS-B) data through power that the position lights provided. The position lights were not on during the accident flight, so no data were transmitted. According to the MARPAT Aviation owner, pilots did not routinely turn on the rear position lights when operating the helicopter in daylight. Title 14 *CFR* 91.225(f) requires each person operating an aircraft equipped with ADS–B to "operate this equipment in the transmit mode at all times." The investigation did not determine if the operator was aware of this regulation.

logbook showed that he flew the accident helicopter for 8.0 hours in June 2020, 10.8 hours in June 2021, and 2.3 hours in June 2022 (not including the accident flight). A volunteer pilot flew with the accident pilot before the 2022 reunion event; the volunteer pilot reported that the accident pilot conducted approaches, pedal turns, and hovers so that he could "get to know the aircraft again." The volunteer pilot also reported that the accident pilot did not practice any emergency procedures (including the transfer of helicopter control from a passenger to the pilot-in-command during an emergency) or autorotations.[6]

1.2.2 MARPAT Aviation Mechanic

The MARPAT Aviation mechanic, age 47, was an airframe and powerplant mechanic for MARPAT Aviation's Part 145 repair station. He had been continuously employed by MARPAT Aviation since 2009 except for a few months during 2016 when he worked for a helicopter operator in Myrtle Beach, South Carolina.

1.3 Aircraft Information

The accident helicopter (see figure 1) was manufactured for the US military by Bell Helicopter in 1962. According to MARPAT Aviation, the helicopter was flown in Vietnam from 1962 to 1971 and was subsequently sold to a civilian entity. The helicopter had a two-bladed main rotor system that provided lift and thrust and a two-bladed tail rotor system that provided lateral thrust for directional control. The helicopter was also equipped with a skid-type landing gear. The registered owner of the helicopter (since November 2003) was a friend of the owner of MARPAT Aviation; the helicopter owner was not affiliated with the operator.

[6] The volunteer pilot was not a flight instructor. The volunteer pilot stated that the "chief pilot" might have practiced autorotations with the accident pilot. The "chief pilot," also referred to as the "senior pilot," was an honorary title for another volunteer pilot; he was not the chief pilot for MARPAT Aviation. During a postaccident interview, the senior volunteer pilot stated that he did not fly with the accident pilot before the 2022 reunion event began.

Figure 1. Accident helicopter **(**Source: **The Logan Banner).**

The helicopter was powered by an Ozark Aeroworks T53-L-11D turboshaft engine that was installed on the helicopter in December 1999.[7] The T53-L-11D turboshaft engine had a combination five-stage axial and single-stage centrifugal compressor, an external annular vaporizing combustion chamber, a single-stage gas-producer turbine that drove the compressor, and a single-stage power turbine that drove the output shaft through the reduction gearbox. When viewing the engine aft looking forward, the output shaft rotated clockwise, the compressor rotated counterclockwise, the gas-producer turbine rotated counterclockwise, and the power turbine rotated clockwise.

1.3.1 Maintenance Records

The MARPAT Aviation owner stated that the company did not have a method for documenting discrepancies involving the helicopter. He stated that pilots would have reported any discrepancies directly to him but that "none were ever reported."

[7] The T53 engine was formerly a Honeywell/AlliedSignal/Textron Lycoming product. Honeywell transferred the engine type certificate to Ozark Aeroworks on May 6, 2022.

Maintenance records showed that the helicopter's most recent annual inspection was completed on March 29, 2022, at MARPAT Aviation; at that time, the helicopter had an aircraft total time of 9,029 hours, an engine total time of 5,569 hours, and a time since engine overhaul of 569 hours. The aircraft logbook entry for the work stated that the "aircraft and engine have been inspected in accordance with "FAR 43 [*Federal Aviation Regulations* Part 43] appendix D annual inspection, and were determined to be in airworthy condition."[8] According to the work order, the engine oil and engine fuel filter were replaced, and a compressor wash was performed (to increase compressor efficiency by removing dirt and contaminants). An engine run was subsequently performed, which found no anomalies. The Part 43 Appendix D checklist items were initialed by the MARPAT Aviation mechanic, indicating that he performed this work, and the MARPAT Aviation owner, who had an inspector authorization, signed off on the work.[9]

The second-to-last entry in the aircraft logbook, dated June 17, 2021, was also an annual inspection conducted at MARPAT Aviation according to Part 43 Appendix D. The work order for this maintenance showed that the engine oil, engine fuel filter, and torque pressure transducer (which was leaking) were replaced and that a compressor wash was performed. The engine run that was subsequently performed found no anomalies.

According to the operator, the helicopter had flown about 14 hours between the date of the March 2022 maintenance and the June 2022 accident. Thus, at the time of the accident, the aircraft total time was 9,043 hours, the engine time since new was 5,583 hours, and the engine time since overhaul was 583 hours.

According to the aircraft logbook, on April 9, 2013, tail rotor blades with serial numbers ATR-72106 and ATR-274125 were installed on the helicopter. According to the component card for the tail rotor blade with serial number ATR-72106, the component total time was 1,025 hours at the time of installation; the component card for the blade with serial number ATR-274125 showed a component total time of 1,017 hours at the time of installation. About 237 hours had elapsed from the time of blade installation (aircraft total time of 8,792 hours) to the time of the last blade inspection before the accident (aircraft total time of 9,029 hours). Thus, at the time of

[8] Appendix D to 14 *CFR* Part 43 was titled "Scope and Detail of Items (as Applicable to the Particular Aircraft) To Be Included in Annual and 100-Hour Inspections." Section 1.7.2 describes some of the requirements for annual and 100-hour inspections conducted under Appendix D.

[9] The NTSB attempted to conduct a follow-up interview with the MARPAT Aviation mechanic about this and other annual inspections that were conducted according to Part 43 Appendix D, but the mechanic did not respond to our request. (The NTSB interviewed the mechanic on July 28, 2022, but no information about Appendix D inspections was discussed then.)

the last blade inspection, the blade with serial number ATR 72106 had 1,262 hours total time, and the blade with serial number ATR-274125 had 1,254 hours total time.

The manufacturer's established life limit (retirement time) for the tail rotor blades was 1,200 hours.[10] Life-limited components are to be removed from service upon reaching the established life limit.

1.3.2 Special Airworthiness Certification

The FAA issued a special airworthiness certificate for the accident helicopter. A special airworthiness certificate has several categories, including experimental and restricted. At the time of the accident, the helicopter had a special airworthiness certificate in the experimental exhibition category. Experimental exhibition aircraft are flown to demonstrate their flight capabilities, performance, or unusual characteristics for events such as air shows.[11]

A special airworthiness certificate in the experimental category is issued to operators of an aircraft that either does not have a type certificate or does not conform to its type certificate and is in a condition for safe operation. According to the FAA, when the accident helicopter was operated under an experimental airworthiness certificate, the helicopter was not considered to be type certificated (under type certificate data sheet No. H3SO).

The helicopter had previously been operated under a restricted-category certificate; such operations are limited to the special purposes identified 14 *CFR* 21.25(b), Issue of Type Certificate: Restricted Category Aircraft, and may include agricultural and forest conservation flights.[12] Table 1 shows the accident helicopter's certificate history between November 2003 (when the friend of the MARPAT Aviation owner became the registered owner of the helicopter) and the accident date.

As shown in table 1, at the time of the accident, the helicopter's special airworthiness certificate in the experimental exhibition category was dated

[10] See section 1.8.1 for more information about life-limited components.

[11] Title 14 *CFR* 91.319, Aircraft Having Experimental Certificates, paragraph (d)(1), states that "each person operating an aircraft that has an experimental certificate shall…advise each person carried of the experimental nature of the aircraft." The NTSB notes that, according to photographs of the accident helicopter, "EXPERIMENTAL" appeared over the left and right cargo/passenger doors.

[12] MARPAT Aviation had a contract with the state of West Virginia to use the accident helicopter to provide firefighting services during firefighting season. During other times of the year, the owner would work with the FAA to change the airworthiness certificate from the restricted category to the experimental category to participate in events such as exhibition flights.

December 5, 2014. The certificate was issued by the Charleston, West Virginia, Flight Standards District Office (FSDO).

Table 1. Certificate history for the accident helicopter.

Date	Type of certificate
November 20, 2003	Restricted
May 21, 2010	Experimental
September 24, 2010	Restricted
May 15, 2012	Experimental
April 10, 2013	Restricted
May 17, 2013	Experimental
October 29, 2013	Restricted
December 5, 2014	Experimental

The FAA issues operating limitations along with special airworthiness certificates. The operating limitations are presented in a separate document that is dated and signed by an FAA inspector.[13] The Charleston FSDO issued experimental exhibition operating limitations for the accident helicopter on December 5, 2014 (the same day as the helicopter's special airworthiness certificate in the experimental exhibition category).[14] According to FAA records, on that date, the owner of MARPAT Aviation signed an "Acknowledgment of Special Operating Limitations" letter certifying that he "read and understand[s] the Special Operating Limitations which are part of the Special Airworthiness Certificate" for the accident helicopter.

1.4 Meteorological Information

The weather reporting station at 6L4 recorded the following conditions at 1645 on the day of the accident: scattered clouds at 4,900 ft above ground level, a visibility of 10 statute miles, the wind variable at 6 knots, a temperature of 90°F, a dew point of 70°F, and an altimeter setting of 30.00 inches of mercury.

[13] The FAA aviation safety inspector who approved the special experimental exhibition airworthiness certificate and operating limitations for the accident helicopter between 2010 and 2014 passed away several years before the accident. Thus, the NTSB was unable to determine the reason for some of the inspector's actions.

[14] The 7-page operating limitations document contained 44 separate limitations for the accident helicopter. The operating limitations that were most relevant to this investigation are discussed later in this report. The document stated that the limitations were issued "per Memorandum of Deviation to Order 8130.2G. Chapter 4, Section 10 dated December 21, 2011…and are part of the Special Airworthiness Certificate (FAA Form 8130-7) for N98F dated 12/05/2014." The operating limitations are part of attachment 5, N98F Airworthiness Records, to the operations factual report in the public docket. The Memorandum of Deviation to FAA Order 8130.2G is discussed in section 1.8.1.1 of this report.

1.5 Wreckage and Impact Information

1.5.1 On-Scene Examination

The debris path spanned the 26-ft asphalt road and continued into a ditch at the base of the rock face. The main wreckage was located 542 ft beyond an intact utility cable, which was one of three cables that crossed the road at a height of 180 ft.[15] The other two utility cables were located 220 and 397 ft from the intact utility cable, and both were found severed. All major components of the helicopter were located near the accident site.

Examination of the wreckage revealed that the cockpit and cabin had impacted the road and a guardrail and that the cockpit and cabin were consumed by the postcrash fire. The empennage, which comprised the tailboom, vertical fin, and horizontal stabilizer, remained attached to the aft fuselage. Additional wreckage, including pieces of plexiglass, the aft cap of the left skid, and a section of a tail rotor blade, was found about 40 ft above the main wreckage on a ledge of the rock face. A rock with green paint transfer was also located there. Figure 2 shows the accident scene.

Both main rotor blades remained installed on the main gearbox, which was in its normally installed area but had separated from the airframe. A fractured piece of the main gearbox forward fairing was found away from the main wreckage and near the two severed powerlines. The input driveshaft, which had separated from both the main gearbox and the engine, was found under the main gearbox.

One of the two tail rotor pitch change links had separated from its pitch change horn, and the hardware for the links was not present. The NTSB Materials Laboratory subsequently examined the pitch change horn and found deformation on one side. The tail rotor controls were separated, with multiple impacts evident from the tail rotor to the forward section of the tailboom, and were consumed by the postcrash fire forward of the tailboom.

[15] In this report, the terms “utility cable” and “powerline” are synonymous.

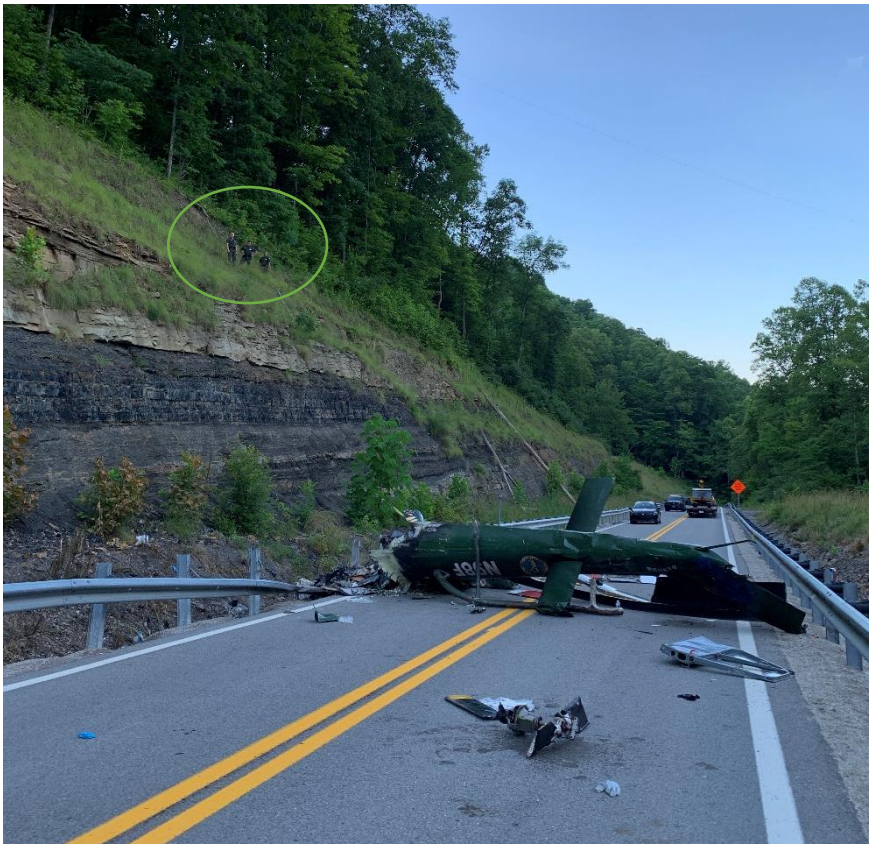

Figure 2. Accident scene.

Note: The circle denotes the area where the NTSB found pieces of plexiglass, the aft cap of the left skid, a tail rotor blade segment, and green paint transfer onto a rock.

A visual on-scene examination of the engine's power turbine blades through the engine exhaust diffuser revealed that two nonconsecutive blades were fractured near their roots and were missing. A full-length power turbine blade was present between the two missing blade locations. Evidence of tip rubbing was observed between the power turbine blades and the engine case. The engine was subsequently examined at the engine manufacturer's facility, as discussed below.

1.5.2 Engine Examination

Postaccident examination of the engine at Ozark Aeroworks found thermal distress toward the front and along the bottom of the engine. The accessory gearbox housing was partially consumed by the postcrash fire, and the top of the engine was undamaged. The impeller compressor housing exhibited static impact marks that had the same size, shape, and spacing as the impeller airfoil leading edges, which were in good (shiny) condition and did not exhibit material transfer or significant rub damage; this evidence was consistent with the gas-producer turbine not rotating or

rotating slowly at the time of impact. All the compressor blades were present and intact with no rub, impact, or ingestion damage; this evidence was also consistent with the gas-producer turbine not rotating at impact.

The No. 2 bearing, which supported (radially) the aft end of the compressor shaft of the gas-producer turbine, was found with its roller elements flattened and thermally distressed, as shown in figure 3. The outer race exhibited considerable material transfer, and the cage was in good condition with its silver plating still visible and no evidence of damage or thermal distress. Significant thermal distress and evidence of bulging and distortion were observed on the aft compressor shaft. Widespread thermal distress and material transfer were observed in the area of the No. 2 bearing. The NTSB Materials Laboratory analyzed the No. 2 bearing and determined that the observed heat damage and material transfer were consistent with skidding of the bearing rollers.

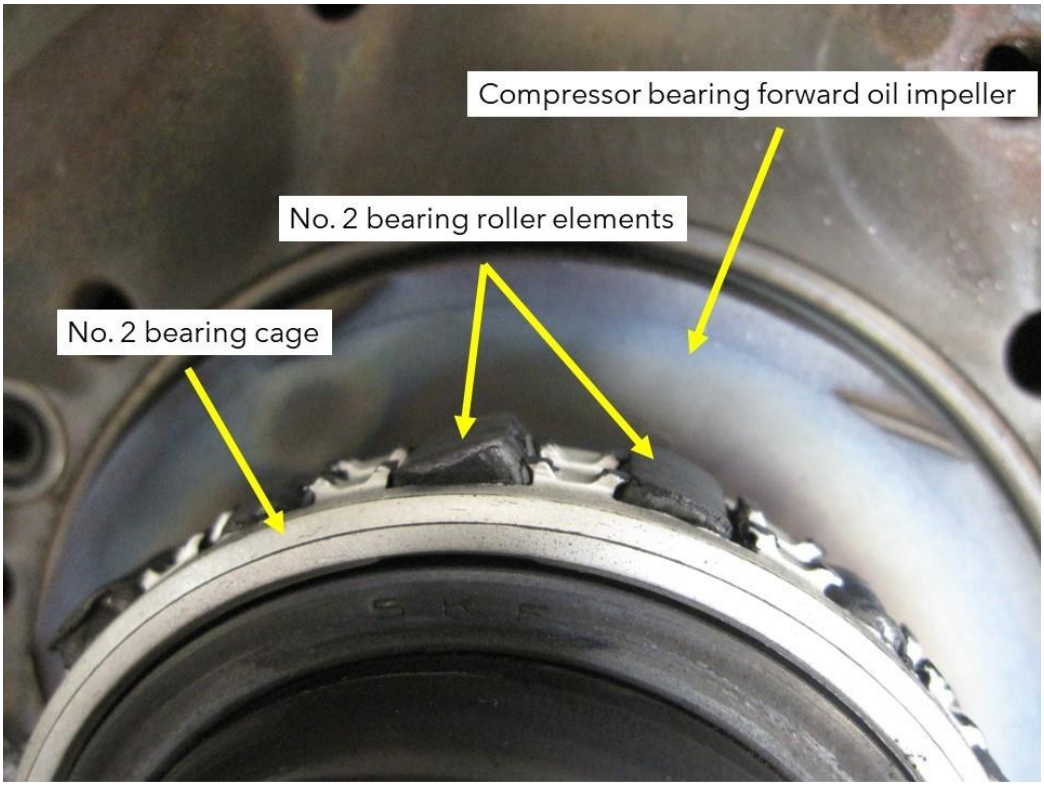

Figure 3. Close-up view of No. 2 bearing roller elements.

The No. 2 bearing compartment was dry with no evidence of oil; the oil jets on the No. 2 bearing retaining plate, which provided lubrication to the No. 2 bearing, were clear and unobstructed. The No. 2 bearing scavenge tube had black ferrous debris; the oil pressure supply tube was clear. Low-pressure brake cleaning fluid was used to test whether the oil supply and scavenge tubes were obstructed. The fluid flowed freely through the supply tube with no material debris collected, but no fluid flowed from the scavenge tube, indicating an obstruction. Material deposits from the scavenge tube were analyzed by the NTSB Materials Laboratory using energy dispersive x-ray spectroscopy. The analysis determined that the deposits were consistent with the material composition of the No. 2 bearing roller elements.

The gas-producer turbine exhibited the following:

- lateral movement of the turbine disk when pressure was applied manually;
- heavy 360° circumferential wear and material transfer on the inner diameter surface of the rear compressor (stub) shaft, which was consistent with contact with the power turbine front shaft; and
- turbine blades that were intact and full length but exhibited tip rub marks and material transfer.

This observed damage was consistent with the rotating gas-producer turbine rotor not receiving the necessary radial support to keep the rotor from contacting the surrounding static components. Continuity was confirmed between the compressor and gas-producer turbine. The static damage observed in the compressor section and the rotational damage observed in the gas-producer turbine were consistent with an engine failure.

The power turbine exhibited circumferential rub marks on the blade roots and the wheel at the blade slots on the aft side of the turbine disk, which were consistent with rotational contact with the forward face on the inner cone of the exhaust diffuser assembly; a diagram of the assembly is shown in figure 4.

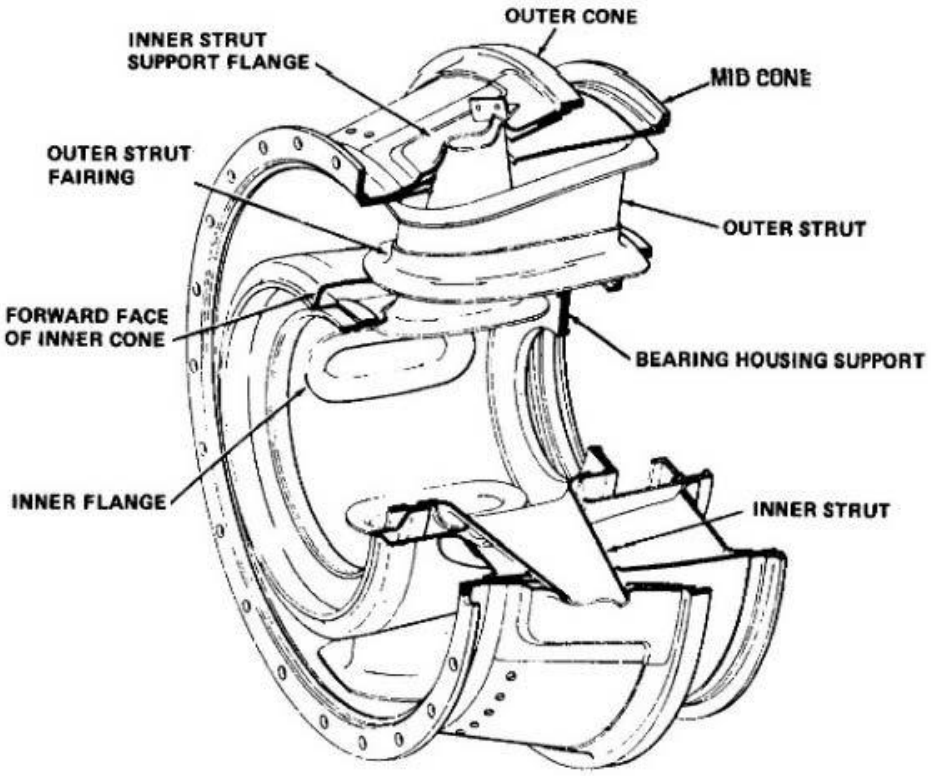

Figure 4. Exhaust diffuser diagram (Source: Ozark Aeroworks).

The power turbine had consecutive blades (positioned around a 180° arc) that exhibited leading-edge rotational contact rub at the blade roots (consistent with contact with the power turbine nozzle inner support aft face) and the outboard ends (consistent with contact with the outer ring support rear ledge). Further, the NTSB noted the following:

- the heaviest power turbine blade airfoil rub was centered around the fractured power turbine blade location;
- the power turbine blade tips exhibited heavy tip rub marks and a loss of blade shrouds around a 180° arc;
- the power turbine nozzle assembly support exhibited 360° circumferential rub and some material transfer along the blade path shroud, which were consistent with contact with the power turbine blades tips; and

- the power turbine front shaft exhibited localized 180° heavy rub, mushrooming (bulging), and an ovalized forward lip, which were consistent with contact with the rear compressor (stub) shaft.

A longitudinal crack through the power turbine shaft was also observed. The localized and non-uniform damage observed was consistent with rotation of the power turbine rotor.

The NTSB Materials Laboratory analyzed the two fractured power turbine blades, which are shown in figure 5, and determined that one blade exhibited heat tinting from rub damage at the leading edge and features consistent with overstress. The other blade exhibited similar heat tinting at the leading edge, similar fracture features across most of the fracture, and fatigue in a small area of the blade trailing edge. Examination of the fatigue origin area using a scanning electron microscope found no evidence of any anomalies or pre-existing damage associated with fatigue crack origins.

The exhaust diffuser exhibited multiple cracks around each outer cone inner strut support flange.[16] The support flange for the inner strut at the 6:00 position was fractured around the perimeter of the strut, separating the inner strut from the outer cone. The inner strut at the 12:00 position had separated from the bearing housing support and exhibited extensive rubbing damage, which was consistent with the inner strut separating at some point before the accident and operating in that condition for a considerable amount of time.

[16] The exhaust diffuser has four inner struts (located at the 12:00, 3:00, 6:00, and 9:00 positions labeled aft looking forward) that provide structural support for the housing of bearing Nos. 3 and 4. The inner struts connect the exhaust diffuser outer cone and bearing housing support.

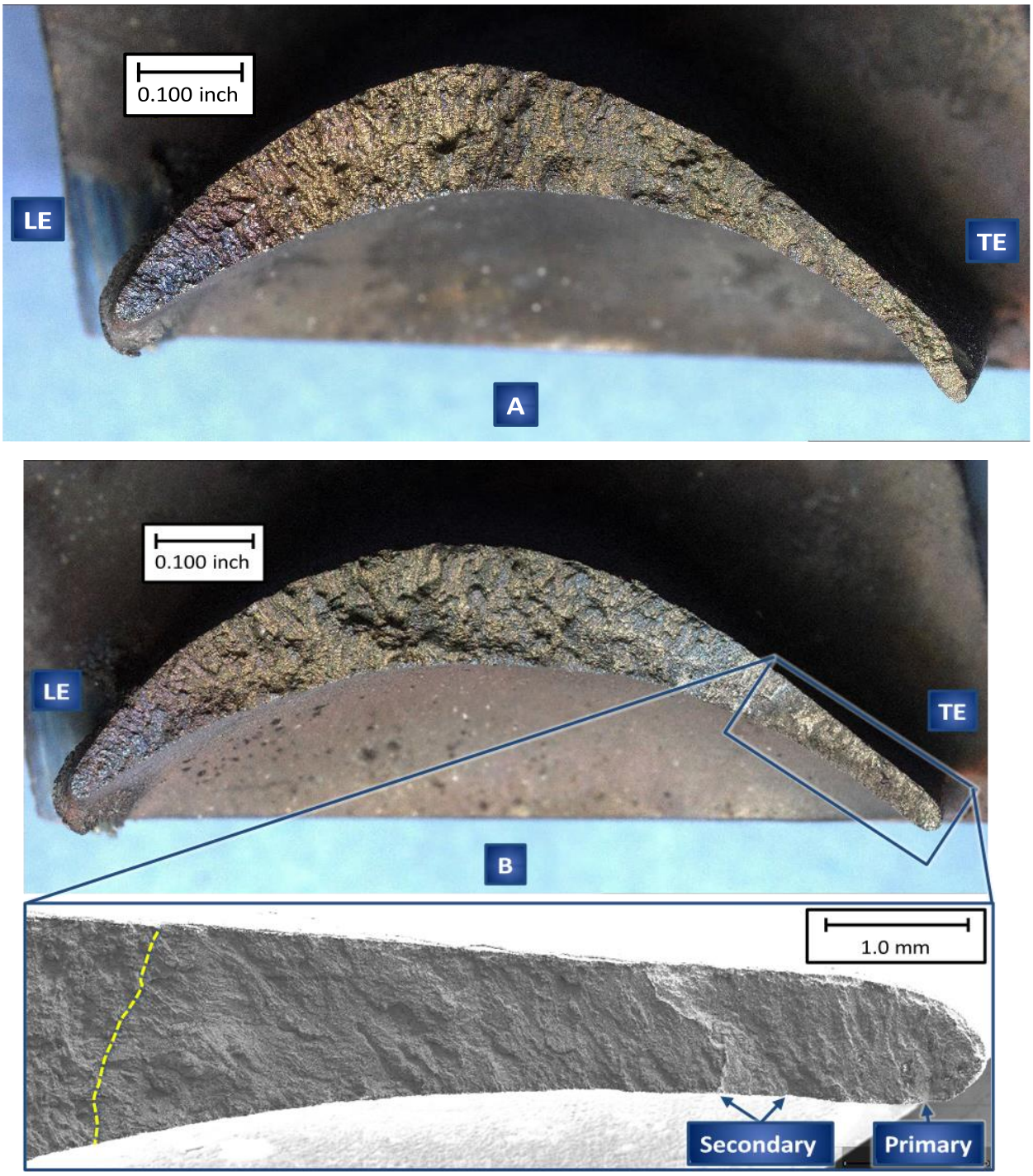

Figure 5. Power turbine blade fracture surfaces (top and center images) and blade trailing edge showing fatigue origin areas (bottom image).

Note: The blades were arbitrarily labeled "A" (top image) and "B" (center image). The yellow dashed line (bottom image) shows the fatigue boundary. LE, leading edge; TE, trailing edge.

The NTSB Materials Laboratory's examination of the exhaust diffuser (after the inner cone was separated from the support) found that the four inner strut inner flanges that connected to the No. 3 and No. 4 bearing housing support were fractured or cracked in the radius where the inner flange transitioned to the inner strut, as shown in figure 6.

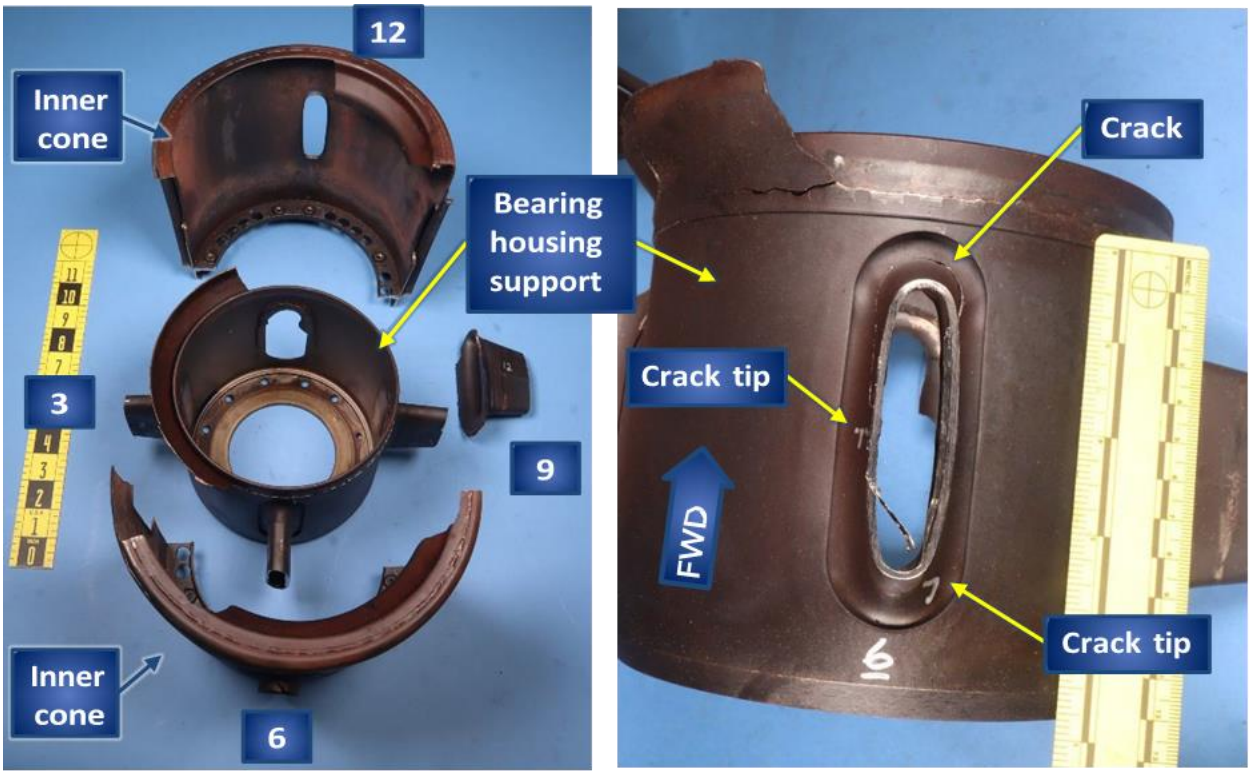

Figure 6. Bearing housing support and inner struts.

Note: The numbers on the left image indicate the 12:00, 3:00, 6:00, and 9:00 positions (viewed facing aft).

The cracks around the outer cone inner strut support flanges showed fatigue features from multiple origins; the cracks also had a relatively uniform straw-colored oxide tint, which was consistent with exposure to hot exhaust gases before the accident. The spot weld seam, which connected the forward face of the inner cone to the bearing housing support, was cracked and separated around two-thirds of its circumference. The fracture surface had relatively smooth fatigue features emanating from several individual spot welds, and the fatigue regions had oxides that were dark gray to black in color and extended nearly or completely through the inner cone wall thickness in multiple areas, which was consistent with relatively slower fatigue crack growth in these areas with exposure to hot exhaust gases before the accident.

During the engine disassembly, the exhaust diffuser cover was removed from the aft end of the inner cone, exposing the bearing housing rear cover for bearing

Nos. 3 and 4. The bearing housing rear cover had separated circumferentially through the outer flange just aft of the front attachment plate. The separated outer flange piece was loose and resting in the bearing housing bore and against the exhaust diffuser cover, and the forward piece remained attached to the aft end of the bearing housing support on the exhaust diffuser. The interior surface of a rolled piece of outer flange material adjacent to the plane of separation was rough and oxidized due to corrosion. The Materials Laboratory found that the outer flange had separated due to wall thinning resulting from the corrosion, as shown in figure 7.

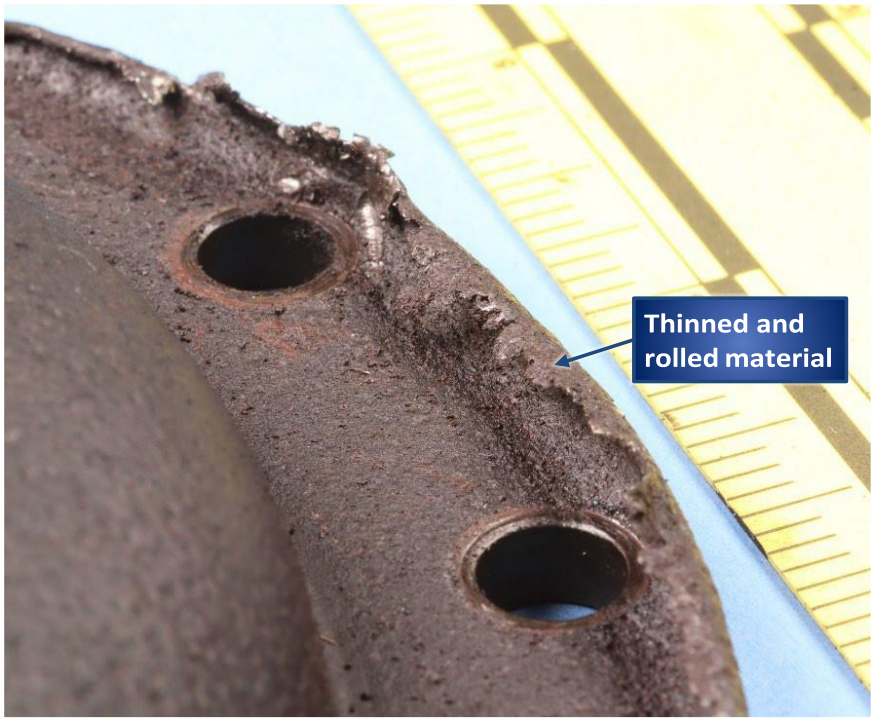

Figure 7. Outer flange separation surface at the outside diameter of the rear bearing cover.

1.6 Medical and Pathological Information

The State of West Virginia Office of the Medical Examiner, Charleston, West Virginia, performed an autopsy of the pilot-in-command. His cause of death was blunt force and thermal injuries. Toxicological testing performed by the FAA's Forensic Sciences Laboratory detected no ethanol, carboxyhemoglobin, or drugs of abuse. The Medical Examiner's office also performed autopsies on all five passengers and determined that their cause of death was also blunt force and thermal injuries.

1.7 Organizational and Management Information

1.7.1 MARPAT Aviation

MARPAT Aviation, LLC, was incorporated in West Virginia on September 22, 2003. The MARPAT Aviation office was located at 6L4. The company had one employee—the mechanic for MARPAT Aviation's Part 145 repair station.

1.7.1.1 Huey Reunion Events

MARPAT Aviation sponsored the annual Huey reunion events. The MARPAT Aviation owner stated that six volunteer pilots took turns flying the helicopter during the 2022 Huey reunion event. The owner also stated that the volunteer pilots "came in and got current" on the helicopter by performing three takeoffs and landings.[17] The owner described the reunion flights as "exhibition flights" with a "historical helicopter." None of the reunion flights were coordinated with the Charleston FSDO; the owner thought that such coordination was not required (as discussed further in section 1.7.2).

The MARPAT Aviation website (accessed June 10, 2024) stated the following regarding the 2022 Huey reunion event, which was to be held from June 21 to 26 (emphasis in original):

> Take the right seat and YOU can fly N98F!
>
> - You **DO NOT need to be a pilot** to make a reservation to fly!
> - Reservations will be for a 30-minute flight.
> - Each right seat flight requires a **$250/30-minute** donation to pay for fuel.
> - You can book as many 30-minute flights as you wish, but in fairness to all, we ask that you **do not book back-to-back flights**. Please spread your 30-minute flights out over the day and/or the week.

[17] MARPAT Aviation did not have standard operating procedures for the helicopter or a formal training program for volunteer pilots who flew the helicopter during reunion events. Title 14 *CFR* 61.57, paragraph (a), General Experience, stated the following: "no person may act as a pilot in command of an aircraft carrying passengers or of an aircraft certificated for more than one pilot flight crewmember unless that person has made at least three takeoffs and three landings within the preceding 90 days." (The paragraph also stated that the person was to act "as the sole manipulator of the flight controls" and that the required takeoffs and landings were to be "performed in an aircraft of the same category, class, and type.")

During a postaccident interview, the MARPAT Aviation owner stated that the $250 was not a required donation but was instead the cost of fuel for a 30-minute flight.

The website also stated that, for those who wanted to ride in (and not fly) the helicopter, "no need to make a reservation...just show up! Rides will be given on a first come, first served basis between 8:30am and 5:30pm. Show up, make a small donation and have a great time!" The website further indicated that "children must be old enough to wear their own seatbelt" and could not be held on an adult's lap.

For the 30-minute flights, the pilot-in-command and the right-seat passenger would typically fly a 15-minute route twice. Figure 8 shows the estimated flightpath of the 15-minute route according to a map that MARPAT Aviation provided during the investigation. Postaccident statements from passengers who were previously aboard the accident helicopter indicated that the helicopter would sometimes be flown off course (that is, beyond the 15-minute flight route).

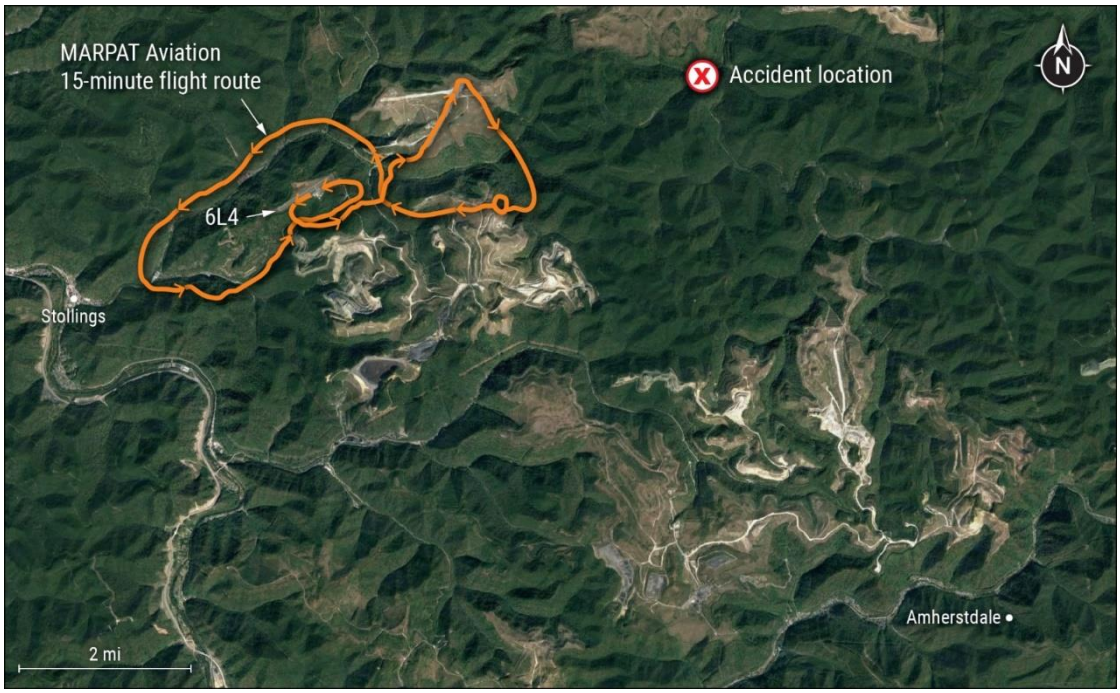

Figure 8. Estimated location of the flight route in relation to the accident site.

On June 19 and 20, 2022, the senior volunteer pilot (who was discussed in section 1.1) provided a safety briefing to other volunteer pilots regarding the operation of the helicopter during the reunion event. According to witnesses, the volunteer pilot stated that "the safety pilot is the aircraft commander and in charge of all operations" and that "only the safety pilot will pick the aircraft up or set the aircraft down on any hard surface."

1.7.1.2 MARPAT Aviation Checklists

MARPAT Aviation developed a checklist for 100-hour and annual inspections when the helicopter was under a restricted-category certificate. The NTSB's review of this checklist found that it included detailed criteria for inspecting the engine, flight controls, tailboom, and other helicopter components.[18] For example, the checklist noted, in the engine section, that the second-stage power turbine blades through the engine exhaust diffuser were to be checked for cracks.

Because experimental-category aircraft are not required to have a type certificate, the FAA can determine the inspection and maintenance requirements based on the nature of the aircraft (which, for former military turbine-powered aircraft, was Part 43 Appendix D). For inspections when the accident helicopter was operated under an experimental airworthiness certificate, MARPAT Aviation developed and used a checklist that was based on the requirements of Part 43 Appendix D.[19]

1.7.2 Federal Aviation Administration

FAA oversight of MARPAT Aviation's Part 145 repair station certificate was conducted by the Charleston, West Virginia, FSDO. As of November 2022, the FSDO was staffed with a front-line manager, a principal maintenance inspector (PMI), an assistant PMI, a principal avionics inspector, a principal operations inspector, and an operations inspector-in-training.[20] The Charleston FSDO was responsible for six

[18] The maintenance records that were made available for this investigation did not include any inspection checklist that MARPAT Aviation used when the helicopter was operated under a restricted-category certificate.

[19] The checklist also contained information from 14 *CFR* 43.15, Additional Performance Rules for Inspections. This regulation stated that "each person performing an annual or 100-hour inspection shall use a checklist while performing the inspection. The checklist may be of the person's own design." The regulation further stated that "each person approving a turbine-engine-powered aircraft for return to service after an annual, 100-hour, or progressive inspection shall, before that approval, run the aircraft engine or engines to determine satisfactory performance in accordance with the manufacturer's recommendations."

[20] The FSDO was similarly staffed at the time of the July 29, 2022, interview with the front-line manager (which occurred about 5 weeks after the accident).

aircraft that had experimental exhibition certificates, including the accident helicopter.[21]

FAA surveillance for Part 91 operations is generally limited to periodic aircraft or ramp inspections.[22] These inspections are not part of a scheduled workplan for FAA inspectors; as a result, the accident helicopter and MARPAT Aviation were not part of any routine operational surveillance that the FAA conducted. According to FAA records, the PMI's last surveillance visit at MARPAT Aviation was on May 2, 2019 (more than 3 years before the accident), but that visit was to inspect MARPAT Aviation's Part 145 repair station.[23] (The surveillance that the FAA conducted for MARPAT Aviation's repair station certificate was unrelated to the operation of the accident helicopter.) The PMI stated that scheduled oversight was not required for experimental aircraft and that surveillance of those aircraft would be conducted in the same manner as that for any Part 91 operation.

FAA Order 8900.1, Flight Standards Information Management System, was issued in September 2007 to establish a repository for policy and guidance regarding aviation safety inspector job tasks. The order did not require inspectors to provide routine surveillance for Part 91 operators with experimental aircraft (including MARPAT Aviation) to ensure that they were complying with the operating limitations associated with each experimental certificate.

Operating limitation No. 4 to the accident helicopter's December 2014 experimental airworthiness certificate stated that "the owner operator must submit an annual program letter to the geographically responsible FSDO where the aircraft is based. All operations must be conducted in accordance with these limitations and the program letter." The operating limitations also stated that that the program letter was required to include "a list of events at which the aircraft will be exhibited (the list may be amended as necessary)." The FAA stated that it used program letters to plan its surveillance of experimental aircraft.

[21] According to a November 21, 2022, email from the FAA, a total of 3,717 US aircraft were issued experimental exhibition certificates, which was less than 1% of all certificates that the FAA had issued at the time. Of these 3,717 aircraft, 217 (6%) were rotorcraft, and 53 (24%) of those rotorcraft were UH-1 helicopters. A subsequent FAA email stated that, as of March 27, 2024, 227 rotorcraft had experimental exhibition certificates and that 55 of these rotorcraft were UH-1 helicopters.

[22] FAA Order 8900.1, section 4, defined a ramp inspection as "surveillance of an airman, operator, air agency, or aircraft…sufficient to show compliance with [federal regulations] during actual operations at an airport or heliport."

[23] FAA records also showed that another inspector from the FSDO performed surveillance of the company's Part 145 repair station on May 3, 2022. The PMI stated that he was "on and off as PMI for a while" but that all required surveillance activities were completed for the repair station certificate.

The NTSB requested all program letters that MARPAT Aviation sent to the Charleston FSDO, and the FAA provided the two program letters that it had received from the MARPAT Aviation owner. The first letter, dated December 12, 2018, stated that the accident helicopter would be used for a holiday celebration in downtown Logan, West Virginia. The second letter, dated August 2021, stated that the helicopter would be used for functions between September 10 and 12, 2021, and on October 15, 2021. (No evidence indicated that the FAA performed surveillance of the accident helicopter at either event.) The FAA did not have a program letter for 2022 or any other correspondence from MARPAT Aviation indicating that the helicopter would be used for the Huey reunion event in June 2022.

During a postaccident interview, the MARPAT Aviation owner stated that he was not required to notify the FSDO about the reunion event because it would be occurring at the helicopter's "homebase," where the helicopter was continuously on exhibit. The MARPAT Aviation owner also stated that operating limitation No. 4 to the experimental airworthiness certificate applied only when the helicopter was on exhibit at a location other than 6L4. The owner thought that the helicopter could operate within a 15-mile radius around 6L4 without notifying the FAA. When interviewed, the PMI stated that the helicopter's operating limitations contained no such provision and that the operator should have notified the FSDO about the reunion event.[24]

1.8 Additional Information

1.8.1 Federal Aviation Administration Order 8130.2

FAA Order 8130.2 establishes policies and procedures for issuing airworthiness certificates for aircraft. Version G of the order, titled "Airworthiness Certification of Aircraft and Related Products," was dated August 31, 2010.

Order 8130.2G, chapter 4, section 10, paragraph 4110 placed aircraft with experimental airworthiness certificates into one of seven groups to establish standardized operating limitations and inspection requirements. Group 5 was applicable to the UH-1B helicopter because that group included turbine-powered aircraft with a maximum gross takeoff weight of less than 12,500 pounds. According to the order, group 5 aircraft had to fully comply with either manufacturer or country-of-origin life limits (if specified) as well as a manufacturer, a country-of-origin, or an FAA-approved inspection and maintenance program.

[24] The NTSB's review of the helicopter's operating limitations confirmed that they contained no such provision.

Paragraph 4113 of Order 8130.2G contained a table that detailed the operating limitations for each aircraft group. One of the operating limitations for group 5 aircraft was that turbine-powered rotorcraft operated under an experimental exhibition certificate were to be maintained under an FAA-approved inspection program that met the requirements of 14 *CFR* 91.409(f). The regulation stated the following:

> The registered owner or operator of each airplane or turbine-powered rotorcraft…must select, identify in the aircraft maintenance records, and use one of the following programs for the inspection of the aircraft:…
>
> (3) A current inspection program recommended by the manufacturer.
>
> (4) Any other inspection program established by the registered owner or operator of that airplane or turbine-powered rotorcraft and approved by the [FAA] Administrator.[25]

1.8.1.1 Memorandum of Deviation to Order 8130.2

On December 21, 2011, the FAA issued a Memorandum of Deviation to Order 8130.2G, chapter 4, section 10. The memorandum revised the operating limitations for experimental airworthiness certificates that were issued for the purpose of exhibition. The procedures in the memorandum were to be used instead of those in Order 8130.2G. The memorandum was in effect when the accident helicopter received its experimental airworthiness certificate in December 2014 (the certificate that was current at the time of the accident).

The Memorandum of Deviation, paragraph 4111(c)(4), required an FAA-approved inspection program that met the requirements of section 91.409 but allowed the owner or operator of a turbine-powered rotorcraft (including the UH-1B helicopter) to use the inspection provisions of sections 91.409(a), (b), (c), (d), or (f).[26] The memorandum also allowed turbine-powered rotorcraft with an experimental exhibition certificate to be inspected under Part 43 Appendix D, which

[25] For information about the provisions of subparagraphs (1) and (2) of paragraph (f), see 14 *CFR* 91.409 (accessed June 10, 2024).

[26] For information about the provisions of paragraphs (a) through (d), see 14 *CFR* 91.409 (accessed June 10, 2024).

addressed the items to be included in a 100-hour inspection and an annual inspection.[27]

Further, the operating limitations in the Memorandum of Deviation included a new limitation that addressed life-limited components. The limitation stated that an aircraft could not be operated "unless the replacement for life-limited articles specified in the applicable technical publications pertaining to the aircraft and its articles are complied with," and the manner of compliance was provided for "type-certificated products" and "non-type certificated products." (See appendix C for more information.) According to this operating limitation, products that are not type certificated but had manufacturer-recommended life limits, such as the accident helicopter's tail rotor blades, were required to have an equivalent level of safety for those life-limited items.[28]

1.8.1.2 FAA Order 8130.2G, Change 1

The FAA issued Order 8130.2G, change 1 (to chapter 4, section 2) on July 2, 2012. This version of the order was in effect when the helicopter received its last restricted-category certificate in October 2013. One of the operating limitations for this certificate stated the following:

> (15) This model rotorcraft must be serviced and maintained in compliance with [US Army] TM [Technical Manual] 55-1520-219-10 and TM 55-1520-219-20…. Component overhaul intervals and replacement times shall be in accordance with the TBO [time between overhaul]/Replacement schedule found in TM 55-1520-219-20, unless superseded by [an] appropriate Airworthiness Directive. Component life limits to be as specified in U.S. Army TM 55-1520-219-20. These and other applicable documents are specified in Richard's Heavylift

[27] The FAA stated that, as of March 27, 2024, 126 turbine-powered former military aircraft were inspected and maintained according to the provisions of Part 43 Appendix D and that 12 of these aircraft were UH-1 helicopters. The FAA also stated that, as of April 29, 2024, 104 rotorcraft and 22 airplanes comprised the 126 turbine-powered former military aircraft.

[28] FAA Order 8110.4C, Type Certification, states that equivalent-level-of-safety findings are made "when literal compliance with a certification regulation cannot be shown and compensating factors in the design can be shown to provide a level of safety equivalent to that established by the airworthiness standards." A manufacturer's established life limit could be used to meet the equivalent level-of-safety requirement for life-limited components in the operating limitations of the rotorcraft because the FAA would already have approved that life limit. MARPAT Aviation did not have documentation showing an equivalent level of safety for the tail rotor blades.

Helo, Inc. Instructions for Continued Airworthiness Report, Report No. 001 dated May 16, 2007.[29]

Change 1 of Order 8130.2G did not modify the original requirements for the issuance of experimental airworthiness certificates for the purpose of exhibition and did not incorporate the Memorandum of Deviation procedures for issuing those certificates. Thus, the Memorandum of Deviation procedures remained in place until the release of subsequent versions of Order 8130.2.

1.8.1.3 Subsequent Versions of FAA Order 8130.2

The FAA issued version H of Order 8130.2, titled "Airworthiness Certification of Products and Articles," on February 4, 2015, which was about 2 months after the accident helicopter received the experimental airworthiness certificate that was current at the time of the accident. As a result, the accident helicopter was not required to comply with the requirements of version H and subsequent versions.

According to Order 8130.2H, former military turbine-powered helicopters with experimental exhibition certificates were required to be maintained under an inspection program recommended by the helicopter manufacturer or a North Atlantic Treaty Organization military service. In addition, Order 8130.2H, chapter 4, section 10, paragraph 468 introduced a reference to FAA Advisory Circular (AC) 43-209A, "Recommended Inspection Procedures for Former Military Aircraft," dated April 12, 2013; section 1.8.3 in this report provides information about the AC.

The FAA issued the current version of the order, 8130.2J, titled "Airworthiness Certification of Aircraft," on July 21, 2017. This version of the order had generally the same requirement as version H regarding the type of inspection for former military turbine-powered rotorcraft. Version J advised FAA inspectors that the operating limitations in appendix D of the order "are not sufficient to mitigate every safety risk you may encounter with a particular aircraft or operation" and that inspectors were to prescribe additional operating limitations considered necessary for safe operation based on inspections and assessments of potential safety hazards.

[29] Richards Heavylift Helo has held FAA type certificate data sheet No. H3SO since October 18, 2005. The Richards Heavylift Helo report, dated 2007, indicated that tail rotor blades with part number 204-011-702-15 (which were on the accident helicopter) had a retirement time (life limit) of 1,200 hours. US Army Technical Manual 55-1520-219-20 (which is discussed in section 1.8.4 in this report along with US Army Technical Manual 55-1520-219-10) provided the same life limit for the tail rotor blades (Department of the Army 1972; Department of the Army 1969).

In addition, appendix A, section 4, paragraph g(3) of the order stated that the duration of experimental exhibition certificates "is unlimited unless good cause exists to establish a specific period."[30]

1.8.2 Federal Aviation Administration Part 43 Appendix D

Paragraph (d) of 14 *CFR* Part 43 Appendix D stated the following:

> Each person performing an annual or [a] 100-hour inspection shall inspect (where applicable) components of the engine and nacelle group as follows: (1) Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks… (8) Exhaust stacks—for cracks, defects, and improper attachment… (10) All systems—for improper installation, poor general condition, defects, and insecure attachment.

Paragraph (d)(3) addressed reciprocating engines only and stated that the internal engine was to be inspected for "cylinder compression" and that, if weak cylinder compression was found, the engine was also to be inspected for "improper internal condition and improper internal tolerances." The paragraph did not discuss inspection steps for a turbine engine compressor and blades. Tables 2 and 3 in sections 2.4 and 2.5, respectively, provide more information about the requirements of Part 43 Appendix D.

1.8.3 Federal Aviation Administration Advisory Circular 43-209A

FAA AC 43-209A provided guidance on the development of inspection program requirements for the certification of former military aircraft in the experimental exhibition category. Paragraph 5 of the AC, titled "Inspection Program Content," stated the following:

> Owners/operators of former military aircraft requiring yearly condition inspections in accordance with the appropriate operating limitations must submit a program developed to the scope and detail of part 43 appendix D (or other FAA-accepted program) and guidance contained within this AC prior to the initial certification inspection of the aircraft.

Paragraph 8 of AC, titled "Storage," stated the following:

> Extended periods of inactivity can have a negative effect on the airworthiness of an aircraft and its components. Inspection programs

[30] These provisions also appeared in previous versions of FAA Order 8130.2.

should consider time limitations as well as environmental conditions with procedures for preservation of the article.[31]

Paragraph 16 of the AC, titled "Experimental Aircraft Inspection Program," stated the following regarding inspection criteria:

Inspection programs should encompass the scope and detail of part 43 appendix D using additional criteria based on guidance from this AC, from manufacturers, or country of origin's recommended maintenance and/or inspection guidelines.

1.8.4 US Army Technical Manuals

When the accident helicopter received its April and October 2013 restricted-category certificates under the provisions of FAA Order 8130.2G, change 1 (see section 1.8.1.2), the operating limitations included a reference to US Army Technical Manual 55-1520-219-20, "Organizational Maintenance Manual – Army Model UH-1B Helicopter," which was dated June 30, 1972. The technical manual established the inspection intervals for specific areas of the UH-1B helicopter.[32]

Chapter 3 of the technical manual addressed inspection requirements and stated that the engine area included "all surfaces, components, and equipment associated with engine installation, located above [the] engine work deck and within [the] engine cowling, tailpipe fairing, and air intake area" (Department of the Army, 1972). The technical manual detailed the inspections that supplemented the preventive maintenance inspection checklists in three other US Army technical manuals: 55-1520-219-PMD (preventive maintenance—daily), -PMI (preventive

[31] Manufacturers typically provide procedures for the storage and preservation of aircraft and engines when they are inactive for prolonged periods. A review of the aircraft and engine logbooks found no entries showing that storage or preservation activities were performed at MARPAT Aviation during the 2 years preceding the accident. For example, an aircraft logbook entry dated August 9, 2019, showed an aircraft total time of 8,916 hours. The next aircraft logbook entry, which was dated June 22, 2020, showed the same aircraft total time. The engine total time matched the aircraft total time, indicating that the helicopter and its engine did not operate for more than 10 months. From June 2020 to June 2021 (the next entry in the aircraft logbook), the helicopter accumulated 52 flight hours. From June 2021 to March 2022, the helicopter accumulated 61 flight hours. The logbook did not show when those flight hours were accrued.

[32] The operating limitations for the accident helicopter's most recent experimental airworthiness certificate did not include this requirement. The operating limitations for the helicopter's May 2010 experimental certificate (which was the first experimental certificate issued by the Charleston FSDO) stated that the helicopter was to be inspected "in accordance with the scope and detail of [US Army Technical Manuals] TM-55-1520-219-10 and TM-55-1520-219-20."

maintenance–intermediate), and -PMP (preventive maintenance–periodic).[33] Chapter 3 also stated that compliance with these checklists was required to ensure that "latent defects are discovered and corrected before malfunctioning or serious trouble results." Chapter 5 addressed powerplant and related systems and contained procedures on removing, installing, inspecting, and troubleshooting the engine inlet, exhaust, fuel and oil systems, and engine controls.

Part 43 Appendix D does not contain any specific references to US Army technical manuals. As a result, any requirements to use these manuals during inspections and maintenance would need to be incorporated into an aircraft's operating limitations.

Chapter 16 of US Army Technical Manual 55 1520 219-20 contained procedures for the storage of UH-1B helicopters. The procedures detailed the following storage categories: "short term" (1 to 45 days); "intermediate storage" (46 to 180 days); and "flyable storage," which was defined as temporary storage in which the helicopter could be made ready for flight on short notice. For that storage category, the engine would be run for about 10 minutes at idle, after which protective covers (or barrier material and tape) would be installed on the engine inlet and exhaust.[34] With the helicopter was in flyable storage, the engine was to be operated at idle for about 10 minutes at least once every 7 days.

1.8.5 UH-1 Helicopter Inspection Planning Guide

When the US government began selling former military UH-1 helicopters to civilian entities, an effort was also begun to develop nonmilitary inspection guidance for these helicopters. This effort resulted in the Interagency Committee for Aviation Policy, which was established by the General Services Administration. According to the General Services Administration's website (accessed June 10, 2024), the committee comprised "aviation leaders from across the Government" to "promote sound policy and foster the highest aviation standards."

[33] MARPAT Aviation had a copy of US Army Technical Manuals 55-1520-219-10 and 55-1520-219-20 but did not have a copy of Technical Manuals 55-1520-219-PMD, -PMI, or -PMP. MARPAT Aviation could have found US Army technical manuals as well as other UH-1 resources from a UH-1 operator/industry collaborative website, such as www.uh1ops.com (accessed June 10, 2024), which was created in 2014. For former military UH-1 helicopters, the requirements in Technical Manual 55-1520-219-PMD were converted from daily (while the US Army operated the helicopter) to every 10 hours or 14 days, whichever came first.

[34] The NTSB asked MARPAT Aviation (via email) if it had taken actions, such as covering the engine inlet and exhaust, to preserve the accident helicopter for long-term storage, but no response was received.

The committee issued the *UH-1 Series Inspection Planning Guide* to provide UH-1 helicopter restricted-category certificate holders and operators with "an alternative reasonable basis for inspection program development" (General Services Administration, 2002). The guide was developed by representatives from the federal government and industry. The original issue date for the guide was March 26, 1996. Revision 1 of the guide was issued on March 12, 1997, and revision 2 was issued on March 1, 2002. MARPAT Aviation had a draft copy of the guide dated November 6, 1995. The engine inspection criteria and intervals did not significantly change between the November 1995 and March 2002 versions of the guide.

Chapter 2 of the guide listed several recurring inspections, including a preventive maintenance inspection every 10 hours or 14 days, whichever came first. Chapter 3 of the guide contained instructions for performing a preventive maintenance inspection of the engine. One of the steps was to "inspect [the] power turbine blades through [the] exhaust diffuser and inspect [the] exhaust diffuser for…cracks and burnt areas." The guide also stated that, for aircraft that would be out of service for more than 30 days, a preventive maintenance inspection was to be performed before the aircraft could return to service.

1.8.6 Other Pertinent Regulations

Title 14 *CFR* 119.1 addressed the applicability of certification requirements for air carriers and commercial operators. In general, aircraft operators conducting commercial operations must be certificated under Part 119 before transporting passengers (or property) for compensation or hire and must hold an FAA-issued air operator certificate for operations conducted under Parts 121, 125, or 135. Section 119.1(e)(2) provided an exception to the operating certificate requirement for certain nonstop commercial air tours conducted in an airplane or a helicopter. For Part 91 operations, an FAA letter of authorization (issued under 14 *CFR* 91.147, Passenger Carrying Flights for Compensation or Hire) was required to operate according to the exception in section 119.1(e)(2). MARPAT Aviation did not have this FAA letter of authorization.

Title 14 *CFR* 91.146 stated that passenger-carrying flights for the benefit of a charitable, nonprofit, or community event were not subject to the certification requirements of Part 119. Charitable flights were allowed to be operated under Part 91 with specific conditions. A charitable event was considered to be an event that raises funds for the benefit of an organization that qualifies as a charitable organization under Department of the Treasury regulations. Neither MARPAT Aviation nor the Huey reunion event was associated with such a charitable organization.

Title 14 *CFR* 91.319, Aircraft Having Experimental Certificates: Operating Limitations, stated in paragraph (a) that "no person may operate an aircraft that has an experimental certificate— (1) for other than the purpose for which the certificate was issued; or (2) carrying persons or property for compensation or hire." On April 10, 2024, the NTSB received an email from the FAA, stating that MARPAT Aviation did not operate the helicopter in accordance with section 91.319(a)(2).

1.8.7 Living History Flight Experience Flights

The FAA established its living history flight experience (LHFE) policy in the mid-1990s to provide a means for private owners and operators of historically significant US-manufactured World War II military aircraft to conduct limited passenger-carrying flights for compensation to generate funds for maintaining and preserving such historically significant aircraft. Operators providing LHFE flights can be exempted from certain Part 119 and Part 91 regulations, allowing exemption holders to carry passengers for compensation or hire under either a limited or an experimental airworthiness certificate.

As of November 2022 (5 months after the accident), 21 owners or operators of historically significant military aircraft held LHFE exemptions from the FAA; 6 of these exemption holders operated UH-1 helicopters. MARPAT Aviation did not have an LHFE exemption and did not apply for any other exemptions to operate the accident helicopter for compensation or hire with an experimental-category airworthiness certificate.

1.8.8 Related Previous Accident

The Australian Transport Safety Board (ATSB) investigated a similar accident involving a UH-1H helicopter on April 17, 2018, in Talbingo, New South Wales. The engines failed while the helicopter was conducting long-line lifting operations. During the subsequent forced landing, the helicopter collided with trees and a riverbed. The pilot sustained serious injuries, and the helicopter was destroyed.

The ATSB's investigation found that the engines failed because the inner struts in the exhaust diffuser had fractured. According to the ATSB website (accessed June 10, 2024), the fracture "was the result of high-cycle metal fatigue, which had not been detected for at least 36 routine maintenance inspections prior to the accident." In addition, the ATSB found that "maintenance practices and processes were likely inadequate" to detect the fracture and prevent the impending failure.

2. Analysis

2.1 Introduction

This accident occurred during a flight offered as part of an annual reunion event that showcased a former military turbine-powered UH-1B helicopter. A volunteer safety pilot (the pilot-in-command) was in the left seat, and a pilot-rated passenger, who made a required "donation" to fly the helicopter, was in the right seat.[35] The four other passengers each made a "small donation" to ride in the helicopter. About 15 minutes after the flight departed, the helicopter impacted two powerlines and a rock face located about 3.5 nautical miles east of the airport while attempting a forced landing. The helicopter came to rest partially inverted on its right side on an asphalt road, and a postcrash fire ensued.

The accident site was located away from the flight route shown in figure 8 (section 1.7.1.1), but the investigation was unable to determine, based on the available evidence, why the helicopter was operating off the planned course. Postaccident examination of the engine found static damage in the compressor section; rotational damage in the gas-producer turbine; and additional damage to the exhaust diffuser, rear bearing cover, No. 2 bearing, and two power turbine blades.[36]

This analysis summarizes the accident sequence (section 2.2) and the events that led to the above-mentioned engine damage on the helicopter (section 2.3). This analysis also discusses the following:

- the FAA's insufficient inspection and maintenance requirements for the UH-1B and other former military turbine-powered aircraft (section 2.4),
- the operator's inadequate inspection and maintenance of the accident helicopter (section 2.5),
- the operator's inadequate management of the helicopter's experimental airworthiness certificate (section 2.6),
- the FAA's lack of oversight of the accident helicopter's experimental airworthiness certificate (section 2.6),
- the lack of guidance for FAA inspectors to perform routine surveillance of operators with experimental exhibition airworthiness certificates, and

[35] Section 2.6 discusses the operator's use of the term "donation."

[36] The NTSB could not determine, from the available evidence, if the power turbine blades fractured before or during the accident flight.

- the need for a method to ensure that operators of experimental exhibition aircraft meet their annual obligation to submit program letters to the appropriate FSDO (section 2.6).

The NTSB notes that the investigation of this accident was hampered by the lack of data in several areas, including aircraft position.[37] Further, MARPAT Aviation did not establish standard operating procedures for the helicopter or have flight logs or written documentation of the maneuvers that volunteer pilots practiced before the reunion flights. As a result, the investigation could not fully assess the operator's procedures, training, or evaluation of pilots for the reunion event. In addition, the FAA staff members who were responsible for the Memorandum of Deviation to Order 8130.2G (which revised the operating limitations for experimental airworthiness certificates for the purpose of exhibition) are no longer working at the agency, so the investigation could not determine the reason for those revisions. Nevertheless, after completing a comprehensive review of the available evidence, the investigation established that the following factors did not contribute to the cause of the accident:

- *Helicopter structures and systems*: The accident helicopter's airframe, main rotor system, and flight control system showed no evidence of a preimpact malfunction or failure. A fractured piece of the main gearbox forward fairing was found away from the main wreckage but near the two severed powerlines, demonstrating that the helicopter was intact until it contacted the powerlines.

  A tail rotor blade pitch change link rod end was found separated at the accident site. Examination of the associated pitch horn showed deformation on one side, indicating that the attachment hardware was likely present during the accident flight and had fractured and separated due to impact forces. Thus, the accident helicopter's tail rotor system also showed no evidence of a preimpact malfunction or failure.
- *Weather/visibility*: Visual meteorological conditions prevailed on the day of the accident, and the reported weather indicated no environmental restrictions to visibility that would have reduced the pilot's ability to see the powerlines.

[37] Title 14 *CFR* 91.225(f) generally requires ADS-B data to be transmitted for each flight, but no ADS-B data were transmitted for the accident flight because the helicopter's position lights (which allowed ADS-B data to be transmitted) were not on during the flight. Even though the pilot-in-command of the accident flight should have ensured that the helicopter was capable of transmitting ADS-B data during the flight, such capability would likely have had no effect on the outcome of the flight because no one at MARPAT Aviation would have been following the flight. Also, the helicopter's flightpath might have been too low for ground stations to receive transmitted ADS-B data.

Thus, the NTSB concludes that the helicopter structures and systems and the weather conditions were not factors in this accident.

2.2 Accident Sequence

The main rotor blades did not exhibit the significant impact fragmentation typically associated with a powered impact, indicating that a partial or total loss of engine power occurred before impact. The loss of engine power (discussed further in the next section) required an emergency autorotation and a forced landing. Although the road below the rock face was clear of trees and was fairly straight, the helicopter contacted powerlines during the forced landing, which resulted in a loss of control. The helicopter subsequently impacted the rock face, road, and guardrail near the bottom of the rock face. The guardrail impact likely caused the fuel tanks to rupture, which led to the postcrash fire. No evidence indicated that the helicopter entered the autorotation incorrectly. The NTSB concludes that, during the accident flight, the helicopter engine lost power, which necessitated an emergency autorotation, but the pilot was unable to maintain control of the helicopter after it struck powerlines.

Volunteer safety pilots, including the accident pilot, were briefed that "the safety pilot is the aircraft commander and in charge of all operations" and that "only the safety pilot will…set the aircraft down on any hard surface." The NTSB could not determine, from the available evidence for this investigation, whether the safety pilot or the pilot-rated passenger in the right front seat was the pilot flying during the forced landing. However, the safety pilot, as the pilot-in-command for the flight, was responsible for handling any emergency situation, including an autorotation due to a loss of engine power.

Autopsies performed on all six helicopter occupants determined that their cause of death was blunt force and thermal injuries. The accident was not survivable.

2.3 Loss of Engine Power

The helicopter was equipped with an Ozark Aeroworks T53-L-11D turboshaft engine, and the loss of engine power that occurred during the accident flight resulted from the engine-related events described below.

The fatigue regions at the spot welds attaching the inner cone to the bearing housing support on the exhaust diffuser had relatively smooth fracture features with dark oxides, which were consistent with stable fatigue crack growth. The cracks eventually linked together, progressed radially outward to the forward face of the inner cone, and continued around the inner cone, thus reducing the structural support at the forward end of the bearing housing support.

The rear bearing cover showed a pre-existing separation in the outer flange due to wall thinning from corrosion. The loss of the outer flange on the rear bearing cover reduced the load transfer between the bearing housing support and the inner cone at the aft end of the exhaust diffuser. The reduced load transfer to the inner cone at the forward and aft ends of the bearing housing support likely led to increased stresses at the inner strut support attachments, resulting in cracks at the inner and outer flanges for the inner struts.

The cracks in the exhaust diffuser led to reduced support for the No. 3 and No. 4 bearings, causing a misalignment in the power turbine shaft and rubbing on the power turbine blade shrouds.[38] As a result, the power turbine rotor assembly became imbalanced, which led to additional cracking in the exhaust diffuser and rubbing damage between the exhaust diffuser fracture faces.[39] The misalignment in the power turbine shaft led to rubbing with the rear compressor stub shaft, which resulted in frictional heating of the rear compressor stub shaft at the No. 2 bearing. The frictional heat then extended to the No. 2 bearing, causing it to fail.

The No. 2 bearing failure likely occurred later in the engine failure sequence given that the bearing cage was still intact and that it showed no evidence of damage or thermal distress, which would be consistent with the No. 2 bearing operating in a degraded condition for a relatively short period of time. The NTSB concludes that the loss of engine power resulted from the failure of the No. 2 bearing; that failure occurred because of degraded radial support for the power turbine shaft at the No. 3 and No. 4 bearings due to cracks in the exhaust diffuser and a separation of the rear bearing cover outer flange.

2.4 Federal Aviation Administration Inspection and Maintenance Standards

The FAA issued Order 8130.2G in August 2010 to provide inspectors with updated standards for the airworthiness certification of aircraft. Version G of the order stated that turbine-powered rotorcraft operated under an experimental exhibition airworthiness certificate were to be inspected under an FAA-approved program that met the requirements of 14 *CFR* 91.409(f). The Memorandum of Deviation to chapter 4, section 10 of Order 8130G, which became effective in December 2011,

[38] The fatigue crack that initiated in one of the power turbine blades likely resulted from the misalignment in the power turbine shaft and rubbing on the power turbine blade shrouds.

[39] The NTSB evaluated the photographs of the exhaust diffuser in the ATSB's final report (see section 1.8.8) along with the damage description in the ATSB's report. The NTSB determined that the damage patterns that the ATSB found were similar to those observed during this investigation.

then allowed such rotorcraft to be inspected according to the requirements of 14 *CFR* Part 43 Appendix D.

The inspection standards in Part 43 Appendix D did not have sufficient scope and depth for inspecting former military turbine-powered rotorcraft, especially given the complex design of typical former military rotorcraft. The NTSB's review of these standards found that they were generic inspection criteria for aircraft systems and components undergoing annual and 100-hour inspections. These criteria did not comprise an appropriate inspection program for former military turbine-powered rotorcraft; such a program would be expected to have more comprehensive information than only a listing of inspection criteria. For example, Appendix D stated that a reciprocating aircraft engine needed to be inspected for proper cylinder compression but did not specify critical turbine engine components for inspection, such as an engine compressor or turbine, and the necessary inspection steps to ensure the continued airworthiness for a complex turbine-powered aircraft.

Further, Appendix D stated that flight and engine controls were to be inspected for "improper installation and improper operation" and that all systems were to be inspected for "improper installation, poor general condition, apparent and obvious defects, and insecurity of attachment." However, Appendix D did not discuss the steps needed to properly assess the condition of flight and engine controls and system components. The NTSB concludes that the FAA erred when it allowed, via its 2011 Memorandum of Deviation to FAA Order 8130.2G, former military turbine-powered rotorcraft to be inspected and maintained according to Part 43 Appendix D because the inspection standards did not have the sufficient scope and detail to ensure the airworthiness of those rotorcraft.

The NTSB believes that the content of an inspection program should be commensurate with the type of aircraft that was issued an experimental certificate, that is, the more complex the aircraft, the more detailed the inspection program should be. The aviation safety inspector at the Charleston FSDO who approved the experimental exhibition certificates for the accident helicopter could have consulted additional sources, including US Army technical manuals and FAA AC 43-209A, when determining the operating limitations for the certificates.

The US Army technical manuals were referenced in the operating limitations for the restricted-category airworthiness certificates issued to the accident helicopter in April and October 2013. These certificates were issued under the provisions of change 1 to Order 8130.2, which became effective in July 2012. The operating limitations for the restricted airworthiness certificates stated that the UH-1B helicopter was to be serviced and maintained according to US Army technical manuals (including Technical Manual 55-1520-219-20) when the helicopter was operated under a restricted-category certificate (and was thus considered to be a

type-certificated product).[40] Unlike Part 43 Appendix D, Technical Manual 55-1520-219-20 provided inspection criteria for the compressor and turbine blades to ensure that they were not damaged or cracked and that no blades were missing.

US Army Technical Manual 55-1520-219-20 referenced Technical Manuals 55-1520-219-PMD, -PMI, and -PMP, which provided daily (PMD), intermediate (PMI), or periodic (PMP) preventive maintenance checklists for detecting and correcting damage on the UH-1B helicopter. Table 2 compares the requirements of Part 43 Appendix D with the requirements of the checklist in Technical Manual 55-1520-210-PMD.[41] (The interval for that checklist changed from a daily requirement when the US Army operated the helicopter to a 10-hour or 14-day requirement, whichever came first.)

Table 2 also shows that the US Army technical manual required more detailed inspections every 10 hours or 14 days than those required by the annual and 100-hour inspection criteria in Appendix D, which were general in nature. A comparison of the inspection requirements for the engine components that failed on the accident helicopter showed that, unlike Appendix D paragraphs (d)(3) and (d)(8), technical manual numbers 3.9 and 3.11 required inspections of the specific components that exhibited progressive damage that preceded the engine failure.

Table 2. Comparison of *Federal Aviation Regulation* and US Army engine inspection requirements.

Title 14 *CFR* Part 43 Appendix D	US Army Technical Manual 55-1520-210-PMD
(d) Each person performing an annual or [a] 100-hour inspection shall inspect (where applicable) components of the engine and nacelle group as follows: (1) Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks. (2) Studs and nuts—for improper torquing and obvious defects.	**Engine Area (Left Side)** 3.1. Engine cowling or fairing for security, damage, and loose or missing fasteners. 3.2. Engine air inlet, engine accessories and connections for damage and security. Check for fuel and oil leaks. 3.3 Electrical cables, ignition coil and leads; Fire Detector assembly for chafing, cracks and security. Check exciter box for condition and security,

[40] The version of FAA Order 8130.2 at the time (change 1) did not require that the US Army technical manuals be referenced in operating limitations issued for experimental exhibition airworthiness certificates. However, it is noteworthy that the operating limitations for the accident helicopter's May 2010 experimental airworthiness certificate (the first experimental certificate that the Charleston FSDO issued) stated that the helicopter was to be inspected "in accordance with the scope and detail of" Technical Manuals 55-1520-219-10 and 55-1520-219-20. (When the FSDO issued the next experimental airworthiness certificate for the accident helicopter in May 2012, the requirements of the deviation memo were in effect.)

[41] US Army Technical Manual 55-1520-210-PMD applied to the UH-1H helicopter but appears in table 2 because the investigation was unable to find a copy of Technical Manual 55-1520-219-PMD, which applied to the UH-1B helicopter (the accident helicopter model). However, enough similarities exist between the UH-1H and UH-1B helicopter such that Technical Manual 55-1520-219-PMD could be readily adapted for an inspection of the UH-1B helicopter.

Title 14 *CFR* Part 43 Appendix D	US Army Technical Manual 55-1520-210-PMD
(3) Internal engine—for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. If there is weak cylinder compression, for improper internal condition and improper internal tolerances. (4) Engine mount—for cracks, looseness of mounting, and looseness of engine to mount. (5) Flexible vibration dampeners—for poor condition and deterioration. (6) Engine controls—for defects, improper travel, and improper safetying. (7) Lines, hoses, and clamps—for leaks, improper condition and looseness. (8) Exhaust stacks—for cracks, defects, and improper attachment. (9) Accessories—for apparent defects in security of mounting. (10) All systems—for improper installation, poor general condition, defects, and insecure attachment. (11) Cowling—for cracks, and defects.	3.3.1. (Aircraft equipped with ODDS) check engine external oil filter bypass buttond for extended indication. 3.3.2. Chip Detectors for physical security and damage (i.e.broken wires). 3.4. Main and starter fuel manifolds for leaks and security, 3.5. Flow divider assembly inspect for leaks, damage, and security. 3.6. Engine compressor housing visually for cracks, scratches, corrosion and security. 3.7. Fuel control power lever for freedom of movement through full range to each stop. 3.8. Engine mounts visually for cracks, damage, and security. 3.9. Engine combustor chamber housing, exhaust diffuser, support cone, fireshield, firewall gaskets and seals, and tailpipe for cracks, dents, and burned or buckled areas. 3.10. Bleed air tubing for chafing and security. 3.11. Second stage turbine blades; inspect through tailpipe and through exhaust diffuser for cracks, burns, dents or missing blades. 3.12. Anti-collision light for condition, security , and cracked lens. 3.13. M52 smoke generator nozzle for condition and security. Oil lines for condition, security and leakage. **Engine Area (Right Side)** 5.1. Engine cowling or fairing for security, damage, and loose or missing fasteners. 5.2. Main and Start fuel manifolds for leaks and security, 5.3. Starter-generator intake and outlet ducts for deterioration and security. 5.4. Engine compressor housing visually for cracks, scratches, corrosion and security. 5.5. Engine combustor chamber housing, exhaust diffuser, support cone, fireshield, firewall gaskets and seals, and tailpipe for cracks, dents, and burned or buckled areas. 5.5.1. NOTE: Aircraft with Infrared Heat Suppressor (IRS) only: Check “V” clamp (clamp) that attaches the Forward Duct Assembly (Bellmouth Assembly) to the Insulated Exhaust Duct Assembly for visible damage and security. 5.6. Engine mounts visually for cracks, damage, and security. 5.7. MANDATORY SAFETY OF FLIGHT INSPECTION ITEM: Engine oil tank for security and oil level, lines for leaks or damage. Sight gages for damaged or stained glasses. 5.8. Exhaust thermocouple assembly for chafing, cracks and security. 5.9. Electrical cable assembly, ignition coil lead and fire detector assembly for chafing, cracks, and security.

Further, FAA AC 43-209A provided guidance on the development of inspection programs specifically for former military aircraft in the experimental exhibition category. The AC stated that the guidance should be incorporated into a program that the owner/operator would submit to the FAA. The NTSB notes that the April 2013 effective date of AC 43-209A was before the accident helicopter received its experimental airworthiness certificates in May 2013 and December 2014.

The AC included, among other things, procedures that considered time limitations and environmental conditions to mitigate the negative effect that extended periods of inactivity could have on the airworthiness of an aircraft and its components (paragraph 8 of the AC). The AC also recommended the use of inspection criteria from a manufacturer’s inspection guidelines in addition to the

requirements of Part 43 Appendix D (paragraph 16 of the AC). However, no evidence indicated that the aviation safety inspector at the Charleston FSDO coordinated with the operator to incorporate elements from the AC into the operating limitations issued with the helicopter's experimental airworthiness certificates.[42]

With the issuance of Order 8130.2H on February 4, 2015, the FAA returned to more stringent requirements for the inspection and maintenance of former military turbine-powered helicopters with experimental exhibition certificates, such as the accident helicopter. Specifically, this version of the order stated that these helicopters were to be maintained according to a program recommended by the helicopter manufacturer or a North Atlantic Treaty Organization military service. The current iteration of FAA Order 8130.2, version J, which has been in effect since July 2017, has generally the same requirement as version H regarding the type of inspection for former military turbine-powered rotorcraft. However, the accident helicopter was not required to be inspected according to either program because those requirements were not in effect in December 2014, when the helicopter's most recent experimental airworthiness certificate was issued.

In addition, appendix A, section 4, paragraph g(3) of Order 8130.2J (and previous versions of the order) stated that "the duration of exhibition experimental certificates is unlimited unless good cause exists to establish a specific period." Thus, experimental exhibition certificates contained no provision for the responsible FSDO to periodically review and issue new or amended operating limitations for an aircraft operating under such a certificate. The NTSB concludes that, because exhibition experimental airworthiness certificates do not expire, the FAA allowed the accident helicopter to continue to be maintained and inspected according to standards that were inadequate for former military turbine-powered aircraft, even though the FAA had revised those standards well before the accident occurred.

According to the FAA, as of March 2024, 126 former military turbine-powered aircraft (including 12 UH-1 helicopters) were being maintained and inspected under the provisions of Part 43 Appendix D. Other turbine-powered rotorcraft (especially those with experimental exhibition certificates issued when chapter 4 section 10 of the Memorandum of Deviation was in effect) might also be maintained and inspected according to inadequate standards. Therefore, the NTSB recommends that the FAA review all experimental exhibition airworthiness certificates issued to turbine-powered rotorcraft and ensure that their operating limitations meet the standards of the latest iteration of FAA Order 8130.2. The NTSB also recommends that the FAA establish periodic reviews for experimental exhibition airworthiness

[42] This situation has since been mitigated. Specifically, version H of FAA Order 8130.2H states, "refer to…AC 43-209 for additional information on aircraft inspection programs." Also, version J of the order states, "advise the applicant to consider FAA AC 43-209...in developing its inspection program."

certificates to ensure that those aircraft are being inspected and maintained according to the latest iteration of FAA Order 8130.2.

2.5 Operator Inspection and Maintenance of Helicopter

From December 5, 2014, to the date of the accident, the helicopter was certificated under a special experimental exhibition airworthiness certificate. During that time, MARPAT Aviation performed inspections of the helicopter according to the generic inspection criteria for aircraft systems and components in Appendix D to 14 *CFR* Part 43, as required. However, when the accident helicopter was operated under a restricted-category airworthiness certificate (before December 2014), MARPAT Aviation was required, by the associated operating limitations, to maintain the helicopter according to more comprehensive inspection standards, which were reflected in the checklist that the operator developed for those inspections. Table 3 compares the requirements of Part 43 Appendix D with the operator's checklist when the helicopter was operated under a restricted-category certificate. A comparison of the inspection requirements for the engine components that failed on the accident helicopter showed that, unlike Appendix D paragraphs (d)(3) and (d)(8), MARPAT Aviation checklist numbers 9 and 10 required inspections of the specific components with progressive damage that preceded the engine failure.

Table 3. Comparison of engine inspection requirements for the accident helicopter's experimental- and restricted-category certificates.

Title 14 *CFR* Part 43 Appendix D requirements for helicopter while under an experimental-category certificate	MARPAT Aviation 100-hour/annual inspection requirements for helicopter while under a restricted-category certificate
(d) Each person performing an annual or [a] 100-hour inspection shall inspect (where applicable) components of the engine and nacelle group as follows: (1) Engine section—for visual evidence of excessive oil, fuel, or hydraulic leaks, and sources of such leaks. (2) Studs and nuts—for improper torquing and obvious defects. (3) Internal engine—for cylinder compression and for metal particles or foreign matter on screens and sump drain plugs. If there is weak cylinder compression, for improper internal condition and improper internal tolerances. (4) Engine mount—for cracks, looseness of mounting, and looseness of engine to mount. (5) Flexible vibration dampeners—for poor condition and deterioration. (6) Engine controls—for defects, improper travel, and improper safetying. (7) Lines, hoses, and clamps—for leaks, improper condition and looseness. (8) Exhaust stacks—for cracks, defects, and improper attachment. (9) Accessories—for apparent defects in security of mounting. (10) All systems—for improper installation, poor general condition, defects, and insecure attachment. (11) Cowling—for cracks, and defects.	**Engine** 1. Engine cowling and fairing for loose or missing fasteners, damage, security, Fire detector elements for security of attachment and connections. Engine work platform deck for bond separation. 2. Airframe FOD [foreing object debris] screen for foreign material, air inlet filter for FOD, and loose or missing fasteners. Gap between screen sections, not to exceed screen width. 3. Separator, remove top airframe FOD screen assembly and upper air filter, clean sand and dust separator, foam and metal filter and inspect for damage. 4. Inlet housing, guide vanes and first stage compressor blades for oil streak and FOD, housing filter, support pads, front and rear flange for cracks, nicks and corrosion. 5. Engine oil tank for security, lines for leaks, condition and security. Drain and refill every 100 hours or 12 months whichever comes first. 6. Check chip detectors. 7. Engine accessories and connection for condition, damage, and security. 8. Engine compressor housing for cracks, scratches, corrosion, and security. Bleed band assembly for bends, cracks, and security. Air bleed actuator for cleanliness, condition, and security. 9. Engine combustion chamber housing, exhaust diffuser, support cone, fireshield, and tail pipe for cracks, dents, and burned or buckled areas.

Title 14 *CFR* Part 43 Appendix D requirements for helicopter while under an experimental-category certificate	MARPAT Aviation 100-hour/annual inspection requirements for helicopter while under a restricted-category certificate
	10. Second stage turbine blades through exhaust diffuser for cracks, burns, dents, and missing blades. 11. Engine mounts for cracks, damage, and security. 12. Raise engine so mount bearings are free of pillow blocks. Check trunnion bearing for cracks and excessive play. If limits are exceeded or cracks are found, replace bearing. 13. Electrical cable assembly, ignition coil lead, and exhaust thermocouple assembly for cracks, chafing, and security. 14. Main and starting fuel manifolds for leaks and security. Fuel control power lever for freedom of movement through full range to each stop. 15. Starting fuel nozzles, inspect, clean, check reinstall and or replace. 16. Main fuel filter element—inspect and replace if micronic paper type—clean if metal screen type and reinstall. 17. Fuel control cover assembly strainer—inspect, clean and reinstall. Replace servo filter. 18. Inspect, clean, and reinstall fuel control inlet filter element. 19. Power drive rotary booster pump for leaks, condition, and security. 20. Remove, inspect, clean, and reinstall oil filter, Determine source of chips, if any. 21. Check fuel and oil control hose assembly connections for leaks, condition, and security. 22. Starter generator cooling fan used with 200 amp generator, inspect impeller nut for tightness and bearing for binding. 23. Accessory drive gearbox assembly, over speed governor and tachometer drive assemblies for cracked flanges, leakage, and security.

For the accident helicopter's most recent restricted-category operating certificate (dated October 29, 2013), one of the operating limitations (paragraph 15) stated that MARPAT Aviation was required to inspect and maintain the helicopter according to US Army Technical Manuals 55-520-219-10 and 55-1520-219-20. The last time that the helicopter was operated under a restricted-category certificate was almost 8 years before the accident, and detailed inspection records from that time were not available. As a result, the investigation could not assess the degree to which the operator followed the inspection and maintenance procedures in those manuals when the helicopter was operated under a restricted-category certificate. However, the NTSB notes that the operator had a copy of both manuals and thus the necessary documentation (and possibly experience) to conduct inspection and maintenance activities according to the manual requirements when the helicopter was operated under an experimental-category certificate. In addition, the operator could have retrieved other US Army technical manuals from a UH-1 operator/industry collaborative website, such as www.uh1ops.com (accessed June 10, 2024).

The work orders for the accident helicopter's two most recent annual inspections in June 2021 and March 2022 (both of which occurred while the helicopter was under its most recent experimental airworthiness certificate) showed that the operator complied with the requirement to inspect and maintain the helicopter according to the provisions of Part 43 Appendix D. However, the operator's failure to detect the engine issues described in section 2.3 during those

inspections demonstrated that performing only the minimum FAA-required inspection was not sufficient for maintaining the accident helicopter in an airworthy condition.[43] The NTSB requested an interview with the MARPAT Aviation mechanic to discuss the inspections that he performed on the accident helicopter and the storage of the helicopter during prolonged periods of inactivity, but the mechanic did not respond to our request.

The NTSB notes that US Army Technical Manual 55-1520-219-20 required preservation of the helicopter and engine, if they were inactive for at least 7 days, using the storage procedures detailed in the technical manual. However, no evidence indicated that, during prolonged periods of inactivity, the accident helicopter and engine were preserved as stipulated in the technical manual. The extensive corrosion observed within the engine (as discussed in section 1.5.2) would likely have been mitigated if the related procedures in the technical manual had been followed.

MARPAT Aviation missed opportunities to detect the pre-existing engine damage before the 2022 Huey reunion flights began. For example, unlike Part 43 Appendix D, the US Army preventive maintenance daily inspection stated that the power turbine blades and exhaust diffuser were to be inspected to prevent "latent defects" that could lead to a malfunction. The preventive maintenance inspection in the Interagency Committee for Aviation Policy's *UH-1 Series Inspection Planning Guide* stated that such an inspection should be conducted every 10 hours or 14 days, whichever came first.[44] Thus, the operator could have proactively applied the referenced actions but did not do so.

MARPAT Aviation had the ultimate responsibility for maintaining the accident helicopter, which it did according to the minimum inspection standards that the FAA had in place at the time of the helicopter's most recent experimental airworthiness certificate. However, MARPAT Aviation should have understood that those standards were not as rigorous as those that were used when the helicopter was operated under a restricted-category certificate. Section 2.4 detailed the FAA actions that played a role in this accident, but it is equally important to recognize that MARPAT

[43] Between May 2010 and December 2014, the accident helicopter was operated under three restricted-category certificates and four experimental-category certificates (as shown in table 1). With Order 8130.2H, which was issued in February 2015, the FAA implemented more stringent inspection standards for former military turbine-powered rotorcraft. If MARPAT Aviation had continued its pattern of operating the helicopter under a restricted-category certificate for part of a year and an experimental-category certificate for the rest of the year, the operator would have had to follow the more stringent inspection standards in Order 8130.2H.

[44] The Interagency Committee for Aviation Policy's *UH-1 Series Inspection Planning Guide* contained other recommended inspection criteria and intervals for the accident helicopter model, including 50-, 100-, and 150-hour inspections. The operator had a copy of the guide and should thus have been aware of the guide's stated purpose to provide a "reasonable basis for inspection program development" (General Services Administration 2002).

Aviation's decision not to use more rigorous inspection standards when the helicopter was operated under an experimental-category certificate was also a factor that led to this accident. Thus, the NTSB concludes that, although the operator was not required to inspect and maintain the helicopter beyond the criteria in Part 43 Appendix D, the operator was likely aware that more stringent inspection and storage procedures for UH-1-series helicopters existed (and had been previously used), and the operator should have used those procedures to ensure the helicopter's airworthiness.

Further, if the operator had followed the instructions in either US Army Technical Manual 55-1520-219-PMD or the UH-1 inspection guide when the helicopter was under an experimental airworthiness certificate, the power turbine and exhaust diffuser would have been inspected more frequently than every 100 hours and annually. More frequent and more rigorous inspections would have increased the possibility that the operator could have detected and resolved the damage on the power turbine and exhaust diffuser before that damage would ultimately lead to the loss of engine power.

If the fractured turbine blades had been detected by more frequent visual inspections of the turbine wheel, as described in either US Army Technical Manual 55-1520-219-PMD or the UH-1 inspection guide, then other issues with the exhaust diffuser cracks and rear bearing separation would also likely have been detected during disassembly and subsequent inspections of the disassembled parts. The NTSB concludes that the engine exhaust diffuser cracks and the separation in the rear bearing cover could have been detected if the operator had used more frequent inspection intervals, such as those required when the helicopter was operating under a restricted-category airworthiness certificate. The NTSB also concludes that the operator's failure to inspect the engine using more frequent inspection intervals and more rigorous standards readily available to the operator resulted in missed opportunities to potentially detect engine problems that indicated more significant, long-term engine issues.

The rear bearing cover and exhaust diffuser inner struts of the Ozark Aeroworks T53-L-11D turboshaft engine are not visible through the tail pipe, precluding the detection of damage to those parts during a routine visual inspection unless the exhaust diffuser cover is removed. Part of the inner cone is visible up the tail pipe, but the location of the pre-existing cracks at the spot welds and on the forward face of the accident engine inner cone would be hidden from view without removing the exhaust diffuser cover. The NTSB concludes that, for Ozark Aeroworks T53-series engines, a recurrent inspection involving the removal of the exhaust diffuser cover to provide visual access to the rear bearing cover and the exhaust diffuser inner cone and inner struts would increase the probability of detecting damage that could indicate more significant engine issues. Therefore, the NTSB recommends that the FAA require operators of aircraft equipped with Ozark

Aeroworks T53-series engines to perform recurrent inspections of the rear bearing cover and the exhaust diffuser inner cone and inner struts with the exhaust diffuser cover removed.

In addition, the operating limitations for the operator's restricted-category certificate also referenced a 2007 report by the holder of the FAA type certificate data sheet for the UH-1B (Richards Heavylift Helo). The report stated that the tail rotor blades on the accident helicopter had a retirement time (life limit) of 1,200 hours.[45] Because the accident helicopter was no longer be considered a type-certificated product once it received an experimental airworthiness certificate (that is, the helicopter was no longer type certificated under a restricted-category type certificate data sheet), the operator could document an equivalent level of safety instead of following the manufacturer's specified life limit. No such documentation was found; thus, the tail rotor blades were required to be replaced after 1,200 hours.

At the time of the accident helicopter's last inspection in March 2022, one tail rotor blade (serial number ATR-274125) had exceeded its manufacturer-specified life limit by 54 hours, and the other tail rotor blade (serial number ATR-72106) had exceeded its life limit by 62 hours. In addition, at the time of the accident (3 months later), the tail rotor blades had exceeded their life limits by about 68 and 76 hours, respectively. The NTSB concludes that, although the condition of the tail rotor blades was not a factor in this accident, the operator's failure to replace them once they exceeded their life limits further demonstrated the inadequacy of the operator's maintenance procedures for the accident helicopter.

2.6 Operator Management of Certificate and Federal Aviation Administration Oversight of Certificate

As part of the operating limitations for the helicopter's latest experimental airworthiness certificate, the FAA required MARPAT Aviation to provide an annual program letter that described the events planned for the helicopter. The FAA stated that it considered that information when scheduling surveillance activities for the operator and the aircraft.

The MARPAT Aviation owner did not provide a program letter notifying the FAA about any of the reunion flights; the owner incorrectly assumed that he did not need to provide such notification because the flights would be conducted at the operator's home base. The MARPAT Aviation owner should have been aware of the requirement to provide program letters to the Charleston FSDO because paragraph No. 4 in the helicopter's most recent operating limitations addressed the program letters; the owner signed a statement in December 2014 acknowledging that he read

[45] This information was also presented in US Army Technical Manual 55-1520-219-20.

and understood the operating limitations for the helicopter's experimental airworthiness certificate.

Because MARPAT Aviation did not provide a program letter to the FAA about the operation of the accident helicopter at annual Huey reunion events, the Charleston FSDO was unaware that the operator was flying the helicopter at those events. It is important to note that the Charleston FSDO was also unaware of these helicopter flights because the FSDO had not performed routine surveillance of the operator (separate from its Part 145 repair station certificate) before the accident.

The NTSB concludes that program letters are a necessary tool to facilitate FAA surveillance of experimental exhibition aircraft, and operators of such aircraft need to provide those letters to comply with the aircraft's operating limitations. Therefore, the NTSB recommends that the FAA remind operators of experimental exhibition aircraft about the requirement to submit, to the appropriate FSDO, program letters that list all events at which the aircraft will be exhibited. The NTSB also recommends that the FAA develop a method for ensuring that operators of experimental exhibition aircraft meet their annual obligation to submit program letters; such a method could include potential penalties for operators that do not meet this obligation.

The FAA issued Order 8900.1 to establish a repository for policy and guidance regarding aviation safety inspector job tasks. However, the order contained no guidance for inspectors to provide routine surveillance of Part 91 operators with an experimental airworthiness certificate (such as MARPAT Aviation) to ensure that they were complying with the operating limitations associated with that certificate. Instead, the order provided general guidance that was applicable to any Part 91 operation. Thus, in addition to the lack of program letters from the operator to the FAA, the NTSB concludes that the lack of guidance in FAA Order 8900.1 for inspectors to perform routine surveillance of operators with experimental exhibition airworthiness certificates was a factor in the Charleston FSDO's failure to perform such surveillance of the accident operator. Therefore, the NTSB recommends that the FAA revise Order 8900.1 to include inspector guidance requiring routine surveillance of operators of aircraft with experimental exhibition airworthiness certificates.

MARPAT Aviation did not have an operating certificate under 14 *CFR* 119.1 or a letter of authorization under 14 *CFR* 91.147 providing an exception to section 119.1(e)(2). Also, 14 *CFR* 91.319(a)(2) stated that an aircraft with an experimental airworthiness certificate cannot carry persons or property for compensation or hire. The MARPAT Aviation owner did not consider donations to fly or ride in the accident helicopter to be compensation because the operator sought those donations to offset fuel costs. However, in an April 10, 2024, email, the FAA stated that MARPAT Aviation did not operate the helicopter in accordance with section 91.319(a)(2).

MARPAT Aviation could have applied for an LHFE exemption, which would have allowed it to operate the helicopter under Part 91 and seek funds to offset fuel costs. The existing LHFE framework should have provided the opportunity for more oversight than the typical oversight for Part 91 operations (which, in this case, was basically no oversight). Further, on April 13, 2021, the NTSB issued Safety Recommendation A-21-11, which asked the FAA to do the following:

> Revise Order 8900.1, Flight Standards Information Management System, to include guidance for inspectors who oversee operations conducted under any of the living history flight experience exemptions to identify potential hazards and ensure that operators are appropriately managing the associated risks.

On August 29, 2023, the FAA stated that in 2020 it implemented an annual surveillance requirement for all LHFE operators and that it issued additional guidance for inspectors in 2021 and 2022. The FAA also stated that it published aviation safety inspector training and guidance to support the inspectors' LHFE surveillance responsibilities. On July 8, 2024, the NTSB stated that the FAA's actions met the intent of the recommendation and classified it Closed—Acceptable Action. Although the benefits of these enhancements to the LHFE framework would not have been available to MARPAT Aviation at the time of this accident, the existing and revised LHFE framework comprised additional layers of oversight that would likely have identified and mitigated the safety issues identified during this investigation.

Safety Recommendation A-21-11 was one of six new recommendations issued in the NTSB's final report about revenue passenger-carrying operations conducted under Part 91.[46] Safety Recommendation A-21-9 was another recommendation resulting from the NTSB's report. That recommendation asked the FAA to do the following:

> Develop national safety standards, or equivalent regulations, for revenue passenger-carrying operations that are currently conducted under Title 14 *Code of Federal Regulations* Part 91, including, but not limited to, sightseeing flights conducted in a hot air balloon, intentional parachute jump flights, and living history flight experience and other vintage aircraft flights. These standards, or equivalent regulations, should include, at a minimum for each operation type, requirements for initial and recurrent training and maintenance and management policies and procedures.

[46] *Enhance Safety of Revenue Passenger-Carrying Operations Conducted Under Title 14* Code of Federal Regulations *Part 91* (NTSB/AAR-21-03).

On August 29, 2023, the FAA stated that it included Part 91 revenue passenger-carrying operations in its "Rulemaking Prioritization Plan" and was developing rulemaking proposals that might address this safety recommendation. On July 8, 2024, the NTSB stated that it was encouraged by the rulemaking activities that the FAA reported; as a result, Safety Recommendation A-21-9 remained classified Open—Acceptable Response. (The recommendation had initially received that classification on January 5, 2022.)

Safety Recommendation A-21-9 was intended to ensure an increased level of safety for revenue passenger-carrying operations conducted under Part 91. If such a framework had existed for MARPAT Aviation, the operator might have had to ensure that its volunteer pilots had valid commercial pilot certificates, met specific flight currency requirements, and underwent initial and recurrent training specific to the passenger-carrying operation.[47] Also, such a framework could have ensured that MARPAT Aviation was properly maintaining and inspecting the accident helicopter according to a higher standard and safely conducting operations according to standard operating procedures. The NTSB concludes that, if the actions addressed in Safety Recommendation A-21-9 are fully implemented, operators such as MARPAT Aviation and aircraft such as the accident helicopter would be subject to bolstered regulations and the safety enhancements that would result from those regulations. As a result, the NTSB reiterates Safety Recommendation A-21-9.

[47] The accident pilot did not hold a commercial pilot certificate; he held a private pilot certificate, which is not appropriate for a pilot conducting passenger-carrying operations for compensation or hire. The operator had no specific currency requirements for this passenger-carrying operation other than that required by Part 91 for basic currency. In addition to not requiring initial and recurrent training, the operator did not require its volunteer pilots to practice emergency procedures.

3. Conclusions

3.1 Findings

1. The helicopter structures and systems and the weather conditions were not factors in this accident.

2. During the accident flight, the helicopter engine lost power, which necessitated an emergency autorotation, but the pilot was unable to maintain control of the helicopter after it struck powerlines.

3. The loss of engine power resulted from the failure of the No. 2 bearing; that failure occurred because of degraded radial support for the power turbine shaft at the No. 3 and No. 4 bearings due to cracks in the exhaust diffuser and a separation of the rear bearing cover outer flange.

4. The Federal Aviation Administration (FAA) erred when it allowed, via its 2011 Memorandum of Deviation to FAA Order 8130.2G, former military turbine-powered rotorcraft to be inspected and maintained according to Title 14 *Code of Federal Regulations* Part 43 Appendix D because the inspection standards did not have the sufficient scope and detail to ensure the airworthiness of those rotorcraft.

5. Because exhibition experimental airworthiness certificates do not expire, the Federal Aviation Administration (FAA) allowed the accident helicopter to continue to be maintained and inspected according to standards that were inadequate for former military turbine-powered aircraft, even though the FAA had revised those standards well before the accident occurred.

6. Although the operator was not required to inspect and maintain the helicopter beyond the criteria in Title 14 *Code of Federal Regulations* Part 43 Appendix D, the operator was likely aware that more stringent inspection and storage procedures for UH-1-series helicopters existed (and had been previously used), and the operator should have used those procedures to ensure the helicopter's airworthiness.

7. The engine exhaust diffuser cracks and the separation in the rear bearing cover could have been detected if the operator had used more frequent inspection intervals, such as those required when the helicopter was operating under a restricted-category airworthiness certificate.

8. The operator's failure to inspect the engine using more frequent inspection intervals and more rigorous standards readily available to the operator

resulted in missed opportunities to potentially detect engine problems that indicated more significant, long-term engine issues.

9. For Ozark Aeroworks T53-series engines, a recurrent inspection involving the removal of the exhaust diffuser cover to provide visual access to the rear bearing cover and the exhaust diffuser inner cone and inner struts would increase the probability of detecting damage that could indicate more significant engine issues.

10. Although the condition of the tail rotor blades was not a factor in this accident, the operator's failure to replace them once they exceeded their life limits further demonstrated the inadequacy of the operator's maintenance procedures for the accident helicopter.

11. Program letters are a necessary tool to facilitate Federal Aviation Administration surveillance of experimental exhibition aircraft, and operators of such aircraft need to provide those letters to comply with the aircraft's operating limitations.

12. The lack of guidance in Federal Aviation Administration Order 8900.1, Flight Standards Information Management System, for inspectors to perform routine surveillance of operators with experimental exhibition airworthiness certificates was a factor in the Charleston, West Virginia, Flight Standards District Office's failure to perform such surveillance of the accident operator.

13. If the actions addressed in Safety Recommendation A-21-9 are fully implemented, operators such as MARPAT Aviation and aircraft such as the accident helicopter would be subject to bolstered regulations and the safety enhancements that would result from those regulations.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident is the operator's failure to adequately inspect the former military turbine-powered helicopter, which allowed an engine issue to progress and result in a loss of engine power and a subsequent loss of control after the helicopter struck powerlines during a forced landing. Also causal to the accident were the following:

- the Federal Aviation Administration's (FAA) inadequate inspection and maintenance standards for former military turbine-powered aircraft operating with an experimental exhibition airworthiness certificate;

- the operator's use of those standards instead of more rigorous standards, which were readily available to the operator and previously used to inspect and maintain the helicopter; and
- the FAA's inadequate oversight of the operator, which did not detect the inherent risk associated with the operation.

4. Recommendations

4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations.

To the Federal Aviation Administration:

Review all experimental exhibition airworthiness certificates issued to turbine-powered rotorcraft and ensure that their operating limitations meet the standards of the latest iteration of Federal Aviation Administration Order 8130.2, Airworthiness Certification of Aircraft. (A-24-20)

Establish periodic reviews for experimental exhibition airworthiness certificates to ensure that those aircraft are being inspected and maintained according to the latest iteration of Federal Aviation Administration Order 8130.2, Airworthiness Certification of Aircraft. (A-24-21)

Require operators of aircraft equipped with Ozark Aeroworks T53-series engines to perform recurrent inspections of the rear bearing cover and the exhaust diffuser inner cone and inner struts with the exhaust diffuser cover removed. (A-24-22)

Remind operators of experimental exhibition aircraft about the requirement to submit, to the appropriate flight standards district office, program letters that list all events at which the aircraft will be exhibited. (A-24-23)

Develop a method for ensuring that operators of experimental exhibition aircraft meet their annual obligation to submit program letters; such a method could include potential penalties for operators that do not meet this obligation. (A-24-24)

Revise Federal Aviation Administration Order 8900.1, Flight Standards Information Management System, to include inspector guidance requiring routine surveillance of operators of aircraft with experimental exhibition airworthiness certificates. (A-24-25)

4.2 Previously Issued Recommendation Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendation.

To the Federal Aviation Administration:

Develop national safety standards, or equivalent regulations, for revenue passenger-carrying operations that are currently conducted under Title 14 *Code of Federal Regulations* Part 91, including, but not limited to, sightseeing flights conducted in a hot air balloon, intentional parachute jump flights, and living history flight experience and other vintage aircraft flights. These standards, or equivalent regulations, should include, at a minimum for each operation type, requirements for initial and recurrent training and maintenance and management policies and procedures. (A-21-9)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

THOMAS CHAPMAN
Member

ALVIN BROWN
Member

J. TODD INMAN
Member

Report Date: August 14, 2024

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of this accident about 1833 eastern daylight time on June 22, 2022. Investigators from the NTSB's Eastern Region office and an airworthiness investigator from NTSB headquarters responded to the accident scene the next day. Investigative groups were formed in the areas of airworthiness, operations, and powerplants. A specialist in the area of metallurgy was assigned to support the investigation. Parties to the investigation were the Federal Aviation Administration and Ozark Aeroworks.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board's collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board's use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the Federal Aviation Administration

A-24-20

Review all experimental exhibition airworthiness certificates issued to turbine-powered rotorcraft and ensure that their operating limitations meet the standards of the latest iteration of Federal Aviation Administration Order 8130.2, Airworthiness Certification of Aircraft.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Federal Aviation Administration Inspection and Maintenance Standards. Information supporting (b)(1) can be found on pages 34 through 37; (b)(2) can be found on page 38; and (b)(3) is not applicable.

A-24-21

Establish periodic reviews for experimental exhibition airworthiness certificates to ensure that those aircraft are being inspected and maintained according to the latest iteration of Federal Aviation Administration Order 8130.2, Airworthiness Certification of Aircraft.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Federal Aviation Administration Inspection and Maintenance Standards. Information supporting (b)(1) can be found on page 38; (b)(2) can be found on page 39; and (b)(3) is not applicable.

A-24-22

Require operators of aircraft equipped with Ozark Aeroworks T53-series engines to perform recurrent inspections of the rear bearing cover and the exhaust diffuser inner cone and inner struts with the exhaust diffuser cover removed.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5. Operator Inspection and Maintenance of Helicopter. Information supporting (b)(1) can be found on pages 39 and 40; (b)(2) can be found on pages 41 through 43; and (b)(3) is not applicable.

A-24-23

Remind operators of experimental exhibition aircraft operators about the requirement to submit, to the appropriate flight standards district office, program letters that list all events at which the aircraft will be exhibited.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.6, Operator Management of Certificate and Federal Aviation Administration Oversight of Certificate. Information supporting (b)(1) can be found on pages 44 and 45; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-24

Develop a method for ensuring that operators of experimental exhibition aircraft meet their annual obligation to submit program letters; such a method could include potential penalties for operators that do not meet this obligation.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.6, Operator Management of Certificate and Federal Aviation Administration Oversight of Certificate. Information supporting (b)(1) can be found on pages 44 and 45; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-25

Revise Federal Aviation Administration Order 8900.1, Flight Standards Information Management System, to include inspector guidance requiring routine surveillance of operators of aircraft with experimental exhibition airworthiness certificates.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.6, Operator Management of Certificate and Federal Aviation Administration Oversight of Certificate, Title. Information supporting (b)(1) can be found on page 45; (b)(2) is not applicable; and (b)(3) is not applicable.

Appendix C: Federal Aviation Administration Order 8130.2

Version G of Federal Aviation Administration Order 8130.2, paragraph 4113, stated the following:

> (29) All large airplanes, turbojet airplanes, turbopropeller-powered multiengine airplanes, or turbine-powered rotorcraft must be maintained in with accordance an FAA-approved inspection program meeting the scope and content as described in 14 CFR § 91.409(f). Completion of these inspections must be recorded in the aircraft maintenance records.
>
> (30) Inspections for all large airplanes, turbojet airplanes, turbopropeller-powered multiengine airplanes, and turbine-powered rotorcraft must be recorded in the aircraft maintenance records showing the following, or a similarly worded, statement: 'I certify that this aircraft has been inspected on [insert date] in accordance with the scope and detail of [identify applicable inspection program] and found to be in a condition for safe operation.'
>
> (31) No person may operate aircraft other than those described in limitations (29) and (30) of this paragraph unless within the preceding 12 calendar months it has had a condition inspection performed in accordance with the scope and detail of 14 CFR part 43, appendix D, or other FAA-approved programs, and was found to be in a condition for safe operation. This inspection will be recorded in the aircraft maintenance records.
>
> (32) Condition inspection for aircraft other than those described in limitations (29) and (30) of this paragraph must be recorded in the aircraft maintenance records showing the following, or a similarly worded, statement: 'I certify that this aircraft has been inspected on [insert date] in accordance with the scope and detail of 14 CFR part 43, appendix D, and found to be in a condition for safe operation.' The entry will include the aircraft's total time-in-service and the name, signature, certificate number, and type of certificate held by the person performing the inspection.

Paragraph 4113 of the FAA Memorandum of Deviation to Order 8130.2G stated the following:

> (29) All single engine turbojet airplanes and turbopropeller-powered airplanes must be maintained in accordance with an FAA accepted inspection program of such detail to encompass the entire aircraft.

Completion of inspections must be recorded in aircraft maintenance records and include the following items: date, work performed, name and certificate number of person returning aircraft to service.

(30) All large airplanes, turbojet multiengine airplanes, turbopropeller-powered multiengine airplanes, or turbine-powered rotorcraft must be maintained in accordance with an FAA approved inspection program meeting the scope and content as described in 14 CFR § 91.409(f). Completion of these inspections must be recorded in the aircraft maintenance records.

(31) Inspections for all turbine airplanes and turbine–powered rotorcraft must be recorded in the aircraft maintenance records showing the following, or a similarly worded, statement: 'I certify that this aircraft has been inspected on [insert date] [identify applicable inspection program] and found to be in a condition for safe operation.'

(32) The inspections for aircraft must be recorded in the aircraft maintenance records showing the following, or a similarly worded, statement: 'I certify that this aircraft has been inspected on [insert date] in accordance with the scope and detail of 14 CFR part 43, appendix D, and found to be in a condition for safe operation.' The entry will include the aircraft's total time-in-service and the name, signature, certificate number, and type of certificate held by the person performing the inspection.

(33) No person may operate an aircraft unless within the preceding 12 calendar months it has had an inspection performed in accordance with the scope and detail of 14 CFR part 43, appendix D, or other FAA-accepted program, as applicable, and was found to be in a condition for safe operation. This inspection will be recorded in the aircraft maintenance records and include the following items: date, work performed, name and certificate number of person returning aircraft to service.

(41) The aircraft may not be operated unless the replacement for life-limited articles specified in the applicable technical publications pertaining to the aircraft and its articles are complied with in one of the following manners as specified below:

(a) Type-Certificate Products: Replacement of life-limited parts required by 14 CFR §91.409(e) is only applicable to experimental exhibition aircraft when the required replacement times are specified in the U.S. aircraft specifications, or type certificate data sheets.

> (b) Non-Type Certificated Products: Unless otherwise determined by the FAA, all articles installed in non-type certificated products operated in the experimental exhibition category, in which the manufacturer has specified limits, must include in their program an equivalent level of safety for those articles. Although the FAA recommends adherence to part replacements, achieving an equivalent level of safety for non-type certificated products is acceptable. Manufacturers have historically assigned life limits to articles installed in non-type certificated products. These products were typically operated in a military environment which imposed different limitations based on the aircraft's operational and environmental use. Although these limitations are not regulatory by the FAA we have determined that these limits must be evaluated for their current operating environment and addressed in the accepted inspection program. All articles installed in non-type certificated products operated in the experimental exhibition category, in which the manufacturer has specified limits, must include in their program an equivalent level of safety for those articles. The article must be inspected to ensure that it is still in a serviceable condition for safe operation.

Version H of the order, paragraph 470, stated that appendix C was to be referenced when issuing experimental exhibition operating limitations. Appendix C contained table C-1, which provided the following information about operating limitation No. 14 (applicable to all turbine rotorcraft):

> No person may operate this aircraft unless it is maintained in accordance with an inspection program meeting the scope and content described in § 91.409(f). The operator must select and identify in the aircraft maintenance records one of the following programs for the inspection of the aircraft:
>
> > (a) For type-certificated aircraft, a current inspection program recommended by the manufacturer; or
> >
> > (b) For former military aircraft, an inspection program recommended turbine engine by the manufacturer or North Atlantic Treaty Organization (NATO) airplanes, and turbine military service; or

(c) An FAA-approved inspection program.[48]

Note: To extend an inspection interval, the owner/operator must submit a request for that extension with supporting documentation and data to the local FSDO and obtain concurrence from that FSDO.

Inspections must be recorded in the aircraft maintenance records showing the following, or a similarly worded, statement: "I certify that this aircraft has been inspected on [insert date] per [identify applicable inspection program] and found to be in a condition for safe operation."

No person may operate this aircraft unless within the preceding 12 calendar months it has had a condition inspection performed in accordance with the scope and detail of part 43, appendix D, manufacturer or other FAA-approved programs, and was found to be in a condition for safe operation. The inspections must be recorded in the aircraft maintenance All other aircraft not records showing the following, or a similarly worded, statement: "I certify described above. that this aircraft has been inspected on [insert date] in accordance with [insert either: scope and detail of part 43, appendix D; or manufacturer's inspection procedures] and was found to be in a condition for safe operation." The entry will include the aircraft's total time-in-service (cycles if appropriate), and the name, signature, certificate number, and type of certificate held by the person performing the inspection.

Operating limitation No. 15, which was applicable to former military aircraft, stated the following:

This aircraft must not be operated unless it is operated, inspected, and maintained in accordance with appropriate military technical publications and/or manufacturer's recommendations.

Operating limitation No. 19 stated the following:

The aircraft may not be operated unless the replacement for life-limited articles specified in the applicable technical publications pertaining to the aircraft and its articles are complied with in one of the following manners:

[48] Although Part 43 Appendix D was considered to be an FAA-approved inspection program, Order 8130.2H required turbine-powered rotorcraft to be inspected under the provisions of operating limitation 14(b).

> (a) Type-Certificated Products: Replacement of life-limited parts required by § 91.409(e) applies to experimental aircraft when the required replacement times are specified in the U.S. aircraft specifications or type certificate data sheets.
>
> (b) Non-Type-Certificated Products: All articles installed in non-type-certificated products operated under an airworthiness certificate issued for an experimental purpose, in which the manufacturer has specified limits, must include in their program an equivalent level of safety for those articles. These limits must be evaluated for their current operating environment and addressed in the approved inspection program. All articles installed in non-type-certificated products in which the manufacturer has specified limits, must include in their program an equivalent level of safety for those articles. The article must be inspected to ensure the equivalent level of safety still renders the product in a serviceable condition for safe operation.

In FAA Order 8130.2J, chapter 4 provides the procedures for issuing a special airworthiness experimental certificate and references appendix D for issuing operating limitations for nonstandard aircraft. Operating limitation Nos. 15, 16, and 20 in appendix D of Order 8130.2J were nearly identical to operating limitation Nos. 14, 15, and 19, respectively, in appendix C of Order 8130.2H.

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