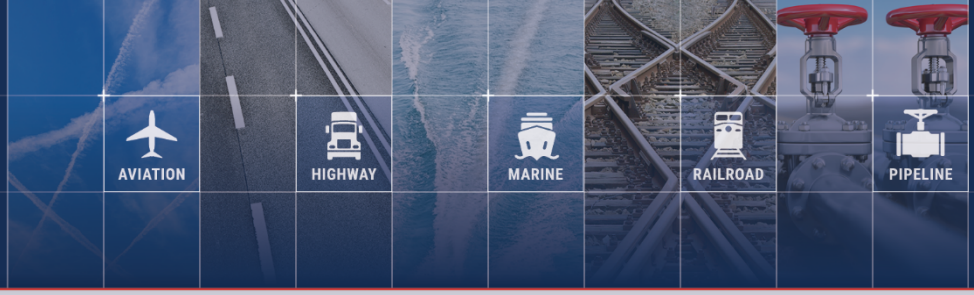

Aviation Investigation Final Report

Location:	Leesburg, Florida	**Accident Number:**	ERA21FA233
Date & Time:	May 25, 2021, 17:47 Local	**Registration:**	N9FH
Aircraft:	BHI H60 HELICOPTERS LLC UH-60A	**Aircraft Damage:**	Destroyed
Defining Event:	Collision with terr/obj (non-CFIT)	**Injuries:**	4 Fatal
Flight Conducted Under:	Part 91: General aviation - Flight test		

Analysis

According to the operator, a new water tank and snorkel were installed on the helicopter to facilitate firefighting operations. Several days of ground testing and calibration were performed before the accident flight, which was the first flight after the water tank was installed. The purpose of the local flight was to check the operation of the fire tank system. The helicopter made six uneventful passes in front of the operator's hangar at the airport and dropped water that was picked up from a lake adjacent to the airport. During each of these passes, the snorkel was observed to be stable. However, during the seventh pass, the snorkel was swinging from the helicopter. The helicopter then began to hover, released the water from the fire tank, and transitioned to forward flight, gaining altitude and airspeed. The snorkel continued to make large and slightly erratic oscillations as the helicopter climbed. Afterward, witnesses heard a loud bang, pieces of the main rotor blade and tail section separated, and the helicopter descended vertically to the ground. A postimpact fire ensued.

Given the sudden change in behavior of the snorkel from a consistently stable condition in normal flight to one with large and erratic oscillations, it is likely that the tank snorkel support structure was compromised and allowed the snorkel's oscillations to increase in such a way that the pump assembly at the end of the snorkel hose contacted the main rotor blade. The contact imparted enough energy to fracture the rotor blade at the contact point, which resulted in an imbalanced rotor system and a subsequent in-flight breakup of the helicopter.

The supplemental type certificate (STC) application for the water tank and snorkel had been approved by the Federal Aviation Administration (FAA) about 1 year prior to the accident. A review of the STC application documentation revealed that the FAA had not classified the

water tank and snorkel system as an external load. The structural analysis of the tank used the incorrect weight of the snorkel hose and pump combination and did not account for operational loads that would be imparted into the tank by the snorkel as called for in the certification basis in the project-specific certification plan (PSCP). Testing of the snorkel and pump loads did not incorporate the water tank structure to which the snorkel was attached. The system safety analysis did not address the hazard of the snorkel contacting the main rotor system. Increased consideration in any of these areas could likely have identified design insufficiencies.

In addition, the production tank that was used during flight testing was examined after the accident. A manual load test was performed with the snorkel attached to the tank snorkel support structure. When the snorkel was pulled manually from the tank, the tank structure between the hose coupler and the tank face deformed between 0.03 and 0.05 inches. These manual loads represented only a small fraction of the loads that the tank snorkel support structure would experience during normal operation. Thus, the documentation that supported the FAA's approval of the STC was insufficient because it failed to consider the failure scenario that occurred during the accident.

Probable Cause and Findings

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

The failure of the water tank snorkel support structure, which allowed the snorkel to contact the main rotor blades. Contributing to the accident was insufficient Federal Aviation Administration oversight of the supplemental type certificate process for the water tank and snorkel.

Findings

Aircraft	Equip attach fittings (on fus) - Failure
Organizational issues	Oversight of reg compliance - FAA/Regulator

Factual Information

History of Flight

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

On May 25, 2021, about 1747 eastern daylight time, a BHI H60 Helicopters LLC, UH-60A, N9FH, was destroyed when it was involved in an accident near Leesburg International Airport (LEE), Leesburg, Florida. The pilot, copilot, and two crewmembers were fatally injured. The helicopter was operated as a Title 14 *Code of Federal Regulations (CFR)* Part 91 post-maintenance test flight.

According to the operator, 8 days before the accident, a new water tank and snorkel were installed on the helicopter, in accordance with supplemental type certificate (STC) SR00933DE, to facilitate firefighting operations. Several days of ground testing and calibration were performed before the accident flight, which was the first flight after the water tank and snorkel were installed. The purpose of the local flight was to check the operation of the fire tank system, which included the new water tank and snorkel.

The helicopter made six uneventful passes in front of the operator's hangar at LEE and dropped water that was picked up from a lake adjacent to the airport. On the seventh pass, an employee of the operator noticed that the snorkel was swinging. He called the LEE air traffic control tower and told the controller to ask the pilot to slow down and land immediately. Before the controller could contact the pilot, the helicopter transitioned to forward flight, gaining altitude and airspeed. The employee noticed that the snorkel was "violently" swinging, and he heard a loud bang. The employee saw pieces of the helicopter, including the tail section, separate from the helicopter. Afterward, the helicopter started to spin and descended below the tree line. The employee then heard an explosion and saw smoke rise above the tree line.

According to another employee of the operator, she did not observe the helicopter's first pass but watched the next six passes. She noted that the water being dropped from the tank was "very dirty." During the helicopter's last pass, this employee noticed that the snorkel was swinging in a large circle and that the snorkel end came very close to the main rotor blades. She immediately started waving her arms at the pilot to try and get his attention, but the pilot did not see her. Shortly after the helicopter climbed transitioned to forward flight and gained airspeed, this employee heard a loud bang and saw multiple main rotor blades separate and hit the tail section of the helicopter. She then saw the tail section fall to the ground and the helicopter enter a flat spin.

Numerous other witnesses from the operator were present at the airport during the helicopter's flight, including some who were recording the helicopter's practice water drops. Twenty-two video clips were provided to the National Transportation Safety Board for review; 19 clips showed the helicopter performing water drops before the accident water drop pass, and 3 clips showed the accident water drop pass. In all the video clips before the accident pass, the helicopter was seen flying straight and level at a constant airspeed and releasing water over a specific point in the airport infield. As the helicopter approached the water release area, the snorkel hose was stable off the left side of the helicopter. As water was released from the water tank, the water was seen impinging on the snorkel hose, and the hose remained stable. In all the video clips showing the accident water drop pass, the snorkel hose made large and slightly erratic oscillations as the helicopter approached the water drop area. The helicopter began to hover and released the water from the tank, and the water impinged on the hose. None of the 22 video clips showed the helicopter's transition to forward flight or climbout immediately before the accident.

A security video camera mounted to a hangar that faces runway 3 captured the helicopter accident after it dropped off the water supply and proceeded down the runway heading. The video showed the helicopter flying away from the camera in level flight. The helicopter yawed suddenly, started to rotate around its vertical axis, and broke apart. The helicopter then descended vertically into the wooded area beside the runway. The behavior of the snorkel could not be observed in the video.

Pilot Information

Certificate:	Commercial	**Age:**	35,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	Helicopter	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	January 21, 2021
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	December 9, 2020
Flight Time:	4873 hours (Total, all aircraft), 1344 hours (Total, this make and model)		

Co-pilot Information

Certificate:	Commercial	**Age:**	35,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	4-point
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	January 21, 2021
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	2135 hours (Total, all aircraft), 2135 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	BHI H60 HELICOPTERS LLC	**Registration:**	N9FH
Model/Series:	UH-60A	**Aircraft Category:**	Helicopter
Year of Manufacture:	1981	**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	80-23461
Landing Gear Type:	Tailwheel	**Seats:**	4
Date/Type of Last Inspection:	December 21, 2020 Continuous airworthiness	**Certified Max Gross Wt.:**	2100 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo shaft
Airframe Total Time:	6603 Hrs as of last inspection	**Engine Manufacturer:**	GE
ELT:	Installed, not activated	**Engine Model/Series:**	T700-GE-701D
Registered Owner:	BRAINERD HELICOPTERS INC	**Rated Power:**	
Operator:	BRAINERD HELICOPTERS INC	**Operating Certificate(s) Held:**	Rotorcraft external load (133), On-demand air taxi (135)
Operator Does Business As:	Fire hawk	**Operator Designator Code:**	

Blackhawk Mission Equipment's STC for the internal water tank and snorkel installation on the UH-60A helicopter was approved on May 21, 2020, by the Federal Aviation Administration's aircraft certification office (ACO) in Denver, Colorado.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	LEE,75 ft msl	**Distance from Accident Site:**	1 Nautical Miles
Observation Time:	17:53 Local	**Direction from Accident Site:**	157°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	8 knots / None	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:	170°	**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:	30.15 inches Hg	**Temperature/Dew Point:**	32°C / 16°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Leesburg, FL	**Type of Flight Plan Filed:**	Company VFR
Destination:	Leesburg, FL	**Type of Clearance:**	VFR
Departure Time:		**Type of Airspace:**	Class D

Airport Information

Airport:	LEESBURG INTL LEE	**Runway Surface Type:**	Asphalt
Airport Elevation:	75 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	13	**IFR Approach:**	None
Runway Length/Width:	6300 ft / 100 ft	**VFR Approach/Landing:**	Traffic pattern

Wreckage and Impact Information

Crew Injuries:	2 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	2 Fatal	**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	On-ground
Total Injuries:	4 Fatal	**Latitude, Longitude:**	28.817965,-81.80863(est)

The wreckage was located in a localized swamp approximately 1,000 ft southeast from the approach end of runway 3. The wreckage was contained in a 31-ft diameter impact crater and had been consumed by fire. Section of all four rotor blades were contained with the main wreckage. The tail rotor remained attached to the vertical stabilizer and was located about 150

ft north-northeast of the main wreckage.

Parts of the newly installed water tank and snorkel assembly were found on the west edge of runway 3. The water pump housing, which was installed near the snorkel inlet, was heavily fragmented. The stainless-steel snorkel suction cage was located about 50 ft west of runway 3 along with a section of main rotor blade. Several pieces of fairings and light material were lodged in the top of trees along the flightpath from the edge of the tree line to the main wreckage.

The landing gear, main rotor system, main rotor drive system, engines, hydraulic system, and forward portion of the tail rotor drive system were thermally damaged by the postcrash fire. Most of the cockpit, cabin, and flight controls were consumed by the postcrash fire.

Portions of the water tank and snorkel hose connecting port were located next to the left main landing gear within the main wreckage. A 10-ft section of the hose assembly (not including the suction pump) was located underneath the forward left side of the fuselage. The upper hose remained attached to the tank snorkel support, and the coupler levers were in the locked position. Portions of the hose had torn away from the tank snorkel support, and the edges were melted. The suction pump and cage were not present on the end of the hose, and the recuperator and fragmented sections of the crown housing remained attached. Most of the molded front section of the tank was fragmented and was largely destroyed by fire. The snorkel port that extends out of the molded front section of the tank was recovered. Examination of the snorkel port where the metal snorkel attachment fixture (coupler) fastened to the tank snorkel port showed that the gasket between the carbon-fiber flange plate and the tank port structure had torn and separated on the aft side. All the flange fasteners were in place.

Tests and Research

The tank that underwent flight testing as part of the STC application process was production tank No. 1. The tank that was installed in the accident helicopter was production tank No. 2. An examination of production tank No.1 and a UH-60A helicopter (N135BH) was performed to document the snorkel attachment assembly in the remaining production water tank.

The water tank, snorkel, and water release gate were combined into a single system that could be placed in the cabin area of a UH-60 helicopter. The system was secured by a square tube-steel external frame that attached to the helicopter's existing upper cargo tie-down points and existing floor tie-down points. The molded front section that contained the snorkel attachment port, motorized water gate assembly (manufactured by Trotter Controls), and vent was designed and manufactured by Leading Edge Composites, which also assembled the tank side

panels, integrated the molded front section to the tank, and installed the water gate assembly and associated controls.

The 15-ft-long and 6-inch-diameter snorkel hose was attached to the water tank using a metal port that was attached to the tank via a carbon-fiber flange that contained a flapper valve fastened by eight AN4 bolts to a nut plate. The snorkel connected to the tank port using two lever camlocks (coupler). The water pump was attached to the free end of the snorkel. A power cable for the pump and a lightning protection cable extended down the length of the snorkel and were secured to the hose using nylon zip ties. The snorkel hose was not secured by any means other than the tank attachment point. The snorkel hose was not retractable.

To determine the tank structure deformation at the snorkel-to-tank interface, the tank port was fastened with 12 AN4 bolts and was torqued. The snorkel was attached to the tank using the coupler camlocks, as designed. A dial gauge was positioned at various points around the tank port. The snorkel was then placed on a wheeled dolly, and manual loads were applied in three separate directions (forward, lateral, and aft). (These test loads represented a fraction of the load that the tank port structure would be subjected to during flight and operation of the snorkel system.) The deflection of the tank port structure was measured as the snorkel was manually pulled away from the port and released back to a static position. The maximum deflection recorded was between 0.03 and 0.05 inches at the tank structure between the hose coupler and the tank face when the snorkel was pulled laterally from the tank.

Additional Information

A supplemental type certification (STC) is the FAA's approval of a major change in the type design of a product that was previously type certificated. An FAA aircraft certification office (ACO) issues the STC. Guidance for applying for and approving an STC is contained in FAA Advisory Circular (AC) 21-40A. The FAA ACO establishes a project team that generally consists of a project manager, engineers or technical specialists, flight test engineers and pilots, manufacturing inspectors, and operations inspectors. The FAA project team coordinates with the STC applicant to develop a project-specific certification plan (PSCP). Blackhawk Mission Equipment hired a program manager and numerous FAA designated engineering representatives (DER) to design the water tank and snorkel system, conduct testing, and provide associated documentation to the FAA project team.

The PSCP listed the following technical disciplines involved in the STC application: structures, electrical systems, mechanical and structures systems, flight analyst and pilot, Designated Airworthiness Representative for Manufacturing, coupon fabrication, and electrical systems and equipment. The Denver ACO assigned a project officer, electrical systems engineer, structures engineer, flight test engineer, flight test pilot, and flight standards representative. Section 4 of the PSCP, titled Project Type, stated the following:

> *This project is a Supplemental Type Certificate for 14 CFR part 29 regulations as determined by the Administrator, for installation of the internal water tank & snorkel install on the BHI H60A/L & S-70A/C model helicopters. The modifications are used in rotorcraft performing "External Load Operations & Do Carriage of Cargo' per 14 CFR Part 21.25(a)(2), (b)(1)(2) and (7).*

The PSCP did not specify the rotorcraft-load combination that would be applicable to the STC. According to the Denver ACO, the airworthiness standards for external loads for a transport-category rotorcraft (14 *CFR* 29.865) were not applied because the standard was directed toward human and nonhuman external cargo and the PSCP did not have 14 *CFR* 29.865 included as part of the certification basis for the project. The PSCP also did not include the airworthiness standards for rotor blade clearances from rotorcraft structure per 14 *CFR* 29.661.

A review of the Blackhawk Mission Equipment STC application package included a structural analysis of the water tank installation report, hose test report, flight test report, and functional hazard assessment (FHA) and system safety assessment (SSA). The structural analysis quantitively evaluated the water tank design and structural materials for emergency landing load cases per 14 *CFR* 29.561(a)(c) at amendment O. Review of the analysis report identified that an inaccurate amount of 100 pounds was used for snorkel and pump weight when the snorkel and pump weight was 137.5 pounds. The 100-pound vertical load was applied to the tank snorkel support calculation and given a margin of safety of +1.25.

Additionally, the calculations considered a static vertical load applied only to the snorkel support. The structural analysis of the snorkel support did not account for the type of dynamic loading that would be seen in operation, such as air loads imparted by the snorkel, lateral loads imparted by the snorkel, water loads imparted by the tank filling operation, water loads imparted by movement of the snorkel and pump horizontally through the water, or loads imparted by the snorkel if the assembly were snagged. After the accident, the FAA stated the following:

> *Subpart C-Strength Requirements in the PSCP, for General (29.301, 29.305(a), 29.307(a)), for flight loads (29.321-29.251, & 29.561(a)(c)) were part of the certification basis. This would have required determination of the lateral and dynamic forces on the snorkel to be used in the analysis.*

A hose test was conducted to determine the force required for the hose to fail in tension. The hose assembly contained a pump at one end and a hose coupler at the other end. The coupler was attached to a steel fixture, and the pump assembly was fixed to the ground. A forklift was used to lift the steel fixture with the coupled end and put tension on the hose assembly until it failed. The test found that the pump separated from the hose with 2,500 pounds of force. The test did not include the water tank snorkel support where the snorkel attaches to the tank or the lighting protection cable.

The flight test report documented the details of the ground and flight test results that were conducted to demonstrate compliance with the applicable FAA requirements. The flight tests included observation of the behavior of the tank and snorkel system at airspeeds from 0 to 193 knots indicated airspeed (1.1 times the never-exceed speed), angle of bank up to 30°, climbs, normal descents, and autorotative descents.

Although the snorkel had been flight tested with up to 30° of bank, the FAA-approved rotorcraft flight manual supplement contained no limitation to restrict operation with the tank and snorkel system to a maximum of 30° of bank. When asked after the accident why the flight test did not either test an angle of bank greater than 30° or establish a 30°-degree angle of bank limitation, the FAA stated the following: "Flight testing was accomplished up to 30 deg. AOB [angle of bank] in both directions….as can be found in the company flight test report BHJ-213-107, Rev A. There was not a AOB limitation created by the applicant as part of the STC." Thus, without an angle of bank limitation specified in the rotorcraft flight manual supplement, normal operation of the tank and snorkel system beyond 30° of bank would be permitted, which would exceed the maximum angle of bank that had been demonstrated during flight testing.

An FHA and SSA documented the most likely failure conditions and mitigations for the water tank and snorkel system. The functional hazard assessment identified 13 discrete failure/hazard conditions and their effect on the rotorcraft or crew. All 13 conditions were verified using a qualitative analysis method. Three conditions were classified as "no safety effect," seven were classified as "minor failure condition," and two were classified as "major failure condition": water tank attachments become unsecure in flight and snorkel pump becomes snagged on ground obstacle or object. The failure condition of the snorkel hitting or getting entangled in the aircraft (other than the tail or main rotor) was classified as a minor failure condition. Additionally, the possibility of the snorkel contacting any portion of the rotor system was not addressed in the FHA or the SSA. The FAA stated the following regarding why neither assessment addressed snorkel contact with the rotor system:

> The FHA/SSA did not include snorkel contact to the rotor system due to required compliance to [14 *CFR*] 29.251 – vibration, using flight testing. Flight test data showed that under normal operating parameters the snorkel structure would not create excessive vibrations to lead to the failure mode of the snorkel contacting the rotor system. These results satisfied [14 *CFR*] 29.1309, 'The equipment, system, and installations whose function is required by this subchapter must be

designed and installed to ensure that they performed their intended functions under any foreseeable operating condition.'

A key part of the system safety assessment is the methodology. Section 5.1 of the FHA/SSA for the water tank and snorkel described the methodology as follows:

> *The safety assessment process begins with the FHA and ends with the verification that the design meets the safety requirements and regulatory standards, The safety assessment process can be either qualitative, quantitative, or both.*
>
> - *Qualitative – Those analytical processes that assess system and aircraft safety in an objective non-numerical manner. Qualitative assessment is based on engineering judgement.*
> - *Quantitative – Those analytical processes that apply mathematical methods to assess the system and aircraft safety.*
>
> *From the flow chart (ref* [FAA] *AC 29-2C) it was determined that a qualitative analysis would be appropriate because the failure conditions identified in the FHA were not hazardous or catastrophic, the dominant failure condition was Major, with the majority of failure conditions either minor or having no safety effect. The water tank system and snorkel are not complex, and the system and installation is similar to a previous design.*

The FHA depth of analysis flow chart (in Advisory Circular 29 2C) states that "Catastrophic and Hazardous/Severe-major failure conditions will likely require both qualitative and quantitative analysis, depending on the system complexity."

Administrative Information

Investigator In Charge (IIC):	Boggs, Daniel
Additional Participating Persons:	Robert Gonzales; FAA; Orlando, FL Javier Casanova; Sikorsky; Jupiter, FL Josh Ricciardi; Firehawk Helicopters; Boise, ID
Original Publish Date:	April 19, 2023
Last Revision Date:	
Investigation Class:	Class 3
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=103146