Aviation Investigation Final Report

Location:	Payson, Arizona	**Accident Number:**	WPR20LA211
Date & Time:	July 7, 2020, 12:13 Local	**Registration:**	N623PB
Aircraft:	Bell UH1H	**Aircraft Damage:**	Destroyed
Defining Event:	Loss of control in flight	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 133: Rotorcraft ext. load		

Analysis

The helicopter was on its fourth short external load flight to reposition supplies for ground firefighting crews using a 100-ft-long line when the accident occurred. The pilot had flown a similar route for each of his three previous uneventful flights that morning. When the helicopter reached a plateau, about halfway through the flight, witnesses observed it begin to fly erratically, transitioning into a brief high nose-up pitch attitude and then wobbling and banking in a series of irregular movements before stabilizing. A few seconds later, the helicopter wobbled and banked erratically again and then entered another high nose-up attitude before it descended rapidly towards the ground. Witness statements indicated that the helicopter either banked left or right while in a high nose-up attitude just before it descended and impacted the ground.

A meteorology study found that at the time of the accident, the density altitude was about 7,980 ft; the wind was from the west-southwest about 10 knots; and sky conditions were clear. Comparison of the helicopter's flight track at the time of the accident and the reported wind conditions indicated the helicopter likely encountered a right quartering tailwind during the first upset and a left quartering tailwind during the second (final) upset. Although the helicopter was operating in high density altitude conditions with a low forward groundspeed, the pilot had completed three successful external load lifts from the same departure point to the same destination before the accident with no reported helicopter instability. Further, although dust devils were reported by witnesses on multiple days before the accident, there were no indications from witnesses that any were present at the time of the accident. Therefore, it is unlikely that meteorological conditions contributed to the inflight loss of control.

The left lateral servo was found at near full extension, and the right lateral servo was found slightly more than half extended. These positions closely corresponded to a cyclic position of full aft and either right or left and were consistent with the extreme nose-up position of the

helicopter immediately before its vertical descent to the ground. The helicopter would normally be controlled by the pilot via small fine cyclic inputs that would rarely exceed half of the full deflection of the cyclic control stick. An intentional full aft and either right or left deflection of the cyclic control by the pilot would not be consistent with the type of operation being performed with an external load, which requires smooth moderate control inputs and adjustments. The control servo positions were consistent with the preimpact attitude of the helicopter and likely indicate that the flight controls were positioned in a full aft and an undetermined lateral cyclic position and fixed there until impact.

Since it is unlikely the pilot intentionally manipulated the cyclic to produce the erratic movements displayed by the helicopter, these movements were likely the result of a hydraulic failure, flight control stiffness event, or hydraulic hardover. A light bulb analysis found that the HYD PRESSURE warning light filament was not stretched at the time of impact, which suggests that the hydraulic pressure had not dropped below 400 pounds per square inch and that the hydraulic control switch had not been turned off by the pilot; therefore, a hydraulic failure likely did not occur. A control stiffness or hydraulic hardover was likely as either could have been caused by a failure within the irreversible valve on either lateral servo. Either malfunction would have made it difficult for the pilot to operate the cyclic and maintain control of the helicopter. However, the investigation was unable to determine whether the loss of control was due to a hydraulic hardover or flight control stiffness event due to a lack of available evidence as the servo components were extensively damaged by impact and postcrash fire.

Probable Cause and Findings

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

A flight control malfunction due to either a hydraulic hardover or a flight control stiffness event, which resulted in a loss of control.

Findings

Personnel issues	Aircraft control - Pilot
Aircraft	(general) - Malfunction
Aircraft	Rotorcraft servo system - Malfunction

Factual Information

History of Flight

Enroute-cruise	Loss of control in flight (Defining event)
Enroute-cruise	Collision with terr/obj (non-CFIT)

On July 7, 2020, about 1213 mountain standard time, a Bell/Garlick UH-1H helicopter, N623PB, was destroyed when it was involved in an accident near Payson, Arizona. The pilot was fatally injured. The helicopter was operated as a Title 14 *Code of Federal Regulations* Part 133 external load flight.

The helicopter was owned by Airwest Helicopters LLC and operated by the United States Forest Service (USFS) at the time of the accident supporting firefighting efforts against the Polles Fire in the Tonto National Forest about 11 nautical miles (nm) west of Payson. The fire was accessible only by helicopter due to the rugged terrain, and ground crews were largely dependent on helicopters for transportation and support.

According to witnesses, the helicopter was transporting supplies externally using a 100-ft-long line and cargo nets for a USFS hotshot firefighting crew that was repositioning on the ground. The pilot transported three loads from site H2 to site H5 uneventfully before the accident and was using an indirect route to the north to avoid a fire area. (See Figure 1.) While transporting the fourth load, witnesses observed the helicopter begin to fly erratically when it reached a plateau while enroute to its destination. During this time, a witness stated that he observed the helicopter enter a high nose-up pitch attitude, and the external payload began to swing. The helicopter then displayed irregular movements for several seconds before the external payload settled and the helicopter appeared to stabilize. However, after about 3 seconds, multiple witnesses observed the helicopter wobble and bank erratically before it entered a steep nose-up attitude and then descended rapidly to ground impact. Two witnesses reported that the helicopter started to twist to the right as it descended. The witnesses did not observe the helicopter on fire during the accident flight nor did the pilot report any anomalies over the assigned air-to-ground radio frequency, Air Guard, or any other assigned frequencies for the fire.

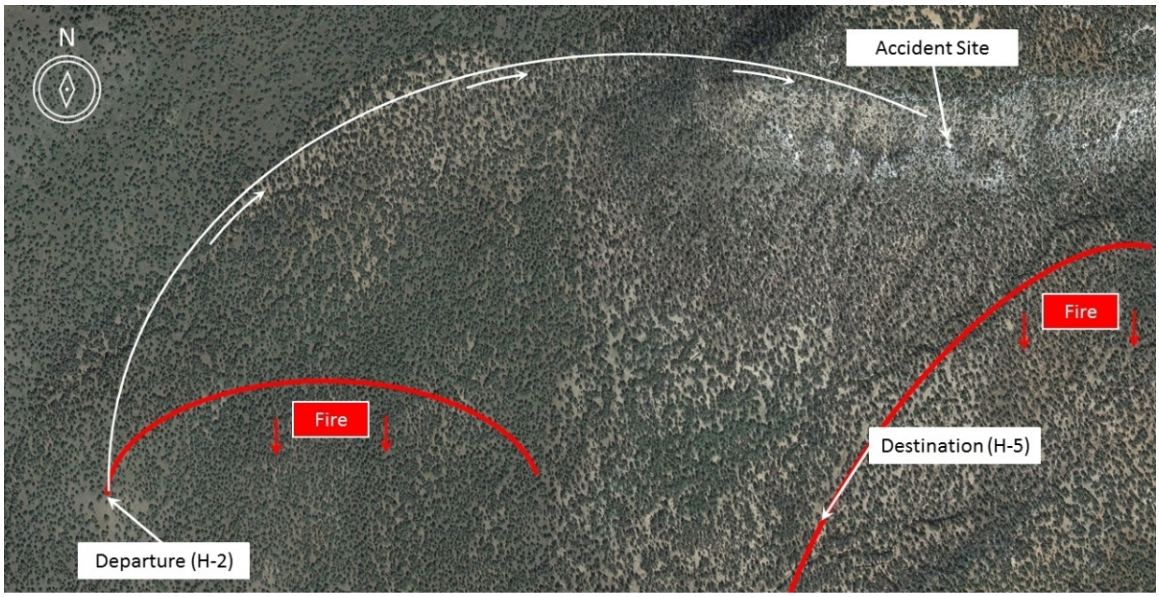

Figure 1: Depiction of helicopter flight path based on witness statements

Pilot Information

Certificate:	Commercial	**Age:**	37,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Unknown
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane single-engine	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	October 1, 2019
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	January 16, 2020
Flight Time:	11000 hours (Total, all aircraft), 172 hours (Total, this make and model)		

According to the USFS, the pilot was required to renew his pilot qualification card every 12 calendar months. The pilot's most recent qualification card was issued on April 17, 2020 and listed an expiration date of April 2021. He was approved for multiple applications including: "water retardant, bucket; Ext load, >50' longline vertical reference (VTR); and snorkel (mirror & VTR)". The pilot was permitted to fly a UH-1 helicopter with an expiration of April 2023 for each of the abovementioned applications. According to the USFS, qualification cards are issued annually to ensure all associated administrative requirements are met, while special missions are evaluated every 3 years.

Aircraft and Owner/Operator Information

Aircraft Make:	Bell	**Registration:**	N623PB
Model/Series:	UH1H	**Aircraft Category:**	Helicopter
Year of Manufacture:	1964	**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	64-13689
Landing Gear Type:	Retractable -	**Seats:**	2
Date/Type of Last Inspection:	May 22, 2020 Annual	**Certified Max Gross Wt.:**	9500 lbs
Time Since Last Inspection:	57 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	10775 Hrs at time of accident	**Engine Manufacturer:**	Honeywell
ELT:	C126 installed, not activated	**Engine Model/Series:**	T53-L-703
Registered Owner:	Aero Leasing LLC	**Rated Power:**	1700 Horsepower
Operator:	Airwest Helicopters LLC	**Operating Certificate(s) Held:**	Rotorcraft external load (133), Commuter air carrier (135)
Operator Does Business As:		**Operator Designator Code:**	XS9A

The USFS required that an interagency load calculation (Form OAS 67/FS 5700) be completed for all flights and that a new calculation be completed when operating conditions changed by 1,000 ft elevation or 5°C in temperature. An interagency load calculation was completed before the pilot's first flight in anticipation of relocating six loads via longline from site H2 to site H5. According to the completed form, the departure and destination were both listed at a pressure altitude of 5,000 ft with an outside ambient temperature of 35°C. The helicopter equipped weight was listed as 5,545 lbs; the flight crew weight was 150 lbs; the fuel weight was 1,200 lbs (171 gallons); and the total operating weight was 6,895 lbs. Based on the pilot's performance computations, which included a gross weight of 9,500 lbs, the maximum allowable external payload was 2,605 lbs. The payload manifest listed the external cargo weight at the time of the accident as 1,975 lbs consisting of 19 cases of Gatorade and the net, hook, swivel and longline. An independent review of the manifest calculated the weight of 19 cases of Gatorade (31 lbs per case) to be 589 lbs plus the hook, swivel, net, and long line for a total external load weight of 664 lbs.

According to the USFS interagency helicopter load calculation form, the helicopter had about 171 gallons of JET-A fuel onboard before its first flight on the morning of the accident. The USFS provided documentation showing that the helicopter flew for about 25 minutes while transporting its first three loads before the accident flight.

Hydraulic System Information

The helicopter flight controls were powered by a hydraulic system that operated the flight control cylinders. According to the rotorcraft flight manual (RFM):

The hydraulic system is used to minimize the force required by the pilot to move the cyclic, collective and pedal controls. A hydraulic pump, mounted on and driven by the transmission supplies pressure to the hydraulic servos. The hydraulic servos are connected into the mechanical linkage of the helicopter flight control system. Movement of the controls in any direction causes a valve, in the appropriate system, to open and admit hydraulic pressure which actuates the cylinder, thereby reducing the force-load required for control movement. Irreversible valves are installed on the cyclic and collective hydraulic servo cylinders to prevent main rotor feedback to the cyclic and collective in the event of hydraulic system malfunction.

The owner of the helicopter operator, who was also an experienced pilot in the accident helicopter, described the amount of force the pilot was required to exert on the flight controls during hydraulic off operation as significantly higher than when the hydraulic boost was enabled. This can limit how quickly a pilot can make control inputs and after a few minutes can result in physical fatigue.

The RFM provided descriptions of three potential hydraulic power related emergency events: hydraulic power failure, flight control stiffness, and flight control servo hardover.

Hydraulic Power Failure

Hydraulic power failure will be evident when the force required for control movement increases; a moderate feedback in the controls when moved is felt, and/or the HYD PRESSURE caution light illuminates. Control movements will result in normal helicopter response. In the event of hydraulic power failure:

1. Airspeed – Adjust as necessary to attain the most comfortable level of control movements.
2. HYD CONT circuit breaker – Out. If hydraulic power is not restored:
3. HYD CONT circuit breaker – In.
4. HYD CONT switch – OFF.
5. Land as soon as practicable at an area that will permit a run-on landing with power. Maintain airspeed at or above effective transitional lift until touchdown.

Control Stiffness

A failure within the irreversible valve may cause extreme stiffness in the collective or two of the four cyclic control quadrants. If the failure is in one of the two cyclic irreversible valves, caution is necessary to avoid over controlling between the failed and operational quadrants.

1. <u>HYD CONT switch – OFF then ON.</u>

Check for restoration of normal flight control movements.
Repeat as necessary.
If control response is not restored:

2. HYD CONT switch – OFF.
If normal operation is not restored:

3. Land as soon as practicable at an area that will permit a run-on landing with power. Maintain airspeed at or above effective transitional lift until touchdown.

Flight Control Servo Hardover

a. Cyclic hardover is caused by a sequencing valve failure within the Irreversible valve on either or both cyclic servos. Cyclic servo hardover will cause the cyclic to move full [r]ight forward, full left rear, full left forward, or full right rear.

b. Collective hardover is caused by a sequencing valve failure within the irreversible valve failure on the collective servo. The collective will move to the full up or full down position.

c. A failure of any flight control servo may render the helicopter uncontrollable unless the following action is taken.

1. HYD CONT select - Select opposite position.
2. LAND AS SOON AS POSSIBLE at an area that will permit a run-on landing with power. Maintain airspeed at or above effective translational lift at touchdown.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	5156 ft msl	**Distance from Accident Site:**	
Observation Time:	12:15 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	9 knots / 18 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	240°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.18 inches Hg	**Temperature/Dew Point:**	32°C / -6°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Payson, AZ (PAN)	**Type of Flight Plan Filed:**	None
Destination:	Payson, AZ (PAN)	**Type of Clearance:**	None
Departure Time:	11:45 Local	**Type of Airspace:**	Class G

Wind

At 1215, the reported wind at Payson Airport (KPAN) located about 11 nm east of the accident site was from 240° at 9 knots with gusts to 18 knots. In addition to the weather at Payson Airport, the local wind information was captured by three remote automated weather stations near the accident site. At 1222, the closest station located 8.5 nm northeast of the accident site reported wind from the southwest at 10 miles per hour (mph) with gusts to 20 mph. At 1211, the next station located 11 nm east of the accident site reported wind from the west-southwest at 7 mph with gusts to 16 mph. At 1209, another station located 14.5 nm northeast of the accident site reported wind from the west-southwest at 2 mph with gusts to 15 mph. Each of the three stations and KPAN indicated temperatures between 32° C (90° F) and 34° C (94° F) with relative humidities of 8 to 10%. The density altitude based on the conditions reported was 7,980 ft.

Dust Devils

Multiple forest firefighters who witnessed the accident provided their weather observations at the time of the event. None of the witnesses observed any clouds or thunderstorms in the area during the event. Two witnesses reported that they had observed dust devils in the area. According to one of these witnesses, the wind speed at the time of the accident was about 5 to 10 mph with higher wind speeds on top of the mesa. He observed dust devils on the day of the accident and large dust devils in the days leading up to the accident. Another witness reported seeing what he described as “ash whirls” in the area but could not remember when they occurred. Most of the witnesses reported light wind from the southwest and did not report any wind gusts.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:		**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	34.271945,-111.52749

The helicopter wreckage came to rest about 0.5 nm north of its drop off destination (site H5) oriented on a heading of 074° magnetic. The wreckage was highly fragmented and mostly consumed by postcrash fire. All major structural components of the helicopter were accounted for at the accident site. The helicopter’s external payload was found 123 ft southeast of the main wreckage.

Wreckage Examination

The wreckage was recovered to a storage location in Arizona, and a wreckage examination was performed by a National Transportation Safety Board (NTSB) helicopter specialist with representatives from the engine manufacturer, the Federal Aviation Administration, and the helicopter operator. The largest pieces of wreckage included the main rotor head, transmission, engine, tail boom aft of the elevator, tail rotor, and gearbox. Additionally, the external load long line, cargo hook, and cargo net were examined. A visual inspection of the long line assembly revealed no evidence of mechanical malfunctions or failures that would have precluded normal helicopter operation.

All flight control tubes and connections in the cockpit and leading up to the upper deck were fragmented or destroyed. The helicopter's three hydraulic servos (right lateral, left lateral, and collective) were separated from their respective connections.

The main rotor had separated from the mast below the rotor head, and the remaining section of mast that was attached to the rotor head displayed fracture signatures consistent with overload. Both main rotor blades were fractured and thermally damaged.

Rotational scoring was observed on the engine power output shaft where the KAflex coupling attached. Movement of the output shaft produced a corresponding rotation of the power turbine rotor. The power turbine spool also rotated without resistance. Examination of the compressor section revealed tearing and battering damage to the 1st stage axial compressor blades. The power turbine section blades and vanes were accounted for and undamaged. Metal spray was observed around the 2nd stage power turbine nozzle vanes. No pre-existing conditions were found that would have prevented normal operation of the engine.

The helicopter's maintenance records showed that the tail rotor assembly had been inspected and re-rigged on multiple occasions outside of routine maintenance from January 18, 2019, to June 24, 2020. Postaccident examination of the tail rotor drive shafts found that drive shaft Nos. 3 and 4 had torsionally sheared. Drive shaft Nos. 5 and 6 were connected to the gearbox. The tail rotor gearbox input and output drives rotated smoothly by hand with no binding. Both tail rotor blades remained attached to the tail rotor hub and to the gearbox through the tail rotor mast.

Postaccident examination of the long line and hook assembly revealed normal wear with no significant damage noted. The assembly was not connected to the helicopter. The eyelet and "pear ring" were attached at the beginning of the long line. The long line cargo hook at the end of the line opened and locked in the closed position manually. The electrical connections between the long line and the hook assembly were not present; however, several separated wires were present at the eyelet and "pear ring" end of the long line.

Annunciator Panel

An NTSB Materials Laboratory examination of the cockpit annunciator panel was completed to determine the status of the light bulb filaments from each annunciator. There were no missing bulbs in any of the individual lights, and hot filament stretching was not found in any bulb. The

system was designed so that the HYD PRESSURE light would illuminate when the system pressure dropped below 400 pounds per square inch. Turning off the cockpit hydraulic control (HYD CONT) switch would also illuminate the HYD PRESSURE light.

Left and Right Lateral Servos

The left lateral servo piston exhibited 10 inches of extension, and the right lateral servo piston showed 7 inches of extension after the accident. An exemplar helicopter of the same make/model was used to determine the resulting cyclic position based on the left and right lateral servo piston measurements. Testing showed that the accident helicopter servo positions corresponded to a cyclic position about full aft of its center position. The testing further showed that the accident helicopter servo positions corresponded to a cyclic position that was either left or right of center.

The internal configurations of the left and right lateral servos were documented using x-ray radiograph and computed tomography scanning. A review of these images revealed indications that the cap covering the left lateral actuator irreversible sequence valve opening was bulging and deformed consistent with exposure to the extreme heat of the postcrash fire. The irreversible valves assemblies for both the right lateral servo and the collective servo had been liberated from their servo assemblies by impact forces, were not recovered with the wreckage, and were presumed destroyed by the postcrash fire. Hence, those valve assemblies were not examined.

According to an aircraft status report furnished by the helicopter operator, the left lateral servo had accumulated about 669 flight hours since it was last overhauled on August 6, 2015, and the right lateral servo had accumulated 617 flight hours since it was last overhauled on January 20, 2016. The servos were required to be inspected “on condition” only and did not have a time before overhaul requirement.

Administrative Information

Investigator In Charge (IIC):	Stein, Stephen
Additional Participating Persons:	Barry Miller; Federal Aviation Administration; Scottsdale, AZ Allie Engel; Honewell Aerospace; Phoenix, AZ Eric Shambora; United States Forest Service; Boise, ID Greg Barlow; Airwest Helicopters; Glendale, AZ
Original Publish Date:	September 14, 2022
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=101560