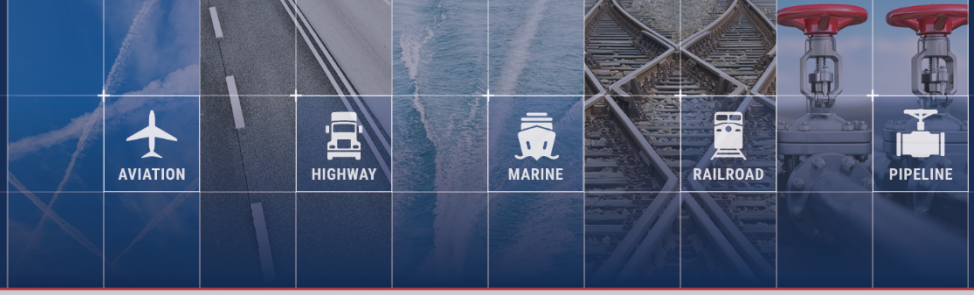

Aviation Investigation Final Report

Location:	Coalinga, California	**Accident Number:**	WPR20LA280
Date & Time:	August 19, 2020, 09:45 Local	**Registration:**	N711GH
Aircraft:	Arrow-Falcon Exporters, Inc. UH-1H	**Aircraft Damage:**	Destroyed
Defining Event:	Loss of control in flight	**Injuries:**	1 Fatal
Flight Conducted Under:	Public aircraft		

Analysis

The pilot was engaged in external load fire-fighting operations when the accident occurred. After dropping several loads of water, the pilot reported abnormal noises and vibrations and stated "it's my hydraulics" before he lost airspeed and control of the helicopter. The helicopter made several uncontrolled rotations before colliding with terrain and erupting in flames. The wreckage was highly fragmented and most consumed by the postimpact fire.

The hydraulic system continuity could not be confirmed due to fire damage. The servos exhibited exposure to fire, including an oxide layer on the outer surface, micro-cracks, resolidified metal, and deformation damage. Foreign high-density particles were found in the hydraulic system. Hydraulic flight control stiffness and hard-over conditions are most likely a result of a malfunction of the servo irreversible valve.

Only one of the three irreversible hydraulic valves was not destroyed in the postcrash fire. Examination of this valve found high-density metal particles deep within the valve assembly and preexisting damage to the seat of a check valve. Since all the servos were operated from a single hydraulic pressure source, it is likely that the other two irreversible valves also had similar particles within their assemblies.

Foreign high-density particles and a worn check valve within the irreversible valve could have interfered with the valves' proper operation and resulted in control stiffness or a hard-over condition. There was no evidence of preexisting mechanical damage on the three servo actuator pistons or rods as the internal moving parts within the servo actuators showed no evidence of gouging. There was no wear damage in the bushing areas or around the housing ball assembly.

Toxicological tests detected the antidepressant medication citalopram and an augmenting agent buspirone in the pilot's system. Given that the pilot was performing complex firefighting tasks when the helicopter developed mechanical problems and he made reasonable decisions to attempt to land the helicopter, he appears to have been functioning at a high level. It appears unlikely that the pilot's use of the antidepressants or his depression were factors in the accident.

The pilot's declaration that he had a hydraulic problem and the final uncorrected right hand descending spiral turn flightpath are consistent with what would be expected if the helicopter experienced control stiffness or a hard-over condition. However, due to the extent of the impact and postimpact fire damage, the reason for the loss of control could not be conclusively determined.

Probable Cause and Findings

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

The pilot's inability to maintain control of the helicopter due to a hydraulic system failure for reasons that could not be fully determined due to the thermal destruction from the postimpact fire.

Findings

Aircraft	Hydraulic, main system - Unknown/Not determined
Personnel issues	Aircraft control - Pilot

Factual Information

History of Flight

Maneuvering-low-alt flying	Loss of control in flight (Defining event)

On August 19, 2020 about 0945 Pacific daylight time, an Arrow-Falcon Exporters, Inc., UH-1H, N711GH, was destroyed when it was involved in an accident near Coalinga, California. The pilot, the sole occupant was fatally injured. The helicopter was operated as a public use firefighting flight.

The accident flight was the pilot's first day working the Hills Fire, which had started 4 days prior. The pilot took off at 0846 followed by another pilot who was flying a Bell 212 helicopter for another operator.

After departure, both helicopters flew south until reaching a small lake/reservoir (the dip site) to fill up the external load buckets attached to their respective helicopters. Thereafter, they flew to a predetermined area and began to unload their water on the fire. After releasing the water, they would return back to the dip site. After the accident pilot delivered about two buckets of water to one location he moved to another location delivering about five buckets of water.

The Bell 212 pilot recalled that after he departed the dip site with a bucket of water, he heard the accident pilot communicate over the air-to-air radio that he felt "abnormal noises and vibrations" and that he was going to make a precautionary landing. The Bell 212 pilot dumped his water and caught up to the accident helicopter with the intention of assisting the pilot in finding a good area to land. He remained a few hundred feet behind and above the accident helicopter. The accident helicopter was about 1,000 ft above ground level and maneuvering at an airspeed between 60 to 70 kts. The accident pilot then stated that the helicopter's "temps and pressures are good." A few seconds later the accident pilot stated "it's my hydraulics." The Bell 212 pilot relayed that he should make a right turn and fly down the ravine to less mountainous terrain (the flats).

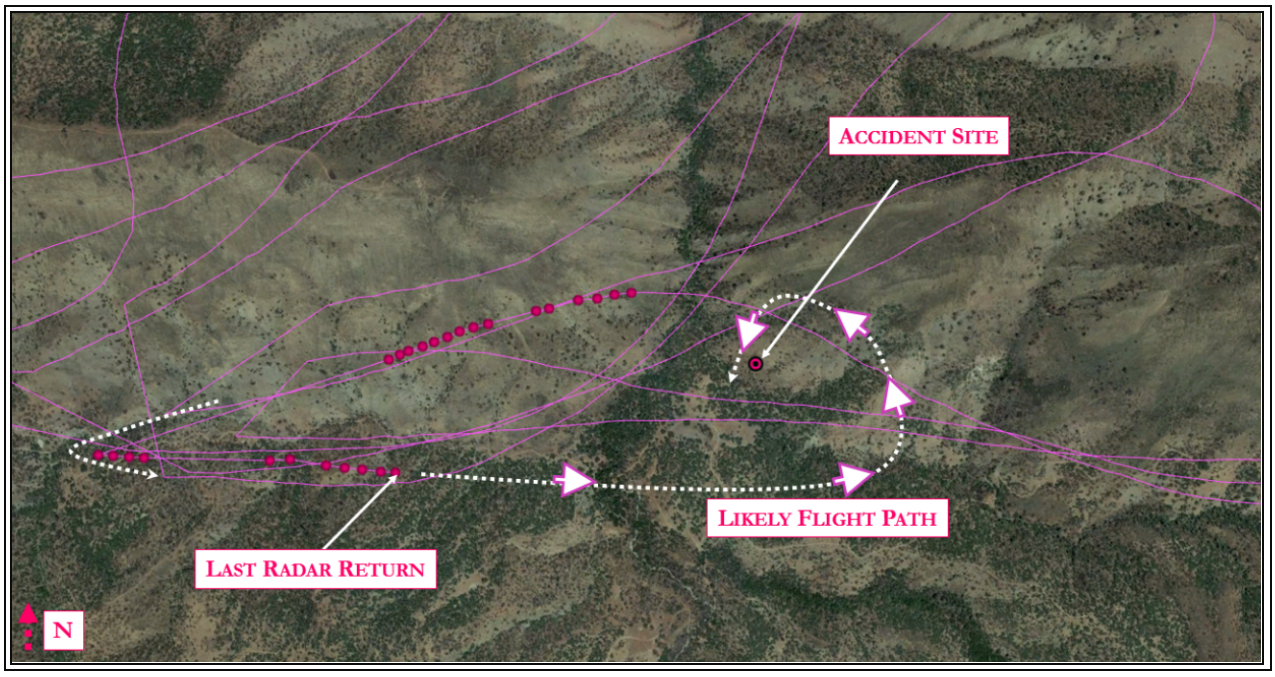

Figure 1: Radar Data

The helicopter started to make a right turn and then banked back to the left while losing airspeed. The Bell 212 pilot noticed the helicopter still had its 100 ft longline and external load bucket attached and told the accident pilot to "release your long line and get forward airspeed," The accident pilot then stated "Mayday, Mayday, Mayday." The left turn steepened remaining in a level pitch attitude, and the helicopter began to make three or four 360° rotations (rapidly swapping the front and back), while drifting north-east. The helicopter then pitched in a nose-low, near vertical attitude and collided into terrain (see figure 2 below). A fire immediately erupted and the Bell 212 pilot made multiple trips to the dip site to fill his bucket and drop water on the accident site.

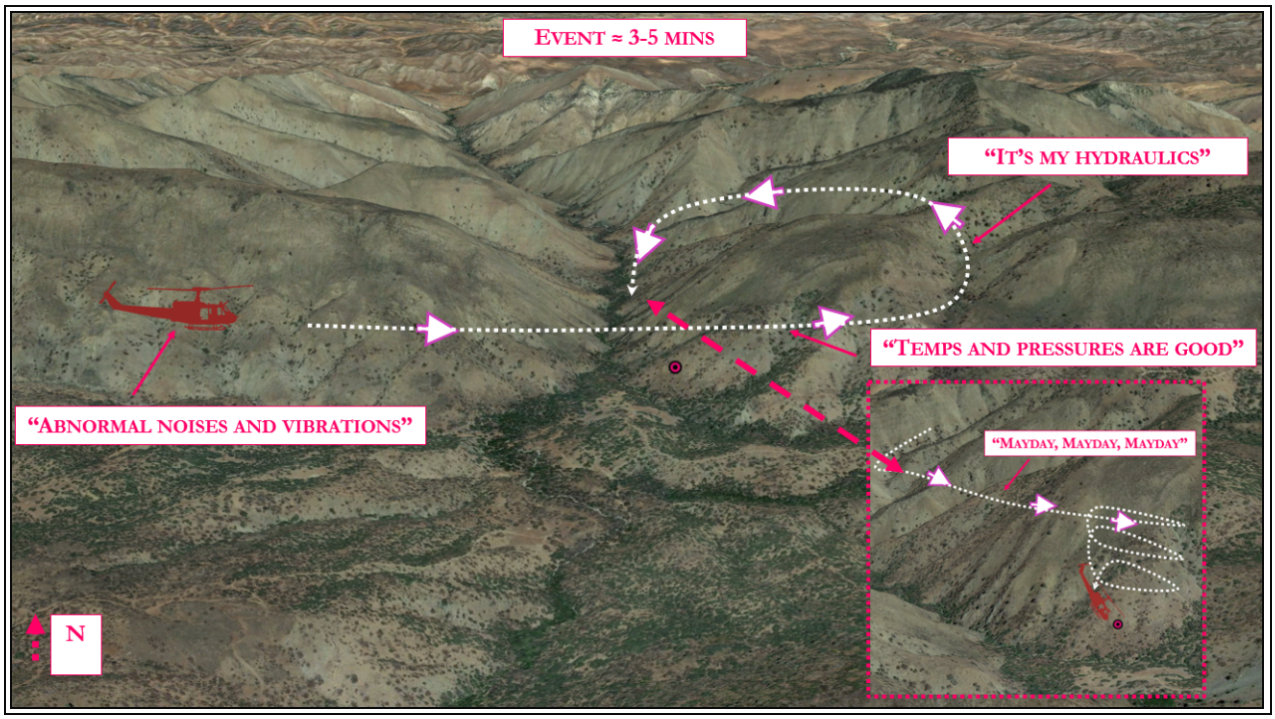

Figure 2: Pilot's Statements Prior to Accident

WRECKAGE AND IMPACT

The helicopter came to rest on a 35° slope with the main wreckage about 25 yards downslope from the initial impact. Most of the wreckage was consumed by fire; the tail rotor assembly was intact. The tail rotor blades were intact, with no evidence of rotational scoring. The wreckage was recovered to a secure location for further investigation.

Airframe/Controls

The wreckage was highly fragmented and mostly consumed by a post-crash fire. The airframe sections that remained were parts of the tailboom, tail rotor, engine deck, cabin doors, landing skid tubes, one cross tube, and the engine. The main rotor head, blades, stabilizer bar, and upper transmission including the rotor mast were lost during the wreckage recovery.

The cockpit was highly fragmented and damaged by fire, with most of the instruments destroyed and unreadable. The engine control panel were separated from the center console and all the switches on the panel were deformed downward. The caution warning panel, located within the wreckage debris and separated from the instrument panel, sustained fire damage and the front plate was illegible due to sooting/melting. The interior of the panel exhibited similar damage and the individual annunciator capsule positions had shifted as a result so the original location of individual bulbs could not be determined. Nine intact bulbs with filaments were removed from the remnants of the panel, of which two exhibited hot filament stretching; their associated position could not be determined. The fuel valve switch

had evidence of damage associated with impact and was unreliable for determining the switch position before impact.

Portions of the cockpit flight controls were identified, but a majority of the system was consumed by fire. The main flight control servos were separated from their input and output control rods. Fragments of both sections of the cyclic lateral control tubes and the lower mixing assembly were identified. The upper flight controls, consisting of the stationary and rotating swash plates and drive links, were not present for examination because they were dropped during recovery. The tail rotor control bell crank quadrant was not located. The tail rotor hydraulic servo was detached from the structure and sustained thermal damage; the input and output fittings were fractured. The tail rotor control forward cables, speed-rig turnbuckles, and aft cables remained within the tailboom.

The elevator spar remained in the tail section, and the left spar extended out of the left side of the tail boom. The elevator control horn assembly was in place in the tail section, and three elevator control bell cranks were identified.

Continuity of the hydraulic system could not be confirmed due to fire damage sustained following impact. The hydraulic pump was separated from the transmission and was missing the splined drive shaft. The hydraulic filter was separated from its mount, and the input/output connectors were fractured. The filter screen was removed, inspected, and no debris was identified. The main rotor head, both main rotor blades, upper transmission, and rotor mast were not recovered, but both stabilizer bar dampers were recovered. Photos from on scene showed chordwise marks on various portions of the unburned blade. The burned blade was too damaged to identify surface score marks from the photos taken.

Segments of the tail rotor drive shaft were numbered from 1 to 6, starting at the tail rotor drive output of the lower transmission. Drive shaft segments 1 to 3 were not recovered and were presumed to have been consumed by the post-crash fire. The drive-shaft bearing-end that connects to the transmission tail rotor drive quill was identified, as well as the drive shaft ends that mate with the support bearings for segments 1 to 3. The aft end of segment 4 was connected to segment 5 through the support bearing. Drive segment 5 was connected to the 42° gearbox, and drive segment 6 was connected from the 42° gearbox to the tail rotor 90° gearbox. One tail rotor blade showed no observable damage, while the other blade had chordwise dirt streaks and heat damage on the outboard half of its trailing edge. On the reverse side of that blade, the outboard 2/3 of the blade had fire damage to the skin and underlying layers. The blade also had a crease in the chordwise direction about 8 inches from the root.

The photos of the cargo hook on-scene and the post examination revealed that the hook portion had separated from its attachment hardware. The final location of the external load bucket is unknown, but the witness said he did not see the bucket being released.

Servos

The National Transportation Safety Board (NTSB) Materials Laboratory examined the left lateral hydraulic servo; right lateral hydraulic servo and its irreversible valve assembly; and the collective hydraulic servo for the main rotor of the helicopter.

The collective actuator, left lateral actuator, right lateral actuator, and an irreversible valve assembly were subjected to x-ray radiograph and computed tomography (CT) scanning to document each component's internal condition. The results of the scan identified high density (metal) particles deep within the irreversible valve assembly.

The right lateral servo showed indications of exposure to a fire, including an oxide layer on the outer surface, micro-cracks, resolidified metal, and deformation damage. The upper housing was disassembled, and the ring seals were found to be fractured. The lower housing contained two circumferential inserts that functioned as raceways, which showed no evidence of wear or damage. The piston portion of the rod contained a groove that incorporated a ring seal, which also fractured into multiple pieces. The hydraulic servo cylinder contained an internal spool and sleeve assembly, but an attempt to pull the push-pull rod out of the port failed. No evidence of corrosion, gouge, or wear damage was found in any of the examined parts.

Disassembly of an irreversible valve assembly for a right lateral servo, revealed the internal valves, including a sequence valve, check valves "A" and "B," a differential pressure relief valve, and an accumulator valve. During disassembly, evidence of bending deformation damage was observed on the cover for the sequence valve, and the inner surface of the cover showed evidence of an oxide layer and micro-cracks. The piston head and sleeve contained ring seals that were fractured and could not be removed with needle-nose pliers. The internal parts of the sequence valve, check valves "A" and "B," and the differential pressure relief valve were intact, except for the fractured ring seals. The seat portion for the check valve "A" showed evidence of wear damage, while the seat portion for check valve "B" showed no evidence of wear.

The left lateral and collective servos were disassembled in a manner that was similar to the right lateral servo. The observations made on those servos were similar to those found on the right lateral servo, with the exception that the left lateral servo's piston was completely retracted (the other servos were in various positions, but not at such an extreme). It could not be definitively determined if this signature could have been indicative of a left hard-over condition and a simulation was not available to support this inquiry. It could not be determined if any of the servos were capable of function normally prior to impact.

Heat from the postcrash fire caused carbonization and multiple fractures of the elastomer seat rings, while foreign particles were found in the hydraulic system. It is unknown how much of the debris was introduced into the hydraulic system during the postcrash fire-fighting phase.

The servos and irreversible valve do not have a specified time-in-service before overhaul requirement and are considered an "on condition" part.

Engine

The engine sustained damage as a result of the impact. The inlet guide vanes displayed tearing and battering, and all five stages of the axial compressor blades were bent opposite the direction of rotation at the tips and displayed leading and trailing edge damage. Vanes on all four stages of the compressor vane assembly displayed leading and trailing edge damage. The interstage bleed centrifugal compressor impeller showed rotational scoring on the shroud line edges of the blades at the inducer with corresponding rotation scoring through 360°. The inducer of the impeller housing assembly and the centrifugal compressor impeller had material build-up on the leading-edge concave side of the blades. Vanes on the first stage power turbine nozzle and blades on the first stage power turbine rotor displayed trailing edge damage, all of which were consistent with the engine operation/rotation at the time of impact.

Metallurgical analysis of the first and second stage gas producer turbine blades identified aluminum, stainless steel, and magnesium deposits on the suction side and pressure side of the blades. These metal spray deposits are consistent with the engine operating at the time of impact. Additionally, white dust-like material covered the interior of the combustion liner. The NTSB Materials Laboratory analysis of the white residue material identified it as magnesium oxide using dispersive x-ray spectroscopy, and the source of the magnesium can be attributed to the engine case which is constructed of magnesium. The source of the stainless steel can be attributed to the compressor section components such as the blades and stator assemblies. The source of the aluminum alloy is not internal to the engine.

Rotorcraft Flight Manual

The US Army UH-1H flight manual (TM 55-1520-210-10) emergency procedures section identifies the following:

Section 9-37. Hydraulic Power Failure.
Hydraulic power failure will be evident when the force required for control movement increases; a moderate feedback m the controls when moved is felt, and/or the HYD PRESSURE caution light illuminates. Control movements will result m 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.

Section 9-38. 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. HYD CONT switch - OFF then ON. 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 restore!
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.

9-39. 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 night 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 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.

MEDICAL AND PATHOLOGICAL

According to the Fresno County Sheriff-Coroner's Office, Fresno, California autopsy report, the cause of the pilot's death was multiple skeletal and visceral injuries due to blunt impact and the manner of death was accident. The medical examiner did not identify any significant natural disease.

Toxicology testing performed by the Fresno County Sheriff-Coroner's Office detected ethanol at 0.11 grams per deciliter (gm/dL) in the pilot's peripheral blood and at 0.068 gm/dL in gastric contents; toxicology testing was negative for tested-for drugs of abuse in blood and gastric contents. The FAA Forensic Sciences Laboratory toxicology testing detected ethanol at 0.082 gm/dL in cavity blood and 0.082 grams per hectogram (gm/hg) in muscle tissue but did not detect ethanol in brain tissue. N-propanol was detected in the pilot's cavity blood and muscle tissue and methanol was detected in his cavity blood. Tissue samples were reported as exhibiting putrefaction. The antidepressant citalopram was detected in the pilot's blood at 5,857 nanograms per milliliter (ng/mL) and in his liver tissue; its active metabolite n-desmethylcitalopram was detected at 602 ng/mL in blood and in liver tissue. The anti-anxiety medication buspirone was detected in the pilot's blood at 1.1 ng/mL and in his liver tissue.

Pilot Information

Certificate:	Airline transport; Commercial; Flight instructor	**Age:**	52,Male
Airplane Rating(s):	None	**Seat Occupied:**	Left
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	Unknown
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Helicopter; Instrument helicopter	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 None	**Last FAA Medical Exam:**	March 12, 2020
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	August 12, 2020
Flight Time:	(Estimated) 11200 hours (Total, all aircraft), 414 hours (Total, this make and model), 11150 hours (Pilot In Command, all aircraft), 225 hours (Last 90 days, all aircraft), 11 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Arrow-Falcon Exporters, Inc.	**Registration:**	N711GH
Model/Series:	UH-1H	**Aircraft Category:**	Helicopter
Year of Manufacture:	2009	**Amateur Built:**	
Airworthiness Certificate:	Restricted (Special)	**Serial Number:**	65-1002
Landing Gear Type:	High skid	**Seats:**	2
Date/Type of Last Inspection:	June 16, 2020 Annual	**Certified Max Gross Wt.:**	9500 lbs
Time Since Last Inspection:	66 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	10389 Hrs as of last inspection	**Engine Manufacturer:**	Honeywell
ELT:	Installed, not activated	**Engine Model/Series:**	T53-L-703
Registered Owner:	Guardian Helicopters Inc	**Rated Power:**	1800 Horsepower
Operator:	Guardian Helicopters Inc	**Operating Certificate(s) Held:**	Rotorcraft external load (133), On-demand air taxi (135), Agricultural aircraft (137)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	11 Nautical Miles
Observation Time:	09:00 Local	**Direction from Accident Site:**	170°
Lowest Cloud Condition:	Clear	**Visibility**	3 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	None / None
Wind Direction:		**Turbulence Severity Forecast/Actual:**	N/A / N/A
Altimeter Setting:		**Temperature/Dew Point:**	21°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Coalinga, CA (C80)	**Type of Flight Plan Filed:**	None
Destination:	Coalinga, CA (C80)	**Type of Clearance:**	None
Departure Time:	08:46 Local	**Type of Airspace:**	

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:**	35.969165,-120.3225(est)

Administrative Information

Investigator In Charge (IIC):	Keliher, Zoe
Additional Participating Persons:	Benjamin Berman; Cal Fire; Sacramento, CA Ryan Smith; Federal Aviation Administration; Fresno, CA Phillip DiFiore; Guardian Helicopters; Van Nuys, CA Allison Engel; Honeywell; Phoenix, AZ
Original Publish Date:	June 14, 2023
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=101831