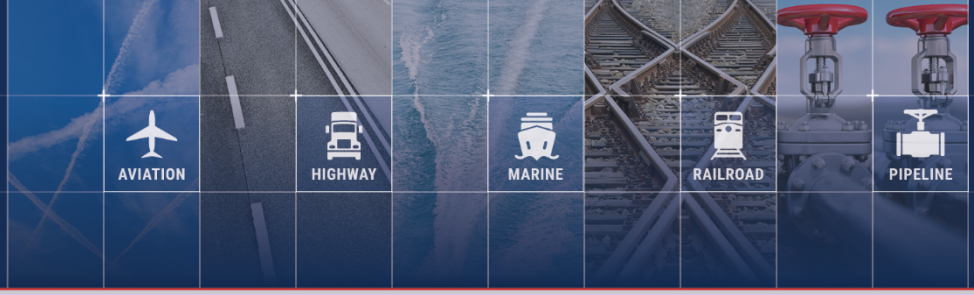

Aviation Investigation Final Report

Location:	Estes Park, Colorado	**Accident Number:**	DEN02GA085
Date & Time:	July 30, 2002, 18:43 Local	**Registration:**	N3978Y
Aircraft:	Aerospatiale SA315B	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Public aircraft		

Analysis

The helicopter was engaged in fire suppression activities. As the pilot made an approach for a water drop, witnesses said the engine made a "high-pitch whine," there was "a loud pop," they saw the rotor blades "slowing down," and heard the blades making a "thump, thump, thump" sound. The pilot was heard to say he was "going down." Witnesses reported seeing purple or blue flames shooting 2 to 3 feet from the exhaust stack. After the helicopter struck the ground and rolled over, witnesses heard the engine spooling down and saw flames coming from the engine "like a blowtorch." A post-impact ground fire, confined to the cockpit area, was quickly extinguished. An examination of the helicopter engine revealed evidence of heat distress aft of the labyrinth seal. The turbine section had a "corn cob" appearance. The first and second stage nozzles showed heat damage. The third stage nozzle was totally destroyed. According to the engine manufacturer, the turbine blades were exposed to "around 1,000 degrees C., about 400 degrees C. beyond the normal operating temperature over a short period of time." According to "Helicopter Aerodynamics," if the rate of descent exceeds 1/4 of the hover induced velocity, the flow conditions are such that the air is going both up and down through and around the rotor in a disorganized and unsteady manner. This is called vortex ring state. It exists until the helicopter is descending at about twice the hover-induced velocity. In the vortex ring state, the helicopter pilot may find himself in the unusual situation where pulling up the collective pitch does not slow the rate of descent. This is known as settling with power. The pilot has entered "a flight condition where the required power is more than the available power." According to the Artouste IIIB Training Manual, engine rotation (nominal) speed is 33,500 rpm, plus or minus 200 rpm. The fuel control unit maintains this speed. If a load is placed on the engine, the fuel-metering valve opens, fuel flow increases, and engine torque increases. Variation from this speed must not exceed 1,000 rpm. The time it takes to return from a speed variation to the nominal engine rotation speed is less than 4 seconds.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the pilot's abrupt collective input during water application to a forest fire. Contributing factors were encountering a vortex ring state, the inadvertent settling with power, the low altitude, and the mountainous terrain.

Findings

Occurrence #1: LOSS OF ENGINE POWER(PARTIAL) - MECH FAILURE/MALF
Phase of Operation: MANEUVERING - AERIAL APPLICATION

Findings
1. (C) COLLECTIVE - ABRUPT - PILOT IN COMMAND
2. (F) VORTEX RING STATE - ENCOUNTERED - PILOT IN COMMAND
3. (F) SETTLING WITH POWER - INADVERTENT - PILOT IN COMMAND
4. (F) ALTITUDE - LOW
5. TURBINE ASSEMBLY - OVERTEMPERATURE
6. TURBINE ASSEMBLY - MELTED

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: DESCENT - UNCONTROLLED

Findings
7. ROTOR RPM - LOW

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
8. TERRAIN CONDITION - MOUNTAINOUS/HILLY

Factual Information

HISTORY OF FLIGHT

On July 30, 2002, at 1843 mountain daylight time, an Aerospatiale SA315B, N3978Y, registered to Roberts Aircraft Co., Granite Canyon, Wyoming, and operated by Geo-Seis Helicopters, Inc., Fort Collins, Colorado, was destroyed when it struck terrain while maneuvering 6 miles southeast of Estes Park, Colorado. The commercial pilot, the sole occupant aboard, was fatally injured. Visual meteorological conditions prevailed at the time, and no flight plan had been filed. The flight originated from a staging area near Estes Park approximately 1840.

The helicopter was engaged in fire suppression activities at the Big Elk fire near the Rocky Mountain National Park. According to the U.S. Forest Service (USFS), several large unburned "islands," approximately 400 acres in size, were in the northwest section of Division B. Due to the abundance of fuel and topography, this area had the greatest potential for the fire to spread towards Estes Park.

According to the USFS, the pilot's day began at 0745 when he was dispatched to the Big Elk Helibase, arriving there about 0800. After being briefed, the pilot began making water drop missions. At 1530, he transported fire managers and reconnoitered a fire area. It was determined that additional water bucket drops would be necessary to cool down certain areas, and pre-treat unburned areas. For the next two hours the pilot made a number of water drops. The pilot returned to the helibase about 1800 and the helicopter was refueled. The pilot took off approximately 1820 and made two additional water drops.

According to witnesses, as the pilot made his approach for a third water drop, they heard engine sounds described as the "engine screaming"; like a "car was in neutral and the engine was running fast"; a "high-pitch whine"; a "high-pitch noise"; a "strange noise" like the engine was "under strain" or "bogging down"; "Rrrrrr"; and an "electronic sound with grinding metal." Some witnesses heard "a loud pop," or a "snap." Witnesses said the rotor blades were "still turning" or "slowing" or "winding down." One witness said the "rotor sound was gone." Many reported hearing the rotor blades making a "thump, thump, thump," or "whoop, whoop, whoop" sound. Witnesses monitoring the helicopter's radio frequency reported hearing the pilot say, "Hey guys, I'm having trouble, I'm going down"; "I'm having trouble here"; "Helicopter going down"; "Going down, going down"; "Boat down," or words to that effect. Witnesses on the ground saw purple or blue flames coming from the exhaust stack. One witness said they were "pinkish-colored." Another witness said the flames "took on a flame-thrower effect, " shooting flames two to three feet out the exhaust stack. Another witness reported seeing the helicopter falling "skid down." Another witness said that hitting the ground and rolling over, they heard the engine spooling down. Flames were seen "coming from the engine after impact" and it "sounded like a blowtorch."

A postimpact ground fire, confined to the cockpit area, was quickly extinguished. Witnesses agreed that when they heard the noises and saw the flames coming from the tailpipe, the water bucket --- although low --- was above the trees.

The accident occurred during the hours of daylight at a location of 40 degrees, 17.99' north latitude, and 105 degrees, 26.94' west longitude, or about 6 miles southwest of Estes Park, Colorado, near Rocky Mountain National Park.

CREW INFORMATION

The pilot held a commercial pilot certificate, dated May 3, 1974, with rotary wing-helicopter, instrument-helicopter, and airplane single-engine land ratings. He also held a second class airman medical certificate, dated May 23, 2002, with the restriction, "Must have available glasses for near vision." When he applied for this certificate, he estimated his total flight time at 8,000 hours, 50 hours of which were accrued in the previous six months. The USFS reported that the pilot had 7,730 hours of total time, 900 hours in the Aerospatiale SA315B, and over 7000 hours in rotorcraft. The pilot had 200 hours of flight time within the previous 90 days, 100 hours within the previous 30 days, and 8.7 hours within the previous 24 hours before the accident. According to FAA Civil Aeromedical Institute (CAMI), a review of his medical file disclosed "no major medical problems."

AIRCRAFT INFORMATION

N3978Y (s/n 2520), a model SA315B Llama, was manufactured by Aerospatiale in 1978. It was equipped with a Turbomeca Artouste IIIB turboshaft engine (s/n 815), rated at 858 shaft horsepower. It was owned by and registered to Roberts Aircraft Company of Granite Canyon, Wyoming, operated by Geo-Seis Helicopters, Inc., of Fort Collins, Colorado, and under contract to the Rocky Mountain Interagency Helitack. It was equipped with a 100-foot long line. One end was attached to a quick-release on the bottom of the helicopter, and the other end was attached to a 144-gallon "Bambi" bucket. Opening the bucket and dropping its contents was pilot-controlled by activating a cockpit release, either manually or electrically.

According to the helicopter maintenance records, the last inspection was performed on May 10, 2002. The airframe had accrued 202 hours since this inspection, and had a total time-in-service of 3,709 hours at the time of the accident. The turbine nozzle guide vanes had accumulated 4,707 total hours and were original equipment. According to Turbomeca, the nozzles are not cycle-limited.

According to FAA Special Airworthiness Information Bulletin (SAIB) No. NE-03-30, dated March 13, 2003, the French Military Services had previously sold surplus Aerospatiale Alouette and Lama helicopters, powered by Turbomeca Artouste II, III, and Astazou XIV engines, to the public. The Bulletin noted that the helicopters "may not have been maintained within the framework of a civil regime and their configuration may not conform to the type definition

approved by the Civil Aviation Authority." The French Direction Generale de l'Aviation Civile (DGAC) issued various airworthiness directives to mandate the proper actions to be taken, prior to the next flight, for authorized use of these engines for civil operation. "The FAA, however, does not recognize these surplus foreign military engines as eligible for installation on any civil aircraft having an Airworthiness Certificate other than 'Experimental'. We will not issue an Airworthiness Certificate other than 'Experimental' for aircraft and engines released as surplus by a foreign military service, even if these products have been subsequently resold by a manufacturer, owner/operator, repair facility, or part supplier, due to the lack of historical fleet records. This data is essential to verify the modification standards, the applied repair solutions, the scheduled and unscheduled maintenance practices, and in particular, the life cycle remaining for the critical parts. Without complete knowledge of the previous operational usage and all the aspects of its quality system for maintaining the engines, we cannot find the appropriate level of continued airworthiness for safe operation" as required by Title 14 CFR Part 21.29. These "aircraft and engines cannot be used for civil operation in the US, other than as 'experimental' category aircraft. You cannot presume that their accessories, spare parts, whether new, used or parted out, are eligible for installation of FAA type certificated products used for civil operation."

Turbomeca Service Bulletin No. 218 72 0094 (originally issued August 16, 1995, and most recently updated on August 9, 1997), applicable to Artouste IIIB and B1 engines, outlined the procedures to be taken to convert former military engines to civilian use. The Bulletin required an "engine Airworthiness statement" containing "(1) the knowledge of the engine configuration and of the compliance with the maintenance instructions defined by Turbomeca (periodic inspections, general overhaul, repair); (2) the statement of conformity with the approved design introduction sheet (certified definition, performance); (3) the compliance with the Airworthiness data approved by the Authority (Airworthiness Directive, Service Bulletin, life limits); (4) the presence of the engine data plate, and (5) that the engine be originally assembled by Turbomeca." The Bulletin said "the contractor must provide the military documentation of the engine follow up certifying that operation, possible storage, engine maintenance and repair were carried in compliance with the engine manufacturer prescriptions. If these documents are missing, the engine can only return to service for civilian operation after being completely disassembled for identification of the parts."

According to Heli-Support, Inc., the engine was converted from military to civilian operation on May 10, 2002. At that time, the engine had accrued 1,598.9 hours since overhaul. Heli-Support, Inc., did not perform the last overhaul. The company said that section "E" of the engine logbook contained all the necessary documentation, including modifications made to the engine, and "all required AD's and [Service] Bulletins were complied with...[and] all engine components and accessories were within Time Between Overhaul limitations."

METEOROLOGICAL INFORMATION

Visual meteorological conditions prevailed throughout the area. According to the weather observation made at 1830 by the Roosevelt Hotshots (a firefighting team), the dry and wet

bulb temperatures were 75 degrees and 56 degrees F., respectively; the relative humidity was 33 percent, and the wind was from the northeast, varying from calm conditions to 5 knots.

The 1746 METAR (routine aviation weather) observation at Broomfield-Jefferson County (Jeffco) Airport (BJC), located 45 miles southeast of the accident site, was at follows: Wind, 160 degrees at 17 knots; visibility, 40 statute miles; temperature, 33 degrees C.; dew point, 8 degrees C.; sky condition: scattered clouds, 6,000 feet, ceiling, 12,000 feet broken; altimeter, 30.07 inches of Mercury (Hg).

WRECKAGE AND IMPACT INFORMATION

The on-scene examination of the helicopter was conducted on July 31. Physical evidence indicated the helicopter impacted forested, mountainous terrain in a 60-degree nose low, 30-degree right skid low attitude, then rolled over on its right side. The fuel tank was breached and was leaking fuel. It was estimated the helicopter had 70 gallons of Jet-A on board at the time of the accident. The intact main rotor blades bore no evidence of tree strikes. The tail rotor blades and grips bore little or no impact damage. The right skid and post, cross tube and frame post were broken away from the skid assembly. The water bucket was found still attached to the long line and dangling from a nearby tree. The long line was wrapped around the mast of the helicopter and was still attached to the belly hook. The bucket chute was open and only residual water remained in the bucket.

Cockpit examination showed the fuel flow and fuel shutoff levers were open. The collective control was in the full up position, and the cyclic control was slightly forward and left of neutral. The left antitorque pedal was about 1.5 inches forward of the right pedal. There was drive shaft continuity from the tail rotor to the transmission. Flight control continuity was partially established from the cockpit controls to the various servos.

MEDICAL AND PATHOLOGICAL INFORMATION

An autopsy (#2002CA-81) was performed by the Larimer County Medical Examiner's Office. FAA's CAMI conducted a toxicological screen (#198001) and, according to its report, no evidence of carbon monoxide, cyanide, ethanol, or drugs were detected.

SURVIVAL ASPECTS

According to rescuers, the pilot had a 4-point restraint system fastened, and was wearing appropriate personal protective equipment that consisted of a crash helmet, Nomex flight suit and gloves, and leather boots.

TESTS AND RESEARCH

The helicopter was examined at the facilities of Heli-Support in Fort Collins, Colorado, on August 2, 2002, and again on January 14, 2003. Both the fuel control unit (FCU) and fuel pump

were bench tested. Flows and pressures met or exceeded manufacturer's specifications. Both units were then disassembled and examined. The fuel pump piston exhibited a surface irregularity and discoloration. The transmission was examined. The mast turned freely by hand and all the gears were meshed and turned. Disassembly of the transmission revealed no anomalies. The belly hook electrical and manual releases were tested under various and maximum limit loads. The release operated satisfactorily.

Disassembly of the engine revealed no anomalies in the compressor or combustion chamber. The turbine section was destroyed and had a "corn cob" appearance. Evidence of extreme heat distress was noted aft of the labyrinth seal. The first, second, and third stage turbine wheels exhibited moderate heat damage. The first stage nozzle was the least damaged. The second stage nozzle exhibited moderate heat damage. The third stage nozzle was totally destroyed.

The engine turbine section and the fuel pump piston were shipped to Turbomeca in Tarnos, France, and examined on February 18, 2003. Metallurgical examinations were conducted between May 12 and 15, 2003. Both of these examinations were conducted in the presence, and under the auspices, of an air safety investigator from the Bureau d'Enquetes et d'Analyses pour la Securite de l'Aviation Civile. According to Turbomeca's report received on September 17, 2003, the 1st, 2nd, and 3rd stage turbine wheel blades were fractured (intergranular) at their tips, the trailing edges of the 2nd stage NGV assembly vanes were damaged, and the 3rd stage NGV vanes were completely deteriorated. The report stated that these "blades were exposed to very high temperature (about 400 degrees C. beyond the normal operating temperature for the 2nd and 3rd stage turbine blades)."

The combustion chamber was not damaged, but the outer surface of the mixing unit and the 1st stage nozzle guide vanes were partially covered by a fine film of carbon powder, "likely due to the ingestion of smoke by the engine."

Longitudinal sectioning of the 1st, 2nd, and 3rd stage blades and 3rd stage NGV vanes were subjected to microscopic examination. The report stated, "The deterioration found on all the above components result from overheating over a short period of time." The report also stated that hardness tests indicated "the temperature reached in the area of the turbine blades was around 1,000 degrees C."

The fuel pump piston was examined. It moved "freely in the body" and was removed "without difficulty." The report stated the surface irregularity noted previously was attributed to "the valve rubbing against the bore and correspond to the valve working position." The discoloration was due to "the transfer of metal from the valve to the body."

ADDITIONAL INFORMATION

A mechanic who worked for a Cody, Wyoming, fixed base operator and who had maintained Aerospatiale helicopters and Turbomeca engines for over 20 years, was consulted. He said he had seen many Artouste IIIB engines with similar damage, and it was due to "vortex ring state,"

or the helicopter "settling with power." Author R.W. Prouty, in his book "Helicopter Aerodynamics," discussed vortex ring state. He wrote, "If the rate of descent exceeds 1/4 of the hover induced velocity, the flow conditions are such that the air is going both up and down through and around the rotor in a disorganized and unsteady manner. This is called 'vortex ring' state. It exists until the helicopter is descending at about twice the hover induced velocity.

"In the vortex ring state, the helicopter pilot may find himself in the unusual situation where pulling up the collective pitch does not slow the rate of descent. This is known as 'settling with power.' In other words, "Not only does power go up, but the thrust goes down." The pilot has entered "a flight condition where the required power is more than the available power."

According to the Artouste IIIB Training Manual, engine rotation (nominal) speed is 33,500 rpm, plus or minus 200 rpm. This speed is maintained by the fuel control unit, an isochronous (equal time) speed governor. It does this by metering the engine fuel flow. If a load is placed on the engine, the fuel-metering valve opens, fuel flow increases, and engine torque increases. Variation from this speed must not exceed 1,000 rpm. The time it takes to return from a speed variation to the nominal engine rotation speed is less than 4 seconds.

In addition to the Federal Aviation Administration, parties to the investigation included the U.S. Forest Service, Turbomeca Engine Corporation, American Eurocopter (Aerospatiale), Heli-Support/Roberts Aircraft, and Geo-Seis Helicopters, Inc.

The airframe was released to United States Aviation Insurance Group on December 9, 2002. The engine was released to the insurance company on August 2, 2002.

Pilot Information

Certificate:	Commercial	**Age:**	52,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	May 23, 2002
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 17, 2002
Flight Time:	7730 hours (Total, all aircraft), 900 hours (Total, this make and model), 7730 hours (Pilot In Command, all aircraft), 200 hours (Last 90 days, all aircraft), 100 hours (Last 30 days, all aircraft), 9 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Aerospatiale	**Registration:**	N3978Y
Model/Series:	SA315B	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	2520
Landing Gear Type:	Skid	**Seats:**	5
Date/Type of Last Inspection:	May 10, 2002 AAIP	**Certified Max Gross Wt.:**	5070 lbs
Time Since Last Inspection:	202 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	3709 Hrs as of last inspection	**Engine Manufacturer:**	Turbomeca
ELT:	Installed, activated, did not aid in locating accident	**Engine Model/Series:**	Artouste IIIB
Registered Owner:	Roberts Aircraft Co.	**Rated Power:**	858 Horsepower
Operator:	Geo-Seis Helicopters, Inc.	**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:	U.S. Forest Service	**Operator Designator Code:**	EKKL

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	BJC,5670 ft msl	**Distance from Accident Site:**	45 Nautical Miles
Observation Time:	17:46 Local	**Direction from Accident Site:**	130°
Lowest Cloud Condition:	Scattered / 6000 ft AGL	**Visibility**	40 miles
Lowest Ceiling:	Broken / 12000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	17 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	160°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.06 inches Hg	**Temperature/Dew Point:**	33°C / 8°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Estes Park, CO (NONE)	**Type of Flight Plan Filed:**	None
Destination:	Boulder, CO (1V5)	**Type of Clearance:**	None
Departure Time:	18:40 Local	**Type of Airspace:**	Class G

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:		**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	40.29972,-105.44889

Administrative Information

Investigator In Charge (IIC):	Scott, Arnold
Additional Participating Persons:	James S Finn; FAA Flight Standards District Office; Denver, CO James M Morrison Kenneth Arnold Archie Whitten James Hennessy Scott McAlpine
Original Publish Date:	March 30, 2004
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=55374