



**National Transportation
Safety Board**

Memorandum For The Record

DATE: November 2, 2018

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SUBJECT: Details of Aircraft Wreckage Examination for N5187S/N454AR

On October 3, 2018, the NTSB, FAA, MD Helicopters, Rolls-Royce Engines and Air2 completed initial on-site documentation of the accident scene and removed the wreckage from the field to an access road east of the site. On October 4, 2018, the helicopter was recovered by Dawson Aircraft Recovery and transported to their facility in Clinton, AR. On October 5, 2018, NTSB, FAA, MD Helicopters, Rolls-Royce Engines, Air2, and Boeing met at Dawson Aircraft Recovery to complete a wreckage layout and examination; the following notes summarizes these activities.

Airframe

Fuselage/Landing Gear

The airframe exhibited significant crush damage to the right-hand side. All doors were removed prior to flight. The Plexiglas windshields were broken and fragmented. The lower right-hand side of the fuselage structure appeared crushed and deformed. The left-hand side door frame assembly appeared deformed inward. The aft fuselage was fracture separated. The tailboom assembly was fracture separated into three pieces with impact damage consistent with a main rotor blade strike. The empennage, including the vertical stabilizer, horizontal stabilizer and tip plates, and tail rotor assembly, was fracture separated from the aft tailboom just forward of the vertical stabilizer. The left-hand tip plate was fracture separated from the horizontal stabilizer. The left-hand side of the vertical stabilizer exhibited a diagonal gouge consistent with a tail rotor blade strike. A dent was observed on the trailing edge of the lower portion of the vertical stabilizer. The tail skid appeared undamaged. Both the horizontal and vertical stabilizers exhibited varying degrees of damage including dents, deformation, gouges, and tears. Three parallel gouges were observed on the underneath side of the forward edge of the left-hand horizontal stabilizer toward the center attach point to the vertical stabilizer. The red cover on the beacon was missing but observed in the wreckage gathered from the accident site. The filaments of the beacon light appeared "squiggly". One of the engine access doors remained attached, while the other was observed separated from the airframe. The mast support structure and static mast assembly remained in place. The engine air inlet installation and inlet barrier filter were fracture separated from the airframe. The skid type landing gear were fracture separated from the airframe at the braces. The left-hand aft strut remained attached to the skid tube at the foot. The left-hand forward strut was detached from the

skid tube at the foot and the strut was fractured about mid-span. The right-hand forward and aft struts were detached from the skid tube at the foot. The skid tubes were intact.

Cockpit/Instruments

The cockpit was set up for left-hand command. The left-hand seat support structure exhibited significant deformation. The seat belt anchors and attachment hardware were intact. The inertia reel for the shoulder harness was actioned by pulling on the shoulder harness, and the inertia reel functioned appropriately. The center pedestal console was dislodged from its normal position and was observed lying toward the right-hand side of the cockpit. The caution/warning light panel was removed, and the light bulb filaments examined for stretch by the IIC. The filaments of the light bulbs for the transmission oil pressure, generator out, transmission oil temperature, engine out, main rotor transmission chip, engine chip and fuel filter indicator lights appeared stretched. The filaments of the light bulbs for the tail rotor transmission chip and fuel low indicator lights appeared normal.

Main Rotor System

All five main rotor blades were separated from the main rotor hub and exhibited varying degrees of damage including bending, warping, trailing edge separation, fractures, and deformation consistent with the rotor system being driven at impact. All main rotor blade tips were missing, and varying degrees of impact damage were observed at the outboard ends of all five main rotor blades. The root fitting remained attached to the yellow blade but was separated from the main rotor hub. All other main rotor blades were fracture separated outboard of their root fitting.

Main Transmission and Drivetrain

The panels were removed from the cabin interior to expose the main transmission drive shaft and oil cooler blower, as well as to expose the bottom end of the control tubes going up through the control tube tunnel. The main transmission drive shaft was a Kamatics KAflex drive shaft. It remained connected at the main transmission input shaft but was fracture separated at the coupling to the overrunning clutch. The main transmission drive shaft was rotated by hand and the oil cooler blower rotated, as did the main rotor head and tail rotor drive shaft segment attached to the main transmission output shaft. The two magnetic chip detectors were removed from the main transmission and no particulate matter was observed on either chip detector. Fluid was observed through the site glass on the main transmission. The coupling at the overrunning clutch could be rotated in one direction but not in the other direction as appropriate. The tail rotor drive shaft was fracture separated into five pieces. The forward end remained attached at the main transmission output shaft and the aft end remained attached at the tail rotor gear box. A large section remained in the mid-section of the tailboom and two other sections of the tail rotor drive shaft were located in the wreckage gathered from the accident site. The large section of tail rotor control tube exhibited damage consistent with a main rotor blade strike. The tail rotor was rotated by hand and the attached segment of the tail rotor drive shaft rotated accordingly. The magnetic chip detector was removed from the tail rotor gear box and no particulate matter was observed on the chip detector. Very little fluid was observed through the site glass on the tail rotor gear box; however, a puddle of an oil-like substance was observed underneath the gearbox on the floor.

Tail Rotor System

The anti-torque pedals were partially obstructed by the deformed canopy frame. Once cleared, the anti-torque controls were continuous to the station 142.62 bellcrank where the control rod was fractured. Aft of this, there were fractures of the tail rotor control rod in the area of the aft fuselage section and tailboom fractures. The tail rotor was actioned by hand and the attached segment of the tail rotor control tube responded appropriately. One of the tail rotor pitch change links was fracture separated at the pitch change arm. The pitch change bearing was rotated by hand and it rotated smoothly. The tail rotor blades remained attached to the tail rotor hub. The two blades exhibited bending near the root end. One blade exhibited trailing edge separation.

Flight Control System

Single left-hand pilot controls were installed. The collective stick was fractured aft of the friction lock mechanism. The collective stick could still be moved, and collective control continuity was verified up to the collective bellcrank above the tunnel control rod. The cyclic stick was fractured and connected only by the electrical wiring. The cyclic separated where the cyclic stick fits into the housing base. Lateral and longitudinal control continuity was confirmed up to the lateral bellcrank above the tunnel control rod. Longitudinal control continuity was confirmed up to the longitudinal idler bellcrank above the tunnel control rod. The cyclic trim position was checked by removing the upper bolts of the lateral and longitudinal control rods and checking the cyclic control position. The lateral control trim was near full left lateral trim position and the longitudinal control trim was near mid travel. The cyclic trim control coolie hat was missing on the cyclic grip. The trim actuators were tested by applying battery power at the trim motor wires exposed where the cyclic stick had fractured. The lateral and longitudinal trim actuators extended and retracted normally. Wiring continuity from the trim switch to the trim motors was interrupted by damage to the trim switch wiring. When looking at the front of the trim switch, the wires from the left, center and lower switch studs were not connected to the switch. At the cyclic stick fracture, the wires going to the grip appeared stretched, with the blue wire stretched and separated. An ohmmeter continuity check confirmed the switch functioned when the five-position switch was actioned in the up, down, left, right and center off positions. The upper flight controls, above the upper tunnel control rods, were extensively damaged and exhibited multiple fractures to the mixer controls, bellcranks and control links going to the stationary and rotating swashplates and pitch links. The main rotor hub had multiple fractures to the strap packs, pitch housings and feathering bearings, the blades were separated outboard of the root fitting with blade root section still attached to the pitch housings. The yellow main rotor strap pack and main rotor blade was separated from the hub.

Fuel System

The access covers to the fuel cells were removed from the cabin floor. The fuel shut-off arm was observed in the closed position. The fuel cell to engine line was removed at the left fuel cell cover and several ounces of fuel flowed out of the line. The left fuel cell cover was removed. The fuel float was observed to be free to move as appropriate. The start pump was removed and both fuel inlet ports appeared unobstructed. No fuel was observed in either fuel cell. A small amount of

reddish-brown sediment was observed in spots at the bottom of the left fuel cell. The right fuel cell was ruptured.

Engine

Dried muddy water spots were noted randomly distributed on the engine external surfaces and within the engine compartment. The engine remained within the engine compartment. Both struts on the right-side engine mount were broken at the threaded portion of the rod end connection. The bolt on the upper strut of the left-hand engine mount was sheared. The lower mount was intact but pushed forward towards the firewall. The engine had shifted laterally approximately 4-1/2". The compressor inlet was displaced from the forward firewall by approximately 4".

The only visible areas of external engine damage were contained to the right-hand side from impact forces. Areas of note included the right-hand compressor discharge tube, outer combustion case, both turbine heat shields, and the right-hand exhaust duct. Various ancillary rigid tubes in the vicinity of these components had also suffered from impact and crush damage. Otherwise, the engine did not reveal any obvious signs of damage from impact forces, internal engine failure, or evidence of fire.

The engine to transmission drive shafting was fractured at the KAflex coupling fingers forward of the freewheeling unit. Scoring and battering damage was noted between bore of the rotating coupling on the overrunning clutch and the aft stub end of the KAflex coupling.

Both N1 and N2 rotors could be rotated by hand and were smooth and quiet. Continuity from the 4th-stage power turbine wheel to the power output shaft was established. Continuity was also confirmed throughout the N1 rotor system from the compressor impeller to the starter-generator cooling fan. A borescope was used to verify rotation of the gas producer turbine rotor, which was continuous.

The 1st-stage turbine nozzle guide vane and blades appeared visually normal when viewed with the borescope. Oil staining was noted at the 3 o'clock position on the stage 1 nozzle guide vane and along the length of the combustion liner to the burner drain valve.

Fuel was detected up to the fuel spray nozzle. Approximately 2 teaspoons of clean, clear fuel were drained from the flex line between the turbine fire shield check valve and the fuel spray nozzle. The inlet hose to the engine fuel pump was removed and about 3 tablespoons of clean fuel drained out. The engine fuel filter canister was removed in order to access the filter. A small amount of fuel was present in the canister and the filter was clean, clear, with no sign of foreign debris.

The engine was removed for better accessibility and further examination. The compressor inlet guide vanes, struts, and 1st-stage rotor blades were mostly void of any noticeable impact damage or FOD. One 1st stage blade contained leading edge damage that was bent opposite direction of rotation. Small pieces of foam debris were noted behind the 1st-stage blade row. A borescope was inserted to approximately the 3rd stage blade row. No discernible damage was noted. The 4th-stage turbine blades did not display signs of impact or thermal related damage when viewed thru

the exhaust duct outlets. Random pieces of dirt and dried mud were laying in the exhaust collector support and 4th-stage blade row.

Control continuity could not be fully established from the collective twist grip and throttle to the engine Power Turbine Governor (PTG) and Fuel Control Unit (FCU). The PTG linkage was fractured at the firewall bell crank rod end. The remainder of the linkage to the PTG was capable of actuating the PTG from stop to stop. The FCU linkage was jammed forward of the firewall. The FCU pointer indicator registered 90 on the scale and was up against the max hard stop. All B-nuts were found to be at least hand tight and torque stripe painted. Following removal of the engine both control unit assembly actuator arms could be manually rotated from stop to stop.

The fuel spray nozzle was removed and inspected. There was no evidence of obstruction in the fuel spray nozzle inlet. The nozzle tip was covered with a thin, uniform layer of soot and light carbon. The nozzle was disassembled to inspect the internal thimble screen and spray tip. Both were not obstructed and appeared visually unremarkable.

The magnetic chip detectors were removed and inspected. Both chip detectors were void of ferrous metal debris. The engine pressure oil filter was removed and inspected. The filter and housing were oil wetted and the filter appeared clean and clear of contamination inside the pleats. The engine oil was not drained from the bottom of the gearbox but residual oil collected at various oil system entry examination points appeared clean, clear, non-odor smelling, and void of foreign debris. The airframe auxiliary engine oil filter bypass indicator was extended. The filter assembly was not disassembled and inspected further.