Aviation Investigation Final Report

Location:	West Windsor, New Jersey	**Accident Number:**	ERA12FA563
Date & Time:	September 15, 2012, 12:00 Local	**Registration:**	N58020
Aircraft:	Aerospatiale AS 355F1	**Aircraft Damage:**	Substantial
Defining Event:	Sys/Comp malf/fail (non-power)	**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General aviation		

Analysis

During cruise flight, witnesses on the ground reported hearing a grinding or popping noise, which was followed by the separation of the yellow main rotor blade. Examination of the fore/aft servo revealed that the internal threads of the upper rod end fitting on the servo were severely worn. The lower threaded portion of the upper rod end was not found secured into the servo's upper end fitting and was not recovered. Additionally, the upper end fitting was packed with soil as the lower threaded portion of the upper rod end had separated from it prior to ground impact. A 100-hour maintenance inspection of the accident helicopter had been completed on the morning of the accident and a 600-hour inspection of the accident helicopter was completed about 3 months prior to the accident. Neither inspection detected the worn threads on the fore/aft servo upper end fitting. The fore/aft servo had been overhauled about 4 years prior to the accident. Additionally, the fore/aft servo was repaired 10 months prior to the accident and no anomalies were observed with the threads at that time.

The operator used Mastinox, a corrosion inhibiting compound, during installation of the upper rod ends to the right-roll, left-roll, and fore/aft servos. The helicopter manufacturer's maintenance manual listed only G.355 grease and did not prescribe for the use of Mastinox. However, the standard practices manual stated that a torque correction factor of 0.4 is used for G.355 grease, but not for Mastinox, since the latter is not a lubricant. The torque value listed in the manual for the rod ends already took a torque correction factor into account. A higher torque value would theoretically have been necessary when Mastinox was used in place of G.355 grease. The operator stated an adjusted torque value was not used during installation of the upper rod ends using Mastinox. Evidence of sealant at the junction of the upper rod end and nut, which was required to be applied during servo installation per the maintenance procedures, was not found on either the right-roll or left-roll servos. While the lack of sealant may not result in a catastrophic event, its breakage or absence (and/or radial play of a servo end bearing) noted during a maintenance inspection could be indicative of a loss of torque.

Review of the helicopter manufacturer's checklists and maintenance manuals revealed some guidance for servo inspections. The daily operating check (after the last flight of the day) included an instruction to check the main rotor servos for security and absence of leaks. The 600-hour inspection called for

checking the radial play of the end bearings; however, there were no instructions to specifically check the threads of the servo end fitting or the torque of the rod end nut.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: Disconnection of the upper rod end from the fore/aft servo due to severely worn threads, which resulted in a loss of control and separation of a main rotor blade during cruise flight. Contributing to the accident were incorrect maintenance procedures and inadequate maintenance inspections performed by the operator, and insufficient inspection criteria provided by the helicopter manufacturer.

Findings

Aircraft	Rotorcraft servo system - Fatigue/wear/corrosion
Personnel issues	Scheduled/routine inspection - Maintenance personnel
Organizational issues	(general) - Manufacturer
Personnel issues	(general) - Maintenance personnel

Factual Information

History of Flight

Enroute-cruise	Sys/Comp malf/fail (non-power) (Defining event)
Enroute-cruise	Loss of control in flight
Uncontrolled descent	Collision with terr/obj (non-CFIT)

On September 15, 2012, at 1200 eastern daylight time, an Aerospatiale AS 355F1, N58020, operated by Analar Corporation, was substantially damaged when it impacted terrain following an in-flight breakup near West Windsor, New Jersey. The commercial pilot was fatally injured. The positioning flight was conducted under the provisions of 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed and no flight plan was filed for the planned flight to Atlantic City International Airport (ACY), Atlantic City, New Jersey. The flight originated from Princeton Airport (39N), Princeton, New Jersey, about 1155.

According to the owner and president of the operator, the helicopter had flown during the summer with a loaner main transmission, while its own transmission was sent out for repair. After the repair was complete, the helicopter's main transmission was received and then reinstalled on September 13, 2012. After the installation, the president conducted a maintenance ground run, followed by a 30-minute maintenance test flight, with no anomalies noted. Earlier during the day of the accident, the accident pilot completed a roundtrip flight uneventfully, with a relative of the helicopter owner onboard. Specifically, the pilot flew from 39N to the West 30th Street Heliport (JRA), New York, New York, picked up the passenger, and flew back to 39N. At the conclusion of that flight, the helicopter was "hot fueled" to its maximum fuel capacity and then departed on the accident flight to pick up another relative of the helicopter owner at ACY. The president estimated that the helicopter had flown approximately 1 hour 10 minutes since the installation of the transmission when the accident occurred.

According to information from the Federal Aviation Administration (FAA), the helicopter was in radio and radar contact with McGuire Approach Control. Radio and radar contact were lost at 1200 and no distress calls were received. Witnesses near the area of the accident site reported hearing a banging, explosion, or engine rev noise, followed by a piece separating from the helicopter and the helicopter spiraling nose down toward the ground.

Pilot Information

Certificate:	Commercial	**Age:**	65,Male
Airplane Rating(s):	Single-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 With waivers/limitations	**Last FAA Medical Exam:**	September 12, 2011
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	May 2, 2012
Flight Time:	11100 hours (Total, all aircraft), 2200 hours (Total, this make and model), 21 hours (Last 90 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

The pilot, age 65, held a commercial pilot certificate with ratings for airplane single-engine land, rotorcraft helicopter, instrument airplane and instrument helicopter. His most recent FAA second-class medical certificate was issued on July 21, 2012. It was a deferred issuance due to a new onset of atrial fibrillation. He was previously issued a second-class medical certificate on September 12, 2011. According to employer records, the pilot had a total flight experience of approximately 11,100 hours; of which, about 2,200 hours were in the same make and model as the accident helicopter. The pilot had flown about 21 hours during the 90 days preceding the accident.

Aircraft and Owner/Operator Information

Aircraft Make:	Aerospatiale	**Registration:**	N58020
Model/Series:	AS 355F1	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	5227
Landing Gear Type:	Skid	**Seats:**	6
Date/Type of Last Inspection:	September 15, 2012 AAIP	**Certified Max Gross Wt.:**	5291 lbs
Time Since Last Inspection:	1 Hrs	**Engines:**	2 Turbo shaft
Airframe Total Time:	11431 Hrs as of last inspection	**Engine Manufacturer:**	Rolls Royce
ELT:	Installed, not activated	**Engine Model/Series:**	250-C20F
Registered Owner:	FIG HCRS LLC	**Rated Power:**	420 Horsepower
Operator:	Analar Corporation	**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:		**Operator Designator Code:**	CZIA

The six-seat helicopter, serial number 5227, was manufactured in 1982. It was equipped with two Rolls-Royce (Allison) 250-C20F, 420-shaft horsepower engines. The helicopter was maintained under a manufacturer's approved inspection program. It's most recent inspection was a 100-hour inspection, which was completed on the morning of the accident in conjunction with the installation of the repaired main transmission. At that time, the helicopter had accumulated 11,431.3 hours of operation. The helicopter's most recent 600-hour inspection was completed on June 5, 2012. At that time, the helicopter had accumulated 11,332.7 hours of operation.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	TTN,212 ft msl	**Distance from Accident Site:**	7 Nautical Miles
Observation Time:	11:53 Local	**Direction from Accident Site:**	260°
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	9 knots / 16 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	350°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.13 inches Hg	**Temperature/Dew Point:**	21°C / 9°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Princeton, NJ (39N)	**Type of Flight Plan Filed:**	None
Destination:	Atlantic City, NJ (ACY)	**Type of Clearance:**	VFR flight following
Departure Time:	11:55 Local	**Type of Airspace:**	

Trenton Mercer Airport (TTN) was located about 7 miles west of the accident site. The recorded weather at TTN, at 1153, was: wind 350 degrees at 9 knots, gusting to 16 knots; visibility 10 miles; sky clear; temperature 21 degrees C; dew point 9 degrees C; altimeter 30.14 inches Hg.

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	40.299999,-74.668609

The helicopter came to rest upright in a cornfield, on a magnetic heading of 305 degrees. A postcrash fire consumed a majority of the cockpit and cabin. Due to fire damage, flight control continuity could not be confirmed. Both antitorque pedals were installed. The right cyclic was installed and the left cyclic was located in the field next to the rotorhead, consistent with its removal prior to flight. The right collective was installed and fire damaged. The left collective was not recovered. The majority of the instrument panel, including the caution warning panel, was consumed by fire. Three identifiable engine instruments were recovered; however, their indicating needles were loose. One front seat buckle was identified and noted as unclasped. Both forward cabin doors were found about 50 yards from the main wreckage. The doorpost and segments of the windshield remained attached to the right door. The doorpost and windshield were found separated from the left door (for more information, see Wreckage Plot in the public docket).

The aft section of tailboom was not consumed by fire and exhibited impact damage. The right horizontal stabilizer was separated near the root and a segment of the right horizontal stabilizer was recovered about 165 yards southeast of the main wreckage. The separation signatures were consistent with main rotor blade contact. The left horizontal and upper vertical stabilizers remained attached and were undamaged. The ventral fin remained attached; however, the lower end of the fin sustained impact damage. The tailboom had separated forward of the horizontal stabilizer. The tailrotor driveshaft remained intact from the tailrotor gearbox to just prior to the forward spline, where the tailrotor driveshaft had melted. One tailrotor blade remained attached to the tailrotor hub. The other tailrotor blade separated at the hub and was found 25 yards north, consistent with impact damage. The left engine cowling, with its intake screen, was located about 140 yards south of the main wreckage. The cowling was coated with clean (light yellow/brown) oil on both sides.

The rotorhead, located about 100 yards southwest of the main wreckage, included the top portion of transmission (the conical housing with the epicyclic and ring gear attached), the main rotor shaft, the starflex, and the red and blue main rotor blades with their sleeves and spherical thrust bearings attached. Also included were two servos (left-roll and right-roll) and three pitch change rods. A third servo (fore/aft) was found near the rotorhead, but had separated at both rod end connections; both upper and lower rod end bearings remained attached to the stationary swashplate and conical housing, respectively. The entire yellow main rotor blade and sleeve assembly had separated from the rotorhead and was later recovered about 270 yards southeast of the main wreckage. The yellow star arm had separated from the starflex and was located about 40 yards south of the main wreckage. The lower (stationary) scissor link assembly separated from both hinges and was not recovered. The rotorhead had separated from the main transmission near the upper flange of the bevel gear reduction module's cylindrical housing; the fracture surface remained intact with the separated rotorhead (for more information, see Airworthiness Group Chairman Factual Report in the public docket).

Metallurgical examination of the retained components revealed that the upper rod end of the fore/aft servo (actuator) remained attached to the swashplate and exhibited a bending overstress fracture near its neck. The lower threaded end of the upper rod end (shank, nut, and lock washer) was not in the actuator and was not recovered. The mating threads of the fore/aft servo upper end fitting exhibited severe wear, consistent with thread wear occurring over a period of time. The upper end fitting was packed with soil, consistent with its exposure prior to ground impact. Additionally, new thread impressions were observed, below the original worn threads, consistent with a vibration of the shank in the actuator hole. Metallurgical examination of all other retained components did not reveal any preimpact mechanical malfunctions (for more information, see Materials Laboratory Factual Report in the public docket.)

Evidence of Mastinox, a corrosion inhibiting compound, was found on the threaded shank of the left-roll and right-roll servo's upper rod end (threaded shank of fore/aft servo upper rod end not recovered). Evidence of Mastinox was not found on the remnant upper rod end and end fitting of the fore/aft servo; however, the operator reported that they used Mastinox for the servo connections due to the dissimilar metals (aluminum and steel) and covered the Mastinox with a "thin" layer of grease. No evidence of grease was observed on the servo rod ends or fittings. For the servo rod ends' threaded connection, the Eurocopter maintenance manual (MM) listed only G.355 grease and did not prescribe for the use of Mastinox. However, the Eurocopter standard practices manual stated that a torque correction factor of 0.4 was used for G.355 grease, but not for Mastinox. According to a representative from Eurocopter, the torque value listed in the manual for the rod ends already took the torque correction factor into account and a higher torque would have been necessary when Mastinox was used in place of G.355 grease. The operator reported that they did not adjust torque factor when using the Mastinox with a "thin" layer of grease. Additionally, evidence of sealant at the junction of the upper rod end and nut was not found on either the left-roll or right-roll servos (the sealant area on fore/aft servo was not recovered for inspection). Maintenance procedures for the installation of the rod ends of the servo-controls were found in the Eurocopter Maintenance Manual (MET) Work Card (WC) 67.30.15.401. Review of the WC revealed "…Apply a bead of sealant on the nut (8) and the thread of the ball end (1)…"

Medical and Pathological Information

An autopsy was performed on the pilot by the Mercer County, Office of the Chief Medical Examiner, West Trenton, New Jersey, on September 17, 2012. The cause of death was noted as "Massive multiple traumatic injuries." Toxicological testing was performed on the pilot by the FAA Bioaeronautical Science Research Laboratory, Oklahoma City, Oklahoma. Review of the toxicological report revealed:

"Metoprolol detected in Blood"

Additional Information

Fore/Aft Servo

The Air Equipment F6103 31026-010 (serial number 68) fore/aft servo was manufactured in 1981 and installed on the accident helicopter in 1994. It's most recent overhaul was completed by Aerocopter Component Services (ACS), Ontario, Canada, in March 2008. In August 2010, the fore/aft servo was repaired by ACS and recertified to manufacturer specifications in accordance with Air Equipment Component Maintenance Manual (CMM) No. 67-39-10. Specifically, a bearing was replaced due to play in the pilot valve. In November 2011, the fore/aft servo was again repaired by ACS and recertified to manufacturer specifications in accordance with the same CMM. During the second repair, items were replaced due to hydraulic fluid seepage. A manager at ACS stated that during the most recent repair, the threads were inspected per the CMM and no discrepancies were observed at that time. Review of the CMM revealed, "…check all male and female threads for general condition…"

Review of MET WC 05.21.00.603, titled "Daily Operating Checks" (after last flight of day) revealed, "Servocontrols, hydraulic system. Security, absence of leaks, lines."

Review of MET WC 05.23.00, titled "Basic Inspection" (T Inspection/600-hour Inspection), section 6.3, revealed:

"Servo-controls and particularly rod end bearings
(Fig. 1, DETAIL B) :
Disconnect a mounting pin (W.C. 67.30.00.402 or 67.30.15.402).
Manually check that radial play (J) is normal, the second anchoring point being used as fulcrum. J
If in doubt, remove servo-control as per W.C. 67.30.00.402 or 67.30.15.402 for check in workshop.
Connect or install servo-control as per W.C. 67.30.00.402 or 67.30.15.402."

While the Basic T/600-hour inspection called for checking radial play of the rod end bearings, there was no specific guidance to check either the security (torque) of the rod end nut to the servo end fitting or to inspect the condition of the threaded connection. Review of Eurocopter Standard Practices Manual W.C. 20.02.05.404 contained general guidance for the inspection of threaded components, which must be performed each time an externally threaded part is removed. Other than the note in the daily operating check to look for security and absence of leaks, there was no other guidance specifically pertaining to the security of the rod end connection to the servo end fitting.

Administrative Information

Investigator In Charge (IIC):	Gretz, Robert
Additional Participating Persons:	Peter J Mirales; FAA/FSDO; Philadelphia, PA Jon Michaels; Rolls Royce; Indianapolis, IN Seth Buttner; American Eurocopter; South Prarie, TX
Original Publish Date:	December 2, 2013
Last Revision Date:	
Investigation Class:	Class
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=85046