Aviation Investigation Final Report

Location:	Sunburst, Montana	**Accident Number:**	WPR12TA364
Date & Time:	August 18, 2012, 12:15 Local	**Registration:**	N3939A
Aircraft:	AMERICAN EUROCOPTER LLC AS350B3	**Aircraft Damage:**	Substantial
Defining Event:	Flight control sys malf/fail	**Injuries:**	2 None
Flight Conducted Under:	Public aircraft		

Analysis

The pilot was maneuvering the helicopter in a 3-foot in-ground-effect hover in preparation for departure on a border patrol flight when he heard a loud "bang," which was immediately followed by a decay in the main rotor rpm and a right yaw. The pilot performed an autorotation, and, after touchdown, he conducted the emergency shutdown procedures.

The postaccident airframe examination revealed that the tail rotor moved independently of the main rotor. Further examination revealed that the aft flange of the main gearbox transmission drive shaft was liberated from its flex coupling at the engine output. The castellated nuts that secured the flex coupling to the aft flange of the shaft were found loose, and the bolts were sheared. An examination of the bolts and flex coupling determined that the nuts were most likely hand-tightened and that cotter pins were not installed on three attachment bolts between the flex coupling and flange portion of the drive shaft.

A review of the maintenance records revealed that, about 75 flight hours before the accident, the engine had been removed so that maintenance personnel could perform a modification. Maintenance personnel removed the bolts to the engine-to-main gearbox flex coupling and then partially reassembled the flex coupling bolts, which was not in accordance with the helicopter's maintenance manual engine removal procedure. Although no comments were found in the engine maintenance logbooks indicating that the flex coupling was disassembled from the tail portion of the helicopter, the maintenance performed involved disassembly of the drive shaft. The cotter pins likely were not installed on the attachment bolts during the most recent maintenance, which allowed the nuts to start to back out of the three attachment bolts.

Probable Cause and Findings

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

The improper installation of the engine-to-main gearbox flex coupling, which resulted in the failure of the flex coupling and a loss of power to the rotor system during takeoff.

Findings

Aircraft	(general) - Incorrect service/maintenance

Factual Information

History of Flight

Maneuvering-hover	Flight control sys malf/fail (Defining event)
Takeoff	Flight control sys malf/fail

On August 18, 2012, about 1215 mountain daylight time, a Eurocopter AS350B3, N3939A, experienced a flight control malfunction while in a low hover at a helipad near Sunburst, Montana. The Department of Homeland Security Customs and Border Protection (CBP) was operating the public-use helicopter under the provisions of Title 14 Code of Federal Regulations Part 91. The certified flight instructor and crew member were not injured; the helicopter sustained substantial damage. The pilot was preparing to depart at the time for a local area border patrol flight. Visual meteorological conditions prevailed and no flight plan had been filed.

In a written statement, the pilot reported that he was maneuvering the helicopter in a three foot in-ground-effect hover in preparation for departure on a border patrol flight. He heard a loud "bang," which was immediately followed by a decay in the main rotor rpm and yaw to the right. The pilot performed an autorotation and after touchdown conducted the emergency shutdown procedures.

The initial examination of the helicopter revealed that the tail rotor moved independently of the main rotor. Further inspection disclosed that the aft flange of the main gearbox transmission drive shaft was liberated from its flex coupling at the engine output. The nuts that secure the flex coupling to the aft flange of the shaft were found loose and the bolts were sheared. The other three bolts that attach the spline coupling to the flex coupling were also sheared, but the nuts remained attached. Three loose, bent cotter pins were located in the vicinity. One of the sheared bolt ends (broken off at the cotter key holes) was found on the portable landing platform of the helicopter. The helicopter had only made one departure from the landing platform on the day of the incident, and the pilot has stated that he did not see anything on the engine deck during the preflight.

Pilot Information

Certificate:	Commercial; Flight instructor; Private	**Age:**	32
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Airplane single-engine; Helicopter; Instrument airplane; Instrument helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 2 Without waivers/limitations	**Last FAA Medical Exam:**	July 5, 2012
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	February 15, 2012
Flight Time:	3000 hours (Total, all aircraft), 300 hours (Total, this make and model), 2890 hours (Pilot In Command, all aircraft), 45 hours (Last 90 days, all aircraft), 25 hours (Last 30 days, all aircraft)		

The pilot, age 32, held a CFI with the following ratings: rotorcraft-helicopter, instrument-helicopter, airplane single-engine, and instrument-airplane. He additionally held a commercial pilot certificate with ratings in airplane multi and single-engine land and single-engine sea. He held a second-class medical certificate without limitation issued on July 05, 2012. The pilot reported having a total flight time of 3,000 hours, of which 400 hours was amassed in helicopters. He had accumulated 300 hours in the same make and model as the accident helicopter of which 250 hours he was acting in the capacity of pilot-in-command. Over the last 90 days he had logged 45 hours, 25 hours of which were logged in the last 30 days.

Aircraft and Owner/Operator Information

Aircraft Make:	AMERICAN EUROCOPTER LLC	**Registration:**	N3939A
Model/Series:	AS350B3	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	4806
Landing Gear Type:	Skid	**Seats:**	6
Date/Type of Last Inspection:	March 30, 2012 Annual	**Certified Max Gross Wt.:**	5225 lbs
Time Since Last Inspection:	75 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	889 Hrs as of last inspection	**Engine Manufacturer:**	TURBOMECA
ELT:	Installed, not activated	**Engine Model/Series:**	ARRIEL 2B1
Registered Owner:	DEPT OF HOMELAND SECURITY CUSTOMS & BORDER	**Rated Power:**	848 Horsepower
Operator:	DEPT OF HOMELAND SECURITY CUSTOMS & BORDER	**Operating Certificate(s) Held:**	None

The AS350B3-2B1, serial number 4806, was a main rotor-tail rotor configured single-engine helicopter manufactured in 2009. The helicopter's first production flight was in March 2010 and had acquired 965 hours total time. A Turbomeca Arriel 2B1, serial number 46186, 848-shaft horsepower engine was the original Eurocopter installed engine in the airframe and had accumulated the same total time in service.

The engine power output was directed through a reduction gearbox to a drive shaft that was connected to the main rotor gearbox (MGB) located at the forward end, and the tail rotor drive shaft located at the aft end.

Maintenance History

In accordance with the Eurocopter maintenance program, the shaft and couplings between the engine and MGB are to be inspected at every 100 hours as stated in Aircraft Maintenance Manual section 05-20-02; procedures outlined in 63-10. A complete list of the inspections where the coupling was inspected is contained in the public docket for this report.

According to CBP, the helicopter was taken out of service on March 23, 2012 to complete the necessary 100/110/150 hour inspection. At that time, the helicopter had a recorded total airframe flight time of 889 hours, equating to about 75 flight hours prior to the accident. The inspection coincided with the arrival of a representative from Turbomeca coming to perform TU-166 modification, where the engine would be removed; the modification consisted of inserting blade dampers between the gas generator turbine disc and turbine blade platform in an effort to minimize the effects of high pressure blade vibratory excitation and increase the blade tolerance. The 100/110/150 hour inspection commenced with the plan that the maintenance technicians would complete the inspection up to the point of the engine removal by Turbomeca. Thereafter, the inspection was to be completed.

During the 150 hour inspection, while accomplishing procedure 63-11-00 (6-18), maintenance personnel discovered evidence of oil in the coupling housing, but they could not immediately identify where the source of the leak was located. Accordingly, with seeing evidence of a leak, a mechanic had to perform 63-11-00, 6-1, which required him to follow a series of maintenance procedures. The first of which was 63-11-00 (4-1), and contained the steps necessary to remove the MGB forward coupling. Maintenance personnel stated that upon removal, the shaft was visually inspected and there was no evidence of an anomaly; the aft coupling was not disassembled. Upon completion of the inspection, the mechanic traced the source of the leak to be the power shaft seal and freewheel shaft seal, both of which were then placed on order.

Following the arrival of a Turbomeca representative, the engine was removed and the TU-166 modification completed as planned. At this time maintenance personnel completed work order 3939A-2012-I-0020-025 which documents the removal and replacement of the power shaft and freewheel shaft magnetic seals. The 100/150 hr. inspection resumed where the shaft was reinstalled in accordance with procedure 63-11-00 (6-1). After removal of the shaft, it directs that procedure 63-11-00, 4-2 be accomplished, which is reinstallation of the MGB / Engine Coupling. Following this work the engine was reinstalled and the 100/150 hr. checklist was completed; the aircraft was then returned to service.

This is the last airframe logbook entry for a major inspection prior to the failure of the coupling bolts was recorded as occurring on August 15, 2012 at 964.8 hours or 0.2 prior to the accident.

A review of the logbook entries disclosed that there was no indication that the MGB coupling had ever been dissembled or that the cotter keys were absent. If a cotter key is found to be missing, the maintenance manual required the shaft to be removed and a torque check of coupling the bolts. There was no indication that the rear coupling had ever had a missing cotter key or that the bolts had been checked for torque since manufacture. The records revealed that the forward coupling had the bolts removed on two separate occasions to facilitate removal of the shaft, one of which was in December 2010, when the transmission seal was replaced and the other was the aforementioned TU-166 modification.

Prior Failures

According to Eurocopter, although targeted maintenance on the forward coupling was not performed, nor required, per the maintenance manual, mechanics in previous events disconnected it as a shortcut step during an engine removal/installation. The similar events have occurred due to incorrect or inappropriate aircraft maintenance in other helicopters within 100 hours of engine installation. The NTSB database revealed that two similar events have occured: WPR10FA112, occurred in January 2010 and LAX04TA052 on November 24, 2003.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:	Clear	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.14 inches Hg	**Temperature/Dew Point:**	27°C / -4°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Sunburst, MT	**Type of Flight Plan Filed:**	None
Destination:	Sunburst, MT	**Type of Clearance:**	None
Departure Time:	12:15 Local	**Type of Airspace:**	

Wreckage and Impact Information

Crew Injuries:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 None	**Latitude, Longitude:**	48.885833,-111.89611(est)

Tests and Research

Material Laboratory Examination

The engine-to-main gear box drive shaft and flex coupling assembly were sent to the NTSB Materials Laboratory, and examined from October 22, 2012.

When assembled, three bolts attach the flex coupling assembly to the main gear box drive shaft. Castellated nuts are to be attached to the threaded end of the bolts and tightened to the appropriate torque. As an additional safety feature, cotter pins are to be attached between the bolts and castellated nuts. Bolts were found inserted in the through holes of the flex coupling. One bolt was intact. The two

other bolts contained a fracture that intersected the cotter pin holes, and a thread fragment separated from these two bolts. The cotter pin hole for the three bolts did not contain a cotter pin or fragment of a cotter pin. Scanning electron microscope (SEM) examination of the fracture faces from the bolt fragments revealed micro-void coalescence features typical of overstress separation with no evidence of fatigue cracking. The specified bolts, washers, and castellated nuts for the main gear box drive shaft-to-flex coupling connection were accounted for and recovered.

A SEM examination of the three intact cotter pins revealed the ends contained opposing beveled surfaces that intersected at the core of the cotter pin cross section, consistent with the orientation of knife edges typically found on a cutting plier. SEM examination of each leg fragment revealed one end contained severe deformation and a fracture surface. The other end of each leg fragment contained a flat surface that was perpendicular to the length of the cotter pin. The flat surface showed metal shear flow that was made in one direction. The edge of the flat surface exhibited an isolated area that contained a fracture face. The fracture surfaces on the leg fragments showed evidence of micro-void coalescence typical of overstress separation with no evidence of fatigue cracking.

The flange portion of the main gear box drive shaft contained three arms. Each arm contained an impact mark at the same respective position. The impact marks were consistent with the threaded portions of the bolts from the flex coupling assembly and nuts impacting the flange portion of the main gear box drive shaft while the flex coupling assembly was rotating clockwise looking forward with respect to the main gear box drive shaft.

The bolts were manually removed from their respective holes with ease. The bolts and recovered nuts showed no evidence of a crack. Examination of the aft face of the flex coupling assembly revealed the exposed bolt holes contained deformation on one side and at the same respective position for each hole. The forward and aft faces of each washer, forward and aft faces of the coupler assembly in the areas that corresponded to position of the washers, and underside portion of each nut contained no evidence of fretting damage. The first thread adjacent to the underside portion of each nut had partially separated and fractured. The inner portion of the recovered nuts contained an elastomer in the bore portion at the castellated end indicating the nuts were a self-locking. The forward face of the flex coupling contained a crack that intersected one of the bolt holes.

Additional Information

On the Arriel 2B1 engine, the drive shaft can be installed on the engine into the splined engine flange without removing the flex coupling cotter pins and nuts. This is the method described by the Eurocopter maintenance manual.

Administrative Information

Investigator In Charge (IIC):	Keliher, Zoe
Additional Participating Persons:	Vincent Ecalle; BEA Bureau d'Enquêtes et d'Analyses; Paris Andy Campbell; U.S. Customs and Border Protection; DC Edward Fournier; U.S. Customs and Border Protection ; DC Matthew Rigsby; Federal Aviation Administration; Fort Worth, TX
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