National Transportation Safety Board
Aviation Accident Final Report

Location:	Reno, Nevada	**Accident Number:**	WPR10FA112
Date & Time:	January 17, 2010, 12:50 Local	**Registration:**	N904CF
Aircraft:	Eurocopter AS350 B3	**Aircraft Damage:**	Substantial
Defining Event:	Collision with terr/obj (non-CFIT)	**Injuries:**	3 None
Flight Conducted Under:	Part 91: General aviation - Positioning		

Analysis

The pilot reported that he lifted the single-engine helicopter from the helicopter pad for the emergency medical service positioning flight to pick up a patient. The pilot maneuvered the helicopter into a 25-foot hover and, just as he was beginning the transition to forward flight, he heard a loud bang. The helicopter experienced a power loss and the pilot lowered the collective slightly, resulting in a hard landing on the pad. A surveillance camera that captured the accident sequence indicated that after the helicopter lifted into a hover over the pad, the nose abruptly rotated right 90 degrees and the helicopter descended vertically in a slight nose-down attitude, landing hard on the helipad.

The postaccident airframe examination revealed that the nuts that attach the engine-to-main gear box flex coupling were not present on their respective bolts. The nuts and associated washers were located loose and clumped together just forward of the gimbal ring in the transmission input housing. An examination of the bolts and flex coupling by the Safety Board Materials Laboratory concluded that the nuts most likely had been hand tightened and that cotter pins had not been installed on the bolts. The improper installation lead to the failure of the flex coupling and resulted in a loss of power to the rotor system.

Maintenance records showed that 59 flight hours before the accident the engine had been removed, the helicopter painted, and then the engine was reinstalled. The time between the engine removal and the reinstallation was 88 days. The mechanic who removed the engine stated that he removed the bolts to the engine-to-main gear box flex coupling, and then partially reassembled the flex coupling bolts. This action was not in accordance with the AS350 maintenance manual engine removal procedure. The mechanic who installed the engine 88 days later stated that he did not check the flex coupling bolts because the removal of those bolts is not specified in the maintenance manual as part of the engine removal or replacement procedure. The overall maintenance activity involved a 100-hour inspection, which included a

visual inspection of the engine-to-main gear box flex coupling. Although a visual inspection of the engine-to-main gear box flex coupling is a required action, the Quality Assurance inspector signed off the maintenance without performing the visual inspection of the flex coupling.

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 gear box flex coupling, which resulted in the failure of the flex coupling and a loss of power to the rotor system during takeoff. Contributing to the accident was the mechanic who removed the engine's failure to follow the operator's maintenance procedures. Also contributing was the Quality Assurance inspector's failure to follow the operator's post-maintenance inspection requirements.

Findings

Personnel issues	Installation - Maintenance personnel
Aircraft	Engine/transmission coupling - Not inspected
Aircraft	Engine/transmission coupling - Incorrect service/maintenance
Aircraft	Engine/transmission coupling - Failure

Factual Information

HISTORY OF FLIGHT

On January 17, 2010, at 1250 Pacific standard time, a Eurocopter AS350 B3, N904CF, landed hard on the helicopter pad at Renown Regional Medical Center, Reno, Nevada. The helicopter was operated by Air Methods, d.b.a. Care Flight, under the provisions of Title 14 Code of Federal Regulations, Part 91, as a positioning flight. The pilot and the two medical crew were not injured, and the helicopter was substantially damaged. Visual meteorological conditions prevailed, and a company visual flight plan had been filed. The flight originated at the Renown Regional Medical Center.

The pilot reported to the Safety Board investigator that the purpose of the helicopter emergency medical service (HEMS) flight was to fly to Humboldt General Hospital, Winnemuca, Nevada, to pick up a patient for an inner facility transfer to Renown Regional Medical Center. He lifted from the Renown helicopter pad and positioned the helicopter in to a high hover, 25 feet, per the normal operating procedures. Just as the pilot was beginning his transition to forward flight he heard a loud bang, and the helicopter experienced a partial power loss. The pilot lowered the collective slightly and landed hard on the helicopter pad.

Two of the Renown Medical Center's surveillance video cameras captured the accident sequence. The videos depicted the helicopter on the helicopter pad with the nose pointed to the northwest. A windsock in the vicinity of the helicopter pad was limp at the time of rotor engagement. The helicopter lifted into approximately a 30-foot hover over the pad and about 10 seconds after the helicopter lifts, the helicopter's nose abruptly rotates right 90 degrees, then it descended vertically with the nose pitched down about 20 degrees, and the forward portion of the skids and cockpit chin bubble impact the ground. The helicopter rebounded from the ground impact, and came to rest on collapsed landing skids facing 180 degrees from the original takeoff orientation. The main rotor stopped turning after 1 minute 25 seconds, and the crew began to egress the helicopter about 2 minutes after the accident.

PERSONNEL INFORMATION

The pilot, age 61, held a commercial pilot certificate with rotorcraft-helicopter, and instrument helicopter ratings, issued October 23, 2008. He held a first-class medical certificate with the limitation that he wear corrective lenses and possess glasses for near and intermediate vision, issued on October 14, 2009. The pilot reported having 14,300 flight hours in helicopters, and 9,544 hours in the AS350. Over the last 90 days he had logged 46 hours, 11 hours of which were logged in the last 30 days.

AIRCRAFT INFORMATION

The AS350B3 is a main rotor-tail rotor configured single engine helicopter, serial number (S/N) 3676, manufactured in 2003. The interior was configured with the pilot seat on the right side; the patient litter was located on the left side and extended over the area where the copilot seat would traditionally be. There were two crew seats mounted along the rear cabin bulkhead.

It was powered by a Turbomeca Arriel 2B1, 848 shaft HP engine. The engine power output is directed through a reduction gearbox, and to a drive shaft that is connected to the main gearbox at the forward end and the tail rotor drive shaft at the aft end.

Review of the maintenance records revealed that the airframe had 3,939.5 hours at the time of the accident. The most recent inspection was the A21, B61, and tail rotor (AD 2001-26-55) performed on January 17, 2010. The A21 inspection is a daily airworthiness inspection, the B-61 is a 20-hour engine inspection, and both were conducted in accordance with the Air Methods Approved Airworthiness Inspection Program (AAIP).

Examination of the helicopter maintenance records revealed that on August 3, 2009, at 3,880.4 hours total airframe time, the engine had been removed and the airframe was sent to the Gold Metal Paint Co. for paint finishing work. On October 29, 2009, the engine was reinstalled at the Air Methods certified repair station in Englewood, Colorado. On November 2, 2009, an A-26 (100-hour) inspection was performed, which included the Eurocopter 'S' interval maintenance inspection. The 'S' interval maintenance included inspection of both the flex couplings on the engine-to-main gearbox shaft. On November 11, 2009, an engine power assurance check was performed, with 'Checked Good' logbook entry noted. The helicopter was approved for return to service on December 1, 2009.

WRECKAGE AND IMPACT INFORMATION

The helicopter was removed from the Renown Helipad, and transported to the Air Methods maintenance facility in Reno, Nevada, and secured for further examination. On January 25, 2010, technical representatives from American Eurocopter, Turbomeca USA, Federal Aviation Administration (FAA), and Air Methods Corporation inspected the helicopter under the supervision of the Safety Board investigator-in-charge (IIC).

The left skid was collapsed into the forward fuselage area. The fuselage-tailboom junction exhibited buckled skin. The main fuselage structural beams were deformed. Full control continuity was established for the cyclic, collective, and anti-torque controls. External power was supplied to the cockpit avionics, and the Vehicle and Engine Multi-function Display (VEMD) energized. The VEMD data displayed the accident flight was flight number 7211. Flight 7211 total time was 2 minutes and 8 seconds. Three failures were recorded; test reference 69-OAT (left module), test reference 69-OAT (right module), test reference 124-amber gov OAT VEMD-OAT sensor FADEC (left module), and an NF over limit of 510 rpm. The outside air temperature (OAT) sensor is located under the nose of the helicopter and was impact damaged.

No main rotor blade damage was observed. The main gearbox (transmission) rotated freely in both directions with the corresponding rotation of the main gearbox input flange, but without the corresponding rotation of the engine and tail rotor. Hardware that is associated with the engine to main gearbox drive shaft flex coupling was identified on the engine deck. The engine-to-main gearbox shaft coupling tube was removed, revealing that the engine side flex coupling was detached from the engine-to-main gearbox shaft. Metal shavings were identified inside the perimeter of the aft side of the coupling tube. The flex coupling remained attached to the engine output spline. The three bolts that connect the flex coupling to the transmission shaft

appeared sheared and the bolt fracture surfaces appeared smeared. The three nuts and two associated washers were loose and located clumped together just forward of the gimbal ring in the transmission input housing. No cotter pins were located on the bolts or in the main gearbox input housing. The three bolts attaching the flex coupling to the splined engine flange were present, with nuts, and cotter pins in place.

The engine was attached to the airframe at both the front and rear engine mounts. No apparent damage to the mounts was observed. The engine deck was clean, and no fluids were observed leaking from the engine. The aircraft to engine interface connections were intact and secure. All engine pipes, hoses, and harnesses were intact and properly connected and secured to the engine. The fuel shutoff lever in the cockpit was in the closed position. Oil was visible through the site glass on the oil tank and the level appeared to be within limits.

The engine was removed to facilitate examination of the transmission shaft. The oil filter and fuel filter by-pass indicators were not popped (systems not in by-pass). The electrical magnetic plug, oil filter, and fuel filter were clean. A small metallic sliver was found on the accessory gearbox (MO1) magnetic plug. The fuel pump and metering unit appeared to be undamaged. The free wheel shaft assembly rotated smoothly in both driving and freewheeling directions. Contact damage to the front face of the clutch housing was observed. The engine drive shaft splined nut and lock exhibited rotational scarring. Removal of the engine front support revealed damage to the inside surface of the support. The nose cone and axial compressor blades were unremarkable. The bleed valve was in the open position. The containment ring was unremarkable. The power turbine wheel assembly was easily rotated by hand. The free turbine blades were unremarkable. The reduction gear box casing (MO5) was unremarkable. The reduction gearbox (MO5) magnetic plug was clean. The flexible coupling to the tail rotor drive shaft was intact.

TESTS AND RESEARCH

Material Laboratory Examination

The engine-to-main gear box drive shaft and flex coupling assembly were sent to the Safety Board Materials Laboratory, and examined from April 14-16, 2010.

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. As additional safety feature, cotter pins are to be attached between the bolts and 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 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 bolts, washers, and nuts that were specified for the flex coupling-to-main gear box drive shaft connection were accounted for and recovered.

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 are 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.

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 main gear box drive shaft on the aft face of the flange portion also contained deformation marks on one side of the bolt holes at the same respective position for each hole that corresponded to the marks found on the aft face of the flex coupling. 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 cracks that intersected each bolt hole.

ADDITIONAL INFORMATION

A Federal Aviation Administration (FAA) inspector interviewed the mechanics that removed and reinstalled the engine. The FAA inspector reported that the engine-to-main gearbox drive shaft had been disconnected from the splined engine flange by the mechanic that removed the engine on August 3, 2009. This step was not per the AS350B3 Maintenance Manual. The "removing mechanic" did not tag the disconnected flex coupling and partially reinstalled the flex coupling by finger tightening the nuts on to the bolts. The "removing mechanic" made the following discrepancy logbook entry “Removed engine for inspection,” and the following continuity logbook entry for step #9 “Removed fwd shaft from eng side.” (Note: The discrepancy logbook records a particular maintenance action. The continuity logbook records each step that was used to complete the particular maintenance action.) The engine was reinstalled by a different mechanic on October 29, 2009. The “installing mechanic” entered the corrective action for step 9 in the continuity log as “Installed fwd end short shaft per AS350MM ch 65.” The ‘short shaft’ is common terminology for the first length of the tail rotor drive shaft that connects to the engine and is located in the aft area of the engine. The ”installing mechanic” did not realized the engine-to-main gearbox drive shaft needed to be reconnected because there is no step in the AS350 B3 maintenance manual to disconnect it to remove or install the engine. The engine reinstallation write up was signed off by the Quality Assurance inspector without a visual inspection of the engine-to-main gear box flex coupling.

The engine-to-main gearbox drive shaft flex coupling is covered by the flared coupling housing and coupling tube. Inspection of the flex coupling involves utilizing an inspection mirror positioned through a inspection hole in the flared coupling housing and visually observing that the nuts were on the bolts and cotter pinned.

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.

History of Flight

Autorotation	Collision with terr/obj (non-CFIT) (Defining event)
Takeoff	Loss of engine power (total)

Pilot Information

Certificate:	Commercial	**Age:**	61,Male
Airplane Rating(s):	None	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Helicopter	**Restraint Used:**	
Instrument Rating(s):	Helicopter	**Second Pilot Present:**	No
Instructor Rating(s):	Helicopter	**Toxicology Performed:**	No
Medical Certification:	Class 1 With waivers/limitations	**Last FAA Medical Exam:**	October 14, 2009
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	November 5, 2009
Flight Time:	14300 hours (Total, all aircraft), 9544 hours (Total, this make and model), 13700 hours (Pilot In Command, all aircraft), 46 hours (Last 90 days, all aircraft), 11 hours (Last 30 days, all aircraft), 2 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Eurocopter	**Registration:**	N904CF
Model/Series:	AS350 B3	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	3676
Landing Gear Type:	Skid	**Seats:**	4
Date/Type of Last Inspection:	January 17, 2010 AAIP	**Certified Max Gross Wt.:**	
Time Since Last Inspection:	0 Hrs	**Engines:**	1 Turbo shaft
Airframe Total Time:	3940 Hrs at time of accident	**Engine Manufacturer:**	Turbomeca
ELT:	C126 installed, activated, did not aid in locating accident	**Engine Model/Series:**	Arriel 2B1
Registered Owner:		**Rated Power:**	848 Horsepower
Operator:		**Operating Certificate(s) Held:**	On-demand air taxi (135)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KRNO,4415 ft msl	**Distance from Accident Site:**	2 Nautical Miles
Observation Time:	12:55 Local	**Direction from Accident Site:**	
Lowest Cloud Condition:	Scattered / 6000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	Broken / 9000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	13 knots / 18 knots	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	170°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.71 inches Hg	**Temperature/Dew Point:**	11°C / -1°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Reno, NV (NV57)	**Type of Flight Plan Filed:**	Company VFR
Destination:	Winnemucca, NV	**Type of Clearance:**	None
Departure Time:	12:50 Local	**Type of Airspace:**	

Airport Information

Airport:	Washoe Medical Center Heliport NV57	**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	None
Runway Length/Width:		**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	3 None	**Aircraft Damage:**	Substantial
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 None	**Latitude, Longitude:**	39.526111,-119.796112(est)

Administrative Information

Investigator In Charge (IIC):	McKenny, Van
Additional Participating Persons:	Don Morgan; Federal Aviation Administration; Reno, NV Lindsay Cunningham; American Eurocopter Inc; Grand Prairie, TX Archie Whitten; Turbomeca USA; Grand Prairie, TX Eric Lugger; Air Methods; Englewood, CO Sean Shambo; Federal Aviation Administration; Denver, CO
Original Publish Date:	March 16, 2011
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=75272