National Transportation Safety Board
Aviation Accident Final Report

Location:	BURLINGTON, North Carolina	**Accident Number:**	MIA01FA006
Date & Time:	October 16, 2000, 23:55 Local	**Registration:**	N355DU
Aircraft:	Aerospatiale AS-355-F2	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General aviation - Ferry		

Analysis

About 5 minutes before landing at a hospital, the main rotor gearbox (MGB) oil pressure warning light illuminated. The pilot continued to the hospital, landed, and performed an immediate engine shutdown. A mechanic disconnected the wiring to the MGB oil pressure switch and the light went out. The mechanic stated he believed the oil pressure switch had failed and he asked the pilot to run the helicopter, hover the helicopter, and if everything was normal, to fly it back to the base hospital. The pilot did the run and hover, and then departed the hospital. The helicopter crashed about 1 minute later. Witnesses stated they heard the helicopter approach the crash site at a low altitude and making a slow thumping noise. Examination of the MGB showed the oil pump idler gear had seized in the oil pump due to undetermined reasons and the oil pump drive shaft had failed due to overstress. The teeth on the engine input gears, intermediate gears, and MGB drive gear in the MGB combining gearbox had failed due to high-temperature overstress, which was the result of oil starvation. The helicopter was not equipped with a MGB oil pressure indicator. The maintenance procedure for trouble shooting an illuminated MGB oil pressure warning light is to first check the electrical circuit, and if this does not correct the problem, to change the oil pressure switch. The mechanic stated he did not have the maintenance manuals with him while working on the helicopter. The MGB had been installed in the helicopter after overhaul, 3 days and 4 flight hours before the accident.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The mechanics failure to comply with manufacturers instructions for correction of a illuminated main rotor gearbox oil pressure warning light resulting in the helicopter being dispatched on a ferry flight with a failed main rotor gearbox oil pump, failure of the main rotor gearbox combining gearbox gears due to oil starvation, loss of main rotor RPM, and the helicopter colliding with trees and the ground during an uncontrolled descent.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: CRUISE

Findings
1. ROTOR DRIVE SYSTEM,MAIN GEARBOX/TRANSMISSION - FAILURE,PARTIAL
2. REASON FOR OCCURRENCE UNDETERMINED
3. ROTOR DRIVE SYSTEM,MAIN GEARBOX/TRANSMISSION - NO PRESSURE
4. (C) PROCEDURES/DIRECTIVES - NOT FOLLOWED - COMPANY MAINTENANCE PERSONNEL

Occurrence #2: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: TAKEOFF - INITIAL CLIMB

Findings
5. ROTOR DRIVE SYSTEM,MAIN GEARBOX/TRANSMISSION - FAILURE,TOTAL
6. ROTOR RPM - NOT POSSIBLE - PILOT IN COMMAND

Occurrence #3: IN FLIGHT COLLISION WITH OBJECT
Phase of Operation: DESCENT - UNCONTROLLED

Findings
7. OBJECT - TREE(S)

Occurrence #4: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
8. TERRAIN CONDITION - GROUND

Factual Information

History of the Flight

On October 16, 2000, about 2355 eastern daylight time, a Eurocopter AS-355-F2, N355DU, registered to Duke University, and operated by Corporate Jets, Inc., as a Title 14 CFR Part 91 maintenance ferry flight, crashed shortly after takeoff from Alamance Regional Medical Center, Burlington, North Carolina. Visual meteorological conditions prevailed at the time and no flight plan was filed. The helicopter was destroyed and the commercial-rated pilot was fatally injured. The flight originated about 1 minute before the accident.

The helicopter was dispatched, with the pilot and 2 flight nurses, from Duke University Medical Center, Durham, North Carolina, to Alamance Regional Medical Center, at about 2209, to pick up a patient. The flight nurses stated that about 5 minutes before landing at Alamance Regional Medical Center, the main transmission oil pressure warning light illuminated. The pilot observed the light and reported to them that they were about equal distance from the Burlington-Alamance Regional Airport and the Alamance Regional Medical Center. They elected to continue to the Alamance Regional Medical Center and land. After landing the pilot stated he would not do an engine cool down, and immediately shutdown the engines. During the shutdown, one of the flight nurses reported noticing a burning type smell. This was brought to the pilot's attention and he stated it was probably due to the quick shutdown. The flight back to Duke Hospital with the patient was canceled and a mechanic was dispatched to repair the helicopter. One of the flight nurses stated that prior to leaving in an ambulance with the patient, she went back to the helicopter and spoke with the pilot. The pilot told her it was probably a short in a light switch. (See flight nurse statements.)

The mechanic stated he arrived at the helicopter about 2330. The pilot reported to him that all was normal except for the transmission oil pressure light being illuminated. The mechanic stated he then inspected the helicopter for excessive oil leaks and none were found. He then disconnected the wire from the transmission oil pressure switch and the light went out. The mechanic stated in interview with the NTSB that he did not reconnect the transmission oil pressure switch wire prior to the helicopter taking off. Due to past years of problems with this switch as known by himself and the pilot, they made a decision to ground run and hover the helicopter and if there were no other indications such as vibration, noise, chip light, or temperature indication, and if the pilot felt comfortable with the helicopter, the pilot would fly it back to Duke Hospital. The mechanic observed from the ground, and after a period of run up and then hovering time, the pilot turned on his landing light and took off. (See mechanic statement).

Transcripts of communications between the pilot of N355DU and the Duke University Medical Center, Life Flight Operation Center, showed that pilot reported at 2224 that the main gearbox oil pressure light had illuminated and that they would land at Alamance Regional Medical Center. At 2228, the pilot reported arriving at Alamance Regional Medical Center. At 2347, the pilot reported that N355DU is in service. At 2348, the helicopter is dispatched from Alamance Regional Medical Center. No further transmissions were received from the pilot. (See transcript of communications.)

Witnesses located near the crash site, about 1.3 statute miles east-southeast from the takeoff point, reported hearing the helicopter approaching at what appeared to be a low altitude. They stated the helicopter did not sound normal to them and was making a steady drone and a low velocity thumping noise. They then heard the sound of tree limbs breaking and the helicopter crash to the ground. A postcrash fire erupted. (See witness statements).

Personnel Information

The pilot held a FAA commercial pilot certificate, last issued on January 21, 1994, with airplane multiengine land, rotorcraft helicopter, and instrument airplane and rotorcraft ratings. The pilot held a FAA Class 2 medical with no limitations, issued on June 14, 2000. Corporate Jets, Inc., hired the pilot on September 6, 1994. The pilot was assigned as a pilot on the Eurocopter AS-355 on April 25, 1996. The pilot received the 12-month knowledge, competency, and line check required by 14 CFR Part 135 on December 16, 1999. The pilot received a 6-month instrument flight rules proficiency checkon June 13, 2000. At the time of the accident the pilot had accumulated about 3,700 total flying hours, 3,400 flying hours in rotorcraft helicopters, and 400 flight hours in the Eurocopter AS-355. (See Pilot/Operator Aircraft Accident Report and pilot records.)

The mechanic, who worked on the helicopter at the Alamance Regional Medical Center, prior to the accident, holds a FAA mechanic certificate with powerplant and airframe ratings, last issued on August 17, 1970. The mechanic holds a FAA private pilot certificate, with an airplane single engine land rating, issue on September 6, 1968. At the time of the accident the mechanic held a FAA third class medical certificate, issued on October 20, 1999, with the limitation that the holder shall wear correcting lenses while exercising the privileges of the certificate. Corporate Jets, Inc., hired the mechanic, on September 1, 1992. The mechanic received Eurocopter AS-355 Airframe Field Maintenance training on May 27, 1994. (See mechanic records.)

Aircraft Information

The helicopter was a Eurocopter (formerly Aerospatiale) model AS-355-F2, serial number 5489, manufactured in 1991. The helicopter was equipped with 2 Rolls-Royce (formerly Allison) 250-C20F, 420 shaft horsepower engines. At the time of the accident the helicopter had accumulated about 4,267 total flight hours. The helicopter was inspected on July 12, 2000, 75 flight hours before the accident, when it received a 100 hour and 200 hour airframe inspection in accordance with the operators approved aircraft inspection program. On October 12, 2000, about 4 flight hours before the accident, the helicopter received a 30-hour inspection.

On October 12, 2000, about 4 flight hours before the accident, the main rotor gearbox assembly was replaced with main rotor gearbox serial number M5091, which had zero flight hours since overhaul by Eurocopter on October 9, 2000. This main rotor gearbox had accumulated about 6,870 total flight hours since new. This main rotor gearbox had oil pump serial number M5070 installed in it. The oil pump had zero hours since overhaul by Eurocopter on June 14, 1999, and had accumulated about 4,339 total flight hours since new. During

overhaul of the oil pump, a new driven gear or idler gear was installed and a used drive gear was installed. The total time in service for the used drive gear could not be determined.

Main rotor gearbox installation records showed that preservative oil placed in the gearbox after overhaul was drained and the transmission was serviced with new oil. The pilot who performed the test flight after the transmission installation and the pilot who flew the helicopter prior to the accident pilot stated the main rotor gearbox contained the normal amount of oil when inspected during preflight inspections. Records show that at the time of the accident, the helicopter was on the seventh flight since installation of the main rotor gearbox, and the helicopter had flown about 4 flight hours since the installation. (See maintenance records.)

Meteorological Information

Visual meteorological conditions prevailed at the time of the accident. The Burlington-Alamance Regional Airport automated surface weather observation taken at 2354, was wind calm, visibility 4 miles in fog, skies clear, temperature 55 degrees F., dewpoint temperature 54 degrees F., altimeter setting 30.10. The airport is located about 2 nm south of the accident site.

At the location of the accident, the moonrise was at 2117 and the moon had an 87 percent illumination. Sunset was at 1841.

Wreckage and Impact Information

The helicopter crashed east of a residence located at 2613 Churchill Drive, Burlington, North Carolina. The accident site coordinates are 36 degrees 3 minutes 42.6 seconds north latitude, and 079 degrees 29 minutes, and 1.2 seconds west longitude. Examination of the crash site showed the helicopter collided with trees while descending on an easterly heading, which separated the tail boom. The fuselage then continued easterly for about 50 feet and collided with the ground while in a right side low attitude. All components of the helicopter, which are necessary for flight, were located on or around the main wreckage.

Examination of the main wreckage, which consisted of the main cabin, main rotor system and gearbox, and engines, showed that a post crash fire had consumed it. The main skids right fore and aft cross tubes were broken. The main rotor blades were in place on the rotor head and the blades had very little rotational damage. One blade had an impact mark on the leading edge near the tip. All separation points in the flight control system were consistent with overstress separation or fire damage. The main rotor head rotated and the bevel gear in the main rotor gearbox turned. The lower mast bearing had no damage and turned freely. The main rotor gearbox lower housing and combining gearbox housing were burned away. All combining gears were separated and had melting, smearing, and fire damage. The main rotor gearbox oil pump drive shaft was separated near the mid span and the oil pump gears were found in the debris. The oil pump housing and oil pump gear bushing areas was consumed by fire. The main rotor gearbox oil pressure switch and associated wiring was destroyed by fire.

Examination of the tail boom showed that the tail boom had separated from the helicopter during impact with trees. The aft end of the tail boom, which included the tail rotor,

tail rotor gearbox, and vertical fin, was found lying below the trees that had been impacted. The horizontal stabilizer was also separated and lying beneath the trees. The remainder of the tail boom remained in a tree. The tail rotor blades had very little rotational damage. The tail rotor gearbox and drive shaft rotated freely and separation points in the tail rotor controls and drive system were consistent with overstress separation. The vertical fin had a 4-inch diameter impact mark on the trailing edge. (See Eurocopter report.)

Examination of the No. 1 engine showed that the accessory gearbox assembly and accessories were destroyed as a result of the post crash fire. The power turbine section had impact damage and there was rotational rubbing damage from the power turbine wheel. The gas producer turbine and compressor sections rotated freely. The engine to main rotor combining gearbox drive shaft had no pre-crash damage. Continuity of the engine was confirmed and all damage was consistent with impact and post crash fire damage.

Examination of the No. 2 engine showed that the accessory gearbox assembly and accessories were destroyed as a result of the post crash fire. The power turbine section had impact damage and there was rotational rubbing damage from the power turbine wheel. The gas producer turbine rotated freely. The compressor section had foreign object damage from ingestion of debris. The compressor rotated freely. The engine to main rotor combining gearbox drive shaft had no pre-crash damage. Continuity of the engine was confirmed and all damage was consistent with impact and post crash fire damage. (See Rolls-Royce report.)

Medical and Pathological Information

Postmortem examination of the pilot was performed by Dr. Robert L. Thompson, M.D., Pathologist, Office of the Chief Medical Examiner, Chapel Hill, North Carolina. The cause of death was attributed to multiple traumatic injuries. No findings, which could be considered causal to the accident, were reported. Postmortem toxicology studies on specimens obtained from the pilot were performed by the Office of the Chief Medical Examiner, and by the FAA Toxicology Laboratory, Oklahoma City Oklahoma. The tests were negative for carbon monoxide, drugs, and ethanol. (See toxicology reports.)

Tests and Research

The Eurocopter Fault Isolation Manual for the AS-355 helicopter states in the section on Main Rotor Gearbox Lubrication, Trouble Shooting, that the recommended method for trouble shooting a main rotor gearbox oil pressure warning light illumination is, first, check the warning light electrical circuit. Next, replace the oil pressure microswitch. Finally, if there is no electrical anomaly, remove the main rotor gearbox and rotor mast assembly for major overhaul. The mechanic who worked on N355DU at the Alamance Regional Medical Center prior to the accident stated to NTSB after the accident that he did not have the fault isolation or maintenance manuals with him. He stated he disconnected the wires from the oil pressure microswitch to the warning light, and the warning light went out. He stated he believed the oil pressure microswitch had failed and he would replace the microswitch after the pilot ferried the helicopter back to the Duke University Medical Center. (See Fault Isolation Manual pages and mechanics statement.)

The Flight Manual for the Eurocopter AS-355 states in section 2.1, titled Red Lights, that illumination of the main rotor gearbox (MGB) oil pressure light indicates minimum MGB oil pressure warning. The pilot action is to reduce engine power and test the indicator lights to verify that the MGB temperature light also illuminates. The next step is to land as soon as possible. The procedure has a note, which states "the MGB has successfully passed a bench test consisting in running the gearbox for 45 minutes with zero oil pressure, at the power corresponding to minimum power in level flight (at 55 kt)." Eurocopter personnel stated that the minimum power in level flight at 55 knots is about 190 kilowatts. They stated the power required for hovering is about 450 to 500 kilowatts. (See Eurocopter Report.)

The accident helicopter was not equipped with a main rotor gearbox oil pressure gauge. Eurocopter personnel reported to NTSB that Eurocopter Service Bulletin AS-355 No. 01.04, dated December 11, 1990, gives instructions for installing a main rotor gearbox oil pressure gauge in the helicopter. (See Service Bulletin AS-355 No. 01.04.)

Metallurgical Examination

Metallurgical examination of 5 gears from the main rotor combining gearbox, the gears and drive shaft from main rotor gearbox oil pump, the gearbox input pinion, 2 pieces of the tail rotor drive shaft, a portion of the tail rotor control rod, the lower mast bearing, lower vertical shaft bearing, the upper drive adapter, and the No. 2 engine fourth-stage turbine nozzle was performed by the NTSB Material Laboratory, Washington, D.C.

All five main rotor combining gearbox gears had a charred appearance with white deposits on the surfaces. Large deposits of previously molten metallic material were observed on the No. 2 engine input gear. The gear teeth on each gear were flattened nearly to the base of the teeth. The tooth deformation on the five gears was uniform around the circumference. Overall tooth deformation in the right intermediate gear was greater than that in the left intermediate gear. The tooth deformation for the No. 1 engine input gear, left intermediate gear, No. 2 engine input gear, and right intermediate gear was smeared toward the counter-clockwise direction (as viewed from the aft), consistent with a clockwise rotation of the engine input gears relative to the intermediate gears. The teeth in input gear to the main rotor gearbox bevel gear appeared to be evenly flattened and did not have a smeared appearance.

The main rotor gearbox oil pump drive shaft, was fractured about mid span. Multiple shallow spiraling cracks were observed along the entire length of the shaft. The fracture surface was flat with a rough area at the center. Deformation at the surface adjacent to the fracture surface was consistent with a clockwise rotation of the upper surface relative to the lower surface. The orientation of the spiral cracks and fracture surface features are consistent with an overstress failure in torsion, where the upper end of the drive shaft rotated clockwise relative to the lower end.

The oil pump drive gear (which is attached to the oil pump drive shaft) and the idler gear teeth were examined after cleaning and no impressions or marks from foreign objects were observed. The bushing area for the idler gear shaft had circumferential marks and were rougher than the drive gear shaft bushing area. Orange-colored material was observed accumulated on the surface of the idler gear shaft bushing area, and less material was observed

on the drice shaft bushing area. The orange-colored material was identified as predominately copper.

The fracture surfaces on the tail rotor drive shaft and the tail rotor control rod were consistent with overstress separation. (See NTSB Materials Laboratory Factual Report.)

Additional Information

The NTSB released the wreckage of the helicopter on October 18, 2000, to Jay Heffernan, Director of Safety, Corporate Jets, Incorporated. Components retained by NTSB for further examination were released to Dennis Kruger, Insurance Adjuster, ACE USA, Leaf River, Illinois.

Pilot Information

Certificate:	Commercial	**Age:**	39,Male
Airplane Rating(s):	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):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last FAA Medical Exam:**	June 14, 2000
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	3700 hours (Total, all aircraft), 400 hours (Total, this make and model), 50 hours (Last 90 days, all aircraft), 30 hours (Last 30 days, all aircraft), 1 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Aerospatiale	**Registration:**	N355DU
Model/Series:	AS-355-F2 AS-355-F2	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	5489
Landing Gear Type:	High skid	**Seats:**	5
Date/Type of Last Inspection:	July 10, 2000 AAIP	**Certified Max Gross Wt.:**	5600 lbs
Time Since Last Inspection:	72 Hrs	**Engines:**	2 Turbo shaft
Airframe Total Time:	4192 Hrs	**Engine Manufacturer:**	Rolls-Royce
ELT:	Installed, activated, did not aid in locating accident	**Engine Model/Series:**	250-C20F
Registered Owner:		**Rated Power:**	420 Horsepower
Operator:		**Operating Certificate(s) Held:**	On-demand air taxi (135)
Operator Does Business As:		**Operator Designator Code:**	BAQA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Night/bright
Observation Facility, Elevation:	BUY ,617 ft msl	**Distance from Accident Site:**	2 Nautical Miles
Observation Time:	23:54 Local	**Direction from Accident Site:**	170°
Lowest Cloud Condition:	Clear	**Visibility**	4 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30 inches Hg	**Temperature/Dew Point:**	55°C / 54°C
Precipitation and Obscuration:	N/A - None - Fog		
Departure Point:	(4NC3)	**Type of Flight Plan Filed:**	None
Destination:	DURHAM , NC (NC92)	**Type of Clearance:**	None
Departure Time:	23:54 Local	**Type of Airspace:**	Class G

Airport Information

Airport:		**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:	0	**IFR Approach:**	
Runway Length/Width:		**VFR Approach/Landing:**	Forced landing

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:**	36.079524,-79.440948(est)

Administrative Information

Investigator In Charge (IIC):	Kennedy, Jeffrey
Additional Participating Persons:	JAMES ALLEN; GREENSBORO , NC KEN ARNOLD; GRAND PRAIRIE , TX MICHAEL A WEBER; INDIANAPOLIS , IN JAY HEFFERNAN; WEST MIFFLIN , PA
Original Publish Date:	November 28, 2001
Note:	The NTSB traveled to the scene of this accident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=50472

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report. A factual report that may be admissible under 49 U.S.C. § 1154(b) is available here.