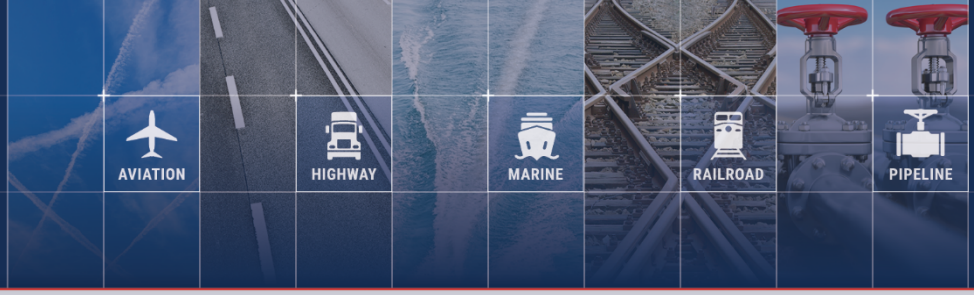

Aviation Investigation Final Report

Location:	NEWPORT, Rhode Island	**Accident Number:**	NYC94FA106
Date & Time:	June 30, 1994, 19:40 Local	**Registration:**	N76UT
Aircraft:	SIKORSKY S-76B	**Aircraft Damage:**	Substantial
Defining Event:		**Injuries:**	3 None
Flight Conducted Under:	Part 91: General aviation - Executive/Corporate		

Analysis

AFTER DISCHARGING PASSENGERS ON AN ISLAND, THE S-76 HELICOPTER DEPARTED FOR A RETURN FLIGHT TO THE MAINLAND. ONE MINUTE AFTER TAKEOFF, AT 500 FEET ABOVE THE WATER, A VIBRATION FOLLOWED BY A LOUD BANG OCCURRED. THE MAIN GEAR BOX (MGB) CHIP LIGHT ILLUMINATED AND THE NUMBER ONE ENG DROPPED OFF LINE. A FORCED LANDING WAS INITIATED, THE EMERGENCY FLOATS WERE INFLATED AND A DITCHING TO WATER WAS ACCOMPLISHED. THE NUMBER ONE ENG WAS SHUT DOWN, AND THE ACFT WAS WATER TAXIED ON THE SECOND ENG. AFTER A SECOND BANG WAS HEARD THE NUMBER TWO ENG WAS SHUT DOWN. EXAMINATION REVEALED THAT THE LEFT HAND (NUMBER ONE ENG) HELICAL GEAR IN THE MGB, FAILED FROM FATIGUE CRACKS ACROSS THE 12 ATTACHING BOLT HOLES. THE TORQUE REQUIRED ON THE 12 NUTS WAS 4OO INCH POUNDS. THREE NUTS HAD LESS THEN 60 INCH LBS, THE REMAINING NINE HAD NO TORQUE. BOTH MGB OIL PUMPS WERE SEIZED FROM FOD THAT ENTERED THE PUMPS THROUGH AN ALTERNATE OIL PATH, THAT BY-PASSED THE OIL SCREENS. THE NUMBER TWO ENG PINION GEAR IN THE MGB, FAILED DUE TO OVERHEATING FROM THE LACK OF LUBRICATION. ELAPSED TIME WAS LESS THAN 6 MINUTES FROM INITIAL FORCED LANDING TO SECOND ENGINE SHUT DOWN.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the failure of the left hand helical gear in the main gear box (MGB), due to undertorqued attaching bolts installed by the manufacturer, which resulted in a partial MGB failure. This failure resulted in the loss of the number one engine, illumination of the MGB chip light and a ditching to salt water on emergency floats.

Findings

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

Findings
1. ROTOR DRIVE SYSTEM,MAIN GEARBOX/TRANSMISSION - UNDERTORQUED
2. ROTOR DRIVE SYSTEM,MAIN GEARBOX/TRANSMISSION - FAILURE,PARTIAL
3. (C) PROCEDURE INADEQUATE - MANUFACTURER

Occurrence #2: FORCED LANDING
Phase of Operation: DESCENT - EMERGENCY

Findings
4. 1 ENGINE

Occurrence #3: DITCHING
Phase of Operation: LANDING

Findings
5. TERRAIN CONDITION - WATER

Factual Information

HISTORY OF FLIGHT On June 30, 1994, at 1940 eastern daylight time, a Sikorsky S-76, N76UT, owned by United Technologies Corporation and piloted by Mr. James A. Williams, was substantially damaged during a forced landing and ditching to the Narragansett Bay near Newport, Rhode Island. The two pilots and passenger were not injured. Visual meteorological conditions prevailed and a visual flight rules flight plan had been filed for the flight operating under 14 CFR 91.

The helicopter had departed Hartford, Connecticut, and proceeded to Goat Island, Rhode Island, with passengers. According to the flight crew, the flight to Goat Island was uneventful. The passengers were discharged at Goat Island and N76UT departed for the return leg over water back to Hartford. The pilot-in-command (PIC) reported that about 1 minute after a normal takeoff, while level at 500 feet above the water, he heard a unusual "hum" from some where in the aircraft. In a statement provided by the PIC, he stated:

"...Within a few more seconds the noise got considerably louder, coupled with noticeable vibrations, followed by a loud bang. I announced we were going down, called for floats to be armed, called for floats to be deployed and subsequently ditched in the water...I secured the left engine that had failed to flight idle and continued to water taxi to safer waters. After approximately 2 minutes there was a loud rumble at which time I secured the right engine..."

According to the Federal Aviation Administration (FAA) Inspector's statement, the PIC stated to him that shortly after the transmission chip detector light illuminated, the transmission low oil pressure light illuminated, followed by an un-commanded reduction of power on the number one engine.

The pilot-not-flying (PNF) reported that shortly after takeoff, he heard a "buzzing" sound that quickly became a rumble, then a severe vibration. Almost simultaneously he heard a muted explosion and the main transmission chip caution light illuminated, followed by an engine out warning tone. He further stated that during the emergency, he had been communicating on the helicopters VHF radio; however, after the water landing he utilized a portable cellular phone, dialed 911, and reported his situation to the police. The police contacted the Coast Guard, who arrived on the scene within several minutes of receiving the call.

The deck of the responding Coast Guard ship was higher then the helicopter. This required the crew of N76UT to exit the helicopter into the sea water before they could be recovered. The Coast Guard ship then took the helicopter in tow and proceeded to a land dock.

The accident occurred during the hours of dusk at approximately 41 degrees, 29 minutes north latitude, and 71 degrees, 22 minutes west longitude.

PERSONNEL INFORMATION

PILOT-IN COMMAND

The PIC, Mr. James A. Williams, holds an Airline Transport Pilot Certificate with ratings for airplane multi-engine land and rotorcraft helicopter. He holds a Commercial Pilot Certificate with ratings for airplane single engine land, single engine sea, and glider. Mr. Williams also holds a Flight Instructor Certificate for airplane single and multi-engine land, rotorcraft helicopter, glider, and instrument airplane.

His most recent Federal Aviation Administration (FAA) Second Class Medical Certificate was issued on December 21, 1993.

The pilot operator report indicated that Mr. Williams had accumulated a total of 10,000 flight hours, of which 2,000 hours were in the S-76.

PILOT-NOT-FLYING

The PNF, Mr. Wesley A. Smith, holds an Airline Transport Pilot Certificate with ratings for airplane multi-engine land and rotorcraft helicopter. He held a Commercial Pilot Certificate with a rating for airplane single engine land.

His most recent Federal Aviation Administration (FAA) Second Class Medical Certificate was issued on May 27, 1994.

The pilot operator report indicated that Mr. Smith had accumulated a total of 6,500 flight hours, of which 1,000 hours were in the S-76.

WRECKAGE

The helicopter remained upright on the emergency floatation equipment; however, the fuselage partially submerged and salt water came in contact with the entire lower portion of the main fuselage, cabin floor and tailboom. The remainder of the helicopter was undamaged except for the number one engine and the main gear box (MGB).

The number one engine compressor section displayed small nicks and dents on the compressor blades. The top aft area of the MGB, near the tail rotor take-off, displayed a rupture in the case approximately 4 inches wide by 18 inches long. The two speed sensors, normally mounted in that area, were hanging outside of the case still attached to their electrical harnesses.

Several pieces of the MGB case, and two segments of a helical gear rim, were found on the number one engine deck. There was no indication of debris penetration or damage to any of

the surrounding helicopter structure or systems.

Turning the number one input flange in a clockwise direction did not drive the main rotor head, the tail take-off flange, or back drive the number two input flange. Turning the number two input flange in a clockwise direction, also did not drive the main rotor head, the tail take-off flange, or back drive the number one input flange.

The MGB, serial number A231-00072, part number 76351-09600- 042, was removed on July 2, 1994, and transported to the Sikorsky Aircraft Overhaul and Repair Facility for further evaluation.

TESTS AND RESEARCH

Main Gear Box (MGB)

On Sunday, July 3, 1994, Sikorsky personnel initiated the disassembly and inspection of the MGB at the Sikorsky Aircraft Facility. The FAA Flight Standards District Office (FSDO) Inspector, David G. O'Donnell, responsible for the on scene investigation, and the NTSB investigator-in-charge (IIC), were not present, and did not learn of the disassembly until July 5, 1994.

A document dated July 8, 1994, with a section labeled "Notes and Observations," was provided to the FAA and NTSB by the Director of Sikorsky Product Safety. This provided the observations made on July 1, 1994, and the disassembly of the MGB on July 3, 1994.

During the disassembly, the right and left side chip detectors were removed, and numerous ferrous debris was found on the magnetic wafers of both detectors. The screen portion of the detectors contained minor debris. The lubrication probe jets were removed and no evidence of debris was found on either screen element. The oil filter assembly was in the by-pass, as indicated by the red button extension. Some metallic debris was identified in the filter element.

In addition to the segments of helical gear found outside of the MGB, the remaining pieces were found inside of the MGB. These segments were determined to be part of the left hand (number one engine) helical gear rim. The center section of the helical gear remained bolted to the tail rotor take-off (TTO) spur pinion. The helical gear rim was separated from the center section of the gear, in the vicinity of the bolt holes where the 12 bolts join the helical gear and the TTO. The self-locking nuts on 2 of the 12 bolts were determined to have 60 inch pounds of torque, and a third had 20 inch pounds of torque. Eight of the remaining nuts had no measurable torque. The 12th nut was missing from the bolt. Sikorsky torque specifications required 400 inch pounds on each of the 12 nuts.

The nuts on each of the main input assemblies were removed, and the torque values were recorded in the tightening direction. The values were found to be as follows:

Number 1 Input Assembly actual reading blue print

part number 76351-09137-101 250 foot pounds 250 ft/lbs part number 76351-09135-101 350 ft/lbs 600 ft/lbs

Number 2 Input Assembly

part number 76351-09137-101 350 ft/lbs 350 ft/lbs part number 76351-09135-101 350 ft/lbs 600 ft/lbs

On July 8, 1994, the NTSB IIC met with FAA and Sikorsky representatives at the Sikorsky Facility in Stratford, Connecticut. During this meeting a further examination of the MGB was conducted.

The number one and two MGB oil pumps shafts were sheared at their fuse points. The left hand accessory drive helical gear was fractured 360 degrees through the web of the lightening holes, and the gear rim was found in the sump of the MGB separated from the shaft section. Both of the MGB oil pumps were seized and could not be rotated. The pumps were removed for further examination.

All of the right hand (number two engine) bevel pinion gear teeth were missing. Molted metal fragments could be seen at the toe and heel of each tooth area. Blue heat indications were present over the entire bevel pinion tooth area. Large quantities of metallic debris was found in the lower housing cavity of the MGB.

MGB Oil Pumps

On July 14, 1994, the MGB oil pumps were examined at the Lear Romec Facility, under the supervision of James Davidson, of the Cleveland, FSDO. The Lear Romec report stated:

"Upon disassembly of both [pumps]...it was noted that extensive amounts of FOD contamination was found in and around critical areas of close tolerance, within the pumping element. The contamination consisted primarily of ferrous chips and shavings ...All ferrous pumping components such as the rotor and blades were fully intact and had no areas of metal removal...Ingestion of metallic particles and other debris into the pumping elements caused binding in precision clearances between blade tips and the liner I.D., eventually locking up the pumps. This resulted in an over torque condition leading to shaft shear in both units."

NTSB Metallurgist's Factual Report

The National Transportation Safety Board, Office of Research and Engineering, Materials Laboratory Division, examined the input bevel pinion, corresponding castellated nut, helical gear, tail take-off (TTO) pinion, and the 12 bolts and attaching nuts that secure the TTO pinion

to the helical gear. The report stated:

Helical Gear: "...In the assembled condition, the aft face of the helical gear in the vicinity of the bolt-though holes contacts the forward face of the tail-take-off (TTO) pinion ... Severe fretting damage was noted all around the aft surface between the holes...Bench binocular microscopic examination of the fractured gear pieces...revealed features characteristic of a fatigue crack emanating from multiple origins on the aft surface ...Propagation of all fatigue cracks was toward the forward face and terminated after they propagated through nearly 60 to 80% of the wall cross section. The original fracture features across the entire wall cross section...were obliterated by post accident mechanical damage. The mating fracture exhibited similar features....The radial fracture between through-holes...displayed fatigue markings indicating propagation outboard...The remaining fractures indicated...features typical of overstress separations ....The spline for this gear appeared to contain no damage...."

TTO Pinion: "...Examination of this gear revealed the forward face of the gear in the prescribed area was coated with a yellowish coating which a representative from Sikorsky indicated was a typical color for the aluminum bronze ekonol coating. This coating contained severe fretting damage that in the most part was between the through-holes corresponding to fretting damage on the mating aft face of the helical gear...."

Bolts: "...The shank of bolts "1", "2", "3", "11", and "12" exhibited severe rub damage. The first two threads next to the shank of bolt "1" also exhibited similar rub damage. Less severe rub damage was noted on the shanks of the remaining bolts. The mating holes for these bolts also exhibited rubbing damage...."

ADDITIONAL INFORMATION

The MGB removed from N76UT, was manufactured by Sikorsky Aircraft and designed to accumulate 3,000 hours before requiring overhaul. At the time of failure, N76UT and this MGB, had accumulated 1,972.1 hours.

A review of the aircraft maintenance records revealed that this MGB experienced four MGB chip detector light illuminations during it's service life. The first two chip lights occurred at 97 and 174 hours of service, where small amounts of "fuzz" were observed during the maintenance inspection. The third light occurred at 1,011 hours of service, where a small piece of garlock seal spring was observed on the left hand chip detector. The fourth chip detector light occurred at 1,965 hours of service, 7 hours before the MGB failure. After performing the Sikorsky serviceability check, in accordance with S-76B Maintenance Manual 66-10-00, no contamination was noted and the helicopter was returned to service.

The MGB oil filter has a differential pressure indicator (DPI) installed to measure the pressure difference between the input and output lines. An increase in differential pressure will pop the DPI red button out, which then requires a maintenance procedure to be performed. On six occasions, the DPI red button was found popped on this MGB. The first five occasions

occurred at 834, 1,059, 1,265, 1,603 and 1,865 hours of service. The last occasion occurred at 1,962 hours of service, 10 hours prior to the MGB failure. During all six occasions the transmission filter was replaced, and no defects were noted.

The MGB contains a left and right oil pump. The oil path to each pump is through its respective chip detector assembly. The pumps then provide pressure to a common line to lubricate the MGB. Each chip detector assembly is surrounded by a screen to catch material and protect the oil pumps. Although there were several pounds of metal particles in the MGB sump, and both of the oil pumps were seized from the ingestion of metal particles, there was a low volume of material collected on the screens. Examination of the chip detector/screen assembly revealed that the screen did not completely protect the oil path to the pumps. A designed alternate oil path existed, allowing unscreened oil to pass to both MGB oil pumps. This design is common to all S-76 MGB's.

During the meeting on July 8, 1994, the certification of the MGB, without oil pressure, was discussed. A representative of the Transmission Design Engineering Department stated, the original certification of the MGB without oil pressure, was accomplished with both engines providing approximately 60 percent engine power to the MGB, with a load applied to the main and TTO output shafts. After approximately 18 minutes, the left and right bevel pinion gears failed from overheating. During the MGB failure on June 30, 1994, after the left engine dropped off line, the right engine was operated as necessary to accomplish the water landing and taxi. The total time of the single engine operation was less then 6 minutes. During this period of time the right bevel pinion failed due to overheating. This eliminated all engine power from the MGB.

Also, during the meeting on July 8, 1994, the requirements for a technical inspector (TI) reviewing the torquing of nuts and bolts was discussed. It was stated the required inspection stamps on the build-up records, are those of the certified mechanic who actually does the torquing, the mechanic who completes the assembly (often the same individual), and the inspector who verifies that these steps have been completed. The inspector is not required to witness the torquing process.

Sikorsky Aircraft issued an alert service bulletin, covering all S-76 models with the 76351-09600 series main gear box, as a result of the accident. The purpose was to perform a one-time inspection to check the torque on the 12 attaching bolts and nuts which secure the tail take-off pinion to the helical gear. In addition, an improvement in the fastener configuration was to be accomplished.

As of October 1, 1994, 45 main gear boxes had been inspected. There were no helical gear nuts and bolts found with reduced torque. Seventeen of the gear boxes had in excess of 1,500 hours of operation.

The helicopter, minus the main gear box, was released on July 1, 1994, to Robert Bauer, the United Technology Corporation, Flight Department Operations Manager. The main gear box

was released on October 17, 1994, to William McCauley of the Sikorsky Aircraft Product Safety Division.

Pilot Information

Certificate:	Airline transport; Commercial; Flight instructor; Foreign	**Age:**	50,Male
Airplane Rating(s):	Single-engine land; Single-engine sea; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	Glider; Helicopter	**Restraint Used:**	
Instrument Rating(s):	Airplane; Helicopter	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine; Glider; Helicopter; Instrument airplane	**Toxicology Performed:**	No
Medical Certification:	Class 2 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	December 21, 1993
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	10000 hours (Total, all aircraft), 2000 hours (Total, this make and model), 6500 hours (Pilot In Command, all aircraft), 200 hours (Last 90 days, all aircraft), 50 hours (Last 30 days, all aircraft), 5 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	SIKORSKY	**Registration:**	N76UT
Model/Series:	S-76B S-76B	**Aircraft Category:**	Helicopter
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	760362
Landing Gear Type:	Retractable - Tricycle; Emergency float	**Seats:**	8
Date/Type of Last Inspection:	May 26, 1994 100 hour	**Certified Max Gross Wt.:**	11700 lbs
Time Since Last Inspection:	47 Hrs	**Engines:**	2 Turbo shaft
Airframe Total Time:	1972 Hrs	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	PT6B-36A
Registered Owner:	UNITED TECHNOLOGIES CORP	**Rated Power:**	981 Horsepower
Operator:		**Operating Certificate(s) Held:**	None
Operator Does Business As:		**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Dusk
Observation Facility, Elevation:	OQU ,19 ft msl	**Distance from Accident Site:**	10 Nautical Miles
Observation Time:	19:45 Local	**Direction from Accident Site:**	340°
Lowest Cloud Condition:	Unknown	**Visibility**	5 miles
Lowest Ceiling:	Overcast / 1000 ft AGL	**Visibility (RVR):**	
Wind Speed/Gusts:	12 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	240°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29 inches Hg	**Temperature/Dew Point:**	21°C
Precipitation and Obscuration:	N/A - None - Fog		
Departure Point:	GOAT ISLAND , RI (RI21)	**Type of Flight Plan Filed:**	VFR
Destination:	EAST HARTFORD , CT (EHT)	**Type of Clearance:**	None
Departure Time:	19:30 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:	2 None	**Aircraft Damage:**	Substantial
Passenger Injuries:	1 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	3 None	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	Pearce, Robert
Additional Participating Persons:	DAVID O'DONNELL; BEDFORD , MA JOHN KLAWIN; WINDSOR LOCKS , CT
Original Publish Date:	March 27, 1995
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=38675