Aviation Investigation Final Report

Location:	The Woodlands, Texas	**Accident Number:**	FTW01FA111
Date & Time:	May 1, 2001, 12:42 Local	**Registration:**	N16CG
Aircraft:	Mitsubishi MU-2B-40	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	2 Fatal
Flight Conducted Under:	Part 91: General aviation - Personal		

Analysis

Visual meteorological conditions prevailed for the planned cross-country flight for which the pilot obtained a weather briefing, filed an IFR flight plan, and received an ATC clearance. Approximately 8 minutes after takeoff, radar indicated the airplane was at 11,200 feet msl, heading 241 degrees, with a ground speed of 180 knots. No distress calls or additional communications with the pilot were recorded, and radar contact was lost. The airplane impacted the ground in an uncontrolled descent. The right wing tip tank separated from the airplane and was found 0.18 nautical miles from the main wreckage. The teardown and examination of both engines disclosed that the type and degree of damage was indicative of engine power section rotation and operation at the time of impact. There were no complete systems intact at the accident site due to the impact sequence and post-impact fire which consumed the aircraft. The landing gear and flaps were found in the retracted position. The portion of the right propeller shaft coupling found at the site was fractured through 360 degrees. Metallurgical examination revealed that the propeller shaft coupling failed in fatigue. The presence of the fatigue cracks indicated the coupler fractured in fatigue in service, and the fatigue cracks were not the result of ground impact. The circumferential fracture intersected the ends of several internal spline teeth. The origin of the fatigue crack could not be determined because of severe corrosion damage on the fracture surface. Fatigue propagation was in the aft direction and from the inside to the outside of the coupling. The engine core rotating components would have bee free to rotate when uncoupled from the propeller shaft. The maintenance records indicated that the failed coupling had accumulated approximately 4,000 hours since new, and 1,250 hours since engine overhaul in 1989. Since 1990, as a result of fatigue fractures, the manufacturer introduced several design changes for the propeller shaft coupling via optional Service Bulletins to be accomplished at the next access or hot section inspection (HSI). Impact and thermal damage of the right propeller precluded a determination of the in-flight blade angles. The calculations by the airplane manufacturer indicated that "the [intact] airplane was capable of continued flight" with the right propeller feathered, and that the "airplane can keep attitude, but cannot climb and cannot maintain

altitude" with the right propeller in the flat pitch or wind milling positions, respectively. Metallurgical examination of the component brackets and associated bolts from the right tip tank revealed the separation of the tip tank resulted from a single-event overstress fracture of both the forward and aft tank attachment fittings. Calculations showed that a 3.763 radians per second (35.9 RPM) spin rate would cause the failure of the forward wing fuel tank attachment fitting. There had not been a previous in-flight separation of a wing tip fuel tank on this model airplane.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The pilot's failure to maintain airplane control following a loss of right engine power, which resulted in impact with terrain in an uncontrolled descent. A contributing factor was the loss of right engine power as a result of the fatigue failure of the propeller shaft coupling.

Findings

Occurrence #1: LOSS OF ENGINE POWER(TOTAL) - MECH FAILURE/MALF
Phase of Operation: CLIMB - TO CRUISE

Findings
1. 1 ENGINE
2. (F) REDUCTION GEAR ASSY,PROPELLER SHAFT - FAILURE
3. MAINTENANCE,SERVICE BULLETIN/LETTER - NOT PERFORMED

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: CLIMB - TO CRUISE

Findings

4. (C) AIRCRAFT CONTROL - NOT MAINTAINED - PILOT IN COMMAND
5. STALL/SPIN - INADVERTENT - PILOT IN COMMAND
6. FUEL SYSTEM,TANK - SEPARATION

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
7. OBJECT - TREE(S)
8. TERRAIN CONDITION - GROUND

Factual Information

HISTORY OF FLIGHT

On May 1, 2001, approximately 1242 central daylight time, a Mitsubishi MU-2B-40, twin-engine turbo propeller driven airplane, N16CG, struck trees and terrain during an uncontrolled descent near The Woodlands, Texas. The airplane, co-owned by the pilot and passenger, was operated by the pilot under 14 Code of Federal Regulations Part 91. The commercial pilot and his passenger sustained fatal injuries, and the airplane was destroyed by impact forces and a post-impact fire. Visual meteorological conditions prevailed in the vicinity of the departure airport. An instrument flight rules (IFR) flight plan was filed for the personal cross-country flight which departed Conroe, Texas, at 1233, with a planned destination of Alamorgordo, New Mexico.

Witness interviews were conducted by the NTSB investigator-in-charge (IIC), FAA inspectors, and local authorities. One witness stated that "it did not seem as though the propellers were under power, but free and rotating. The rudder appeared to be in the opposite direction of the spin." Several other witnesses stated that one of the propellers was not turning. One witness reported hearing an engine "roaring."

One witness reported that "engine surges continued for three or four cycles then changed to an oscillating sound" Subsequently, this witness went into his house, and upon returning to the outside, recalled that the "oscillating sounds were louder and sounded like he still had power on."

One witness reported that at least one engine was running at high power and surging out of control. Another witness stated that "the engine would idle roughly, then accelerate extremely rapidly, then choke back down and idle roughly, then accelerate at full power again." One witness heard "the airplane engine revving up and idling down, not cutting out, and observed the airplane flying erratic, then enter a flat spin, and the right fuel tank was missing."

Several witnesses at a local construction job site reported that "the end piece of a wing" was missing.

Witnesses at a local practice football field heard "a loud buzzing noise that would cut in and out." The witness at a local football field, who had initially observed the airplane, reported that "the airplane was in a flat spin", and subsequently, other witnesses observed the airplane in a "vertical spin."

Another witness reported the airplane was in a "flat spin" and the right fuel tank was missing. This witness described the airplane as "trying to come out of the spin." Subsequently, the

airplane "went into a flat spin again."

One witness, who was located in his back yard, heard an "unusual engine noise. The noise was repetitive with about a two second count between the loudest parts of the sound." This witness did not hear any stopping, starting, or stalling of the engines. This witness who observed the twin engine airplane at an estimated altitude of 4,000 feet, "spinning as though one wing was anchored and spinning about that point," stated that one of the wing tip fuel tanks and a portion of the wing outboard from the engine was missing. Further, this witness reported that when the airplane came out of the spin, the engine noise sounded normal.

Another witness heard "the sound of a turboprop feathering it's blades on and off." This witness observed the airplane at about "1,500 feet in a flat spin, nose 5 degrees down" until the airplane went below the tree line.

One witness, near the local golf course, reported that the airplane "appeared to be having engine trouble. The noise was very loud. The engine would idle roughly then accelerate extremely rapidly then choke back down and idle roughly then accelerate at full throttle again. This occurred at least a dozen times."

One witness at the local golf course described the sound like "engines out of sink." This witness observed the airplane in a right hand flat spin with the nose in a slight down position (10-20 degrees). According to this witness, the airplane made about 6 turns before it went behind the tree line.
Another witness observed the airplane approximately 600-800 feet above ground "spinning and tumbling end over end and falling at about 45 degrees" toward a creek.

One witness observed the airplane "in a circular motion, counterclockwise" as it disappeared behind the tree line.

PERSONNEL INFORMATION

A review of the FAA records by the NTSB IIC revealed that the pilot was issued his most recent FAA third-class medical certificate on January 24, 2000, with the limitation that he wear corrective lenses while acting as a pilot. The pilot held a commercial pilot certificate with the ratings and limitations of airplane multiengine land and instrument, and private privileges for airplane single-engine land.

According to the pilot's flight data supplied by the family, the pilot began flight training in September 1967, and in May 1969, he received his private pilot certificate with the airplane single-engine land rating. The instrument rating was added in December 1987, and the multiengine land rating was added in June 1991. The pilot obtained his commercial pilot certificate, in April 1992, with the airplane multiengine land and instrument ratings. In March 1994, the pilot began flying the MU-2 airplane. As of March 10, 2001, the pilot had accumulated 112.2 hours total flight time in the 12 months prior to the accident.

Approximately every 90 days during the 4 years prior to the accident, the pilot attended recurrent training at the facilities of Flight Safety International, Houston, Texas. From February 5, 2001, to the date of the accident, the pilot had accumulated 26.2 hours total flight time in the accident airplane. The pilot's most recent Mitsubishi recurrent simulator training was accomplished in April 2001 at the facilities of Flight Safety International, Houston. This training consisted of 15 hours of ground school and 6 hours of flight simulator time. According to these training records, dated April 26, 2001, the pilot had accumulated 2,839.1 hours total flight time of which 1,108.0 hours were in the Mitsubishi airplane (555.9 hours in N16CG).

Further, the training records indicated that the pilot had satisfactorily completed the training and testing requirements to act as pilot-in-command (PIC) of a Mitsubishi MU-2B-40 for CFR Part 91 operations. At the time of the accident, the pilot was returning from his latest recurrent training to his home base of operations. The Flight Safety personnel described the pilot as safety minded with good situational awareness, excellent checklist utilization, and professionalism in the piloting of the MU-2 airplane. They further stated that the pilot had good system and operational knowledge of the MU-2 airplane.

Interviews with immediate family members and acquaintances disclosed no evidence of any activities that would have prevented the pilot from obtaining sufficient rest in the 72 hours before the accident.

AIRCRAFT INFORMATION

Aircraft Registration Review

In July 1979, Mitsubishi MU-2B-40, serial number (SN) 418SA, was issued registration number N140MA (changed to N16CG on November 11, 1979). The FAA Standard Airworthiness Certificate was issued on November 9, 1979. At the time of the accident, the airplane was configured to carry seven passengers and one pilot.

The airplane history indicates that on September 24, 1981, the airplane was involved in a wing-to-wing ground collision in which substantial damage was incurred to the right wing from the wing-to-fuselage attachments and fuselage bell frames to the right tip tank. The aircraft was repaired and returned to service.

On January 4, 1991, the airplane was deregistered from the United States Civil Aircraft Registry for export to Caracas, Venezuela. Subsequently, the airplane was entered on the Venezuela registry as YV-11CP.

On December 21, 1995, the airplane was deregistered from the Venezuelan Register, imported to the USA, and re-entered on the United States Civil Aircraft Registry. On February 23, 1996, the FAA airworthiness certificate was re-issued for the aircraft, and it was purchased by Aberg,

LTD, Rockford, Illinois. In October 1997, the airplane was purchased by Anaconda Aviation Corporation, Boca Raton, Florida. The airplane was registered to the current owners on October 23, 1997.

Maintenance Records Review

The FAA aircraft records, insurance records, pilot's computer records, and available maintenance records were reviewed by the respective manufacturer's representatives and the NTSB IIC.

Installed in each engine nacelle was a Honeywell (formerly Garrett) TPE331-10-511M engine. In 1989, the right engine, SN P37159, had accumulated 2,647.6 hours time since new (TSN), and the left engine, SN P36383C, had accumulated 864.8 hours TSN. According to engine service records, at the manufacturer's facility in Phoenix, Arizona, dated September 28, 1989, engine SN P-36383C received hot section and gearbox inspections at an engine time of 864.8 hours time since new (TSN) and 959 cycles since new (CSN) In December 1989, both engines were installed at zero time in the airplane by Intercontinental Jet, Inc., at Tulsa, Oklahoma. In June 2000, the 6 month, 12 month, 2 year, 100 and 500 hour inspections were performed at an accumulated airplane time of 2,439.1 hours. In February 2001, the left engine had accumulated 2,104.3 hours TSN (1,239.5 SMOH), and the right engine 3,887.1 hours TSN (1,239.5 SMOH).

Both engines had the Hartzell propeller model HC-B4TN-5 with LT10282NSB-5.3R blades installed. Prior to March 2001, the left propeller hub was SN CDA3189, and the right propeller hub was SN EAA1209M1. In February 1996, the blades for the right propeller were shot peened. Airworthiness Directive (AD) 83-08-01 (Service Instructions No. 140A) for torque sequence of bolts was complied with in July 1999, and the propellers balanced. In February 2001, the left propeller and the right propeller were overhauled and re-installed on the respective engines. In March 2001, at a total aircraft time of 2,481.9 hours, the propellers were removed and reinstalled on the opposite engines such that EAA1209M1 was installed on the left engine and CDA3189 was installed on the right engine.

Pilot Computer Records Review

According to the pilot's computer records in part: In February 2001, "right prop blades [were] installed wrong causing [a] bad vibration." In March 2001, "reset blades in hubs (they were installed wrong) also weighed prop saddle weights found 1 weighed 1 ounce more than the other three. Repositioned blade pitch with bender to near zero error prop[eller] balanced with very little vibration. Switched left prop[eller] to right engine to verify vibration was in the right [propeller] and not in the right engine. The vibration moved to the left engine when the right prop[eller] was installed on the left engine. The right prop[eller] after installation on left engine was balanced .16 at 70% torque and .20 at 100% torque. The left prop[eller] after being installed on the right engine balanced to .08."

Maintenance Personnel Interviews

The president of Brit International Aviation, Inc., at Conroe, Texas, reported to the NTSB IIC that during a flight on February 5, 2001, the airplane had a substantial vibration, and the vibration subsided when the right engine was pulled back. During the flight, he observed the right rear engine nacelle was vibrating. Following the flight, a maintenance check of the propeller revealed that the right propeller was out of track. The pilot was informed of the discrepancy, and that the propeller shop wanted to look at the propeller. The pilot stated that the airplane had a vibration ever since he had purchased the airplane. The pilot flew the airplane back to Alamogordo, and about two weeks later, flew the airplane to the propeller shop for further evaluation/maintenance repair.

The manager of Millennium Propeller (formerly Dallas Propeller), at Lancaster, Texas, reported to the propeller manufacturer's representative that both propellers were overhauled in February 2001. There had been a vibration problem on the left side for several years, and the vibration did not improve after the overhaul. In March 2001, the left propeller (CDA3189) was disassembled, checked, and one blade counterweight was modified to make all the blades the same weight. The propellers were dynamically balanced and checked. The work reduced approximately 75 percent of the vibration.

The aircraft mechanic at Alamogordo reported to the aircraft manufacturer's representative that the airplane had a vibration on the right propeller following the overhaul in March 2001, at Lancaster. Two to three weeks later, the mechanic flew with the pilot to the propeller shop at Lancaster where both propellers were checked. During the disassembly of the right propeller, it was found that one blade was at the maximum allowable and the opposite blade was at the minimum allowable balance which, according to the mechanic, "gives an out of track condition and a low frequency vibration." Following the repair (dynamic balance of the hub, blades, and clamps) of the right propeller, it was installed on the left engine, and the left propeller was installed on the right engine. According to the pilot's mechanic, during the return flight to Alamogordo, there was a vibration.

The president of Brit International Aviation, Inc., reported that he flew the airplane with the pilot on the morning of the accident, and the vibration was a lot better, but there was still a vibration. A change in power settings and speed did not seem to change the frequency of the vibration. The flight returned to Conroe where the airplane was refueled. When the pilot performed the checklist procedures for the pre-start and start items, everything checked "good" prior to the departure for Alamorgordo.

Weight and Balance

Weight and balance data for the airplane dated February 17, 2001, indicated the maximum gross weight of the airplane was 10,470 pounds with a basic empty weight (BEW) of 7,000.10 pounds. Prior to the flight, the airplane was refueled with the main fuel tanks and outer tanks topped and 60 gallons added per side to the tip tanks. According to the manufacturer's

representative, the gross weight at the time of the accident was 10,391.7 pounds. The Jet A fuel truck and fuel farm fuel were checked for water contamination (ppm), flow rate, and specific gravity. The fuel was found to be within specifications.

METEOROLOGICAL INFORMATION

An NTSB Meteorologist derived the following information from his review of National Weather Service (NWS), National Centers for Environmental Prediction (NCEP), National Climatic Data Center (NCDC), Center Weather Service Unit (CWSU), Aviation Weather Center, Geostationary Environmental Satellite-8 (GOES-8), and air traffic control (ATC) data.

A Surface Analysis chart prepared by the NWS NCEP indicated a ridge of high pressure over the southeastern United States. The chart showed a weak area of high pressure over the northern Gulf of Mexico. Finally, the charts indicated a weak trough of low pressure over northeastern Texas.

At 1153, the NWS surface observations for Conroe indicated scattered clouds at 2,800 feet and 3,900 feet; visibility 10 statute miles; temperature 78 degrees Fahrenheit; dew point 64 degrees Fahrenheit; wind from 150 degrees at 10 knots; altimeter 30.04 inches of Mercury.

A Center Weather Advisory (CWA) issued by Houston CWS, issued at 1250, stated in part: Developing area level 2-3 showers/isolated thunderstorms... 15 nautical miles wide...moving from 150 degrees at 5 knots. Tops generally FL200-250 locally to FL300.

A review of the AFSS weather briefing for the pilot indicated that the flight route was dominated by a high pressure area with southwesterly flow. There were a couple of radar echoes south of the planned flight route; however, there were no thunderstorms or radar echoes for the remainder of the flight. A pilot report (PIREP) indicated tops to the west were 6,000 feet. There were no known in-flight weather advisories in effect for the time and location of the accident. The terminal forecast [area forecast] for southeast Texas was calling for a broken ceiling at 2,500 feet with scattered clouds at 3,000 feet. Winds aloft forecast showed northwest winds at 15 to 25 knots from 15,000 to 21,000 feet msl.

COMMUNICATIONS

The air traffic control data and transcripts were reviewed by the NTSB IIC. The pilot called the Conroe Automated Fight Service Station (AFSS), received a standard weather briefing for the flight from the Montgomery County Airport (CXO), Conroe to the Alamogordo-White Sands Regional Airport (ALM), Alamogordo.

The pilot filed an IFR flight plan to Alamogordo. A clearance (CXO..IAH.J86.JCT..PIO..ALM) was issued at 1231:08 for the flight from CXO to ALM.

1232:29 N16CG was released off of CXO runway 14 and cleared into controlled airspace with

an assigned heading of 090 and an altitude of 3,000 feet.

1235:36 The Houston Terminal Radar Approach Control (TRACON) departure North controller established radar contact with N16CG and cleared the aircraft to climb to 5,000 feet and turn right to a heading of 160 degrees.

1236:22 The controller cleared N16CG to maintain 12,000 feet and fly heading 170 degrees.

1237:12 The controller cleared N16CG to fly heading 220 degrees.

1237:58 The controller instructed N16CG to contact the Houston TRACON departure West controller on frequency 123.8 Megahertz.

1238:55 The pilot reported to the departure West controller that N16CG was at 7,700 feet climbing to 12,000 feet.

1239:00 The controller cleared N16CG to fly heading 240 degrees and join the J86 airway.

1240:33 The controller instructed N16CG to contact the Houston Air Route Traffic Control Center (HOU ARTCC) controller on frequency 132.15 Megahertz.

1240:45 The controller repeated the instruction for N16CG to contact HOU ARTCC on 132.15 Megahertz.

1240:50 N16CG acknowledged the frequency change. Radar data indicated the airplane was at 11,200 feet msl, heading 241 degrees, with a ground speed of 180 knots.

No distress calls or additional communications with the pilot were recorded.

1242:06 Radar contact was lost for N16CG at altitude 1,200 feet msl, heading 067 degrees, ground speed 13 knots.

WRECKAGE AND IMPACT INFORMATION

The accident site, latitude 30 degrees 08.94 minutes North; longitude 095 degrees 30.56 minutes West, was approximately 13 nautical miles southwest of the Montgomery County Airport, Conroe, Texas. The elevation at the accident site was 230 feet msl and the terrain consisted of a heavily wooded area. The wreckage distribution path was on a measured magnetic heading of 225 degrees for a distance of 66 feet. The aircraft came to rest inverted at the base of several trees. One tree, approximately 3 feet in diameter and 60 feet long, was found lying on the ground extending from the periphery of the left engine crater toward the southeast, and this tree exhibited numerous scrapes, gouges, and missing bark along the trunk. Slash marks, consistent with propeller strikes, were found on another tree on the periphery of the left engine crater. Ground scars and tree scrapes were consistent with a

vertical impact. The cockpit and fuselage were destroyed, and there were no complete systems intact at the accident site.

The left wing tip tank was found approximately 5 feet west of the main wreckage. The right wing tip tank was not found at the accident site. Portions of the right tip tank attachment brackets and bolts were found attached to the right wing.

Flap actuators (inboard and main) for each wing were found at the retracted position. The aileron trim actuator measured 3.53 inches extended, which, according to the manufacturer's representative, correlates to the neutral trim position. The elevator trim actuator measured 2.25 inches, which according to the manufacturer's representative, equates to 2 degrees nose up trim. The rudder trim actuator measured 7.0 inches, which according to the manufacturer's representative, equates to 4 degrees left trim. The landing gear travel nut was in the retract position. The landing gear selector and indicator were destroyed.

The flight control cables were examined and found intact. The control wheel and rudder pedals were destroyed. The flight control cables found in the vicinity of the control wheel and rudder pedals had the swaged ends intact. The flight control counterweights were found at the accident site. Two seat belt buckles were found in the closed position.

The left power lever was found in the flight idle position. The right power lever was found in the takeoff position.

The Honeywell TPE331-10-511M, left engine, S/N P36383C, core rotating components were free to rotate and were uncoupled from the propeller shaft. Debris, consistent with dirt, was found in the inlet and the first-stage compressor impeller. When the six o'clock igniter was removed, dirt was found in the cooling vent holes. The feather valve motion was checked by hand and the valve was found to actuate freely.

The Honeywell TPE331-10-511M, right engine, S/N P37159C, core rotating components rotated with resistance. Some of the stators exhibited leading edge damage. According to the manufacturer's representative, four adjacent bull gear teeth were deformed to a shape corresponding to the circumference of the high speed pinion. The high speed pinion was intact. The propeller pitch control housing exhibited thermal damage with the cam, NTS lockout insert, and beta tube sleeve found at the accident site. The torque sensor housing exhibited thermal deformation with the associated gears found at the site. The propeller governor, idle spur gear, tach/generator, and starter generator driveshaft were intact. A portion of the propeller shaft coupling was found at the site.

The left propeller was found in a ground crater approximately 1-foot deep. All 4 blades remained attached at the hub, exhibited S-bending, and torsional twisting toward low pitch. The spinner dome was crushed on 3/4 of its circumference. According to the manufacturer's representative, blade counterweights were in "extreme reverse blade angle." The propeller remained attached to the engine. Adjacent to the left propeller was a felled tree that had

numerous tree strikes consistent with propeller slash marks. The slash marks were used by the manufacturer's representative to calculate a 9,032 fpm rate of descent.

The right propeller was found at the periphery of a ground crater more than one foot deep. According to the manufacturer's representative, the blades had "very mild bending and no twisting." The right propeller had extensive fire damage. Metal, identified as cadmium by the manufacturer's representative, had melted on several of the steel propeller parts. Approximately 1/3 of the spinner bulkhead was missing. One propeller blade was completely missing (melted) except for a 4-inch fragment of the blade tip, and according to the manufacturer's representative a "small amount of crystallized residue inside the blade clamp" which remained attached at the hub. There was a piece of molten metal underground, located beneath and forward of the right propeller. Most of the paint was missing/burned off the remaining three blades. The mounting flange was intact and the propeller remained attached to the engine. According to the manufacturer's representative, the blade counterweights were at a "very low blade angle, and the piston was near the reverse blade angle position."

The right wing fuel tip tank was recovered on August 5, 2001, at 30 degrees 08 minutes 50.2 seconds North latitude and 095 degrees 30 minutes 42.8 seconds West longitude, approximately 0.18 nautical miles on a 220 degree magnetic heading from the accident site. The tank was separated into several pieces and was on the edge of an island created by the drying of the previous marshy area.

MEDICAL AND PATHOLOGICAL INFORMATION

Autopsies conducted by the Harris County, Texas, Medical Examiner determined the cause of death for the pilot and passenger was blunt force injuries and extensive thermal body burns. The autopsy for the pilot revealed a 90% blockage in a coronary artery and 75% blockage in another coronary artery.

The FAA Civil Aeromedical Institute's (CAMI) Forensic Toxicological and Accident Research Center examined the pilot's specimens taken by the medical examiner. According to CAMI, the pilot's toxicology showed no indication of alcohol or performance-impairing drugs at the time of the accident.

FIRE

Fire damage was consistent with a fuel-fed fire erupting on impact.

EMERGENCY RESPONSE

The initial notification of an airplane "spinning and falling" to the ground was made at 1244 by witnesses in The Woodlands, Texas. The 911 dispatcher contacted local agencies, via the dispatch telephone system. Local authorities located the airplane within 12 minutes of the accident. Thick woods, underbrush, and the lack of roads or paths in the area hampered the

fire department response to the site. Initially, hand held fire extinguishers were utilized. Subsequently, trees were cut down to make a pathway for the fire fighting equipment to reach the site. Emergency response personnel reported that the accident was not survivable.

TEST AND RESEARCH

All examinations of the aircraft, engines, and propellers were conducted under the supervision of NTSB personnel. An examination of the aircraft, engines, and propellers was conducted in July 2001 at Air Salvage of Dallas (ASOD), Lancaster, Texas. Disassembly of the propellers was conducted at ASOD. The engines were shipped from ASOD to the manufacturer's facility in Phoenix, Arizona, where they were further examined and disassembled.

Left Propeller

The spinner dome for the left propeller hub was crushed and two of the blade counterweights created dents in the spinner. Three of the blades and clamps were in the reverse pitch position, and one blade and clamp were at a blade angle in the normal operating range. The feather stops were intact. There were no internal marks in the piston that could be used to calculate blade angle. Two of the blade link arms exhibited compressive bending. There was one mark in the cylinder that occurred in a reverse pitch condition. The start locks were operable. All four blade clamps were intact. All four blades exhibited aft bending, aft "S" bends, and twisting toward low pitch. Two of the blades exhibited chordwise bending.

Right Propeller

The spinner dome for the right propeller was crushed. The front half was missing and portions had melted and wrapped around a blade counterweight. The blade angle was near the reverse pitch stop at the time the mark occurred. Three blade clamps were at a very low blade angle position at or near the reverse pitch stop. There were no impact marks that could be used to determine a blade angle. The cylinder had an impression mark that equates to a blade angle of 18 degrees. One start lock was missing, one had thermal damage, and two start locks were intact and did not show signs of engagement. One blade was bent aft about 30 degrees with the outer 1/3 bent forward and the tip melted. One blade was bent aft with the tip melted. One blade was bent aft at the shank with the outer 1/3 bent forward and the tip melted. One blade was destroyed by fire.

Left Engine

Disassembly of the left engine revealed physical evidence of rotational scoring on the following: shroud line edge of the 1st-stage compressor impeller, shroud line edge of the 2nd-stage compressor impeller, 1st-stage turbine blade tip shroud, blade tips of the 1st-stage rotor, and the 3rd-stage turbine blade tip shroud. Distribution of dirt and debris was found throughout the compressor section, combustion sections, and the turbine sections. According to the manufacturer’s representative, the teardown and examination of the left engine

disclosed that the type and degree of "damage was indicative of engine rotation and operation at the time of impact."

Left Propeller Shaft Coupling

The left propeller shaft coupling, PN 865888-3, was removed for metallurgical examination. The manufacturer's metallurgist observed an area of the fracture surface that exhibited features indicative of overload. The left propeller shaft coupling was retained for further examination at the NTSB Materials Laboratory.

Examination of the left propeller shaft coupling by the NTSB metallurgist revealed that the fractures exhibited features typical of overstress separation.

Right Engine

Disassembly of the right engine revealed physical evidence of rotational scoring on the following: blade exit on all blades on the shroud line of the 2nd-stage compressor impeller, 1st-stage turbine blade tip shroud, 1st-stage turbine rotor, 1st-stage aft blade platforms, forward vane support of the 2nd-stage turbine stator, 2nd-stage turbine blade shroud, trailing edge of 5 blade tips of the 2nd-stage turbine rotor, forward vane support of the 3rd-stage turbine stator, forward face on the 3rd-stage turbine stator abradable seal, and the 3rd-stage turbine blade tip shroud. Distribution of dirt and debris was found throughout the compressor section, combustion sections, and the turbine sections. According to the manufacturer's representative, the teardown and examination of the right engine disclosed that the type and degree of damage was "indicative of engine power section rotation and operation at the time of impact with the ground."

The right aft bull gear bearing and the right propeller shaft assembly were retained for further examination at the NTSB Materials Laboratory. Examination of the right aft bull gear bearing and the right propeller shaft assembly by the NTSB metallurgist revealed that the fractures exhibited features typical of overstress separation.

Right Propeller Shaft Coupling

The right engine propeller shaft coupling, PN 865888-3, was found fractured through 360 degrees. The propeller shaft coupling was removed for further examination. The manufacturer's metallurgist observed an area of the fracture surface that exhibited features indicative of fatigue. The right propeller shaft coupling was retained for further examination at the NTSB Materials Laboratory.

Examination of the fractures from the right propeller shaft coupling by the NTSB metallurgist revealed the root and crown of an inner spline tooth on the forward end of the adapter were flat. Two flat fractures were located on a slant plane relative to the root face of a spline tooth. The two fractures were located at the most aft edge of the reduced diameter portion of the

coupler. One of the fractures contained crack arrest marks typical of fatigue cracking. The origin of the fatigue cracking could not be determined because of severe corrosion damage on the fracture surface. However, the fatigue crack intersected the corner radius between the flank of a spline and the flat root, as well as the flank itself. Scanning electron microscopic examination of the fracture showed that the fine fracture features had been destroyed by corrosion. The crack arrest marks were typical of fatigue cracking. The crack arrest marks were found in the transition region between the reduced and larger diameter portions of the coupling. Fatigue propagation was in the aft direction and from the inside to the outside of the coupling.

Right Wing Fuel Tip Tank Brackets

In August 2001, the component brackets and associated bolts from the recovered tip tank were removed from the tank and examined at Materials Analysis, Inc. under the supervision of the NTSB IIC. According to the metallurgist, the "separation of the right-wing tip fuel tank resulted from a single-event overstress fracture of both the forward and aft tank attachment fittings. The forward fitting, which was the primary-load carrying member, failed initially, leading immediately to the deformation and overload failure of the aft fitting. The fracture pattern of the forward fitting and lack of evidence of direct impact damage on the fitting indicated that the fracture was induced by loads applied by the tip tank."

An NTSB metallurgist reviewed the Material Analysis, Inc. report titled "Failure Analysis of Tip Tank Fittings from N16CG. The NTSB metallurgist found that the documentation supports the explanation of the fracture sequence.

Tip Tank Loads and Stress

Based upon information provided by the NTSB IIC and the manufacturer's representative, Materials Analysis, Inc. prepared a loads and stress analysis of the MU-2 wing tip fuel tank to estimate the aircraft spin rate. Calculations showed that a 3.763 radians per second (35.9 RPM) spin rate would cause failure of the forward wing tank attachment fitting." The major load on the tip tank fittings was centrifugal force from the aircraft spin rate. The maximum load on the lower bolt of the forward fitting was calculated to be 15,038 pounds, and the maximum load on the forward fitting was calculated to be 13,372 pounds.

An NTSB metallurgist reviewed the Material Analysis, Inc. report titled "Loads and Stress Analysis of MU-2 Wing Tip Tank from N16CG to Estimate Aircraft Spin Rate." The NTSB metallurgist found that the report shows the calculated stresses that would be necessary to cause the wing tip tank to fail from centrifugal force.

ADDITIONAL INFORMATION

Historical Data for the Propeller Shaft Coupling

According to Honeywell's detailed history, the initial production of the Shaft-Coupling, Rigid, (propeller shaft coupling) P/N 865888-1 occurred in 1965. The P/N 865888-1 coupling was not released for use in TPE331-5 or -10 engines. To date, P/N 865888-3/-6/-8/-10 has been installed in 16 different TPE331 engine models. The coupling is a one-piece component which is part of the propeller's reduction gearbox nosecone module used in Honeywell TPE331-5 and -10 series engines with a 1,591 RPM propeller shaft speed. The coupling is mounted on the propeller shaft and mates with the gearbox's planetary reduction gear. The propeller shaft coupling's function is to transmit torque from the reduction gearbox to the propeller shaft. The failure of the propeller shaft coupling will result in a loss of continuity from the reduction gearbox to the propeller shaft, and therefore, a loss of propeller drive.

The 865888-3 configuration (-3) propeller shaft coupling configuration was introduced in 1966. The length of the (-3) coupling was increased by 0.040 inches from the original 865888-1 design. The (-3) configuration has eight lubrication slots machined into the forward section of the coupling. The lubrication slot corners have a 0.015-0.035 inch radius and a 0.005-0.015 inch edge break, per design. With the even number of slots, the corner of the slots could intersect the corner radius of the internal spines with a .005 to .015 inch radius, creating an increased stress concentration.

On May 15, 1985, Honeywell completed a metallurgical examination on a (-3) propeller shaft coupling that failed in a TPE331-10 engine. Honeywell concluded that "the coupling shaft fractured in a fatigue mode initiating at a corner radius, where the spline root and the shaft end face slot corner radii converge. It is suggested that the eight slots at the coupling shaft end face be located so that none of the slot corner radii converge or coincide with the spline root radius, thus eliminating the sharp radius, where the fracture occurred."

On April 10, 1990, Honeywell completed a metallurgical examination on the (-3) propeller shaft coupling from the #1 engine involved in an aircraft accident (DEN 90-F-A055). Honeywell concluded that "the coupling shaft fractured in a fatigue mode initiating at a sharp corner radius (less that 0.002 inches) where the shaft end face slot corner radius converges with the inner spline root radius."

On April 27, 1990, as a result of the aforementioned findings, Honeywell introduced propeller shaft coupling, part number 865888-6, to the field per optional Service Bulletin (SB) TPE331-72-0662 released on April 27, 1990. This new design added larger radii for the lubrication slot corners and increased edge breaks. However, the lubrication slot corners could still intersect with the corner radius of the internal spines.

On August 23, 1990, part number 3107065-1, which is a reworked (-3), was introduced to the field per recommended SB TPE331-72-0708. The rework modified the lubrication slots, to include larger edge breaks, larger slot corner radii, and wider slots to make the edge break in the middle of the spline teeth instead of at the corners of the splines.

On September 13, 1990, Honeywell completed a metallurgical examination on two (-3)

propeller shaft couplings that failed in TPE331-10 engines. Honeywell concluded that "the fracture modes of the coupling shafts were fatigue. The separations initiated at the sharp corner radii where the shaft end face slot corner radii converge with the inner spline root radii."

On April 16, 1993, propeller shaft coupling, part number 865888-8, was introduced to the field per optional SB TPE331-72-0827. The design added larger corner radii for the lubrication slots, larger spline corner radii, larger edge breaks, and an additional lubrication slot to insure "clocking" of the slot edge breaks to the middle of the spline teeth instead of at the corners of the splines.

On May 20, 1993, propeller shaft coupling, part number 865888-10 and rework configuration part number, 3107092-1 were introduced to the field per the latest recommended SB TPE331-72-0873. The 865888-10 and 3107092-1 designs are the same as the -8 design, except they include shot peening of the lubrication slots. Part number 3107092-1 is the reworked configuration of part numbers 865888-3/-6, and 3107065-1, with the added shot peening to the reworked areas. There have been no reported failures of the latest propeller shaft coupling design. According to the manufacturer, there are over 2,000 propeller shaft couplings of the previous designs remaining in the field.

The maintenance records for N16CG indicated that the failed coupling had accumulated approximately 4,000 hours since new, and 1,250 hours since engine overhaul. During the overhaul, the coupling underwent a fluorescent penetrant inspection (FPI) and a dimensional check. The airplane's records revealed no evidence that the SB's applicable to the propeller shaft coupling were complied with during an maintenance.

Airplane Performance

At the request of the NTSB IIC, an airplane performance study was prepared by the airplane manufacturer with respect to a propeller position at feather, flat pitch, and wind milling, respectively, on the flight capability of the airplane. The manufacturer examined the continued flight capability of the airplane, based on wind tunnel test data, at an airspeed of 180 knots and an altitude of 11,200 feet msl with the right propeller in the feathered position, the flat pitch position, and the wind milling position, respectively. The calculations by the manufacturer indicated that "continued flight is achievable" with the right propeller feathered. The calculations by the manufacturer indicated that the "airplane can keep attitude, but cannot climb and cannot maintain altitude" with the right propeller in the flat pitch or wind milling positions, respectively.

The study also indicated that lateral/directional control of the intact airplane was possible with a feathered right propeller within bank angles of approximately 22 degrees left and approximately 24 degrees right. With the right propeller in flat pitch, lateral/directional control was possible within bank angles of approximately 25 degrees left and approximately 17 degrees right. With the right propeller wind milling, lateral/directional control was possible within bank angles of approximately 25 degrees left and approximately 16 degrees right.

Tip Tank Bracket Inspections

According to the aircraft manufacturer's representative, there had not been a previous in-flight separation of a wing tip fuel tank. The representative further reported 452 airplanes in the MU-2 active fleet. On June 18, 2001, Service Bulletin (SB) 098/57-003 was issued by Mitsubishi Heavy Industries, LTD., to provide an inspection procedure to conduct a one-time inspection of the tip tank attach brackets to insure that no cracks exist. Service center maintenance personnel performed the SB on 36 MU-2B aircraft with no cracks found for the attach brackets.

Administrative Information

The Safety Board was notified of the accident about 1330 on May 1, 2001. The NTSB team was dispatched. Safety Board specialists provided assistance in the areas of Metallurgy, Meteorology, and National Resource Specialist.

Parties to the investigation were the FAA, Mitsubishi Heavy Industries America, Inc., Honeywell, Hartzell, and Materials Analysis, Inc.

The airplane wreckage was released to the owner's representative on December 3, 2002.

Pilot Information

Certificate:	Commercial; Private	**Age:**	64,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	January 24, 2000
Occupational Pilot:	No	**Last Flight Review or Equivalent:**	April 28, 2000
Flight Time:	2839 hours (Total, all aircraft), 1108 hours (Total, this make and model)		

Aircraft and Owner/Operator Information

Aircraft Make:	Mitsubishi	**Registration:**	N16CG
Model/Series:	MU-2B-40	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal	**Serial Number:**	418SA
Landing Gear Type:	Retractable - Tricycle	**Seats:**	8
Date/Type of Last Inspection:	June 30, 2000 100 hour	**Certified Max Gross Wt.:**	10470 lbs
Time Since Last Inspection:		**Engines:**	2 Turbo prop
Airframe Total Time:	2439.1 Hrs as of last inspection	**Engine Manufacturer:**	Garrett
ELT:		**Engine Model/Series:**	TPE331-10
Registered Owner:	On file	**Rated Power:**	665 Horsepower
Operator:	On file	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	CXO,245 ft msl	**Distance from Accident Site:**	13 Nautical Miles
Observation Time:	11:53 Local	**Direction from Accident Site:**	17°
Lowest Cloud Condition:	Scattered / 2800 ft AGL	**Visibility**	10 miles
Lowest Ceiling:	None	**Visibility (RVR):**	
Wind Speed/Gusts:	10 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	150°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	30.04 inches Hg	**Temperature/Dew Point:**	26°C / 18°C
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Conroe, TX (CXO)	**Type of Flight Plan Filed:**	IFR
Destination:	Alamogordo, NM (ALM)	**Type of Clearance:**	IFR
Departure Time:	12:33 Local	**Type of Airspace:**	Class B

Airport Information

Airport:	Conroe/Montgomery Airport CXO	**Runway Surface Type:**	
Airport Elevation:	245 ft msl	**Runway Surface Condition:**	Unknown
Runway Used:	14	**IFR Approach:**	Unknown
Runway Length/Width:	6000 ft / 150 ft	**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	1 Fatal	**Aircraft Fire:**	On-ground
Ground Injuries:	N/A	**Aircraft Explosion:**	On-ground
Total Injuries:	2 Fatal	**Latitude, Longitude:**	30.148889,-95.509445

Administrative Information

Investigator In Charge (IIC):	Roach, Joyce
Additional Participating Persons:	Ralph Sorrells; Mitsubishi Heavy Industries America, Inc.; Addison, TX Tom McCreary; Hartzell Propeller, Inc.; Piqua, OH Dave Chapel; Honeywell ; Phoenix, AZ Tom Munkhaugen; Federal Aviation Administration, FSDO; Houston, TX Bob Henley; Federal Aviation Administration, Headquarters; Washington, DC Raymond J Claxton; Materials Analysis, Inc.; Dallas, TX James T Skeen, Jr.; National Transportation Safety Board; Washington, DC Dennis Crider; National Transportation Safety Board; Washington, DC Frank P Zakar; National Transportation Safety Board; Washington, DC Aaron Sauer; National Transportation Safety Board; Arlington, TX
Original Publish Date:	April 15, 2003
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=52186