National Transportation Safety Board
Aviation Accident Final Report

Location:	Fort Pierce, FL	**Accident Number:**	MIA06FA120
Date & Time:	06/25/2006, 1224 EDT	**Registration:**	N316PR
Aircraft:	MITSUBISHI MU-2B-60	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Part 91: General Aviation - Ferry		

Analysis

Witnesses stated that they observed the twin-engine airplane roll into a steep right bank and enter a spin at a low altitude (less than 700 feet) during the initial climb. The airplane then descended and impacted terrain about 1.5 miles from the end of the departure runway. Some witnesses reported hearing an unusual engine noise just before the airplane began to roll and spin. Day visual meteorological conditions prevailed.

Examination of the right engine revealed that the ring gear support of the engine/propeller gearbox had fractured in flight due to high cycle fatigue originating from the corner radii of the high-speed pinion cutout. The reason for the fatigue could not be determined. The ring gear support disengaged from the ring gear due to this failure, resulting in a disconnection in power being transferred from the engine power section to the propeller.

In addition to the ability for a pilot to manually feather the propellers, and an automatic feathering feature, the engine (Honeywell TPE-331) design also includes a “Negative Torque Sensing” (NTS) system that would automatically respond to a typical failed engine condition involving a propeller that is driving the coupled engine. Feathering the propeller reduces drag and asymmetric yawing due to the failed engine. All Federal Aviation Administration (FAA) certification evaluations for one-engine inoperative handling qualities for the airplane type were conducted with the NTS system operational. According to the airplane manufacturer, the NTS system was designed to automatically reduce the drag on the affected engine to provide a margin of safety until the pilot is able to shut down the engine with the condition lever.

However, if a drive train disconnect occurs at the ring gear support, the NTS system is inoperable, and the propeller can come out of feather on its own, if the disconnect is followed by a pilot action to retard the power lever on the affected engine. In this scenario, once the fuel flow setting is reduced below the point required to run the power section at 100% (takeoff) rpm, the propeller governor would sense an “underspeed” condition and would attempt to increase engine rpm by unloading the propeller, subsequently driving the propeller out of feather toward the low pitch stop. This flat pitch condition would cause an increase in aerodynamic drag on one side of the airplane, and unanticipated airplane control difficulty

could result due to the asymmetry.

The emergency procedure for an in flight power loss, regardless of the cause, published in the Airplane Flight Manual (AFM) required that the power lever for the failed engine be moved forward to the Takeoff position (following the step to immediately shut down the engine by moving the condition lever to the Emergency Stop position). Additionally, a "WARNING" follows this procedure to reiterate that the pilot must "...NOT RETARD FAILED ENGINE POWER LEVER." The warning also states: "PLACE FAILED ENGINE POWER LEVER TO TAKEOFF POSITION DURING THE FEATHERING OF PROPELLER AND LEAVE THERE FOR REMAINDER OF THE FLIGHT."

Postcrash examination of the wreckage revealed evidence that both condition levers were in the "Takeoff/Land" position. The left engine power lever was in the "Reverse" position, and the right engine power lever was in the "Flight Idle" position.

Based on an analysis of evidence from the wreckage and technical data from the airframe and engine manufacturers, a likely scenario for the accident sequence is as follows: Shortly after takeoff, and after being instructed to change frequencies, the pilot may have perceived a loss of power in the right engine and an associated rise in rpm. The right propeller then went into a feathered position about 3 seconds later. The pilot then reduced the right engine power lever, contrary to the AFM procedure. At this point, the fuel flow decreased, leading to a decrease in power section rpm. The propeller governor then sensed an under-speed condition. As a result, oil was routed to the propeller by the propeller governor, causing the propeller to come out of feather toward a flat pitch (increased drag) position. The pilot may not have been aware that the propeller came out of feather. As a result of the increased drag condition on the right side of the airplane, the airplane yawed and rolled to the right and entered a spin. In an attempt to control the airplane, the pilot reduced power on the opposite (left) engine. However, at this point, the airplane was not at a sufficient altitude to recover.

The investigation revealed that a TPE331 engine gearbox uncoupling event is an unusual engine failure that results in substantially different engine indications to a pilot in comparison to a typical flameout event in which the NTS system in operable.

According to the engine manufacturer, there have been five incidents of similar TPE331 ring gear support cracks during about 29 million engine hours of service history. All of the cracks originated at the high-speed pinion cutout detail. Three of these incidents were shop findings, one incident resulted in an in-flight shutdown at altitude followed by a safe landing, and the other incident was this accident.

The accident pilot reportedly accumulated 11,000 hours of total pilot experience, 2,000 of which were in the same make and model as the accident airplane. About 300 hours were logged within the previous six months of the accident. The pilot received recurrent training the same make and model about 11 months before the accident.

On March 3, 2008, the airplane manufacturer published MU-2 Service News No. 110/00-017, entitled "Power Lever Position Warning for In-flight Engine Failure" which reiterated the warning that the failed engine power lever must not be retarded. In January 2009, the airplane manufacturer also published Service News No.114/00-020, entitled "Engine Failure Modes,"

which provided additional detail for pilots regarding an uncoupled gearbox, and again reiterated the AFM procedure and warning. In addition, the engine manufacturer intends to issue a letter to provide a description of the engine symptoms and recommended actions in the event of an uncoupling event, or in the event of an engine failure for any reason.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the pilot's loss of aircraft control during the initial climb which was precipitated by the sudden loss of thrust and increase in drag from the right engine, and the pilot's failure to adhere to the published emergency procedures regarding the position of the failed engine power lever. Contributing to the accident was the fatigue failure of the right engine's ring gear support for undetermined reasons, which rendered the propeller's automatic drag reducing system inoperative.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: TAKEOFF - INITIAL CLIMB

Findings
1. (C) REDUCTION GEAR ASSY - FATIGUE
2. (C) TURBOSHAFT ENGINE,POWER OUTPUT SHAFT - DISCONNECTED
3. PROPELLER FEATHERING - NOT AVAILABLE

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: TAKEOFF - INITIAL CLIMB

Findings
4. ALTITUDE - LOW
5. (C) EMERGENCY PROCEDURE - NOT FOLLOWED - PILOT IN COMMAND

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

Factual Information

HISTORY OF FLIGHT

On June 25, 2006, about 1224 eastern daylight time, a Mitsubishi MU-2B-60, N316PR, registered to and operated by Flyin Cloud LLC., as a Title 14 CFR Part 91 ferry flight, crashed shortly after takeoff from Saint Lucie County International Airport, Fort Pierce, Florida. Visual meteorological conditions prevailed, and an instrument flight rules flight plan was filed. The airline transport-rated pilot, the sole occupant of the airplane, received fatal injuries, and the airplane was destroyed. The flight was originating at the time of the accident.

The accident pilot had flown to the Bahamas, discharged passengers, and had returned to the U.S., landing at Saint Lucie County Airport (Fort Pierce Airport), where he cleared U.S Customs and refueled. At the time of the accident the pilot was on a flight to Murfreesboro, Tennessee, to have scheduled 100-hour maintenance performed on the airplane.

A review of the FAA Port Pierce Air Traffic Control Tower (ATCT) recorded communications revealed that the pilot had initially contacted the Fort Pierce tower controller, stating "tower 65PR ready to go runway 14." At 1222:39 the tower controller responded stating, "on departure turn left heading zero niner zero runway one four cleared for takeoff." The accident pilot responded, "left to zero niner zero, one four cleared to go, papa romeo thanks." At 1223:44 the controller stated, "Mitsubishi six five romeo heading zero nine zero contact miami center", and the pilot responded "zero niner zero going to miami, have a good day, papa romeo." The controller responded, "see ya." There was no record of further communications between the Fort Pierce tower controller or the Miami Air Route Traffic Control Center (ARTCC) controller and the pilot of N316PR. Subsequent attempts by either controller to establish communications with the flight yielded negative results.

The airplane impacted the terrain in a wooded area, about 80 yards west of U. S. Highway 1 (US-1) about 1.5 miles away from the departure end of runway 14.

Several witnesses saw the accident and reported that the airplane was at a very low altitude, after having just taken off from the Saint Lucie County International Airport. One witness stated that he was traveling north on highway US-1, at Juanita Street, and he witnessed a black twin-engine airplane "in trouble." He said the airplane was in a nose-up attitude, pointing east, and then it yawed to the right, pointing south in a wings level position. It then continued to slowly spin in a clockwise direction until striking the ground and bursting into flames. According to the witness, the right propeller was rotating very slowly, such that he could count its revolutions.

Another witness, an experienced commercial pilot who had accumulated about 6,000 hours of flight experience, and who was also former law enforcement officer/investigator, stated that he was in a car proceeding northbound on State Road 5 (SR-5), also known as US-1, and was at the intersection of highway A1A and highway US-1. He said the weather was broken to overcast, the visibility was 7 miles or more, and there was no rain. He said his attention was drawn to an aircraft departing the Saint Lucie County International Airport to the east, possibly from runway 14. He said the airplane cleared the airport boundary area, and appeared to fly over SR-5, which runs north and south, on the east side of the airport. He said the rate of climb was not consistent with a turboprop, and it did not appear to climb above 500 to 700 feet above ground level. He said the airplane started a wing wobble motion, and that the wings

banked slightly to the left, and then back to the right. He further stated that the motion could have been a slight yaw, but added that he was not sure. Seconds after the wing wobble the airplane started a right turn until the wings were 90 degrees to the ground circling to a westerly direction. Within seconds after achieving a 90-degree bank the airplane pitched slightly upward and then executed a "wing-over" maneuver (to the right) appearing to enter a spin. He said the nose pitched down, and the airplane impacted the ground in nearly a vertical nose down position. The witness further stated that to the best of his recollection it appeared that both propellers were turning until the crash, and added that he could not hear any engine noise because he had his car windows rolled up and the radio playing. He did not see any abnormal smoke coming from the engines or debris from the airplane, nor did he recall if the gear was up or down. In addition he did not observe the flap positions. When asked, the witness said that the engines did not appear to be feathered, and both propellers were definitely rotating.

Three witnesses located in the area of a marine store noticed the accident airplane. The first witness at the store said that he was parked at the store and he noticed a black or dark colored twin-engine airplane about 200 feet above the ground. He said the airplane began to bank to the side and it continued until upside down. It then nosed down behind the tree-line. Another witness, also at the store, said he was exiting the store and walking to his truck in the parking lot when he heard an airplane and glanced to his left. He said he then heard the airplane's engine "throttle up", after which it then spun to the left, and proceeded upside down two times before impacting the ground. The third witness sitting in the store parking lot said that he witnessed an airplane that was heading east. He stated that that he looked back out the window a minute or two later and saw the same airplane rise above the trees, "give full throttle (or so it sounded), then roll over on the left wing, and dove instantly.

A witness stated to an officer with the Saint Lucie County Sheriff's Office, that he was in a mobile home park working on his van, and he heard a sound like a "broken" airplane engine, coming from the airport. He said that he had some experience working on airplane engines before, and that the noise from the airplane sounded like one of the twin engines had a failure. He said he looked up and saw an airplane about 60 feet above banking right. The airplane banked right in a 90-degree to about a 180-degree angle, as if to avoid the mobile home park, and it went head-on into the bushes.

PERSONNEL INFORMATION

Records on file with the FAA cite the accident pilot as Chief Pilot/Manager of Flyin Cloud LLC. The pilot held an FAA airline transport-rated pilot certificate with an airplane multiengine land rating. He also held commercial pilot airplane single engine land and sea ratings, issued on February 5, 2004. In addition, the pilot held an FAA third class medical certificate, with the stated limitation that the pilot must wear correcting lenses when flying, which had been issued on March 24, 2006.

At the time the pilot made application for his medical certificate, he reported having accumulated 11,000 hours total pilot experience, and 300 within the last 6 months. In addition, he had reported having accumulated about 2,000 hours of flight experience in the same make and model airplane as the accident airplane.

The pilot last received recurrent Mitsubishi MU-2 training at Howell Enterprises Inc., Smyrna, Tennessee, from July 19 to 25, 2005, and was scheduled to return to Howell Enterprises Inc.,

for his next recurrent training class on July 24, 2006.

AIRCRAFT INFORMATION

Airframe Information

N316PR, serial number 761SA, was a MU-2B-60 "Marquise", manufactured in 1980, and was a high performance, twin-engine, high-wing turboprop powered airplane. FAA airplane records indicate that on January 26, 2001, Flyin Cloud LLC., purchased the accident airplane from Headrick Properties Inc., Laurel, Mississippi. FAA records did not show Flyin Cloud LLC., as possessing a Title 14 CFR Part 135 (air-taxi) certificate. At the time of the accident the airplane had accumulated about 4,073 flight hours total time.

Engine and Propeller Information

The accident airplane was powered by two Garrett Turbine Engine Company, now Honeywell Aerospace, TPE 331-10-511M turboprop engines, serial number 36117C (left engine), and serial number 36126 (right engine), 940 shaft horsepower engines, de-rated to 715 shaft horsepower.

The airplane was equipped with two Hartzell Propeller Inc. 4-bladed, constant speed, full feathering, reversible-pitch propellers, each propeller of which was 98 inches in diameter. The propellers were model number HC-B4TN-5JL, and their blades are model LT10282NSB-5.3R. The left propeller hub's serial number was CDA3514M2, and the serial number on the right hub was CDA3340M2.

Negative Torque Sensing (NTS) System Information

In addition to the ability for a pilot to manually feather the propellers, and an automatic feathering feature, the engine (Honeywell TPE-331) design also includes a "Negative Torque Sensing" (NTS) system that would automatically respond to a typical failed engine condition involving a windmilling propeller. According to the aircraft manufacturer, when this condition is sensed, the NTS system automatically vents oil pressure from the propeller, allowing the balance springs to drive the propeller toward feather. Feathering the propeller reduces drag and asymmetric yawing member due to the failed engine. All certification one-engine inoperative handling qualities evaluations are conducted with the NTS system operational and the aircraft meets all FAA requirements. Airplane Flight Manual procedures for engine failure instruct the pilot to control the airplane, identify the failed engine by power asymmetry and instrument panel indications then move the condition lever to Emergency Stop to shut down the engine and completed the propeller feathering process. Additionally, the procedures instruct the pilot to move the Power Lever to the Takeoff position to prevent the propeller blades moving toward flat pitch.

An engine flameout will result in NTS activation, with decreasing torque, EGT or ITT, and rpm. The manufacturer stated that the NTS system is the drag reduction component, providing a margin of safety until the pilot is able to shut down the engine with the condition lever and advance the power lever to the takeoff position. However, if component in the engine gearbox fails in such a manner that the propeller uncouples from the power section, the NTS system becomes inoperable, because the system cannot sense torque in this failure mode.

Additional information regarding failure modes of this system, and emergency procedures published in the Airplane Flight Manual (AFM), are provided later in this report.

Maintenance History

A review of the maintenance records revealed that both engines were manufactured by Honeywell in 1979, and entered service on the accident airplane in 1982, in Argentina. Engine logbooks indicate the engines/airplane accumulated about 1,100 hours while in Argentina, with the last entry occurring in 1984. There were no other entries in the engine logbooks until 1998 when the airplane came to the United States.

On October 11, 2000, while in flight, records show that the No. 2 engine had an oil leak, and the pilot secured the engine, and landed the airplane. Post incident examination revealed that the leak was coming from the propeller pitch interconnect tube.

On November 2002, about 2484 hours, records indicate that maintenance was performed as part of a gearbox repair on the No 2 engine. On February 27, 2004, about 3,082 hours, the No. 2 engine underwent an engine shutdown due to the backing off of a nut securing the sun gear to the bull gear, which resulted in an uncoupling of the propeller to the turbine.

On October 28, 2004, about 3387 hours, records showed that the No. 2 engine experienced low oil pressure, the absence of a beta light, and it was noted to be difficult to come off the locks. A small sliver of metal was found in the check valve in the beta block.

On May 3, 2006, about 3282 hours, the No. 2 engine experienced a sudden loss of oil pressure, and was removed from the airplane and repaired. On May 13, 2006, about 4,020 hours total time, the No. 2 engine experienced an oil leak, and it was repaired.

Additional airplane maintenance information was obtained from witness statements. An FAA inspector stated that a gentleman telephoned to report that he and the deceased pilot had been friends for many years, and because of the frequency with which he had flown with the pilot, he could have been on the accident flight under different circumstances. The witness said that the pilot had confided in him after an incident had occurred that the accident airplane had a problem with the right engine, which caused the propeller to go into reverse. According to the FAA inspector, the gentleman stated that the pilot had explained that the accident airplane's right engine had experienced the failure of a particular "pin" during takeoff from Greensboro, North Carolina, over a year previously.

A person at Howell Enterprises Inc, who regularly conducts recurrent training on the MU-2, and who had also given the accident pilot his recurrent training, stated that the pilot told him of three instances of incidents having occurred to the right engine. The first incident was in December 2003, and involved an aborted takeoff in Greensboro, North Carolina. The second, date unknown, was during a planned flight to the Bahamas for vacation, in which during climb-out the right engine oil pressure and torque fluctuated. The third event was during a flight in the Washington DC area, when a problem occurred. The mechanic traveled to where the airplane was located, and he replaced the oil line between the propeller governor and the propeller pitch control.

METEOROLOGICAL INFORMATION

Visual meteorological conditions prevailed at the time of the accident. The Ft. Pierce Airport surface weather observation at 1220, was winds from 240 at 5 knots, visibility 10 statute miles; sky condition, few clouds at 2,600 feet, broken at 4,300 feet, broken at 5,500 feet; temperature 29 degrees C, dewpoint temperature 23 degrees C; altimeter setting 29.88 inHg.

WRECKAGE AND IMPACT

N316PR impacted the terrain in a wooded sloping area consisting of trees, shrubs, and brush, just south of a mobile home park, about 80 yards west of US-1 at the following geographic coordinates: 27 degrees 28.447 minutes North latitude, 080 degrees 20.229 minutes West longitude.

The accident site was located in a rural area of Fort Pierce, in St. Lucie County, about 1.5 miles southeast of the departure runway (runway 14). The airplane came to rest on a magnetic heading of about 210 degrees, and when it impacted a fire ensued. The fire consumed the vegetation in an area from the main wreckage and forward for a radius of about 150 feet, and after the fire was extinguished a strong odor of fuel remained throughout the burned-out area. The crash site encompassed a small debris field and showed evidence of a steep to near vertical descent, consistent with low forward movement associated with an airplane having impacted terrain in a near nose level attitude. The soil in the immediate area was disturbed only in the area of the main wreckage and had signatures consistent with the fuselage having rotated in a clockwise direction. No elongated debris field or ground scarring was noted

Evidence of all components of the airplane was in the immediate area of the main wreckage, and examination of the airframe and flight controls revealed no anomalies. The mostly burnt fuselage, when viewed from the side, displayed fractures and compression damage consistent with a high vertical rate of descent. The unconsumed burned sections of left wing had separated from the fuselage, but remained close to its normal position with the engine and propeller under-slung. The remaining burnt, compressed, and fractured section of wing outboard of the engine drooped downward. Pieces of the left wing tip tank had detached, and were found a short distance outboard and forward of the left wing.

The right wing was bent slightly backwards and had incurred extensive damage throughout, exhibiting an anhedral-type gull shaped appearance, with the right engine under-slung. There was also compression and fracturing noted throughout, consistent with a high vertical impact. The right wing had also incurred extensive fire damage, and sections of aluminum had been consumed or had become molten. When viewed with respect to the terrain, the right wing generally conformed to the slope of the topography, consistent with a vertical impact. The right wing tip tank had separated from the right wing and it had come to rest several feet outboard and slightly forward of the wing. The flaps “flap stopper assembly” and jackscrews were examined, and the flap actuator measurement was noted to be 0 degrees, consistent with the flaps being in the retracted position.

The nose to the fuselage just aft of the wings was consumed by fire, making the airplane structure/cabin area a compilation of damaged parts/debris and ash. Aft of the wings there was progressively less fire damage to the fuselage. The fuselage exhibited outward bulging when viewed along its longitudinal axis consistent with compression, and there was a circumferential fracture immediately forward of the airplane’s empennage, that held the empennage loosely in-place by the control cables.

The empennage had incurred the least amount of fire and impact damage and the beacon atop the vertical stabilizer was undamaged. The leading edge of the vertical stabilizer had been slightly scorched by fire, and the left side of the vertical stabilizer had incurred skin punctures. The rudder and trim tabs were relatively undamaged. There was skin damage to the tailcone in

the area at the intersection of the tailcone, rudder and horizontal stabilizer. Also, there was minor damage to the horizontal stabilizer, however its elevator and trim tabs were relatively intact. The elevator trim actuator measurement was consistent with the trim being set to neutral, and the rudder trim tab was flush with the rudder surface. The landing gear selector had been destroyed however all three landing gears were noted to be in the retracted position.

In the cabin, both propeller condition levers were noted to be in the "TAKEOFF/LAND" position. The left power lever was damaged and it had about 1 inch of the lever protruding from the quadrant, and appeared to be in the reverse position. A stub of the right power lever was in the "FLIGHT IDLE" position, based upon its position relative to switches and the "yellow/black decal". (The pedestal was equipped with a detent to secure the condition levers in the EMERGENCY/STOP position. When a condition lever is placed in EMERGENCY/STOP, fuel is shut off, and the feather valve is pulled, preventing the propeller from coming out of feather, irrespective of where the power lever is later positioned.)

The cabin was mostly consumed in the postcrash fire. The flight instruments and navigation/ communication radios in the cockpit instrumentation panel were destroyed by the impact, or as a result of the fire, and were unreadable.

During the initial examination, two of the four blades on each propeller had detached, however a search of the soil underlying the engines revealed that both blades from each hub had been separated and had been embedded into the terrain in the area where the engines had impacted.

Initial evaluation of the damage to the accident airplane's propellers while on-scene indicated that both propellers were rotating, and were both being operated at about the same energy level at the time of impact. Neither of the two propellers appeared to have been set to "feather", however definite blade angles could not be determined. On October 11, 2006, under the supervision of an engineer with the FAA Chicago Aircraft certification Office, another propeller examination was performed at Hartzell Propeller Inc., Piqua, Ohio, in an attempt to determine the preaccident propeller blade angles. The propeller examinations confirmed the findings of the first examination and revealed that the damage was similar for both propellers, and was consistent with both propellers rotating and being operated similarly at the time of the accident. There were no indications of the propellers having been feathered, and no anomalies were noted that would have precluded normal operation.

All noted damage to the propellers was consistent with the impact, and had similarities that included leading edge damage, rotational scoring, and blade twisting. The respective cylinder had separated from each hub, and both hubs had two fractured blade pilot tubes with one pilot tube pulled out. Both propellers had blade angle witness marks at, or near reverse pitch, consistent with the pitch change mechanisms being driven toward low/reverse blade angle, consistent with the impact. Both had a blade that had been separated at the shank, both had one blade pulled out of the blade clamp, and both had one blade that had significant twisting. A comparison of the blade damage was similar among comparable propellers. Both propellers had remained attached to the engine and the overall blade damage to all 4 propeller blades was similar for each of the two propellers.

On June 26, 2006, each section of wing, with the respective engine attached, was loaded onto a trailer and transported to a hanger at the St. Lucie International Airport. On June 27, 2006, the NTSB completed the on-scene examination/wreckage documentation, and removed all remaining airplane wreckage from the wooded area to the hangar for further examination. At

the hangar, each engine from the accident airplane was further documented, removed from the wing, and prepared for shipment to Honeywell Aerospace for a detailed engine teardown. Details of the examinations are found later in this report.

MEDICAL AND PATHOLOGICAL INFORMATION

On June 27, 2006, a pathologist with the District Nineteen Medical Examiner's Office, Fort Pierce, Florida, performed an autopsy on the pilot's body. According to the medical examiner's report, the cause of death was attributed to blunt force trauma. No findings that could be considered causal to this accident were reported.

The FAA Toxicological Laboratory, Oklahoma City, Oklahoma, conducted toxicological studies on samples obtained from the pilot. Tests were conducted for carbon monoxide, cyanide, volatiles, and drugs, and the result of each test was negative.

TESTS AND RESEARCH

Propeller Governors

On September 8, 2006, under the supervision of an engineer with the FAA Chicago Aircraft Certification Office, both propeller governors were examined at Woodward Governor Company, Aircraft Controls Group, Loves Park, Illinois. Damage did not allow functional tests, however the governors were disassembled, inspected, and no defects, pre-impact damage, or unusual wear was noted.

Fuel Components

On September 8, 2006, both fuel control units (FCUs) were tested at Woodward Governor Company, under the supervision of an engineer with the FAA Chicago Aircraft Certification Office. The unit associated with the left engine, serial number 1486746, exhibited damage consistent with the impact. The functional test in accordance with Woodward Governor TSP-1735, Rev H., was performed, and afterwards the unit was torn down. No preaccident anomalies were noted with the left fuel controller. The FCU, serial number 1484333, associated with the right engine exhibited damage consistent with impact, and its outside was stained consistent with it having undergone heat damage. A functional test, performed in accordance with Woodward Governor TSP-1735, Rev H procedures, was performed, and after the functional test the unit was disassembled, and the silicone diaphragm and altitude compensating bellows were found to have incurred heat damage. No preaccident anomalies were noted.

On September 14, 2006, an examination of both fuel pumps was conducted at Honeywell's facility in Phoenix, Arizona, under the supervision of an FAA inspector. The fuel pumps that were examined were serial number P-3316C, and serial number 98NF45151, and no preaccident anomalies were noted.

Engine Disassembly and Inspection Findings

On August 1 to 4, 2006, teardown inspections of the two Honeywell TPE331-10-511M engines were performed at Honeywell Aerospace, Phoenix Arizona, under the direction of the NTSB. Examination of the No. 1 (left) engine, serial number P36117C, found evidence of power section

combustion and rotation at impact. No evidence of any pre-impact condition that would have prevented normal engine operation was found.

Examination of the No. 2 (right) engine, serial number P36126C, found evidence of power section combustion and rotation at impact. The No. 2 engine's ring gear support was found fractured into three pieces. The ring gear was displaced forward and had disengaged from the ring gear support.

During the teardown of the No 2 (right) engine, P36126C, one axial crack was noted to be visible on the outer diameter of the ring gear, extending forward from the aft side of the ring gear. In addition, the No. 2 engine ring gear support was found to have fractured into three pieces. The ring gear had displaced forward, and had become disengaged from the ring gear support, resulting in a disconnection in power being transferred to the propeller.

Metallurgical Findings of Ring Gear Components

Metallurgical examinations of the ring gear, the ring gear support, and the ring gear retainers (retaining plate pairs) pertaining to the right engine were conducted at Honeywell Aerospace. The intent of the examinations was to document the ring gear support segment to show the overall condition, and to take normal and high magnification photographs in an attempt to determine the fracture mode of the propeller coupling shaft. The examinations also documented damage to multiple areas along the forward face of the ring gear support. Some of the damage included several depressions and marks on the forward face of the ring gear support.

The ring gear support indicated signs of high cycle fatigue originating at the relief cutout corners (corner radii) for the high-speed pinion with primary crack growth occurring in the circumferential direction. There was about a 330° splined section of the ring gear support that had fractured from the ring gear support piece attached to the diaphragm. This section was comprised of two pieces (one arc segment of approximately 270° and one arc segment of approximately 60°). Two retaining plate pairs (of three total) remained attached to the 270° arc segment, and these retaining plates were fractured consistent with the ring gear moving forward relative to the 270° arc segment. There was about a 30° arc segment of the ring gear support containing the third retainer plate pair that remained bolted to the diaphragm.

The ring gear support is manufactured from "4340" steel and the aft face is bolted to the gearbox diaphragm housing. Its forward outer diameter is toothed, and these teeth mate with the splines around the aft inner diameter of the ring gear, and hold the ring gear stationary. Three sets of retaining plates attached to the ring gear support splined diameter capture the ring gear, and retain it axially. The forward inner diameter of the ring gear is toothed and the four planetary gears engage these teeth. The ring gear provides both radial and tangential restraint for the planet gears, which rotate a planetary assembly, that mate to the propeller shaft coupling. The planetary assembly is restrained axially at the aft side through contact between the planet gears and the forward flange on the ring gear support. The planetary assembly is restrained axially at the forward side through contact between the planetary assembly and the aft face of the propeller shaft coupling. The ring gear support restrains the ring gear as loads react through the ring gear support to the diaphragm. The ring gear is manufactured of "9310" steel and it experiences an alternating load from each of the four planet gears with each rotation.

Honeywell's report states that "analysis indicated that an axial load resulting from impact

forces caused the overload separation of the corners of the forward retainer plates on the 270° arc segment of the ring gear support. This enabled the ring gear to become disconnected from the ring gear support. The ring gear then moved forward contacting the nose cone housing with indications of axial impact and with minimal rotation."

NTSB metallurgists reviewed the work of Honeywell metallurgists, and in addition, the NTSB metallurgists conducted examinations of the damaged/affected parts. The affected parts and their data revealed an absence of long-term post-fracture damage to the fracture surfaces, consistent with the ring gear support having fractured shortly before impact.

In addition, in an attempt to better understand and document the axial forces on the retaining plates, the NTSB research engineers developed finite element models based on damage patterns observed on the parts.

Consequences of Gearbox Failure

According to Honeywell's engineers, a gearbox failure that involves complete separation of the ring gear support (drive train disconnect), is a function of the flight idle fuel flow setting and the propeller governor setting, and results in the engine accelerating rapidly in response to the loss of load (an over-speed). The negative torque system will not be active because negative torque is not being sensed. The engine control system will bypass propeller oil, and the propeller will feather. As long as engine rpm remains above 104%, oil will continue to be bypassed, and the propeller will remain in feather.

According to a technical representative with Mitsubishi, if following a propeller disconnect event, the pilot retards the power lever and the engine RPM drops below the engine speed setting (100% for takeoff), the propeller will immediately move out of feather toward the flight idle pitch setting. The TPE331 control system will sense an under-speed and attempt to increase engine RPM by reducing the propeller blade angle toward flight idle pitch (near flat pitch), drag will increase, and unanticipated flight control difficulty might result.

Mitsubishi Heavy Industries America Inc., Aircraft Product Support Division, performed MU-2B drag calculations, and Hartzell Propeller Inc., calculated propeller windmill drag and RPM estimations to determine how long it takes to feather the propeller for scenarios (including the propeller governor operating at 104.5 percent, and a propeller to engine disconnect at the gearbox), and the calculations showed about a 3 second duration to feather the propeller.

During the course of the NTSB investigation, Honeywell performed a risk assessment/analysis of the ring gear support, which documented the failures found to date for the ring gear support and the associated hours on the TPE331 fleet. There were a total of five events, of which three were found during scheduled maintenance. One event resulted in an in-flight shutdown (S/N P36337), and the Fort Pierce (S/N P36126C) event, investigated here, all of which occurred during about 29 million hours of engine operations.

ADDITIONAL INFORMATION

Published Emergency Procedures for In Flight Engine Power Loss

The Mitsubishi MU-2 Flight Manual, Section 3, Emergency Procedures for in flight engine power loss requires that the engine be shut down immediately using the condition lever (condition lever: EMERGENCY STOP). The power lever should be moved to the takeoff

position for the remainder of the flight, and should not be retarded (power lever: TAKEOFF). Furthermore, the MU-2 Flight Manual, Emergency Procedures, page 3-3, Engine Shutdown Procedures Rev. 7, Nov 30, 1995, includes this warning:

"WARNING: Identify failed engine by power asymmetry and engine instruments. Do not retard failed engine power lever. Place failed engine power lever to takeoff position during the feathering of the propeller and leave there for the remainder of the flight."

Post-Accident Actions: Airplane Manufacturer

As a result of this accident and other applicable events mentioned above, on March 3, 2008, Mitsubishi published MU-2 Service News No. 110/00-017, entitled "Power Lever Position Warning for In-flight Engine Failure.

On January 27, 2009 Mitsubishi also published Service News No. 114/00-020, entitled "Engine Failure Modes." This publication stated the following:

"The TPE-331 is equipped with a Negative Torque Sensing (NTS) system that automatically responds to the condition where the propeller is driving the engine (failed engine, windmilling). When this condition is sensed, the NTS system automatically vents oil pressure from the propeller, allowing the balance springs to drive the propeller toward feather. Feathering the propeller reduces drag and asymmetric yawing member due to the failed engine. All certification one-engine inoperative handling qualities evaluations are conducted with the NTS system operational and the aircraft meets all FAA requirements. Airplane Flight Manual procedures for engine failure instruct the pilot to control the airplane, identify the failed engine by power asymmetry and instrument panel indications then move the condition lever to Emergency Stop to shut down the engine and completed the propeller feathering process. Additionally, the procedures instruct the pilot to move the Power Lever to the Takeoff position to prevent the propeller blades moving toward flat pitch.

"Pilots should be aware that under unusual circumstances a failure in the gearbox section of the TPE 331 engine could disconnect the propeller from the power section and could result in substantially different engine indications than a simple engine flameout. The proper pilot response to either mode of failure should be identical however. A flameout will result in Negative Torque Sensing (NTS) activation, with decreasing torque, EGT or ITT, and rpm. The NTS system is the drag reduction component, providing a margin of safety until the pilot is able to shut down the engine with the condition lever and advance the power lever to the takeoff position.

"However, in a prop shaft coupler failure or in other gearbox related failures, the engine drive can become disconnected from the propeller. In this case, there is no NTS protection because the torque sensed by the torque sensor is zero, not negative. With the loss of propeller load on the engine, the entire RPM will increase to the overspeed governor high set point of 103% TO 105% RPM. The propeller governor will sense the engine overspeed and will rapidly release oil pressure from the propeller dome, causing the propeller to feather without pilot input. Note that this feathered propeller/drag reduction occurs ONLY because the propeller governor is sensing the overspeed. Despite the differing indications of a gearbox failure compared to a flameout, the pilot actions must remain consistent – that is, if the pilot observes that the propeller is feathered with the rpm higher than normal, follow the Airplane Flight Manual procedures by placing the Condition Lever of the affected engine in Emergency Stop and advance the Power Lever to Takeoff. Of course, as always, FLY THE AIRPLANE!

“What could happen if a pilot decides not to follow the AFM?

“Assume that a component in the engine gearbox fails in such a manner that the propeller uncouples from the power section, the propeller feathers and the power section continues to run. The pilot observes a sudden yaw, a feathered propeller and high rpm. He has the aircraft under single engine control. All is good. However, if the pilot now decides to disregard the AFM and he does not shut the engine down with the condition lever since the propeller is already feathered, he could be setting himself up for an unsafe condition. Instead of following the AFM engine shutdown procedures, he decides to reduce the rpm back to a “normal” 100% by retarding the power lever. This action reduces the fuel flow and once the fuel flow is reduced past a point where the rpm drops below 100%, the engine will now sense an underspeed condition. In an effort to increase engine speed, the propeller governor will port oil to the propeller dome to move the propeller blades out of feather and toward a flat pitch. The propeller will begin turning. This result will be a high drag event on the side of that propeller, with a potential for loss of control. Although the pilot had the aircraft under control while the propeller was feathered, as the propeller comes out of feather, drag could increase to the point that, unless Emergency Stop is selected with the Condition Lever, control could become much more difficult. Remember, NTS protection is not available in this failure mode.

“This scenario illustrates the importance of following the AFM precisely in the event of any engine failure or malfunction. Follow the Engine Shutdown Procedure, placing the Condition Lever to Emergency Stop and the Power Lever to Takeoff (full forward). Afterwards, continue with the remainder on the non memory Engine Shutdown items when time and circumstance permit. Observe the following WARNING from the Engine Shutdown Procedure in the Airplane Flight Manual:

“WARNING

Identify failed engine by power asymmetry and engine instruments. Do not retard failed engine Power Lever. Place failed engine power lever to takeoff position during the feathering of propeller and leave there for remainder of flight.”

Post-Accident Actions: Engine Manufacturer

Honeywell Aerospace is in the process of writing, and intends to release an Operating Information Letter (OIL) OI331-26, which will provide a description of the engine symptoms and recommended actions in the event of an uncoupling event, or in the event of an engine failure for any reason. Honeywell has also revised the TPE331 engine maintenance manual ring gear support inspection criteria to require magnetic particle and focused inspections under certain conditions.

Pilot Information

Certificate:	Airline Transport; Commercial	**Age:**	57, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land; Single-engine Sea	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 3 With Waivers/Limitations	**Last FAA Medical Exam:**	03/23/2004
Occupational Pilot:		**Last Flight Review or Equivalent:**	07/25/2005
Flight Time:	11000 hours (Total, all aircraft), 2000 hours (Total, this make and model), 2 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	MITSUBISHI	**Registration:**	N316PR
Model/Series:	MU-2B-60	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	761SA
Landing Gear Type:	Retractable - Tricycle	**Seats:**	10
Date/Type of Last Inspection:	05/13/2006, Condition	**Certified Max Gross Wt.:**	11575 lbs
Time Since Last Inspection:	53 Hours	**Engines:**	2 Turbo Prop
Airframe Total Time:	4073 Hours at time of accident	**Engine Manufacturer:**	Honeywell
ELT:	Installed, not activated	**Engine Model/Series:**	TPE-331-10
Registered Owner:	Flyin Cloud LLC	**Rated Power:**	715 hp
Operator:	Flyin Cloud LLC	**Operating Certificate(s) Held:**	None

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	**Condition of Light:**	Day
Observation Facility, Elevation:	FPR, 21 ft msl	**Distance from Accident Site:**	2 Nautical Miles
Observation Time:	1225 EDT	**Direction from Accident Site:**	180°
Lowest Cloud Condition:	Few / 2700 ft agl	**Visibility**	10 Miles
Lowest Ceiling:	Broken / 4100 ft agl	**Visibility (RVR):**	
Wind Speed/Gusts:	5 knots /	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	260°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:	29.88 inches Hg	**Temperature/Dew Point:**	29°C / 22°C
Precipitation and Obscuration:			
Departure Point:	Fort Pierce, FL (FPR)	**Type of Flight Plan Filed:**	IFR
Destination:	Murfreesboro, TN (MBT)	**Type of Clearance:**	IFR
Departure Time:	1223 EDT	**Type of Airspace:**	Class D

Airport Information

Airport:	St. Lucie County International (FPR)	**Runway Surface Type:**	Asphalt
Airport Elevation:	275 ft	**Runway Surface Condition:**	Dry
Runway Used:	14	**IFR Approach:**	None
Runway Length/Width:	4756 ft / 100 ft	**VFR Approach/Landing:**	None

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	N/A	**Aircraft Fire:**	On-Ground
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	27.473611, -80.336667

Administrative Information

Investigator In Charge (IIC):	John W Lovell	**Report Date:**	12/22/2009
Additional Participating Persons:	Robert L Drake; FAA AAI-100; Washington DC, DC Dana S Metz; Honeywell Aerospace; Phoenix, AZ Ralph Sorrels; Mitsubishi Heavy Industries America Inc.; Addison, TX Tom McCreary; Hartzell Propeller Inc.; Piqua, OH		
Publish Date:	12/22/2009		
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		