



# Aviation Investigation Final Report

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<b>Location:</b>	Owasso, Oklahoma	<b>Accident Number:</b>	CEN14FA046
<b>Date &amp; Time:</b>	November 10, 2013, 15:46 Local	<b>Registration:</b>	N856JT
<b>Aircraft:</b>	Mitsubishi MU 2B-25	<b>Aircraft Damage:</b>	Destroyed
<b>Defining Event:</b>	Loss of control in flight	<b>Injuries:</b>	1 Fatal
<b>Flight Conducted Under:</b>	Part 91: General aviation - Personal		

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## Analysis

Radar and air traffic control communications indicated that the Mitsubishi MU-2B-25 was operating normally and flew a nominal flightpath from takeoff through the beginning of the approach until the airplane overshot the extended centerline of the landing runway, tracking to the east and left of course by about 0.2 nautical mile then briefly tracking back toward the centerline. The airplane then entered a 360-degree turn to the left, east of the centerline and at an altitude far below what would be expected for a nominal flightpath and intentional maneuvering flight given the airplane's distance from the airport, which was about 5 miles.

As the airplane was in its sustained left turn tracking away from the airport, the controller queried the pilot, who stated that he had a "control problem" and subsequently stated he had a "left engine shutdown." This was the last communication received from the pilot. Witnesses saw the airplane spiral toward the ground and disappear from view.

Examination of the wreckage revealed that the landing gear was in the extended position, the flaps were extended 20 degrees, and the left engine propeller blades were in the feathered position. Examination of the left engine showed the fuel shutoff valve was in the closed position, consistent with the engine being in an inoperative condition. As examined, the airplane was not configured in accordance with the airplane flight manual engine shutdown and single-engine landing procedures, which state that the airplane should remain in a clean configuration with flaps set to 5 degrees at the beginning of the final approach descent and the landing gear retracted until landing is assured. Thermal damage to the cockpit instrumentation precluded determining the preimpact position of fuel control and engine switches.

The investigation found that the airplane was properly certified, equipped, and maintained in accordance with federal regulations and that the recovered airplane components showed no evidence of any preimpact structural, engine, or system failures. The investigation also determined that the pilot was properly certificated and qualified in accordance with applicable federal regulations, including Special Federal Aviation Regulation (SFAR) No. 108, which is required for MU-2B pilots and adequate for the

operation of MU-2B series airplanes. The pilot had recently completed the SFAR No. 108 training in Kansas and was returning to Tulsa. At the time of the accident, he had about 12 hours total time in the airplane make and model, and the flight was the first time he operated the airplane as a solo pilot. The investigation found no evidence indicating any preexisting medical or behavioral conditions that might have adversely affected the pilot's performance on the day of the accident.

Based on aircraft performance calculations, the airplane should have been flyable in a one-engine-inoperative condition; the day visual meteorological conditions at the time of the accident do not support a loss of control due to spatial disorientation. Therefore, the available evidence indicates that the pilot did not appropriately manage a one-engine-inoperative condition, leading to a loss of control from which he did not recover.

The airplane was not equipped, and was not required to be equipped, with any type of crash-resistant recorder. Although radar data and air traffic control voice communications were available during the investigation to determine the airplane's altitude and flightpath and estimate its motions (pitch, bank, yaw attitudes), the exact movements and trim state of the airplane are unknown, and other details of the airplane's performance (such as power settings) can only be estimated. In addition, because the airplane was not equipped with any type of recording device, the pilot's control and system inputs and other actions are unknown.

The lack of available data significantly increased the difficulty of determining the specific causes that led to this accident, and it was not possible to determine the reasons for the left engine shutdown or evaluate the pilot's recognition of and response to an engine problem. Recorded video images from the accident flight would possibly have shown where the pilot's attention was directed during the reported problems, his interaction with the airplane controls and systems, and the status of many cockpit switches and instruments. Recorded flight data would have provided information about the engines' operating parameters and the airplane's motions. Previous NTSB recommendations have addressed the need for recording information on airplane types such as the one involved in this accident. Recorders can help investigators identify safety issues that might otherwise be undetectable, which is critical to the prevention of future accidents.

## **Probable Cause and Findings**

The National Transportation Safety Board determines the probable cause(s) of this accident to be:

The pilot's loss of airplane control during a known one-engine-inoperative condition. The reasons for the loss of control and engine shutdown could not be determined because the airplane was not equipped with a crash-resistant recorder and postaccident examination and testing did not reveal evidence of any malfunction that would have precluded normal operation.

## Findings

<b>Aircraft</b>	(general) - Not specified
<b>Personnel issues</b>	Use of checklist - Pilot
<b>Aircraft</b>	Gear extension and retract sys - Not used/operated
<b>Aircraft</b>	Engine out control - Not specified
<b>Personnel issues</b>	Aircraft control - Not specified
<b>Not determined</b>	(general) - Unknown/Not determined
<b>Aircraft</b>	Data recorders (flight/maint) - Not installed/available
<b>Aircraft</b>	Audio & video monitoring - Not installed/available

## Factual Information

### History of Flight

<b>Approach</b>	Engine shutdown
<b>Maneuvering</b>	Loss of control in flight (Defining event)
<b>Uncontrolled descent</b>	Collision with terr/obj (non-CFIT)
<b>Post-impact</b>	Fire/smoke (post-impact)

On November 10, 2013, about 1546 central standard time, a Mitsubishi MU-2B-25 twin-engine airplane, N856JT, impacted wooded terrain while maneuvering near Owasso, Oklahoma. The commercial pilot, who was the sole occupant of the airplane, sustained fatal injuries. The airplane was destroyed. The airplane was registered to Anasazi Winds, LLC, Tulsa, Oklahoma, and was operated by the pilot under the provisions of 14 *Code of Federal Regulations* Part 91 as a personal flight. Visual meteorological conditions prevailed for the flight, and an instrument flight plan had been filed. The flight departed Salina Regional Airport (SLN), Salina, Kansas, about 1503 and was en route to Tulsa International Airport (TUL), Tulsa, Oklahoma.

After takeoff, the airplane was radar identified by the Kansas City Center (ZKC) sector R66 controller, and the pilot was cleared to climb to 9,000 feet. About 1506, the pilot was cleared to climb to 17,000 feet. The flight proceeded normally, and at 1518, the pilot was instructed to contact the ZKC sector R72 controller. The pilot did so and was issued the Chanute altimeter setting, 30.30 inches of mercury. About 1527, the R72 controller instructed the pilot to descend at his discretion and maintain 10,000 feet. The pilot reported leaving 17,000 feet. About 1532, the R72 controller instructed the pilot to contact Tulsa approach control, and the pilot acknowledged.

At 1534:09, the pilot contacted Tulsa approach. He reported leaving 11,600 feet for 10,000 feet and having received automatic terminal information service information Charlie. The controller advised the pilot to expect vectors for a visual approach to TUL runway 18L, and the pilot acknowledged the information. At 1537:46, the controller instructed the pilot to turn 10 degrees left and descend to 6,000 feet. At 1540:07, the controller asked the pilot to turn another 10 degrees left and instructed him to descend to 2,500 feet. The pilot acknowledged the instructions.

At 1542:04, the controller advised the pilot that TUL was at the pilot's one o'clock position and 10 miles and asked the pilot to report the airport in sight. The pilot immediately replied, "In sight." The controller cleared the pilot for a visual approach to runway 18L and instructed him to contact TUL tower. The pilot acknowledged both the approach clearance and the frequency change.

The pilot contacted TUL tower at 1542:20 and again reported the airport in sight. The tower controller cleared the pilot to land on runway 18L and asked him to reduce speed to 150 knots or less for spacing behind an aircraft that would be departing from runway 18L. The pilot replied that he was reducing speed and acknowledged the runway assignment.

After the airplane passed the runway 18L outer marker, the airplane began a left turn. At 1544:48, when the airplane was about 90 degrees from the runway approach path, the tower controller transmitted, "Mitsubishi six Juliet tango tower." The pilot replied, "I've got a control problem." The controller responded, "Okay uh you can just maneuver there – if you can maneuver to the west and uh do you need assistance now?" At 1545:06, the pilot replied, "<unintelligible> I've got a left engine shutdown."

At 1545:11, the tower controller contacted the approach controller to advise him that N856JT had a control problem and that other aircraft might have to be cleared out of the area.

At 1545:38, the tower controller transmitted, "Six Juliet Tango are you uh declaring an emergency uh well we'll declare emergency for runway 18L – you say you have an engine out and souls on board and fuel remaining if you have time." The controller made two additional attempts to contact the pilot at 1546:06 and 1546:55, but there was no response. According to the tower's Accident/Incident Notification Record completed after the accident, notification of emergency services occurred about 1546.

Radar data showed the airplane complete a 360-degree left turn near the runway 18L outer marker at 1,100 feet mean sea level (msl) then radar contact was lost.

Seven witnesses observed the airplane in a shallow left turn; the reported altitudes ranged from 400 to 800 feet above ground level (agl). Four witnesses recalled the landing gear in the extended position during the turn, and two witnesses observed that one engine propeller appeared not to be rotating or slowly rotating. One of the witnesses reported seeing a stream of black exhaust following the airplane and four reported not seeing any smoke. Four of the witnesses reported an unusual engine or propeller noise from the airplane, and four did not comment on the engine or propeller noise. Some of the witnesses observed the airplane in a left turn toward the west before the wings began to rock left and right at a 10-15 degree bank angle. Shortly thereafter, the airplane was seen in a bank to the right followed by a "hard" bank to the left. Some of the witnesses observed the airplane spiral toward the ground and disappear from view.

## Pilot Information

<b>Certificate:</b>	Commercial; Flight instructor	<b>Age:</b>	51
<b>Airplane Rating(s):</b>	Single-engine land; Multi-engine land	<b>Seat Occupied:</b>	Left
<b>Other Aircraft Rating(s):</b>	None	<b>Restraint Used:</b>	4-point
<b>Instrument Rating(s):</b>	Airplane	<b>Second Pilot Present:</b>	No
<b>Instructor Rating(s):</b>	Airplane single-engine; Instrument airplane	<b>Toxicology Performed:</b>	Yes
<b>Medical Certification:</b>	Class 3 With waivers/limitations	<b>Last FAA Medical Exam:</b>	October 15, 2013
<b>Occupational Pilot:</b>	No	<b>Last Flight Review or Equivalent:</b>	November 10, 2013
<b>Flight Time:</b>	(Estimated) 2874 hours (Total, all aircraft), 12 hours (Total, this make and model), 2153 hours (Pilot In Command, all aircraft), 43 hours (Last 90 days, all aircraft), 23 hours (Last 30 days, all aircraft), 4 hours (Last 24 hours, all aircraft)		

The pilot, age 51, held a commercial pilot certificate, with airplane single-engine land, airplane multiengine land, and instrument airplane ratings, and a flight instructor certificate with airplane single-engine land, airplane multi-engine land, and instrument airplane ratings. The pilot's most recent flight instructor renewal was completed on October 6, 2013, when he added an airplane multiengine endorsement. The pilot's most recent Federal Aviation Administration (FAA) third-class medical certificate was dated October 15, 2013, and had no limitations. The pilot's application for his medical certificate indicated no use of any medications and no medical history conditions.

According to pilot logbooks recovered at the accident site, which were partially consumed by fire, and other logbooks provided to investigators, the pilot had accumulated at least 2,874.4 total flight hours, of which 1,534.9 were in multiengine airplanes. The pilot accumulated most of his multiengine time in a Cessna 421B, which he owned since 2010.

Interviews with individuals who were in contact with the pilot and cellular telephone records were used to construct the pilot's 72-hour history before the accident. No abnormal routines or health issues were reported or noted.

Interviews were conducted with three pilots who flew with the accident pilot in the months before the accident. Although interviewed separately and not associated with each other, all three pilots had similar descriptions of the accident pilot. They described the pilot as a very good aviator who was studious and modest regarding his pilot skills. All three attested to the pilot's practice of flying in accordance with manufacturer guidance and meticulously following manufacturer checklists. None of the interviewed pilots recalled the pilot displaying any negative or bad flying habits.

#### Pilot's MU-2B-25 Training

Piloting a Mitsubishi MU-2B series airplane requires adherence to special training, experience, and operating conditions, which are provided in Special Federal Aviation Regulation (SFAR) No. 108 (published February 6, 2008, and effective February 5, 2009). Pilots cannot act as pilot-in-command (PIC) of an MU-2B series airplane unless they have logged a minimum of 100 flight hours as PIC in multiengine airplanes. For initial training, the SFAR requires a minimum of 20 hours of ground instruction and a minimum of 12 hours of flight instruction, with a minimum of 6 hours accomplished in the airplane, a level C simulator, or a level D simulator. Pilots must also satisfactorily complete a training course final phase check.

The accident pilot's MU-2B-25 ground school was conducted November 4-10, 2013, at Professional Flight Training, L.C. (PFT), Salina, Kansas. He was the sole student in the class and the training cadre consisted of one SFAR-certified flight instructor who was the school's owner. The instructor reported that ground school with the pilot took about 32 hours, which was consistent with the time normally allotted to teach new pilots. According to the MU-2B flight instructor, the pilot reported to him that he had no previous MU-2B or turbine airplane flight experience before the SFAR training.

The entire flight portion of the pilot's training was conducted in the accident airplane. The first flight was conducted on November 7, 2013, around the local area of Tulsa, Oklahoma. The second flight was conducted between Tulsa and Salina, Kansas. After the airplane landed at SLN, the remaining flights were flown in the local area of Salina. The instructor created training records for each flight, and the

maneuvers flown were graded by assigning a rating of one through four, indicating poor, fair, average, and excellent, respectively. The pilot's scores on the first flight were about 2.8, or just below "average." On each subsequent flight, the pilot progressed, with no evidence of regression in any area. On the final flight, his maneuvers were about 3.8, or nearly "excellent."

Documentation provided by the instructor recorded the time allotted for training. Two total hour metrics were tracked for each flight: the Hobbs meter time and a block time. The Hobbs time recorded airplane operation with weight off of the landing gear, which was determined by a squat switch on the left main landing gear. The block time recorded the time from when the airplane began taxiing from parking to the runway and the time that it returned to parking. During training, the accident airplane recorded 11.5 hours of Hobbs time and 16 hours 35 minutes of block time.

On November 10, 2013, the morning of the accident, the pilot satisfactorily completed the phase check and received an SFAR endorsement in the MU-2B-25. The accident flight from SLN to TUL was the first time the pilot flew as a single pilot in the MU-2B-25 airplane.

### MU-2B Stall Training

In addition to MU-2B ground training, pilots are flight trained in stall recognition and recovery in accordance with flight profiles contained in SFAR No. 108. Pilots must perform approaches to stalls in takeoff, clean, and landing configurations with at least one approach-to-stall maneuver flown while in a 15-30 degree bank turn. Accelerated stalls are performed with both 20-degree and 0 flap configurations. A pilot must recover the airplane at the first indication of a stall, provided by either airframe buffet or the control wheel shaker. The final phase check includes three approach-to-stall maneuvers.

The accident pilot flew three training flights during which landing configuration stalls were performed. In addition, he performed a landing configuration stall maneuver during his final phase check flight, which took place on the morning of the accident.

The Approach to Stall flight profile in the SFAR indicates that, when stall recognition occurs, the pilot should apply maximum engine power and adjust pitch as necessary to minimize the loss of altitude. The SFAR stall recovery procedure is different than the one outlined in FAA Advisory Circular (AC) 120-109, *Stall and Stick Pusher Training*, dated August 6, 2012. The AC "emphasizes reducing the angle of attack (AOA) at the first indication of a stall as the primary means of approach-to-stall or stall recovery." The AC changed the flight profiles used for general pilot certification and evaluation but did not alter the flight profiles in the SFAR. A change to the SFAR flight profiles must be accomplished through the notice of proposed rulemaking process. To date, MU-2B instructors and evaluators are required to instruct in the method that emphasizes minimizing altitude loss per the SFAR. The accident pilot's instructor taught the SFAR method but also instructed him on the AC's AOA recovery method.

In addition to his exposure to both recovery methods in his MU-2B-25 training, the pilot demonstrated knowledge of both methods of recovery in previous airplanes. The FAA's designated pilot examiner for the pilot's airplane multiengine instructor rating reported that, for a ground instructor topic, the pilot taught stall recovery procedures, explaining both methods appropriately.

### Single Engine and Minimum Controllable Airspeed (Vmc) Training

Like stall training, single engine procedures and V<sub>mc</sub> awareness training were taught during the pilot's ground and flight training, as required for completion of the SFAR flight phase check. Single engine training was performed using zero thrust on one engine and by shutting down an engine using an airborne Negative Torque Sensor (NTS) system check (the NTS system is described later in this report). A demonstration of V<sub>mc</sub> occurred on two training flights, and the pilot performed at least one engine shutdown in flight to demonstrate proficiency with an airborne NTS check. Maneuvers with one engine inoperative and a loss of directional control were performed on three training flights and during the pilot's final flight phase check. This maneuver requires the airplane to be configured with flaps at 20 degrees, the landing gear retracted, one engine set at zero thrust, and the other engine set to takeoff power. The airplane is pitched up to reduce the airspeed. As the airplane slows to V<sub>mc</sub> + 10 knots, the instructor blocks the rudder to cause a loss of directional control. At the first indication of a loss of directional control, the pilot reduces airplane pitch and engine power to recover control of the airplane. The pilot had also performed a single engine landing on the morning of the accident during his final phase check.

### Pilot Training Notes

The pilot's handwritten notes from his SFAR training were found in the airplane but were partially consumed by fire. Included in the pilot notes were the following:

- For engine out, center ball
- \*\*120 knots, never go below; 1. Takeoff 2. Landing assured
- V<sub>xse</sub> = 125 knots
- Single-engine flight - remain clean configuration until beginning of approach segment. In approach segment, gear up, flaps 5 degrees, then when landing assured, gear down, [flaps] 20 degrees
- (5 degrees flaps) Blue line, V<sub>xse</sub> 130, V<sub>yse</sub> 140

### MU-2 Pilot Checklist

SFAR No. 108 specifies the use of a pilot checklist (MU-2B-25 (A2PC) YET 06248B) that was accepted by the FAA's Flight Standardization Board (FSB) in 2010. This checklist and the earlier FSB-accepted version are the only checklists accepted for use in MU-2B airplanes during flight operations and training. The expanded checklist accepted in 2010 includes a single page checklist, which is a condensed version of the normal procedures and is commonly known as a quick reference checklist.

The flight instructor reported that the pilot routinely flew with the single page checklist in a pouch located to the left side of the pilot's seat. The expanded pilot checklist was normally stowed behind the co-pilot's seat. A fire-damaged copy of the pilot's checklist was discovered in the wreckage located near the aft facing passenger seat just aft of the co-pilot's seat. The single page quick reference checklist was not located in the plastic retaining sleeve of the expanded checklist and was not located elsewhere in the wreckage; it was possibly consumed by fire.

### Flight Instructor's Training Checklist

PFT developed a training checklist that was not accepted by the FAA's Flight Standardization Board for



training or operation of the MU-2B-25 airplane. Each page of the checklist is labeled as the following: "For Training Purposes Only", and another page contains the following note: "This checklist is for training purposes only. For further detail, the FAA-approved airplane flight manual checklist will be the governing authority." The training checklist comprised items from the accepted checklist, as well as expanded information for the airplane's ground safety checks and NTS airborne checks. However, the training checklist excluded and/or did not follow most of the SFAR No. 108 accepted checklist content. The checklist was also labeled as applicable to other MU-2B airplane models (MU-2B-40 and MU-2B-60) and did not mention the MU-2B-25.

The flight instructor reported using the training checklist solely to accomplish the first flight of training since it contains information that the instructor finds beneficial for pilots new to MU-2B series airplanes. The instructor also reported that pilots normally transition away from the PFT training checklist by the second or third flight. The FAA-accepted checklist was then used for the remainder of training, with the PFT training checklist as a supplemental training aid, if needed.

Examination of the airplane wreckage found a partially consumed PFT training checklist melted to the circuit breaker panel to the left of the pilot's seat. Another PFT training checklist was found in the aft portion of the fuselage.

Interviews with pilots who previously completed training with the PFT MU-2B instructor reported different experiences concerning the unaccepted training checklist. One former trainee reported never using the PFT checklist in flight and emphasized that only the FAA-accepted checklist was used. Another former trainee used the PFT checklist as the sole checklist for almost every flight. His perception was that the instructor pilot wanted to use the PFT training checklist for every flight.

During the course of the investigation, the cockpits of 10 MU-2Bs were examined by a National Transportation Safety Board (NTSB) investigator. Unaccepted checklists were found adjacent to the pilot seats in two airplanes along with the accepted checklist, which was not within the pilot's reach. One airplane had two different checklists on board the airplane within the pilot's reach; however, neither was an accepted checklist. The correct checklist was observed in the remaining seven airplanes.

#### Flight Instructor's Qualification

The instructor who conducted the accident pilot's training was SFAR-endorsed. He estimated that he had flown at least 16,000 hours in MU-2B series airplanes. He began instructing in the MU-2B in 1998 and estimated about 3,000 flight hours as an MU-2B instructor. On August 4, 2013, he renewed his flight instructor's certificate and on August 31, 2013, he completed an MU-2B-20 recurrent training course.

## Aircraft and Owner/Operator Information

<b>Aircraft Make:</b>	Mitsubishi	<b>Registration:</b>	N856JT
<b>Model/Series:</b>	MU 2B-25	<b>Aircraft Category:</b>	Airplane
<b>Year of Manufacture:</b>	1974	<b>Amateur Built:</b>	
<b>Airworthiness Certificate:</b>	Normal	<b>Serial Number:</b>	306
<b>Landing Gear Type:</b>	Retractable - Tricycle	<b>Seats:</b>	7
<b>Date/Type of Last Inspection:</b>	September 19, 2013 Continuous airworthiness	<b>Certified Max Gross Wt.:</b>	9920 lbs
<b>Time Since Last Inspection:</b>	13 Hrs	<b>Engines:</b>	2 Turbo prop
<b>Airframe Total Time:</b>	6581 Hrs as of last inspection	<b>Engine Manufacturer:</b>	Honeywell
<b>ELT:</b>	Installed, not activated	<b>Engine Model/Series:</b>	TPE331-10AV-5
<b>Registered Owner:</b>	On file	<b>Rated Power:</b>	715 Horsepower
<b>Operator:</b>	On file	<b>Operating Certificate(s) Held:</b>	None

The accident airplane was manufactured in 1973 by Mitsubishi as model MU-2B-25, serial number 306, and was a high-performance, twin-engine, high-wing, turboprop-powered airplane. It was issued a standard airworthiness certificate in the normal category on March 1, 1974, and registered to Anasazi Winds, LLC on September 26, 2013. The airplane was equipped with two 750 shaft horsepower (shp) (maximum continuous power rating of 715 shp) Honeywell TPE331-10AV-511M engines, flat rated to 665 shp, per a supplemental type certificate (STC) and Hartzell Propeller HC-B3TN-5M three-blade, single-acting, constant-speed, hydraulically-actuated propellers with feathering and reversing capability.

According to the airplane records and information obtained by a maintenance facility, the most recent inspection was a combined 100 hour/annual inspection completed on September 19, 2013, at a total airframe time of 6,581.4 hours (about 12.9 hours before the accident flight), and the engines had accumulated 936.4 hours since overhaul.

### Weight and Balance Information

Using loading and empty weight information based on estimated weights, fuel load, and wreckage documentation, Mitsubishi Heavy Industries, Inc., computed that the weight and center of gravity of the airplane at landing would have been 8,510 pounds and 30.27 percent mean aerodynamic chord, respectively, which was within weight and balance limits. A gross weight of 8,510 pounds was used for the performance calculations discussed further in this report.

### Avionics Information

The airplane was configured with a Garmin G600 integrated avionics system, standard engine gauges, and a standard annunciator panel. The Garmin system was installed after the pilot purchased the airplane and before his flight training in the airplane. The pilot chose to install the Garmin system because it was the same system in his Cessna 421B airplane. It was estimated the pilot had 3 years and a minimum of 325 hours flying a G600-equipped airplane.

The Garmin G600 is capable of displaying both a primary flight display and a multifunction display. The airspeed indicator is presented in a rolling tape format. The airspeed's numeric display consists of white numbers on a black background located in the middle of the rolling tape.

Located on the right side of the tape is a narrow color-coded speed range strip. During installation of the system, select airspeeds are entered into the system to properly display on the speed range tape. At the bottom of the speed range tape, the tape can be colored red until  $V_{so}$  (stall speed in landing configuration), and above  $V_{so}$ , the range is typically white and green, or solid green, to display the airplane's normal operating range. For  $V_{no}$  (maximum speed for normal operations) through  $V_{ne}$  (never exceed speed), the range is typically depicted as a caution range in yellow until  $V_{ne}$ , where the range tape displays a red and white "barber pole" pattern.  $V_{mc}$  is typically depicted as a red horizontal line.

### Other Cockpit Instrumentation

The engine instrumentation gauges are analog displays, located in the left center portion of the cockpit and arranged in two columns. Each column displays information pertaining to its corresponding engine (for example, the left column's engine torque gauge displays the left engine's torque). The pilot's standby airspeed indicator, located to the left of the G600, has a white arc indicating a flap operating range from 77-175 knots and a green arc indicating a normal operating range from 101-250 knots.

### Annunciator Lights

Two red master caution lights (LH Engine, RH Engine) and a yellow caution annunciator are located in the center of the instrument panel directly below the glare shield. A corresponding annunciator panel is located to the left of the left seat pilot's left leg and contains a series of caution and warning lights.

### Stall Warning System

The airplane was equipped with a control wheel shaker stall warning system. This system uses a lift transducer on the leading edge of the right wing that actuates based on the airflow over the wing. The transducer sends an electrical signal, which is adjusted for the flap setting. When the airplane is about 4-9 knots above stall speed, a vibration or shaking motion is applied to the control wheel, which is audible in the cockpit.

Pilots are exposed to the control wheel shaker through two manners. The control wheel shaker is tested before each flight to ensure proper operation, and pilots likely encounter the control wheel shaker while performing the approach-to-stall maneuvers during SFAR training.

### Autopilot System

The airplane was modified with a Bendix M4D autopilot system per an STC. The M4D is a multi-axis autopilot that controls roll, pitch, yaw, and pitch trim. The autopilot system can be used if one engine is inoperative, provided that the airplane is properly trimmed. This system was integrated with the installed avionics and passed a functional flight check on November 6, 2013.

## Negative Torque Sensing System

According to the MU-2B-25 Pilots Operating Manual, in addition to the manual feathering system, the NTS system provides automatic propeller drag limiting in the event of an engine failure. If an engine fails in flight, the propeller drives the engine by aerodynamic (negative) torque, and the propeller feathering valve operates to dump the oil (from the propeller dome), inducing propeller feathering as in the manual feathering operation. As soon as the negative torque is eliminated, the propeller feathering valve automatically moves back to the normal position and stops dumping oil. Thus, the propeller windmilling drag will remain very low, with no serious effect on airplane maneuvers, even during sudden engine failure. The NTS system is a drag reduction system only; it is not an automatic feathering system. The propeller on the affected engine must be manually feathered for minimum drag.

## Fuel System

The airplane was equipped with five fuel tanks: a main (center) tank with a capacity of 159 gallons total, 156 gallons usable; left and right outer wing tanks with a capacity of 15 gallons each, 15 gallons usable each; and left and right tip tanks with a capacity of 93 gallons each, 90 gallons usable each. Total usable fuel is 366 gallons. Within the main tank is a fuel manifold that supplies fuel to each engine's fuel system through a left and right airframe fuel shutoff valve (main valve).

The airframe fuel system is controlled by four switches on the instrument panel: left and right main valve switches, located on the lower right side of the pilot's instrument panel, to control the fuel shutoff valve in the fuel supply line to each engine, and the left and right tip tank/outer tank switches, located just below the main valve switches.

### Main Valve Fuel Switches

The main valve fuel switches are two-position toggles used to open and close the respective fuel valves between the main fuel tank and left and right engines. The switches have a doghouse-shaped gate between the OPEN and CLOSED positions. The OPEN position is on the upper side of the doghouse-shaped gate, and the CLOSED position is on the lower side of the gate. The fuel switch is typically left in the OPEN position. According to the MU-2B-25 checklist shutdown procedures, all cockpit switches should be turned off except for the main fuel switches. According to Mitsubishi, the fuel switches are used by maintenance personnel to turn off the fuel and should not typically be used by the pilot during a flight.

### Tip Tank/Outer Tank Fuel Switches

The tip tank/outer tank switches control the air shutoff valve in the pressurized air line to each tip tank, the two fuel shutoff valves in the fuel transfer line from each tip tank to center tank, and the electric transfer pump in the outer wing tank. The fuel transfer system allows fuel to be transferred from each wing tip tank to the center (main) tank or from its outer wing tank to the center tank. In the TIP TANK position, fuel is transferred from the tip tank into the center (main) tank by air pressure. When the switch is in the OUTER TANK position, fuel from the outer wing tank is transferred into the center tank. The center fuel tank will be maintained near a full level throughout the transfer process, as all fuel is fed into the center tank.

## Fuel Servicing

The airplane was refueled with 180 gallons of Jet A fuel before the accident flight, for a total of 279 gallons. According to the fixed based operator, the airplane was serviced with a "standard PFT MU-2 fuel load," which was 45 gallons in each tip tank and top off of the outer wing tanks and main fuel tank.

## Fuel Shutoff Valve (FSOV)

The engine-mounted FSOV is a two-position solenoid valve that must be electrically powered to be in the OPEN state. It is normally electrically powered in the CLOSED state by the direct circuit from the STOP position of the run-crank-stop (RCS) switch to the close side of the solenoid valve. When the engine is not operating, two electrical solenoids in the valve extend a ball valve (which is a rod with a ball on the end) so that the ball closes the orifice and prevents the flow of fuel to the engine. When the engine is operating, the ball valve is retracted, creating an opening for the fuel to pass through to the engine. A Belleville washer (spring) holds the ball valve in the commanded position, either OPEN or CLOSED.

The FSOV can also be closed mechanically by selecting the condition lever to the EMERGENCY STOP position. While the condition lever is in EMERGENCY STOP, the valve cannot be electrically actuated. The valve cannot be opened mechanically; it can only be closed mechanically.

By selecting the RCS switch to the STOP position, the fuel valve will close and shut off fuel to the engine, and the engine will begin to spool down immediately. If the RCS switch is returned to the RUN position, the valve will open, but the engine will not relight unless the autoignition switch is in either the AUTO or ON positions, or the pilot depresses the engine start switch and the unfeather switch per the Airplane Flight Manual (AFM) Airstart procedure. In addition, the speed switch must sense an engine rpm of 10 percent or greater, or the speed switch will not open the FSOV and initiate ignition.

## Run-Crank-Stop (RCS) Switch

The RCS switch for each engine, located on the center pedestal between the power and condition levers, is used on the ground for normal engine start and shutdown. The switches electrically open and close the FSOVs, thereby turning the fuel flow to the engines on and off, respectively. Each switch is a three-position gated switch with a single gate between the RUN (forward) and CRANK (center) positions. The switch is spring loaded to move from the STOP (aft) to the CRANK position. During normal operations, the switch is moved to the RUN position for engine start and not moved from the RUN position until the engine is shut down on the ground (with the exception of an NTS in-flight check).

When the airplane is secured on the ground, the RCS switch toggle is spring loaded in the CRANK position. For engine start, the RCS switch toggle is lifted and moved forward to the RUN position. When the RCS switch is positioned to RUN, and if the engine rpm is greater than 10 percent, the FSOV open solenoid is momentarily powered and allows fuel to flow to the engine fuel nozzles. For normal engine shutdown on the ground, the toggle must be lifted up, moved back, and held in the STOP position.

According to the MU-2B-25 engine shutdown checklist, the RCS switch must be held in the STOP position until the engine rpm has decreased below 50 percent. When the toggle is held in the STOP position, the FSOV close solenoid cuts off the flow of fuel to the engine, thereby shutting it down. In addition, when the toggle switch is held in the STOP position, it powers the fuel nozzle purge solenoid open, which vents stored compressor discharge pressure air out through the fuel nozzles. This action clears any residual fuel from the lines to prevent it from back-draining into the combustor, as well as prevents the build-up of partially burned fuel residue in the fuel nozzles' internal passages.

According to the instructor, the pilot was knowledgeable of the RCS switch locations and their function within the systems of the MU-2B-25. During flight training, the instructor shut down each engine in flight on separate occasions using the RCS switch. As mentioned earlier, the pilot performed at least one in-flight shutdown using the RCS switch to demonstrate proficiency in performing an airborne NTS check.

### Other Cockpit Switches

Switches similar to and near the RCS switch are two gated engine power auto limit switches (ENG PWR LIMIT) and two gated ignition switches. The engine power auto limit switches are two-position switches with a single gate. These switches are located to the left of the center pedestal and behind and to the right the pilot's control wheel. The ignition switches are three-position switches with two gates to select CONTINUOUS, OFF, or AUTO IGNITION. These switches are located to the right of the center pedestal.

### Meteorological Information and Flight Plan

<b>Conditions at Accident Site:</b>	Visual (VMC)	<b>Condition of Light:</b>	Day
<b>Observation Facility, Elevation:</b>	TUL	<b>Distance from Accident Site:</b>	5 Nautical Miles
<b>Observation Time:</b>	15:53 Local	<b>Direction from Accident Site:</b>	180°
<b>Lowest Cloud Condition:</b>	Scattered / 9000 ft AGL	<b>Visibility</b>	10 miles
<b>Lowest Ceiling:</b>	None	<b>Visibility (RVR):</b>	
<b>Wind Speed/Gusts:</b>	6 knots /	<b>Turbulence Type Forecast/Actual:</b>	/ None
<b>Wind Direction:</b>	140°	<b>Turbulence Severity Forecast/Actual:</b>	/
<b>Altimeter Setting:</b>	30.26 inches Hg	<b>Temperature/Dew Point:</b>	19°C / 6°C
<b>Precipitation and Obscuration:</b>	No Obscuration; No Precipitation		
<b>Departure Point:</b>	Salina, KS (SLN )	<b>Type of Flight Plan Filed:</b>	IFR
<b>Destination:</b>	Tulsa, OK (TUL )	<b>Type of Clearance:</b>	IFR
<b>Departure Time:</b>	15:00 Local	<b>Type of Airspace:</b>	Class C

At 1553, the TUL automated surface observing system, located 5 miles south of the accident site, reported the wind from 140 degrees at 6 knots, visibility 10 miles, scattered clouds at 9,000 feet, temperature 19 degrees Celsius (C), dew point 6 degrees C, and an altimeter setting of 30.26 inches of mercury.

## Wreckage and Impact Information

<b>Crew Injuries:</b>	1 Fatal	<b>Aircraft Damage:</b>	Destroyed
<b>Passenger Injuries:</b>		<b>Aircraft Fire:</b>	On-ground
<b>Ground Injuries:</b>	N/A	<b>Aircraft Explosion:</b>	None
<b>Total Injuries:</b>	1 Fatal	<b>Latitude, Longitude:</b>	36.2975,-95.874443

The accident site was located in wooded terrain about 5 miles north of TUL at a GPS elevation of about 650 feet. The airplane came to rest upright on a measured magnetic heading of 109 degrees. Several small trees displayed breaks and fractures that were consistent with the airplane impact sequence. The main wreckage area consisted of all major airplane structures and components. Postimpact fire consumed a majority of the fuselage and wing structure. The airplane impacted terrain in a slightly nose-down, left-wing-down attitude which was consistent with the crush damage to the forward fuselage, wings, and wing-tip fuel tanks relative to ground level.

The main wreckage consisted of the cockpit, fuselage, left and right wings, left and right engines, and empennage. All of the flight control surfaces were located in the wreckage debris. The cockpit, including the instrument panel, windscreen, and flight crew seats, was destroyed by postimpact fire. No instrument readings or navigation/communication radio settings were discernible due to thermal damage. The cockpit throttle quadrant was removed for further examination. The cabin area was destroyed by postimpact fire. Charred remains of airplane manuals, pilot logbooks, airplane logbooks, and other miscellaneous papers were located throughout the fuselage structure.

The flight control cables and linkage system were examined for continuity. The elevator and rudder push-pull rods and cables exhibited continuity from the flight controls to the control surfaces. The wing spoiler cables exhibited continuity from the control yokes to the mixing unit located in the center wing section. The push-pull tubes from the mixing unit to the spoilers were destroyed by thermal damage. The attach points of the push-pull tubes to the spoiler bell cranks exhibited continuity. The rudder trim was found in the neutral position, and the elevator trim was found in the 2-3 degrees nose-up position. The left seat right rudder pedal was found in the full-forward position.

The left engine propeller blades were found in a feathered position, and the propeller assembly remained attached to the engine. The right propeller blades exhibited bending, twisting, and leading edge gouge damage. An approximately 4-inch piece of one propeller blade tip was separated and was not located. The blade tip separation fracture surfaces were consistent with an overload failure. The right propeller assembly remained attached to the engine. The left and right engines remained partially attached to the airframe.

The landing gear and landing gear jackscrew were found in the extended position. The flap actuator jackscrew measurement corresponded with the flaps being in the 20-degree position.

On November 12, 2013, the NTSB completed the on-scene examination/wreckage documentation, and a

recovery company removed all remaining airplane wreckage from the accident site. The engines, propellers, and miscellaneous airframe structure surrounding the engines were transported to a facility in Tulsa to prepare for shipment for further examination. Details of the engine and propeller examinations are found later in this report.

## **Communications**

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No problems with communications equipment were reported.

## **Flight recorders**

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The airplane was not equipped, and was not required to be equipped, with a cockpit voice recorder, flight data recorder, or cockpit image recorder.

## **Medical and Pathological Information**

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An autopsy was performed on the pilot by the Office of the Chief Medical Examiner, Oklahoma City, Oklahoma. The autopsy ruled the cause of death as the result of multiple blunt force injuries and the manner of death as an accident. No unusual findings were discovered during the autopsy.

Biological specimens from the pilot's body were forwarded to the FAA's Civil Aerospace Medical Institute for toxicological testing. These specimens tested negative for ethanol and detected the presence of ibuprofen. Ibuprofen is a nonnarcotic analgesic and anti-inflammatory agent used to treat aches and pains, and as an antipyretic to reduce fever.

## **Tests and Research**

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### **Aircraft Performance Radar Study**

The aircraft performance radar study used Airport Surveillance Radar (ASR) data to calculate the position and orientation (pitch, yaw, and roll angles) of the airplane in the minutes preceding the accident. This information was then used to estimate various performance parameters of interest, including horizontal and vertical speeds, terrain clearance, AOA and proximity to stall, and required



engine power.

The ASR-9 radar at TUL received returns from the airplane starting at 15:30:13, when the airplane was 60 nm northwest of the TUL runway 18L threshold and descending through 14,500 feet msl. The TUL ASR continued to track the airplane throughout its approach to TUL, including the last minutes of the flight.

From 15:43:37 to 15:44:04, as the airplane was on final approach between 6.1 and 5.1 nm from runway 18L, there was a 27-second gap in the ASR secondary data (corresponding to five missing radar returns). However, during this time, three primary returns consistent with the position of the airplane were received by the ASR. In addition, the Chelsea/Afton, Oklahoma ATCBI-6 (QAF) radar received secondary returns from the airplane. The QAF secondary returns indicate that the gap in the TUL secondary returns was not due to a problem with the airplane's transponder but to some other unknown cause.

The data indicated that at 15:42:50, the airplane was descending on a southeasterly heading through 2,500 feet msl about 8 nm north of the TUL runway 18L threshold. About 15:43:00, the airplane leveled off briefly at 2,200 feet msl and started a right turn toward the runway. At this time, the airplane was already below the PAPI glidepath for TUL runway 18L. The airplane crossed the extended runway centerline at 15:43:19 and continued the right turn to correct back to the centerline. When the airplane resumed its descent at 15:43:25, the PAPI would have displayed four red lights, indicating that the airplane was below the PAPI centerline.

About 15:44:00, as the airplane was descending through 1,400 feet msl, it started a left turn that continued to the end of the radar data, with the airplane almost completing a full 360-degree turn. During this turn, the pilot reported to air traffic control (ATC) that "I've got a control problem" (at 15:44:51) and that "<unintelligible> I've got a left engine shutdown" (at 15:45:06). The airplane crashed less than 0.05 nm southwest of the last radar return, about 5 nm north of the runway threshold, and about 0.05 nm left (east) of the extended runway centerline.

The airspeed data presented in the study indicated that the airplane was operating close to the 20-degree flaps, one-engine inoperative minimum controllable airspeed ( $V_{mc, 20}$ ) of 93 knots calibrated airspeed (KCAS) during the time that the pilot reported control and engine problems. In addition, the calculations indicated that shortly before the end of the radar data, the airplane's lift coefficient (CL) reached the maximum CL (CL<sub>max</sub>) for the flaps 20 configuration, which suggested that the final descent of the airplane into the ground followed an aerodynamic stall of the wing. This finding was consistent with the condition of the wreckage, its location very close to the last radar point, and witness statements.

The CL and airspeed data computed from the radar returns indicated that the flaps must have been deployed at some time before 15:44:18, because the airplane's calculated CL exceeded the CL<sub>max</sub> for 0-degree flaps beyond this time, but the airplane continued flying. Consideration of the power requirements computed from the radar data suggested that the flaps may have been deployed to 20 degrees around 15:43:30, shortly after the airplane decelerated below the speed at which flaps 20 could be extended (140 KCAS).

The roll angle computed from the radar data indicated that the airplane required about 13 degrees of roll

during the right turn between 15:42:55 and 15:43:50, as the airplane maneuvered to line up with the extended runway centerline. The roll angle required during the final 360 -degree left turn was about 15 to 25 degrees, with the roll angle increasing from about 5 degrees left to 22 degrees left between 15:44:20 and 15:44:30. This increase in roll angle corresponded to the time that the airplane arrested its deceleration and descent (that is, decay in energy) and leveled at about 95 KCAS and 1,100 feet msl, or about 400 feet agl. Associated with this level-off was an increase in required horsepower. The power increased to about the maximum available from one engine for the corresponding flight conditions. Because, as suggested by the pilot's reports of an engine problem, the increase in horsepower was only available from one engine, then any thrust asymmetry between the two engines would also increase and would increase the rudder deflection and/or sideslip angle required to compensate for the asymmetry. Consequently, the increase in roll angle at this time may reflect these changing parameters affecting the trim of the airplane.

Also, by 15:44:15, the airspeed had already decayed to around 95 KCAS, close to the  $V_{mc, 20}$  of 93 KCAS. Consequently, with full power on the operating engine, and at this speed, the airplane was close to the limit of controllability. The airplane may have been easier to control at lower power settings on the operating engine but may still have presented a challenging situation to the pilot, given the low energy state of the airplane and its proximity to the ground.

During the final 360-degree left turn, the highest priority to ensure the safety of the flight would have been to increase the control margin by increasing the airspeed further above the 93 KCAS  $V_{mc, 20}$  speed. However, to increase the speed, a pilot would have to increase power on the operating engine (thereby exacerbating the thrust asymmetry and control problem at low speed, even if additional power were available), trade altitude for airspeed (which a pilot may be reluctant to do if the airplane is already at a low altitude), or perform some combination of these actions. A pilot could also increase the speed and margin from  $V_{mc, 20}$ , by retracting the landing gear, thereby lowering the airplane's drag. Hence, at the time the power was increased between 15:44:10 and 15:44:30, the airplane was already in a difficult situation because of the combination of low altitude, low airspeed, and the reported problem with the left engine.

## Engine Examination

The engines were disassembled at Honeywell's facilities in Phoenix, Arizona, under the supervision of the NTSB. Disassembly and examination of the engines did not reveal evidence of preimpact malfunctions.

Disassembly of the right engine revealed the compressor section 1st stage impeller shroud inner diameter was coated with dirt. After the dirt was removed, there was a continuous rub on the rear of the shroud from about the 8- to 12 -o'clock position and an intermittent rub from about 1- to 3 -o'clock. The rub marks on the shroud corresponded to the rub marks and displaced material on the first stage impeller. One 1st stage impeller blade leading edge was bent opposite the direction of rotation. The impeller was covered with dirt. The edges of the impeller blades had circumferential rub marks and material displaced opposite the direction of rotation that corresponded to the rub marks on the shroud. Dirt and organic material was found at the rear of the combustion chamber on the inside of the liner. The

1st-, 2nd-, and 3rd-stage turbine stators had a slight amount of metal spray on the suction side of the airfoils. The 1st-, 2nd-, and 3rd-stage turbine rotors were intact and did not have any apparent damage to the respective airfoils that were all full length and straight. The turbine blades had a slight amount of metal spray on the suction side of the airfoils, and the blades did not have any circumferential rub marks on the tips.

Disassembly of the left engine revealed the compressor section 1st- and 2nd-stage impeller shroud inner diameters did not have any circumferential scoring or rub marks. The 1st-, 2nd-, and 3rd-stage turbine rotors were intact and did not have any apparent damage to the respective airfoils, which were all full length and straight. The blade tips did not have any circumferential rub marks, and the blades did not have any metal spray materials on the airfoils.

The left engine's FSOV was removed from the engine during the engine disassembly and was flow-checked with air. No air flowed through the valve even though the manual close lever was in the OPEN position. Subsequent testing of the left engine FSOV at three different facilities confirmed the valve operated normally. The disassembly of the left engine FSOV confirmed the latch assembly was intact. When the right engine FSOV was flow-checked after it was removed from the engine, air flowed through the valve. The right engine FSOV could not be tested due to fire damage. All of the external components related to the generation or control of engine power, including the fuel controls and propeller governors, were removed from both of the engines and tested, with no significant abnormalities noted.

#### Propeller Examination

The propellers were disassembled at Ottosen Propellers facility in Phoenix, Arizona, under the supervision of the NTSB. Disassembly and examination of the propellers did not reveal evidence of a preimpact malfunction.

Disassembly and examination of the left propeller assembly revealed that all three blades remained attached to the hub. The propeller hub with the propeller blades still attached was mounted on a fixture. When air was supplied to the propeller, the piston unit moved upward and the blades moved symmetrically from the feather position to the start lock position. When the air was disconnected and the start lock pins were unlocked, the piston went down and the blades moved symmetrically back to the feathered position. There were imprints on the blade butts of all three blades that corresponded to the base of the spindle, with the blades being in the feathered position.

Disassembly and examination of the right propeller assembly revealed that all three blades remained attached to the hub. All three blades were bent and twisted. Two blades were missing their blade tips, and the fracture surfaces had shear lips for the full length of the fractures. The pitch change link arms were intact; however, they were found disconnected at the propeller clamp studs. When air was supplied to the propeller, the piston unit moved upwards, and when the air was disconnected, the piston went down. Blade butt imprints corresponded to the base of the spindle, with the blades being in the middle of the operating range.

#### Cockpit Switches

The airplane wreckage and miscellaneous debris were examined at the wreckage storage facility to locate any cockpit switches. Several cockpit switches were found during the examination and displayed significant thermal damage. The switches were retained for further examination in an attempt to identify specific switches and the switch position at the time of the accident.

The switches were examined at the NTSB Material Laboratory in Washington DC. The remains of the RCS switches were located, including the toggle and switch body of one of the RCS switches. The toggle of this switch was found in the RUN position. The other RCS switch consisted of only the toggle, and it was not possible to determine its position. It was also not possible to determine which switches corresponded to the left or right engines.

The two tip tank/outer tank switches were missing their bottoms and the internal wiring. One tip tank/outer tank switch toggle was centered, corresponding to the OFF position, and one tip tank/outer tank switch toggle was in the up position, corresponding to the TIP TANK position. It was not possible to determine which switches corresponded to the left or right fuel tanks.

Several toggle switches with rounded point-shaped toggles and doghouse-shaped gates were recovered. The examination of an MU-2B-25 cockpit revealed there were several toggle switches with dog house-shaped gates and round point toggles installed in the instrument panel, so it was not possible to identify what these particular switches represented from the accident airplane. In addition, because the shape of the switch bodies is symmetrical, it was not possible to determine the position of any of the switches.

#### Throttle Quadrant

The throttle quadrant sustained extensive fire and thermal damage. The power levers, condition levers, and condition lever bell cranks were missing. The upper part of each power lever bell crank, to which the power levers are attached, was missing; but, on the bottom of the bell crank, the lug to which the linkage is attached was bent and folded over to the right. The connecting link with the nut and bolt was still attached to the left engine's power lever bell crank lower lug.

When viewing an exemplar throttle quadrant, the cross-shaft spindle that passes through the bell cranks for the power and condition levers has two screws at what appear to be top dead center. When the power levers on the exemplar throttle quadrant were positioned to the maximum power position, the upper part of the bell crank was slightly forward of vertical, and the lower part of the bell crank to which the connecting link was attached is slightly aft of vertical. When the accident airplane's throttle quadrant was positioned so that the two screws were at top dead center, the two bent and folded lower lugs of the bell cranks appeared to be slightly aft of vertical. The lower lugs of the bell cranks still had the connecting links with the nuts and bolts attached.

#### Engine Shutdown Testing

On February 12, 2014, members of the Powerplants Group convened at Turbine Aircraft Services, Addison, Texas, to conduct engine shutdown tests on a MU-2B airplane using the RCS switch.

For Test 1, both engines were started and allowed to idle for 5 minutes. The engine ignition was then set to its off position. The interturbine temperature (ITT) on both engines was about 530 degrees C. The left

engine was shut down first followed by the right engine. The RCS switch was moved from the RUN position to the STOP position, where it was held for 3 seconds, then returned to the RUN position. It took the left and right engines ITT to reach 300 degrees C in 3.16 and 4.44 seconds, respectively. The engines continued to spool down until they stopped. White smoke was observed from both engines' tailpipes.

For Test 2, after the engines had stopped per Test 1, the ITT slowly increased so that it was about 350 degrees C. Because of the ITT and the white smoke coming from the engines' tailpipes, both of the engines were dry motored with the starter (that is, they were run on the starter with the fuel and ignition turned off) and the RCS switch in the CRANK position to get the ITT below 300 degrees C. Both engines were started, the engine ignition was set to auto, and the engines were allowed to idle for 3 minutes. The ITT on both engines was about 530 degrees C. The left engine was shut down first followed by the right engine by moving the respective RCS switch from the RUN position to the STOP position, where it was held for 3 seconds, then returned to RUN. The time for the left and right engines ITT to reach 300 degrees C was 3.87 and 3.54 seconds, respectively. The ignition lights flashed on, the engines spooled down until rpm was 75 percent, ITT increased to about 700 degrees C, and rpm slowly increased to about 95 percent. ITT then decreased to about 530 degrees C.

Following the two shutdown tests, the engines were shut down normally by just moving the RCS switch to stop. These shutdowns were not timed, and the engines did not smoke after they were shut down and stopped.

#### Airplane Flight Manual Checklist Emergency Procedures

Section 3 of the MU-2B-25 AFM provides information regarding airplane emergencies, the warning or alerts associated with a particular emergency, and the procedures to follow once the emergency has been identified. Some of those procedures are listed as follows.

#### Engine Failure After Liftoff – Continued Climb (in part)

1. Landing Gear – Up
  
2. Airspeed – V<sub>xse</sub> Minimum for Flap Configuration
  
3. Condition Lever (Failed Engine) – Emergency Stop
  
4. Power Lever (Failed Engine) – Takeoff

WARNING – If an engine failure occurs after liftoff, continued climb is not assured unless operating engine is producing power in accordance with the power assurance chart and the airplane flight manual

procedures are followed.

**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 feathering of the propeller and leave there for the remainder of the flight.

**CAUTION** – Run-Crank-Stop Switch must remain in RUN position.

5. Landing light – Retract

6. Airspeed – Vyse Minimum for Flap Configuration

7. Flaps – 5 degrees

8. Airspeed – 140 KCAS minimum or 135 KCAS minimum (if not modified by S/R 010)

**NOTE** – For airplanes not modified by S/R 010, do not exceed 140 KCAS until flaps are Up.

9. Flaps – Up

10. Airspeed – 150 KCAS

11. Engine Power Limit Switches – Manual

**CAUTION** – Prior to placing the engine power limit switches to the manual position, the operating engine's power lever should be positioned so that the engine will not exceed the Torque/ITT limits.

12. Power (Operating Engine) – As required

**WARNING** – Air conditioning and pressurization system must remain off to attain full climb capability.

13. Engine Shutdown Procedure (Failed Engine) – Accomplish

**NOTE** – Single engine climb rates are best attained with wings level by use of rudder to correct for yawing tendency and using the minimum amount of spoiler necessary to maintain lateral control.

## Engine Shutdown Procedure

If engine failure occurs, or if a sudden loss or significant fluctuation (plus/minus 7.5 percent) of indicated torque pressure occurs, as indicated by airplane yaw, promptly shut down the affected engine and determine the cause prior to further operation.

1. Failed Engine Condition Lever - EMERGENCY STOP

2. Failed Engine Power Lever - TAKEOFF

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 the remainder of the flight.

CAUTION - Run-crank-stop switch must remain in "run" position

3. Trim – Set

4. Power - As required

5. Failed Engine DC Generator Switch – Off

5A. Ignition Switch - Off (Affected Engine)

6. Air Conditioning and Pressurization System - Select operating engine bleed air or ram air (if thrust critical)

NOTE - Ram air position will depressurize cabin. Oxygen may be required.

7. Engine Power Limit Switches - Manual

CAUTION - Prior to placing the engine power limit switches to the [manual] position, the operating engine's power lever should be positioned so that the engine will not exceed the torque/ITT limits.

8. Operating Engine Power Level - Set as required

8A. Voltmeters - Check

NOTE - Both voltmeters should indicate between 27 and 29.5 volts. Amperage on the side of the operating engine should be less than 200 amps.

9. Operating Engine DC Generator Load - Reduce to essential items (if necessary)

10. Prop Synchronizer (if installed) - Off

## Single Engine Landing Procedure

CAUTION - The use of 40 degrees flaps with an engine inoperative is not recommended. Always maintain airspeed above  $V_{xse}$  for flap settings being used until landing is assured.

Before Landing Checklist - Use normal procedures except as follows:

1. Inoperative Engine - Secured (Use Engine Shutdown Procedure)
2. Fuel Quantity and Balance - Check within limitations
3. Cabin Air Selector Switch - Off or Ram
4. Condition Lever (Operating Engine) - Takeoff Land
5. Power Lever (Operating Engine) - Set as required to maintain airspeed and desired flight path
6. Landing Gear - Up
7. Flaps - Up ( $V_{xse} = 135$  KCAS)
8. Airspeed - 150 KCAS

Beginning Final Approach Descent or Base Leg (approximately 1,000 feet agl):

9. Flaps - 5 degrees ( $V_{xse} = 130$  KCAS)
10. Airspeed - 140 KCAS (modified by S/R 010); 130 KCAS (not modified by S/R 010)

When Landing is Assured:

11. Landing Gear - Down
12. Power Lever (Operating Engine) - As required to maintain airspeed and desired flight path
13. Flaps - 20 degrees ( $V_{xse} = 125$  KCAS)
14. Airspeed - 105 KCAS when over runway

WARNING - Do not attempt a go around below 400 feet agl or after 20 degrees of flaps are selected. Altitude loss may approach 400 feet, during transition from approach to climb configuration (Gear down, flaps 20 degrees to Gear up, flaps up).

CAUTION - Up to 20 percent additional runway may be required using this procedure when compared to the normal two engine landing distance.

After Touchdown:



15. Reverse Thrust - As required to maintain directional control

CAUTION - On other than dry, hard surface runways, it is possible to apply more reverse thrust than can be counteracted by rudder, brakes, and nosewheel steering.

#### Airstart Procedure

CAUTION - Ensure engine stoppage was not the result of malfunction which might make it dangerous to attempt a restart

1. Airspeed - 100 to 180 KCAS (150 KCAS Recommended)
2. Altitude - Below 15,000 feet pressure altitude
3. Interstage Turbine Temperature - Below 200 degrees C (if feasible)
4. Prop Synchronizer (if installed) – Off
5. Condition Lever – Taxi
6. Power Lever - Middle of flight idle and takeoff

NOTE - If possible, perform equalizing cooling of engine rotor assembly by wind milling in using unfeather switch intermittently before airstart. If ITT drops during standing of propeller followed after equalizing cooling, perform equalizing cooling again if possible by wind milling about one minute in using unfeather switch intermittently just before airstart even if ITT is below 200 degrees C because thermal distortion of engine rotor assembly may occur.

7. Start Selector Switch - Air Start and Safe
8. Ignition Switch – Off
9. Run-Crank-Stop Switch – Run
10. Engine Start Switch - Press Momentarily (Start Indicator Light Illuminates)
11. Unfeather Switch - Press and Hold to 30 percent rpm minimum
12. Fuel Enrichment Switch - Press and Hold Up to Light Off
  - a. ITT - Monitor (Maximum 1149 degrees C)
  - b. Within 15 seconds past 10 percent rpm or by 25 percent rpm - Indicated combustion or abort start (Place Condition Lever to EMERGENCY STOP)

- c. Above 25 percent rpm with Slow Acceleration - Use fuel enrichment switch
- d. If Acceleration stagnates and ITT continues to rise

Condition Lever - EMERGENCY STOP

NOTE - If abort was caused by high ITT, reduce altitude and increase airspeed, if possible, before attempting restart. If abort was caused by no combustion, reduce altitude and reduce airspeed, if possible before attempting a restart.

CAUTION - Do not allow engine to windmill in the 18 percent to 28 percent rpm range.

13. Condition Lever - As required

14. Power Lever - As required

15. DC Generator Switch - On/Reset if necessary

15A. Ignition Switch - Auto (Ignition Annunciator Light extinguished if Auto-Ignition System installed)

16. Air Conditioning and Pressurization System - Both

#### MU-2B-25 (A2PC) Pilot Checklist Normal Procedures

Section 5 of the MU-2B-25 A2PC pilot checklist provides information regarding airplane normal procedures. Some of those procedures are listed as follows.

#### Descent Procedures

1. Cabin Altitude – Set

Set Cabin Pressure Controller pointer to field elevation plus 1,000 feet. Adjust rate control knob so that the airplane will be fully depressurized prior to landing. Generally, a 300 to 500 fpm cabin descent rate will be comfortable and ensure proper depressurization.

2. Tip Tank/Outer Tank Switch – Off

3. Altimeters – Set

4. Windshield Defog – As required

5. Ignition Switches – As required

Select CONT (auto ignition installed) or ON (manual ignition installed) in icing conditions or heavy participation. Observe duty cycle limitations. In other than these conditions, select AUTO (auto ignition installed) or OFF (manual ignition installed).

CAUTION – Ignition shall be selected to CONT (if auto ignition installed) or ON (if manual ignition installed) during approach and landing while in or shortly following flight in actual or potential icing condition.

6. Anti-ice/De-ice – As required (Add 10 percent KIAS in icing)

a. Pitot Anti-ice – On

i. Pitot and Static Anti-ice (if installed) – On

b. Windshield Heat (if installed) – Low

If descent through icing conditions is anticipated, turn on all anti-ice and de-ice equipment.

7. Taxi Lights (if installed) – As required

Recommended on for descent

Approach Procedures (in part)

1. Landing Data – Computed

2. Fuel Quantity/Balance – Check In-Limits

Tip fuel must be below 65 gallons or an overweight landing inspection will be required. Balance within 22 gallons.

3. Propeller Synchronizer (if installed) – Off

4. Differential Pressure – Zero

Confirm cabin will be depressurized prior to landing.

5. Condition Levers – Takeoff land

Provides maximum thrust in the event of a go-around.

6. Power – As required

7. Airspeed – 140 KCAS minimum (modified by S/R 010); 130 KCAS minimum (not modified by S/R 010)

8. Cabin Sign – On

Brief Passengers

9. Anti-ice System – As required (add 10 percent KIAS in icing)

10. Engine Power Limit Switches – Auto

11. Landing Lights – As required (below 175 KCAS)

12. Flaps – 5 degrees (below 175 KCAS)

Professional Flight Training, L.C. Checklist Normal Procedures (\*\*\*\*For Training Purposes Only\*\*\*\*)

As stated earlier in this report, the instructor provided the pilot a checklist for training purposes only during his MU-2B-25 SFAR training program. Some of the normal checklist procedures are listed as follows.

Descent

1. Cabin Altitude Selector – Set
  
2. Fuel Transfer Switches – Tips Manual or Off
  
3. Altimeters – Set
  
4. Anti/De-ice Systems – As required
  
5. Lights – As required

Approach and Landing

1. Cabin Altitude Diff Pressure – Check for Zero
  
2. Anti/De-ice Systems – As required
  
3. Lights – As required
  
4. Cabin Signs – On

5. Windshield Heat – As required
6. Auto Ignition – Auto or continuous
7. Landing Gear – Down
8. Prop Sync – Off
9. Flaps – 5 degrees
10. Auto Pilot/Yaw Damper – Off
11. Fuel Transfer Switches – Balanced/Off
12. Landing Gear – Check 3 Green
13. Power – 20 percent [torque] or greater
14. Flaps – 20 degrees
15. Airspeed (computed) - Check

## Additional Information

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### Flight Recorder Systems

The NTSB notes that the airplane was not required to have any type of crash-resistant recorder installed. Previous NTSB recommendations have addressed the need for recording information on airplane types such as the one involved in this accident. Recorders can help investigators identify safety issues that might otherwise be undetectable, which is critical to the prevention of future accidents.

On May 6, 2013, the NTSB issued Safety Recommendation A-13-13 and asked the FAA to do the following:

Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder or cockpit voice recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio and images with a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all as specified in Technical Standard Order C197, "Information Collection and Monitoring Systems."

On December 10, 2013, the NTSB classified Safety Recommendation A-13-13 "Open—Unacceptable Response" because the FAA stated that it had not found any compelling evidence to require installation of cockpit recording systems as recommended. Accordingly, the FAA reiterated that it planned no further action to mandate flight deck recording systems and considered its actions complete. Despite the FAA's position, the lack of recording systems on aircraft remains an important safety issue, and the NTSB therefore believes that it would be premature to close the recommendation.

## Administrative Information

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The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, “accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties ... and are not conducted for the purpose of determining the rights or liabilities of any person” (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB’s statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)). A factual report that may be admissible under 49 *United States Code* section 1154(b) is available [here](#).