Federal Aviation Administration

MU-2B SERIES AIRPLANE SAFETY EVALUATION REPORT DECEMBER 2005

This page intentionally left blank

MU-2B Series Airplane Safety Evaluation Report
Errata Number 1
January 17, 2006

- On page 5 of report in “Description of the Airplane” section and on page 23 of Appendix 2, the following corrections need to be made:

  - Report and appendix shows MHI produced 12 different models, but MHI actually produced 13 difference models
  - Report and appendix shows MHI produced 831 MU-2B series airplanes, but MHI manufactured 764 MU-2B series airplanes
  - Report and appendix shows MHI produced 73 of these airplanes specifically for military use, MHI delivered 53 of these airplanes specifically for military use

- On page 21 “Category 2: Airframe and Engines Issues” section and page 23 “Actions for Category 2: Airframe and Engine Issues” section of the report and page 5 of Appendix 1:

  The report shows:

  JCAB TCD 4379-96: Incorporated SB 218A/ 090/76-003, Inspection of feather valve/Linkage Inspection.

  The correct statement in all <u>three</u> places should be:

  JCAB TCD 4379-96: Incorporated SB 229/ 090/76-003, Inspection of feather valve/Linkage Inspection.

- On pages 21 “Category 2: Airframe and Engines Issues” section and page 24 “Actions for Category 2: Airframe and Engine Issues” section of the report shows:

  Mitsubishi Mandatory SB 01661-001

  The correct version should be:

  Mitsubishi Mandatory SB 016/61-001

- On page 6 in “TCDS History” section of the report:
  "In 1986, Beech Aircraft Corporation (now Raytheon Aircraft Corporation) took responsibility for the Models MU-2B-25 and MU-2B-35 airplanes under TC No. A10SW. This brought FAA responsibility for the TC to the Wichita ACO."

  To better clarify:
  The Beech Aircraft Corporation worked under a licensing agreement from MHI for Beech to provide product support of MU-2B series aircraft with MHI was still being responsible for TC No. A10SW.

This page intentionally left blank

EXECUTIVE SUMMARY

The increasing number of accidents in recent years on MU-2B series airplanes prompted the FAA to conduct a thorough and complete safety evaluation involving not only a review of the certification aspects of the airplane, but also including a review of operations, maintenance and training. A data-driven approach was used to evaluate the design, operation, maintenance, and training of the MU-2B series airplanes to determine their current safety level and define necessary steps for their safe operation.

Many different organizations within the Federal Aviation Administration (FAA) worked together to develop this report. In addition, the FAA worked with the airplane and engine type certificate holders, the foreign civil aviation authority responsible for the original airplane approval, user groups, industry representatives, and maintenance providers.

The safety evaluation provided an in-depth review and analysis of MU-2B series airplane accidents, incidents, safety data, pilot training requirements, engine reliability, and commercial operations. The team employed new analysis tools that provided a much more detailed root cause analysis of the service history problems with the MU-2B series airplanes than was previously possible.

An important part of the evaluation was that a Flight Standardization Board evaluated the need for MU-2B specific pilot training and evaluated a Mitsubishi Heavy Industries proposed flight training program. The Flight Standardization Board concluded that MU-2B specific training for pilots is needed.

From all of the information obtained, the FAA identified four different categories of issues prevalent today:

- Category 1: Pilot and Maintenance Training Issues
- Category 2: Airframe and Engine Issues
- Category 3: Maintenance Manual/Flight Manual and Checklist Inconsistencies
- Category 4: FAA Oversight of MU-2B Operations and Maintenance

The report lists specific actions that FAA has either completed or is proposing to address that pertain to the above areas. The development of a Special Federal Aviation Regulation could address many of these issues, including specific pilot training and required proficiency checks; specific maintenance training; an FAA-approved standardized checklist; and requiring the latest revisions to the maintenance manual and the airplane flight manual.

This was the third evaluation of the MU-2B series airplanes. Like the previous two evaluations, the FAA again determined that the airplane meets its original certification basis.

INTRODUCTION

Because of the recent increase in the number of MU-2B accidents per year, the FAA conducted a thorough and complete safety evaluation involving not only a review of the certification aspects of the airplane, but also included a review of operations, maintenance and training. This document presents FAA analysis of the service history and operations of the Mitsubishi Heavy Industries (MHI) MU-2B series airplanes. Those involved in the review included pilots and maintenance personnel, both inside and outside of the FAA.

The FAA does not have an estimate of flight hours for the MU-2B fleet; therefore the term "accident rate" used throughout this report refers to the number of accidents per fleet size (number of airplanes on the U.S. registry), rather than the number of accidents per flight hour.

This report summarizes the analysis to date on the MU-2B series airplanes. We have also developed an appendices document that contains detailed information on our data gathering activities while preparing this report. The appendices are a compilation of the data gathering and investigations from different FAA offices during the course of this safety evaluation. They are arranged to provide a logical flow and are therefore not referenced sequentially in this report.

Design of the MU-2B

MHI designed the MU-2B series airplane in the 1950s using the latest technology and philosophies of the time. The design was for a high-speed, business airplane capable of short takeoffs and landings.

The "Service History of the MU-2B Series Airplane Fleet" section of this document details the service history of this airplane. Because of the complexity of the airplane, successful operation requires that all involved have a thorough knowledge of the airplane's features and limitations. The following data from FAA's Office of Accident Investigation (AAI) is critical to illustrate the importance of understanding the airplane's specific design features and limitations. Compared to similar twin-turboprop airplanes designed in the same era, the MU-2B airplane:

- Accident rate is about twice as high with the fatal rate about 2.5 times higher.
- Fatal accident rates in icing conditions are 4 times higher.
- Fatal accidents involving loss of control on initial climb is 3.5 times higher.
- Fatal accidents involving loss of control while in flight is 3.5 times higher.
- Fatal accidents involving loss of control during emergencies is 7 times higher.

At original certification, the MU-2B series airplanes provided a valuable resource to corporate operators as an economical means of transportation. As this market has looked to other types of airplanes to meet its needs, the MU-2B series airplane is increasingly utilized in cargo hauling and private operations. This switch in operational focus has put the high-performance MU-2B series airplane into the hands of pilots and maintenance providers who, in general, have less experience in high-performance airplanes than when it was used primarily as corporate transportation.

The above statistics illustrate why attention to these problems is critical to the continued operational safety of the MU-2B series airplane fleet.

How the Rest of This Report is Organized

The rest of this document briefly describes data, findings, completed actions, and proposed plans regarding FAA's ongoing analysis of operations and continued operational safety of the MHI MU-2B series airplanes. It is organized as follows:

- Background: provides a description of the airplane, the history of the two different type certificates (TCs) and type certificate data sheets (TCDS) that affect the airplanes, and identifies the typical past and current usage of these airplanes.
- Service History of the MU-2B Series Airplane Fleet: includes the safety history and service difficulty reports (SDR), how specific conditions and components contribute to the history of these airplanes (icing, rigging, etc.), a brief description of the two previous special certification reviews (SCRs) done for the MU-2B series airplanes, and most recently this safety evaluation (which includes the findings of FAA's TapRoot® Cause Analysis among other data gathering tools).
- What Others Believe: presents information received from the Japan Civil Aviation Bureau (JCAB) as a state of design, MHI as the airplane TC holder, and Honeywell International as the engine TC holder. This section also includes ideas of user groups through the Small Airplane Directorate's Airworthiness Concerns Process and special meetings held with selected user groups and training providers.
- Flight Standardization Board (FSB)/Flight Evaluation: describes how FAA performed an FSB to determine the need for MU-2B specific pilot training and to review MHI's proposed training program. This included a multi-pilot check of the operation of the airplane, an evaluation of the proposed standardized pilot checklists, and a review of the airplane flight manual (AFM). Additionally a flight evaluation looked at potential changes to operational procedures such as higher rotation speeds to achieve added safety margins.
- Observations: takes the history of the airplane and the analysis to date and organizes the information to show the prevalent issues facing the MU-2B series airplanes.

- Completed Actions and Proposed Recommendations: consists of FAA's determinations, the actions already completed, and other actions proposed and scheduled.
- Conclusion: Tying it all Together: shows how everything fits together.

BACKGROUND

In the 1950s, surveys identified the need for a fast, economical airplane with short field takeoff and landing capability. MHI responded with an airplane design with the latest state-of-the-art turboprop engines, which provided high cruise performance and efficiency at higher altitudes.

Description of the Airplane

Features of the MHI MU-2B series airplane include the following:

- A high-wing loading in cruise configuration.
- The capability of carrying nine passengers.
- A pressurized cabin.
- A twin-engine turboprop design.
- A highly efficient double-slotted Fowler flap designed to run the full span of the wing to achieve short takeoffs and landings (STOL) capability.
- A rugged landing gear design to allow for the demand on such equipment when utilizing unimproved runways.
- A spoiler system for roll control.

The MU-2B series airplanes incorporate a Honeywell International (formerly known as Allied Signal and Garrett) Model TPE331 series engine and either a Hartzell Model HC-B3TN-5 or HC-B4TN-3 propeller.

These multi-purpose airplanes historically were popular with corporate and business users. MHI produced 12 different models with two basic categories of fuselage length: a “short body” and a “long body” design. MHI chose a spoiler system for roll control instead of ailerons, which allows the full-wing span flaps for STOL capability.

MHI produced 831 MU-2B series airplanes with 397 on the U.S. registry as of August 2005. MHI produced 73 of these airplanes specifically for military use, primarily in Japan.

TCDS History

The FAA type certificated the MU-2B series airplane in November 1965 after completing a validation process between the Los Angeles Aircraft Certification Office (ACO) and the JCAB under Civil Aviation Regulations (CAR) 10 (the regulations that preceded current 14 Code of Federal Regulations (CFR) 21.29 for regulating imported type design airplanes). The FAA (Los Angeles ACO) issued TC No. A2PC to MHI of Nagoya, Japan,

with Japan as the state of design for this TC. The certification basis is CAR 3, which preceded 14 CFR part 23, with special conditions.

In 1963, Mitsubishi's New York trading company proposed a new seven-place executive turboprop airplane for Mooney Aircraft out of Kerrville, Texas. The agreement, which was finalized in 1965, was for MHI to fabricate the airplane and Mooney to assemble and market it. When Mooney Aircraft filed bankruptcy in 1969, MHI organized Mitsubishi Aircraft International, Inc. (MAI) to become a subsidiary of MHI incorporated in the state of Texas. The FAA (Fort Worth ACO) issued U.S. TC No. A10SW to MAI for the Models MU-2B-25 and MU-2B-35 in 1976. The serial number designation for airplanes under this TC includes the letters "SA" to designate San Angelo, the city where the facility is located. The United States is the state of design for TC No. A10SW. This is the second TC for the MU-2B series airplanes, and it also is a CAR 3 certification with special conditions.

The airplanes identified in the two TCs are of similar, almost exactly the same, type design.

The following are significant events in the life of these two TCs:

- In 1986, Beech Aircraft Corporation (now Raytheon Aircraft Corporation) took responsibility for the Models MU-2B-25 and MU-2B-35 airplanes under TC No. A10SW. This brought FAA responsibility for the TC to the Wichita ACO.
- In 1998, Mitsubishi Heavy Industries America, Inc. (MHIA) with support from Turbine Aircraft Services (TAS) assumed the responsibility for the MU-2B series airplane product support program for MHI. Note 5 of TCDS A10SW states that MHIA is licensed by MHI of Japan to maintain the type design and manufacture replacement and modification parts for the MU-2B series airplanes. A similar note should be added to TCDS No. A2PC.
- MHIA currently provides spare parts and technical services for the fleet including field service, engineering, continued airworthiness, TC maintenance, and air safety investigation. TAS provides spare parts handling, storage and distribution, publications distribution, and service center administration for the MHIA-approved service centers and special programs such as the Pilots' Review of Proficiency (P.R.O.P.) seminars offered free of charge to all MU-2B series airplane owners and operators every two years.
- Currently, FAA TCDS revisions for the MU-2B are as follows:
    - ✓ Revision 17, dated June 30, 1975, for TC No. A2PC; and
    - ✓ Revision 14, dated August 25, 2003, for TC No. A10SW.
- The FAA identified problems resulting from two separate offices (Fort Worth ACO and Los Angeles ACO) handling two very similar TCs. During this evaluation, FAA consolidated responsibility of both TCs in the Fort Worth ACO. Now that one office has full responsibility, the FAA completed a fresh look at all mandatory continued airworthiness information (MCAI) actions issued by the

JCAB. The FAA identified four MCAIs that warrant further action. No outstanding continued airworthiness actions have been identified as contributing to any MU-2B accidents. See section “Completed Actions and Proposed Recommendations” of this report and Appendix 1.

Usage

As stated previously, MHI designed and produced the MU-2B series airplane to meet the demand for a fast, economical airplane with short takeoff and landing capabilities. Primarily, corporations used the MU-2B for their business needs.

In recent times, twin-engine, turbo-prop airplane operation has transferred primarily to air taxi (specifically cargo hauling) and personal-flight operations. Though it appears in business operations, the MU-2B series airplanes are rarely seen in today’s corporate operations. This shift to air taxi and personal flight operations for the MHI MU-2B series airplanes is due to the lower cost, perceived reliability, and speed of the airplane as well as the availability of more modern aircraft for the corporate user. There are 65 MU-2B series airplanes utilized in commercial (14 CFR part 135) operations.

This shift in usage exposes the airplanes to the following:

- More frequent night flight operations.
- Accumulating significantly higher hours per year than its previous operations.
- Pilots in parts 91 and 135 operations are not getting the level of training and proficiency checks compared to the corporate pilots of the past.
- Pilots who may operate different model airplanes on any given day, rather than flying just the MU-2B.

Compared to Other Airplanes in 14 CFR Part 135 Operations

The following table shows a comparison of the Mitsubishi MU-2B series airplanes that were involved in 14 CFR part 135 fatal accidents to a sampling of other airplanes used in similar operations. This shows that the MU-2B rate is much higher than several airplane models, but not as high as others. The numbers in the table are based on information from the National Transportation Safety Board (NTSB). The following table shows the rate of part 135 fatal accidents for twin turboprop aircraft compared to total U.S. registered aircraft of each type.

Aircraft Type	**14 CFR part 135 fatal accidents for U.S. registered aircraft as of 8/15/05**
Beech King Air	.002
Piper Cheyenne	.006

Cessna Conquest	.009
Beech 1900	.015
MU-2B	.031
Swearingen SA 226/227	.038
Beech 99	.058
Embraer 110	.075

Note: See the “Completed Actions and Proposed Recommendations” section of this report for FAA recommendations regarding this data.

SERVICE HISTORY OF THE MU-2B SERIES AIRPLANE FLEET

Over the years, the accident rate demographics for the MU-2B series airplanes have changed. From 1966 to 1990, corporate operators were involved in most of the MU-2B accidents. By the mid 1990s, corporate operators largely stopped using the airplanes. In 1997, the corporate accident rate fell to zero and remains there today. Today, the accidents occur primarily in the air taxi category (operated under 14 CFR part 135), primarily in cargo operations.

The FAA has followed the service history of the MU-2B series airplanes since certification and has taken various actions to improve the continued operational safety. Among these actions are miscellaneous airworthiness directive (AD) actions, two SCRs, and this safety evaluation.

Service Difficulty Reports (SDRs)/Service History

The NTSB recorded the first MU-2B series airplane accident in 1968. The number of accidents and fatal accidents increased from 1977 through 1983. Overall accidents in the United States for the MU-2B series airplane fleet is decreasing, but the long-term trend for fatal accidents is stable at about two per year with a recent increase to four in 2004 and three in 2005.

The FAA has 1,123 SDRs in its database for the MU-2B series airplanes. Items of significant importance that have the most SDRs include landing gear actuator gearboxes, engine control cables, and damage to miscellaneous airframe components. However, the number of reports FAA received in recent years has dropped significantly to less than five per year.

Of importance is the fact that general aviation operators (14 CFR part 91) are not required to report service difficulties and utilization information. However, failures, malfunctions, and defects should be reported by the TC holder under 14 CFR 21.3 and repair stations under 14 CFR 145.221. Air taxi operators should report mechanical reliability reports (MRRs) under 14 CFR 135.415 and SDRs under 14 CFR 135.416.

Mandatory Continued Airworthiness Information (MCAI)

Each foreign authority issues an MCAI for an unsafe condition on aircraft that they are the state of design. Following International Civil Aviation Organization Annex 8, FAA evaluates this MCAI to determine appropriate action for the U.S. fleet. These actions may

include issuing an AD, recommending incorporation of the service information via a Special Airworthiness Information Bulletin (SAIB), or taking no action.

For the imported MU-2Bs, the JCAB has issued MCAIs. As discussed in the "TCDS History" section, the FAA has reviewed all this information and is taking appropriate action. No outstanding continued airworthiness actions have been identified as contributing to any MU-2B accidents. See Appendix 1 for more details.

Specific Conditions/Components

- Icing: The most frequent and fatal type of accident for the MU-2B series airplane involves uncontrolled descent from altitude during or after flight in reported or suspected icing conditions. Accident investigations do not always implicate icing as the primary cause of an accident although it may have been a factor in about 22 accidents, including 17 fatal accidents. The NTSB identified icing as a cause or factor in 14 fatal MU-2B series airplane accidents that resulted in 46 fatalities. During the 1997 SCR, FAA issued ADs and alternative methods of compliance (AMOCs) and took other actions to address the icing conditions. These ADs mandated a number of aircraft design changes and a couple of procedural changes to enhance the safety of the MU-2B when flown in icing conditions. Also there was a mandate watch an icing video prior to flight into known icing and to watch that video every two years. No accidents have been attributed to icing conditions since these actions were taken.
- Autopilot: In January 1987, the NTSB noted 10 fatal accidents involving sudden loss of control where the MU-2B series airplane was equipped with Bendix M-4C or M-4D autopilots. The NTSB initially recommended an AD to require inspection, servicing, testing, and scheduled replacement of autopilot components. Review by the FAA, Bendix, and Beech Aircraft found no specific problems with the autopilot that required an AD. After MHI issued a mandatory SB to standardize autopilot configurations and an advisory notice to all MU-2B series airplane owners and operators on the proper and safe operation of the autopilot systems, the NTSB closed the recommendation as "acceptable action." The autopilot has not been identified as a causal factor in any fatal accident since.
- Propeller Blades and Propeller Hubs: The NTSB also noted that failure of propeller blades or hubs caused nine accidents of the MU-2B series airplanes. The FAA issued an AD to require new procedures and retirement of the "N" configuration propeller blades at 10,000 hours based on a Hartzell SB. The FAA also issued AD action to increase the ground idle revolutions per minute (RPM) speed from 72 percent to 76.5 percent. The NTSB closed the recommendation as "acceptable action." A review of 47 Hartzell propellers installed on MU-2B series airplanes indicated recurring problems with blade shanks, clamps, hubs, and hub pilot tubes. The FAA issued ADs to address these issues, and there have been no further accidents caused by propeller failures.

- Rigging (Engine and Aircraft): FAA discussion with MU-2B series airplane operators and maintenance personnel indicates that rigging of the Honeywell TPE331 series engines is critical. Experience in the MU-2B rigging process is the best guarantee for a successful engine rigging. The maintenance manual clearly states differences between two different varieties of fuel controls on the TPE331 series engines to ensure proper rigging procedures are done. Another rigging area of concern is the flap system. Proper rigging ensures desirable flight characteristics especially during one-engine inoperative (OEI) operation with flaps extended. As with engine rigging, utilizing technicians with experience in MU-2B series airplane flap system rigging is critical. During this safety evaluation, the FAA reviewed the Instructions for Continued Airworthiness (ICA) and the Aircraft Maintenance Manual and determined they were acceptable. However, mandatory maintenance training will improve the capability of the maintenance personnel to correctly rig the MU-2B. See Appendix 12.
- Engine Issues: SDR and in-flight shutdown data (IFSD) are insufficient to identify problematic trends. FAA-review of the available IFSD data for the Honeywell TPE331-5/-6/-10 series engines from the past 10 years does not indicate a trend in engine problems. The engine manufacturer reviews IFSD events and typically issues a SB to address any pertinent service issue. The MU-2B IFSD events were determined not to be an unsafe condition and, therefore, have not resulted in any AD action.

Special Certification Reviews (SCRs)

The FAA previously conducted two SCRs of the MHI MU-2B series airplanes, one in 1983-1984 and another in 1996-1997. Appendix 1 of the appendices document contains a detailed account of the findings, recommendations, and actions completed for both SCRs. Following is a brief synopsis of each SCR:

- The 1983-1984 SCR: This SCR looked at the engines, fuel system, autopilot, flight control systems, flight into known icing conditions, engine inoperative characteristics, and handling characteristics during landing approaches in instrument meteorological conditions (IMC). The SCR team's focus was to determine whether the MU-2B design complied with the certificating regulations and if the service history revealed any unsafe features attributed to design. Three teams were established: the Systems and Equipment Review Team, the Powerplant Review Team, and the Flight Test Multiple Expert Opinion Team. The FAA determined that all models of the MU-2B series airplanes complied with the airplane's CAR 3 certification basis. Other items of note from that SCR include:
    - ✓ A minimum crew of one pilot is adequate to safely operate the airplane.
    - ✓ A type rating specifically for the MU-2B series airplanes is not necessary to operate the airplane.

- ✓ Three different ADs were issued to address elevator trim brackets, improved pitot heads, and lockwire safety of the engine inlet bleed air line coupling nuts.
- ✓ MHI issued several flight manual revisions.

- The 1996-1997 Fact Finding SCR: This SCR followed the fatal crash of an MU-2B series airplane on January 15, 1996. The JCAB and MHI participated in this SCR with FAA. The team focused on the following:
  - ✓ The original icing certification.
  - ✓ Airplane characteristics in the icing environment as specified in 14 CFR part 25.
  - ✓ Airplane characteristics in the freezing drizzle icing environment as understood in 1996.
  - ✓ How the characteristics observed above could contribute to an accident scenario.

  The FAA concluded that the JCAB conducted the original icing certification of the MU-2B series airplanes correctly under the CAR, and FAA issued the TCs correctly, including the approval for flight into known icing conditions. The FAA issued two ADs (and AMOCs) based on recommendations from this SCR team. One of these ADs mandated pilot training via video prior to operating in icing conditions. In addition to recommendations that FAA has already addressed, the team also recommended the following items that were never incorporated:
  - ✓ Require through an AD the installation of an ice detector on all MU-2B series airplanes.
  - ✓ Require an AFM limitations section change that mandates a propeller negative torque sensing (NTS) and feather valve check prior to the first flight of the day. MHI issued a flight manual revision for this, but FAA did not mandate it.

The FAA will reconsider these recommendations.

TapRoot® Cause Analysis

The FAA recently conducted an in-depth systemic root cause analysis, using TapRoot® software that System Improvements, Inc. developed. The process helps identify systemic failures. Based on these findings, the software users can develop and implement corrective measures to improve future system performance.

The analysis focused on accidents from January 1, 1996, to August 4, 2005. The analysis showed the MU-2B series airplane to be a complex aircraft requiring operational techniques not typically found in other light turboprop aircraft, but more similar to those of turbo-jet aircraft that require a type rating. Fully understanding the system complexity is much more critical during an emergency situation. The AAI report indicates that an

MU-2B pilot is seven times more likely to lose control and have a fatal accident during an emergency when compared to pilots flying similar types of airplanes in similar situations.

The root causes that TapRoot® identified were:

- **Complex System; knowledge-based decision required:** There is a need for a higher level of knowledge-based decisions.
- **Non-Fault Tolerant System; errors are not recoverable:** The analysis indicates that in many of the accidents errors were undetectable.
- **Human-Machine Interface; unit/aircraft differences:** Differences in the aircraft design, including full span wing spoilers and high drag gear doors with lengthy cycle times, displays, or controls between the MU-2B series airplanes, and other comparable twin-engine aircraft, could have contributed to many of the accidents analyzed.
- **No Training; task not analyzed, or understanding, training objective needs improvement:** Enhanced type-specific pilot training could have reduced the chance of accident-causing errors by addressing the complexities associated with the MU-2B series airplanes.
- **Standards, Policy, Administrative Controls (SPAC) are not strict enough:** The wording used in some of the existing continued airworthiness information (SBs and ADs) may not be precise enough to ensure the desired outcome is achieved. If this information is open to "interpretation," this will jeopardize compliance.
- **SPAC not used, Enforcement needs improvement:** Our research has determined that in some cases, operators did not comply with SBs and ADs.

WHAT OTHERS BELIEVE

During this safety evaluation, FAA received input from the MU-2B series airplane community on data and perceptions related to the training and operating capabilities of the MU-2B series airplanes. Vehicles utilized include:

- Obtaining the ideas of MHIA, MHI as the airplane TC holder, and Honeywell International as the engine TC holder.
- Obtaining operator input through an airworthiness concerns sheet (ACS) to user groups through the Airworthiness Concerns Process.
- Coordinating several meetings with MU-2B series airplane owners, operators, training providers, the JCAB, and various aviation industry groups.

Appendix 7 includes information on the meetings FAA held during this safety evaluation.

The Airworthiness Concerns Process

During the initial phase of this evaluation, FAA's Small Airplane Directorate used its Airworthiness Concerns Process to send out an ACS to gather information and data on the MU-2B series airplanes from user groups. The Small Airplane Directorate uses the ACS to solicit technical information on safety issues prior to taking action. The FAA received over 150 written comments during a two-week period. This represents about 40 percent of the U.S. MU-2B series airplanes owners/operators. Most of the comments focused on training issues. The following summarizes important operator feedback:

- Mandatory pilot training should be considered.
- MHI provides recognized maintenance training.
- The airplane safely provides the performance and operational efficiency that it was intended to, and that initial and recurrent training from an MHI-recognized training facility "is a must" for the continued safe and reliable operation of the airplane.
- The airplane is used successfully in extreme weather conditions, including icing. When the airplane's design features are understood, the MU-2B series airplane is safe and operation is easily managed.
- Mandatory maintenance training should be considered.

MHI as the Type Certificate (TC) Holder and JCAB as the State of Design

During the MU-2B safety evaluation, FAA has worked with both JCAB as the State of the Design for one of the affected TCs and MHI as the TC holder. Additionally, we have worked with MHIA as the licensee of MHI. TAS is under contract to MHIA to provide technical support. The following is important data received during meeting with FAA, JCAB, MHIA, MHI, and TAS.

- Pilot and Maintenance Training: MHIA supports a Special Federal Aviation Regulations (SFAR) to require initial and recurrent MU-2B specific pilot training with a test of the pilot's skills. As a representative of the TC holder, they provided a standardized training program for FAA approval. MHIA also agreed that standardized maintenance training through an SFAR would help operators who are not currently using an MHIA service center.
- Checklists: MHIA discussed the lack of a standardized FAA-approved checklist for operation and the operators' desires for such a checklist. MHIA provided such a checklist for FAA approval.
- SBs, ADs, and AMOCs: MHIA expressed concern that FAA has issued too many icing AMOCs to the MU-2B series airplane ADs. The JCAB asked FAA to review all the JCAB-issued ADs to ensure all issues were addressed.
- Potential Solutions to the MU-2B Series Airplane accident rate: The JCAB, MHI, and MHIA believe that the cause of the increasing accidents is a lack of pilot training. Like the operators, they agree that the best course of action is mandatory training with a required test of the pilot's skills. They also agreed that standardized maintenance training is necessary.
- Process for Delivering Changes: MHI, MHIA, and TAS agreed that an SFAR may be the best course of action to mandate standardized training. MHIA further stated that the current training video for icing could be incorporated into the training syllabus to further ensure it is utilized. One of the benefits of an SFAR is that it can be issued in less time than traditional rulemaking.

Meetings with MU-2B Series Airplane Owners, Operators, Training Providers, and Various Aviation Industry Groups

The FAA held separate meetings with training providers; 14 CFR part 129/135 operators; and 14 CFR part 91 operators and special interest groups. The FAA held these meetings to solicit information. From these meetings, the following were common ideas and perceptions on the maintenance and operations of the MU-2B series airplanes. The following is the public input:

- Maintenance Issues/Training: The training providers identified airplane, engine, and propeller rigging as common problems. The providers identified items critical

to the maintenance of the airplanes as torque sensors, fuel controllers, gearbox drive assemblies, propeller couplings, and propeller balancing. Most critical to the safe operation of the airplane are fuel flow flight idle settings and rigging including proper blade angle settings. The operators believe FAA should mandate type-specific maintenance training because very few of the part 135 operators currently use service centers for their maintenance. Again, the operators stressed that maintenance is critical to the safe operation of the MU-2B series airplanes. Part 91 operators primarily use service centers so they do not face the same maintenance issues as part 135 operators do, but they do agree that good in-house maintenance programs and increased maintenance surveillance help establish the safety of the airplanes.

- Pilot Operating Handbook (POH) and AFM: The training providers and operators agree that the AFM needs revision and "clean-up" to ensure consistency with any new training curriculum developed. Several commented about the owners/operators not incorporating the latest revision levels and problems associated with consistency of the operators having varying revision levels of the manuals. Comments indicated that the older versions of the manuals were better because they included detailed airplane system descriptions.
- SBs, ADs, and AMOCs: Both part 129/135 operators and part 91 operators believe that certain SBs should become ADs and that some one-time inspections should become repetitive through ADs rather than relying on general maintenance to incorporate the repetitive inspection. The operators find the icing ADs confusing and would like to see FAA incorporate these AD requirements into a mandatory training program. This would help clarify the AMOCs currently issued through the icing ADs.
- Potential Solutions to the MU-2B Series Airplane Accident Rate: The trainers explained that it is critical to communicate to the pilots that the MU-2B series airplane operates much differently than other light twins. The operators also agree that the MU-2B series airplane is more difficult to operate than other airplanes in its class, and it demands constant attention. The pilots need to be disciplined, the manuals and maintenance programs standardized, and training programs complete, mandatory, and recurrent. The pilots also communicated a need for a standardized FAA-approved checklist for operations. The groups felt that FAA should look at and address its current oversight responsibilities of maintenance, training, and operations.

FLIGHT STANDARDIZATION BOARD/FLIGHT EVALUATION

The FAA performed a flight standardization board (FSB) to evaluate the need for MU-2B series airplane specific pilot training and to evaluate MHI's proposed training program. The FSB specifically evaluated the proposed flight training program that MHI developed and concluded that specific training for pilots was needed. Additionally, a flight evaluation looked at potential changes to operational procedures such as higher takeoff speeds to achieve added safety margins.

Typically, an FSB is convened for new airplanes that require type ratings. This FSB was unusual in that we were evaluating an airplane that has been operating for years. Aircraft Certification test personnel and a human factors specialist from the FAA's Civil Aeromedical Institute (CAMI) assisted in the FSB.

Flight Standardization Board Effort Overview

The FSB pilots followed the guidance in Advisory Circular (AC) 120-53, "Crew Qualification and Pilot Type Rating Requirements for Transport Category Aircraft Operated Under FAR Part 121" for conducting their flights. They followed the ground and flight training that MHI proposed and then completed a flight proficiency check to validate the effectiveness of the training.

In addition to the FSB effort, Aircraft Certification flight test pilots flew the training profiles. They also looked at potential changes to operational procedures such as higher rotation speeds to achieve added safety margins. As part of this effort, the airplanes used for training were flown through a series of stalls to ensure that they were representative of the approved airplane based on the type design data. Flight test validated an accelerated stall training technique and verified adequate maneuvering margins for OEI operations. They also determined a minimum safe speed to render the engine inoperative for all models of the MU-2B series airplanes. This is typically referred to as a V_{SSE} but is not required for the MU-2B series airplanes. Finally, flight test confirmed the need to follow the MHI OEI approach procedure of keeping the landing gear up until the landing is assured.

The flight training profiles flown by two FSB members included a human factors workload evaluation. One airplane was equipped with several cameras that allowed post-flight evaluation of the pilot's workload. The FSB pilots completed numerous questionnaires developed by human factors specialists to measure task saturation. Questionnaires were completed during interviews and flight video reviews with the human factors specialist.

The FSB team also reviewed and evaluated the training program and the checklists for the MU-2B series airplanes.

Flight Standardization Board Conclusions

In the draft report, the FSB made the following recommendations/observations:

- Mandate MU-2B series airplanes initial and annual recurrent pilot training. The training program must be standardized to be effective.
- Use the MHI-proposed training program as this standardized training.
- Level E training, checking, and currency for the MU-2B series airplanes, which are normally eligible for designation of a type rating were identified. Current regulatory requirements for a single pilot type-rated aircraft are not adequate to address training, checking, and currency necessary for safe operation of the MU-2B. Regulatory changes to type rating requirements or special regulatory measures are needed.
- All MU-2B series airplane operations should be conducted with a standardized normal, abnormal, and emergency checklist in user-friendly format consistent with the most current FAA approved airplane flight manual (latest revision level).
- To support the pilot's takeoff decision, MHI should publish single-engine climb performance data for both flaps 5 and flaps 20 takeoffs with the landing gear retracted and extended.
- All single-pilot instrument flight rules (IFR) operations be conducted with an approved autopilot and that for these single-pilot IFR operating conditions, compliance with current ADs for installation of trim-in-motion warning and autopilot disconnect (140kts) are accomplished. The trim-in-motion warning and autopilot disconnect are useful warning indications and speed awareness tools for the pilot regardless of icing conditions.
- Maintain 14 CFR part 61.57 landing currency in the MU-2B series airplanes exclusively. Landings in other multi-engine land airplanes should not be credited for landing currency in the MU-2B series airplanes.
- Require satisfactory completion of the 14 CFR part 61.56 flight review in an MU-2B prior to operation of an MU-2B.

A draft copy of the FSB report was posted on the following website www.opspecs.com on December 19, 2005, for a two-week public comment period. A final report will be made available on this website after all public comments are evaluated. A draft copy of the report is included in Appendix 9.

OBSERVATIONS

Previous sections of this document have presented the history of the MU-2B series airplanes and the data gathered during the safety evaluation. This section presents the observations found during this safety evaluation. General observations of issues prevalent today are presented first, followed by four categories of specific observations. The observations are based on FAA's analysis and input from all involved, including the airplane and engine TC holders, the JCAB, user groups, owners/operators, and maintenance personnel.

General Observations

- FAA's evaluation concluded that the MU-2B series airplane is a complex aircraft requiring operational techniques not typically found in other light turboprop aircraft, but similar to those of turbo-jet aircraft that require a type rating. Fully understanding the system complexity is much more critical during an emergency situation.
- AFM and POH content and the various training programs may conflict.
- Operators of the aircraft have developed their own procedures for operation that they feel provide a higher level of safety than the published procedures.
- Training programs recommended by MHI provide information not in the AFM (this is similar to other airplane type rating programs.)
- Different training organizations used different procedures for normal and abnormal operations.
- The Mitsubishi MU-2B series airplanes have a higher recent accident rate in 14 CFR part 135 operations than in 14 CFR part 91 operations. Normally, the 14 CFR part 135 operations would be expected to have a lower accident rate.
- There is a need for airplane specific pilot and maintenance training in 14 CFR part 23 airplanes that are complex and high performance, such as the MU-2B series airplanes.
- Training would enhance the maintenance manual procedures for MU-2B series airplane rigging (e.g., engine, fuel control, flaps, flight controls, etc.). This observation was discussed during the aviation industry group meetings.
- Having two ACOs responsible for almost identical type designs may have led to miscommunication on MCAIs.

- ✓ Consolidation of oversight into one FAA office was completed in September 2005 and should prevent FAA future internal miscommunication when responding to MCAIs.
- ✓ As part of this consolidation, all MCAI and mandatory SBs have been evaluated using the Small Airplane Directorate's Airworthiness Concerns Process and some issues have been identified for further investigation.

- Certain recurring SDRs (landing gear actuator gearboxes, engine control cables, etc.) could not be directly tied to any fatal accidents; however, they may still represent a safety concern.
- The fatal accident statistics of the Swearingen SA 226/227, Beech 99, and Embraer 110 airplanes appear similar to the MU-2B in 14 CFR part 135 operations.
- There is a perception that flight into the Centennial Airport in Colorado is challenging and may be contributing to the recent accidents at that airport. In addition to the MU-2B series airplane accidents, other model airplanes were involved in accidents during the same timeframe.

Category 1: Pilot and Maintenance Training Issues

- Specific MU-2B pilot training and testing is not standardized.
- Specific MU-2B pilot training and testing is not mandatory in all operations.
- Specific MU-2B maintenance training is not standardized.
- Specific MU-2B maintenance training is not mandatory.
- There is not a standardized manufacturer maintenance training syllabus.
- The existing airplane maintenance manual is difficult to use without specific training.

Category 2: Airframe and Engine Issues

- As of this report, FAA has issued 29 ADs against the MU-2B series airplanes. A complete list of these ADs is included in Appendix 1.
- As of this report, FAA has issued 33 ADs against the engine and 12 ADs against the propellers on the MU-2B series airplanes. A complete list of these ADs is included in Appendix 1.
- There are no open NTSB or FAA Safety Recommendations on the MU-2B series airplanes.
- According to FAA SDRs, there are only two reports made from January 1, 2005, through August 2005. There were only three SDRs for all of 2004. See Appendix 1 for a chart of SDRs reported since 1974.

- The NTSB has not issued its final reports, conclusions, or recommendations on the last four MU-2B series airplane accidents at the conclusion of the FAA safety evaluation.
- FAA recently completed a fresh look at all previous MCAI actions. No outstanding continued airworthiness actions have been identified as contributing to any MU-2B accidents. From this review, FAA has identified the following as potential AD actions:
    - ✓ JCAB TCD 4889-98: Incorporated SB 233A / 095/77-002, Inspection of engine torque indication system.
    - ✓ JCAB TCD 4379-96: Incorporated SB 218A / 090/76-003, Inspection of feather valve/Linkage Inspection.
    - ✓ JCAB TCD 4890-98: Incorporated SB 234 / 097/73-001, Flight check of the flight idle fuel flow setting.
    - ✓ SBs 241 / 103/57-004, SAIB CE-04-84, Inspection of cracked wing attachment barrel nuts.
- The FAA is considering an NPRM on the MU-2B series airframe to address Mitsubishi Mandatory SB 01661-001 that describes changing blade angle from 16 to 12 degrees and removing Note 3 of the TCDS for TC No. A10SW.
- FAA is evaluating the following engine TPE331 proposed actions:
    - ✓ Spline drive between the Woodward fuel control.
    - ✓ TPE331 turbine wheel (for special-use “lifing”).
- Safety would be enhanced with the use of an autopilot during single-pilot IFR operations in an MU-2B.
- The trim-in-motion warning and autopilot disconnect systems are useful warning indications and speed awareness tools for the pilot.
- Certain safety concerns remain for the following:
    - ✓ Requiring through an AD the installation of an ice detector.
    - ✓ Requiring a propeller NTS and feather valve check prior to the first flight of each day. MHI issued a manual revision for this, but FAA did not mandate it through AD action.

Category 3: Maintenance Manuals/Flight Manuals and Checklist Inconsistencies

- Pilot checklists are not standardized for normal, abnormal, and emergency flight operations
- Some operators are not using the latest AFM revision.
- Some operators are not using the latest maintenance manual revision.
- The AFM and maintenance manual revisions are not incorporated into all MU-2B training programs.
- There is no published comprehensive single-engine climb performance data.

Category 4: FAA Oversight of MU-2B Operations and Maintenance

- FAA has not conducted special surveillance of MU-2B operators.
- The FAA has not yet addressed the inconsistent application of requirements for part 135 operators to comply with mandatory SBs.
- There is concern that some operators are not complying with ADs and inappropriately complying with the AMOCs they choose to use.
- The SDR reporting system is not capturing all service difficulties.
- There is a perception by some operators that the conditions at Centennial Airport may have contributed to recent accidents.

COMPLETED ACTIONS AND PROPOSED RECOMMENDATIONS

This section presents the actions that FAA either proposes or has already completed. These actions are based on the information gathered during the safety evaluation and the observations made in this report. The actions are tied to the four categories presented in the "Observations" section.

Actions for Category 1: Pilot and Maintenance Training Issues

Action	Status
Review maintenance manual for clarity, procedures, and the need for standardized training.	Complete
Work with MHIA to develop standardized training for the maintenance manual.	Proposed
Review the need for training for mechanics that work on MU-2B series airplanes that are used in 14 CFR part 91 and part 135 operations.	Proposed
Conduct an FSB to determine if and what pilot training is required.	Complete
Develop an FAA-approved standardized training syllabus.	Proposed
Mandate a standardized MU-2B specific pilot training. The training should be recurrent and require a test of the pilot's skill.	Proposed

Actions for Category 2: Airframe and Engine Issues

Action	Status
Evaluate all existing mandatory SBs and MCAIs using the Airworthiness Concerns Process to determine whether AD action is necessary.	Complete
Consider AD action on the following: 1. JCAB TCD 4889-98: incorporated SB 233A / 095/77-002, inspection of engine torque indication system. 2. JCAB TCD 4379-96: incorporated SB 218A /	Proposed

090/76-003, inspection of feather valve/linkage inspection. 3. JCAB TCD 4890-98: incorporated SB 234 / 097/73-001, flight check of the flight idle fuel flow setting. 4. SBs 241 / 103/57-004, SAIB CE-04-84, inspection of cracked wing attachment barrel nuts. 5. Mitsubishi Mandatory SB 01661-001 that describes changing blade angle from 16 to 12 degrees and removing Note 3 of the TCDS for TC No. A10SW. 6. Engine action on the spline drive between the Woodward fuel control. 7. Engine action on the TPE331 turbine wheel (for special-use lifing).	
Evaluate the need for an ice detector system and whether it should be addressed through AD action.	Proposed
Revise the icing training AD (including AMOCs) if the subject matter is included in the mandatory training.	Proposed
For single-pilot operation in IFR, evaluate the use of an autopilot.	Complete
Re-evaluate the requirement to have autopilot disconnect and trim-in-motion single-pilot operation in IFR.	Complete
Recommend for single-pilot operation in IFR the use of an autopilot and the requirement to have autopilot disconnect and trim-in-motion through the SFAR.	Proposed
Require through an AD the installation of an ice detector.	Proposed
Require a propeller NTS and feather valve check prior to the first flight of each day.	Proposed
Evaluate SDRs for landing gear actuator gearboxes, engine control cables, etc.	Complete

Actions for Category 3: Maintenance Manuals/Flight Manuals and Checklist Inconsistencies

Action	**Status**
Review and identify the differences in normal, abnormal, and emergency flight operations as published in the AFM and the POH for different models of the MU-2B series airplanes. Compare these	Proposed

procedures to the actual practices of the training providers, owners, and operators.	
Identify and work with MHIA for an FAA-approved standardized checklist.	Proposed
Evaluate the need to mandate the current limitation in the AFM to require a propeller NTS and feather valve check prior to the first flight of each day.	Proposed
Mandate the use of the latest AFM and maintenance manual revisions for training, operations, and maintenance.	Proposed

Actions for Category 4: FAA Oversight of MU-2B Operations and Maintenance

Action	**Status**
Initiate a Special Surveillance Program of MU-2B air taxi operators.	Complete
Complete corrective actions identified in the Special Surveillance Program.	Proposed
Consolidate oversight of the two TCs in one office with the Fort Worth Airplane Certification Office having responsibility.	Complete
Revise both TCDS' to reflect the licensing agreement of MHI and MHIA.	Proposed
Revise TCDS No. A10SW to record the TC holder record per FAA Order 8110.4C (paragraph 3.3.d(5)). Revise TCDS No. A2PC to clarify licensing agreement.	Proposed
Evaluate and enhance the SDR reporting system (14 CFR 21.3 and 14 CFR 145.221). Add MRRs to SDR database.	Proposed
Conduct thorough review of navigational aids, approach and departure procedures, and air traffic control procedures at Centennial Airport in Colorado to identify and correct possible factors relating to the recent accidents.	Proposed
Analyze the safety record of the Swearingen SA 226/227, Beech 99, and Embraer 110 airplanes.	Proposed

CONCLUSION: TYING IT ALL TOGETHER

This report summarizes the data gathering and analysis from numerous FAA organizations. After reviewing all the data available, the FAA concluded that a SFAR would best address many of the issues presented in the "Completed Actions and Proposed Recommendations" section of this report. These issues include requiring:

- Specific pilot training and testing of the pilot's skills.
- Specific maintenance training.
- FAA-approved standardized pilot checklist.
- The latest revisions to the maintenance manual and the AFM.

An SFAR is quick to implement and easy to revise as necessary. Including all of the above items in one SFAR would put many of the necessary actions in one document so it is easily understood and easily accessible to the owners/operators, mechanics, and others involved with the MU-2B series airplanes.

The FAA believes that the implementation of the actions in this report will not only address the present continued operational safety of these airplanes, but also allow us to more fully address these issues in the future.