MITSUBISHI MU-2

...An odd-looking machine that reshaped ideas of how an airplane could perform...

In 1959 Mitsubishi Heavy Industries of Japan decided to build a turbine-powered business airplane. The company had been producing military airplanes since the 1920's, but had no experience with the business-aircraft market. The Mitsubishi airplane would neither evolve from an existing design nor be designed to suit the tastes of Mitsubishi management. Mitsubishi would let the market dictate what it wanted in business transportation.

To find out just what the market wanted, Mitsubishi surveyed a combination of business executives and chief pilots in the U.S. Results of the survey were not surprising. Pilots and passengers wanted speed and comfort but were unwilling to give up the capability to use small unimproved airports.

With those twin goals--high cruise speed with short, rough-field capability in mind, Mitsubishi engineers set to work designing what would become the MU-2 turboprop. The design goals dictated that turboprop engines be used because the turbojet engines then available were not suited for short-field operation. To meet its goals the MU-2 needed to be faster than the competition without sacrificing short-runway performance.

To achieve high speed, Mitsubishi selected a small wing, exactly opposite to the aerodynamic formula used for the Beech King Air and Turbo Commander, which were evolving from earlier piston-powered aircraft at about the same time. A small, highly loaded wing produces less drag and allows higher cruise speeds. It also improves the ride in turbulence because each gust has less wing area to act upon.
The trade-off with small, highly loaded wings is in low-speed maneuvering during takeoff and landing. A highly loaded wing will stall at a higher airspeed, dictating increased speeds and runway lengths for takeoff and landing. The solution is to install high-lift flaps, which can be extended to increase wing area and lift when you need to go slow without drag at cruise.

Mitsubishi engineers selected very effective double-slotted flaps that increase total wing area by more than 25 percent when extended and add enormous amounts of low-speed lift. Use of these large flaps dictated another deviation from the conventional turboprop design because, to be effective for short-field operation, the flaps needed to extend across the entire trailing edge of the small wing, leaving no room for ailerons. Mitsubishi's solution was to install spoilers for roll control. Although roll spoilers were not new in 1961 when the MU-2 prototype design was completed, they had never been used on a business airplane.

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The MU-2 wing went on top of the fuselage for several reasons. First, it provides a low-drag wing-fuselage junction. Second, for rough-field operation a fuselage-mounted landing gear can be made more rugged because loads are transmitted directly to the fuselage rather than through the wing to the fuselage. The MU-2 wing need carry only air loads, not the shock of landing and rough-field operation. Finally, the high wing provides plenty of ground clearance for the props, an important feature for rough fields. There are probably other considerations that Mitsubishi engineers weighed at the time, but the high-wing configuration fell in line with the primary design goals.

The MU-2 fuselage is round because that is the optimum way to design a pressure vessel. Tip tanks were necessary because the small wing did not have enough internal volume to contain the required fuel.

The MU-2B, the first Mitsubishi delivered in this country in 1967, could cruise at a maximum speed of 315 knots, nearly 100 knots faster than the Beech King Air 90, which would prove to be more successful in the marketplace. The MU-2 also met the short-field design goal with the ability, at least at lighter weights, to use 2,000-foot sod strips. The airplane can be landed on target with no tendency to float, and it can be stopped quickly with prop reverse. On takeoff, the big flaps and ample power get the airplane up and climbing with gusto.

In meeting the primary design goals, Mitsubishi encountered some unintended fallout. The airplane did what people said they wanted an airplane to do, but it looked different and didn't handle like an ordinary airplane.

Most MU-2 pilots received their training in the normal way--a checkout. This wasn't really adequate because the MU-2 had little in common with the piston twins the pilots had been previously flying.

The MU-2 is a short airplane, making it more sensitive than many in pitch and in trim. To minimize drag, the horizontal stabilizer is actually an upside down airfoil generating down force. The upside-down airfoil allows the tail to exert the necessary down force at a lower angle of attack and with very little trim drag. As a result, small amounts of pitch trim have a greater effect.

The roll spoilers demanded changes in pilot technique. The best single engine climb is achieved with wings level in the MU-2, rather than banked into the operating engine as on other twins. To achieve wings level with the control wheel centered so the spoilers are flush, the MU-2 pilot needs to use roll trim, which is supplied by electrically driven tabs on the trailing edges of the flaps. In this way the entire wing is trimmed, not just a control surface, which is a very efficient but different system. Because the MU-2's flaps supply a great deal of added lift, the pilot needs a different technique should an engine fail shortly after rotation. Pilots trained in conventional piston twins know that gear-up and flaps-up are priority items should an engine fail

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on climb-out. Raising the MU-2's flaps during an engine failure kills a great deal of lift just when you need it most.

Some of the mishandling of flaps during takeoff emergencies can be blamed on a lack of information supplied to MU-2 pilots. The airplane's V_{YSE} (blue line) is 150 knots, while normal liftoff speed will be about 100 to 110 knots. If an engine fails with the flaps set at the normal 20-degree takeoff position, the MU-2 will climb at the same gradient at 110 to 120 knots, as it will with flaps up at the 150 knot blue line. The gradient is what you care about when an engine quits on takeoff because you need to put distance between the airplane and the trees. Once the airplane has reached a safe altitude, the flaps can be raised and the airplane accelerated to blue line for best rate of climb.

If MU-2 pilots had been trained in jets, they would have known that when an engine quits after liftoff you never touch the flaps until reaching a safe altitude. But MU-2 pilots, for the most part, came from flying piston twins and tried to fly the MU-2 like an Aztec. It didn't work.

As a result of all this and a resulting high accident rate, the MU-2 has been the subject of two investigations by the FAA. The first investigation, in 1981, was not publicized and was conducted by the FAA to examine the approach handling qualities of the airplane. It had been alleged that the MU-2 could develop high rates of sink that were difficult to arrest. FAA pilots found just the opposite. According to the investigation, FAA pilots found that with the MU-2 stabilized on a normal glideslope they could raise the nose without adding power and fly level until the stall warning activated, without the airplane going into a behind-the-power-curve sink.

The second investigation, in 1984, was a Special Certification Review (SCR) conducted by the FAA at the request of the NTSB. The SCR entailed the engines, fuel system, engine-out handling, flight control system, handling qualities in IFR conditions and flight into icing. After nearly 70 hours of test-flying, much of it in icing conditions, the FAA found that the MU-2 does comply with the regulations. Nothing was found in flight testing, accident analysis or examination of systems and structure that was outside the rules or would lead to accidents.

The only changes the FAA asked for as a result of the SCR were to add better pitot heaters to earlier models, safety-wire a coupling nut in the engine lip-heat bleed-air system and require replacement of improved trim-tab brackets on some early airplanes.

The safety record of the MU-2 has not been good, but there has been no pattern of crashes. Pilots have descended into the trees on approach run out of fuel, lost control, flown drunk and made all the mistakes that are the final acts of many pilots in many different airplanes.

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During the SCR the FAA studied cockpit layout and workload to analyze whether a single pilot can safely handle the MU-2 under IFR. The answer from a team of FAA pilots was yes. The need for a special MU-2 type rating was also considered but found unnecessary by the FAA.

A total of 740 MU-2's have been built, with that number split about evenly between the original short-fuselage and the long-body airplane. In the early years, 25 or 30 percent of the turboprops sold each year were MU-2's and the airplane accounts for about 10 percent of all turboprops in the United States.

By any measure the MU-2 is a success. It met its design goals, with great speed and excellent short-field performance, but along the way became controversial because it is unique.

* The above magazine article was sent to us by a Mitsubishi pilot and has been retyped for easier reading

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