THE MU-2 FLAP SYSTEM

by Rick Wheldon

The MU-2 flap system is highly reliable and effective. Before beginning an examination of this system and its potential failure modes, I would like to put this discussion into perspective. Asymmetric flaps or disconnected torque tubes are almost non-existent in all models of the MU-2. While I am aware of several instances of split flaps caused by discontinuity/binding of the outboard flap Teleflex cable, only once did a separation of a torque tube occur. It was caused by a mechanic who improperly installed one of the torque tube couplers, which subsequently decoupled during flap extension on approach. That said, we can now proceed to a discussion of the potential failure modes and pilot responses.

To understand the flap system and flap system failures, let's look at the flap design (Figure 1). The pilot controls flap position with a switch on the center pedestal, or, in some early models, on the center instrument panel. This switch sends electrical signals to an electric motor and gear assembly and also a worm gear / traveling nut / switch assembly, both located in the turtleback section of the center wing area. (The worm gear / traveling nut / switch assembly is identical in concept to a device which is in the cabin floor and which controls the landing gear.) When a new flap position is selected, the switching recognizes that the flaps are actually in a different position than selected, and starts the motor. This turns the worm gear, and the traveling nut rides outboard or inboard until the switches are closed by the traveling nut for the new flap position, at which time the motor is turned off and the cockpit switch matches the traveling nut switch for the selected position. The motor on one side of the aircraft, and the traveling nut assembly on the other side of the aircraft are connected by a torque tube (A), which is held in place with cotter keys on both ends of the torque tube splines. Outboard of the motor on one side and the worm gear assembly on the other are two more torque tubes (B), which drive the inboard flap drives and jackscrews. Further outboard are more torque tubes (C) and (D) which transmit the torque from the inboard flap drive to the center flap drive. Farthest outboard are two flex shafts (E) that transmit the torque from the center flap drive to the outboard flap drive shaft.

If a flex shaft (E) fails, the outboard section of the flap will stop extending, while the center and inboard sections will continue to extend. This asymmetrical extension will likely result in a twisting jammed flap, which will slow, then overload the motor and pop the flap motor circuit breaker. Some asymmetry will likely result. Similarly, if any of the torque tubes between the inboard and center flap drives fail (C or D), the same twisting should result and the flap would likely jam. Cockpit indications for any of the "jammed"

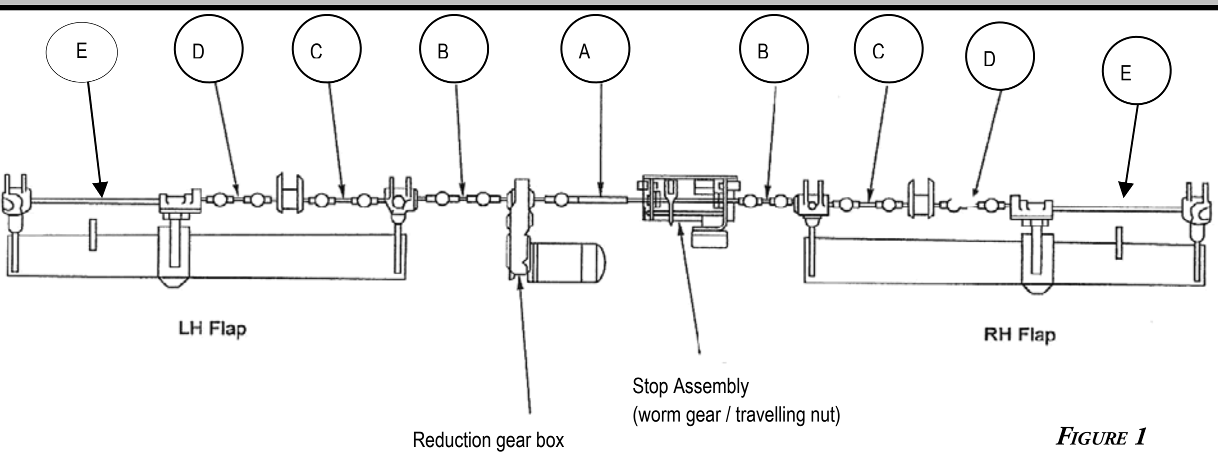

FIGURE 1

flap scenarios would depend on when the torque tube or flex shaft broke. The flap position light may or may not be on, depending on how far the travelling nut had moved before the jam and which side failed, but the pilot in all cases should sense a roll, which he could counteract with spoilers and rudder. Shortly afterwards, the flap motor CB is likely to pop. The aircraft could easily be re-trimmed. Once the pilot sensed an un-commanded roll, he should also place the flap switch back in the previous position, but that would not do anything if the CB had popped.

What about a torque tube failure (B) between either the motor and the left inboard drive, or the worm gear/traveling nut and the right inboard drive. In this case, one flap will move and the other will not. Selecting the previous flap position in the cockpit will quickly return the moving flap to the previous symmetric position. This is the scenario in the SimCom simulator and is a good reason to let your hand linger on the flap switch when selecting a new position. Assuming one of the B torque tubes breaks as the pilot selects the new flap position, the pilot senses the roll associated with the asymmetry and places the flaps back to the previously selected position. The flaps will stop evenly at the previously selected position, and the pilot would land with that flap setting. The flap lights would indicate which flap position was selected.

In this same failure of a B torque tube, if either breaks midway during flap travel, say at 10 when lowering the flaps between 5 and 20, the travelling nut would continue to move and turn off the motor at 20 if it progresses that far, but the broken flap would have stopped at 10. If the pilot did nothing, he would have flaps at 10 and 20. However, pilot reaction should again be to return the flap to its previous position. Because the travelling nut is still working, the motor would reverse and the switches would turn off power to the motor at 5. You will have to live with a small split flap (5 and 10), but the switches would have made and the 5 light would be on (even though the flap with the broken torque tube is at 10).

Finally, what about a disconnected center torque tube (A) between the motor and the traveling nut assembly? If torque tube A disconnected when the pilot selected more flaps, the flap switches would ask for flap extension and would turn on the motor, thus extending the left flap. Because of the disconnected torque tube, the right flap would not extend. The traveling nut would not move, and the control switches would not register that the flap had reached the new selected position. Therefore, the left flap would want to keep running until it reached its max travel, past 40. Reselecting the previous flap position would reverse the motor and drive the left flap back up. (Incidentally, I don't like configuration changes at low altitude. That's one reason why I don't select flaps 40 on short final, to avoid having to deal with this type of failure close to the ground.)

With this failure mode, if the flaps were selected from 0 to 5, reselecting zero would reverse the left flap, and then stop both flaps at full up. When this happens, the pilot should not touch the flap lever again, and consequently make a no flap landing. But what if he was going from 5 to 20 or 20 to 40 when torque tube A disconnects? If the disconnect occurred when the flap was at 5, and the pilot had selected 20, the left flap would move down and the right flap would stay at 5. If left uncorrected, the left flap would go past 40 to the full limit of its travel, and jam. Again, the pilot should initially respond by returning the flap to its previous position. The travelling nut still thinks the flaps are at 5, and the motor would likely stop at 5 because the 5 switches are closed on the travelling nut. If so, he would see a 5 light. But what if the disconnect occurs when the travelling nut is at 10 while the pilot is extending the flaps from 5 to 20. The airplane starts to roll right because the left flap is extending. He correctly reverses the flap switch position. The left flap will now go to full up, because the travelling nut is still not moving (it still is at 10) and the switch is calling for a lesser flap setting. Instead of having 40 and 10, he would have 0 and 10. If the asymmetrical flaps cause the airplane to roll one way, the pilot should always reverse the flap switch to put it back in its original position. If the airplane subsequently rolls the other way, the pilot MUST QUICKLY remove power from the flaps. I think that the electrical master switch is the fastest way to remove power considering that the roll forces are keeping the pilot's hands busy. I recommend the electrical master because it is a prominent guarded switch which is easy to find by feel at the lowermost left corner of the instrument panel. It can't be missed. Once the pilot stops the flaps from moving, which is the immediate control problem, then he can start looking for the flap CB, and restore the electrical master. IN ALL CASES, REMEMBER- YOUR #1 PRIORITY IS TO FLY THE AIRPLANE. (Some operators have put a collar on their flap Circuit Breaker, but I wouldn't recommend looking for a CB, even a collared one, while the control forces are rapidly shifting

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back and forth.)

In this worst case scenario, the left flap is either traveling towards full up or full down until power is removed, or until the flap jams at either the full up or full down stop. It's important to remove power quickly, while the flap split is small, and the electrical master switch is the fastest way that I know of.

Again, I have to emphasize that this last scenario has only happened once, and it required several mistakes by a mechanic who disregarded maintenance manual procedures to cause it.

In 1988, the FAA issued AD 88-23-01, which required either replacement of torque tube joints with improved versions, or repetitive inspections if the joints were not replaced. If not replaced, the center torque tube (A) joints required inspections every 100 hours for tubes with more than 4000 hours time in service. All other 4000 hour torque tubes required either replacement or repetitive inspections at 500 hour intervals. In practice, many operators have elected to replace the center tube joints to remove the 100 hour inspection requirements, but the manufacturer recommends replacement of all joints. With this requirement, as stated earlier, there has been no known mechanical failure of a torque tube over the years, and only one system failure that was clearly attributed to human error.

In summary, the failure modes depicted above are very rare. I have never experienced a flap failure first hand, in over 30 years of flying these airplanes (except annually in the simulator.) This flap system is an extraordinary design, providing us with much of the performance that we have come to value and admire in our aircraft. The manufacturer was certainly doing things right when this airplane was designed 40 years ago. **AAOG**