TRIP REPORT
Visit to NASA Langley Research Center

Hampton, Virginia
March 15, 2001
To Discuss MD-80 Jackscrew Design

(Prepared by Jeff Guzzetti; NTSB Systems Group Chairman)

Jeff Guzzetti (ASA 261 Systems Group Chairman) and John DeLisi (Chief, Aviation Engineering Division) met with 9 NASA engineers and technicians for about 5 hours at the NASA Langley Research Center on Thursday, March 15, 2001. The purpose of this informal meeting was to obtain a fresh, outside perspective on the adequacy of the design of the DC-9 / MD-80 Horizontal Stabilizer Jackscrew Assembly, and to receive input for possible recommendations related to the design.

The folks from NASA came from a variety of backgrounds and included a metallurgist, three system safety and reliability engineers, and several mechanical systems and design engineers. Our host was a safety engineer in NASA's Office of Mission Assurance.

During the first hour of the meeting, we presented a verbal briefing of the facts, conditions, and circumstances of the Alaska Airlines accident. We also showed the majority of the Boeing presentation (on video) that was made at the Public Hearing, as well as drawings and photographs from the docket. An actual jackscrew and nut were also shown. The NASA group asked many salient questions about the service history of the jackscrew, the failure of the torque tube, and the maintenance of the jackscrew.

The following is a summary of NASA's comments on this topic:

- There was widespread agreement from NASA that the jackscrew design was a fairly reasonable and effective way to operate the horizontal stabilizer of an airplane like the DC-9. They did not have any grave concerns about a single assembly, and indicated that it is adequate as long as the maintenance of the acme nut is considered "critical" .

- The NASA folks were very impressed that the jackscrew assembly and all of its components have a proven track record over nearly 40 years of service. Since the accident identified acme nut thread wear as a concern, the Safety Board should concentrate its recommendation efforts in that regard. Don't throw the baby out with the bath water. New hardware will NOT have a proven track records, thus new hazards could be introduced.

- When asked if the assembly should be deemed inadequate solely based on the fact that negligent maintenance can cause a catastrophic failure, many of the NASA folks responded with: "You cannot idiot-proof a piece of hardware…the idiot will always find a way to out-smart the designer." They were comfortable with the concept that maintenance action is required to prevent a catastrophic jackscrew failure.

- They agreed that if the jackscrew is frequently lubricated, then the likelihood of a super-excessive wear rate is very remote. Therefore, a recommendation for a hardware change may not be reasonable, considering that an emphasis on maintenance is what is really needed.

- Since lubrication is critical to the wear rate of the acme nut, an attempt should be made to flush out all of the old grease every time lubrication is performed. Additionally, an analysis of the grease should be performed at frequent intervals.

- Because the wear of the acme nut is critical, there should be a process in place to carefully and frequently check the level of wear, and keep track of the wear RATE.

- It was their opinion that even if Douglas would have been required to perform a detailed Failure Mode and Effects Analysis (FMEA) back in the 1960s for this design, they probably would NOT have considered failures associated with a stripped Acme nut thread, because the FMEA allows one to "take credit" for things like extra-strength of the threads and a "robust" design.

- An FMEA is only as good as the people that perform it. Garbage in, garbage out. FMEAs should never be expected to catch everything.

- The end-play check is probably NOT adequate enough for the reliability of measurement to TREND the wear of a jackscrew. Many felt that the end-play check may be too susceptible to false readings due to metal contamination, tool variances, and human error.

- NASA totally disagreed with the FAA's stance that the acme nut was not part of the system. They also felt that the FAA's stance regarding how FAR 25.1309 would not have addressed the acme nut (because the nut is structure and not a system, the FAA says) is also flawed, because the definition for a "system" in 1309 would cover an item like the acme nut.

NASA felt that the idea of two independent thread spirals in the acme nut is a fairly weak argument for redundancy, since both threads spirals are always carrying load and encompassed in the same nut. An alternate suggestion would have been to recess one set of threads so that it remains in pristine condition in the event that the primary set of threads fails. They said that the separate thread sets would guard against a crack propagating throughout one thread set, and they have seen that type of failure before, but that is the only scenario where a dual-thread holds an advantage. Some of the NASA folks agreed that there could be minor improvements made to the design, so that stripped acme nut threads would not be catastrophic. Possible fixes include:

- Keep the dual set of threads in the acme nut, but have only one set of threads being loaded at time. Then, when that one set wears down, the second set makes contact and begins to carry the load. In this scenario, the nut would always have a brand new set of threads ready to take over in case the wearing threads wore down beyond its limits. This would involve recessing one set of threads in the nut.

- Attach some sort of fork/scissor device on the nut/screw interface, so that if the screw began to slide through the nut (due to stripped threads), the fork/scissor device would sense this and lock the screw and nut in place before it began to slide all the way to the end.

- Beef up the torque tube and end nut so that it can handle the forces of the impact with the bottom of the acme nut as the screw slides through.

- Since the failure of the torque tube involved an off-center load due to the geometry of the lower stop, then change the geometry such that you will never get an off-center load if the acme nut strips out. The current torque tube can easily handle a pure tensile load up to 75,000 pounds, which is way more than the tail forces.

- Utilize an x-ray to check the health of the threads, as opposed to an end-play check were you cannot see what is really going on inside the acme nut.

- Provide a method by which the torque output of the trim motors can be registered, recorded, and displayed to maintenance crews or even cockpit crews. As the acme threads wear, the bearing stresses would increase, thus requiring an increase in torque output to rotate the jackscrew. Therefore, increases in torque would be an indicator of wear.

- Completely purge all old grease out of the acme nut every time it is lubricated. Also analyze the old grease every time.

- Carefully record the end-play data and closely monitor it for trending.