

The 737's Rudder-Control Concerns

By Byron Acohido of the The Seattle Times Co. Sunday, January 15, 1995

There is evidence of growing concern that the rudder system in Boeing 737 jetliners can sometimes malfunction and make the airplane dangerously difficult to control.

Late last year The Boeing Co. asked airlines to insert instructions in the 737 operating manual advising pilots to shut off a device called the yaw damper if an aircraft suddenly veered left or right.

At least two airlines - Alaska and USAir - say they are following the yaw-damper request. A USAir 737 crashed near Pittsburgh last September, killing all 132 passengers and crew members. The cause of that crash is under investigation.

Another airline, United, has accelerated replacement of a 737 rudder-system part in which investigators have found defects.

To critics of the U.S. air-safety establishment, the responses to rudder concerns are something that should have happened long ago. Reports of yaw-damper problems go back more than 20 years.

But critics say air-safety regulation suffers from a weak system for gathering information and analyzing it for dangerous patterns. They also say the system gives manufacturers and airlines too much discretion in reporting problems and too much influence in accident investigations.

The 737, manufactured since 1967, is the most widely flown commercial jetliner in the world. Its low accident rate, according to Boeing's statistics, mark it as one of the safest aircraft ever built. Yet information gathered from pilots, airlines, safety experts, federal records, airline reports and Boeing documents all points to growing concern about long-running difficulties with two rudder-control devices:

-- The yaw damper, an automatic rudder-adjustment mechanism that helps an aircraft fly straight.

-- The rudder's power control unit (PCU), to which the yaw damper and pilots send commands that move the rudder, the large slab in the tail that is one of the principal devices for controlling an airplane's direction.

United Airlines recently began accelerating installation of modified PCUs in its fleet of 737s. The Federal Aviation Administration has ordered that PCU upgrade for all U.S.-flown 737s, but United is moving four years ahead of the FAA's 1999 deadline.

A number of things lie behind the precautionary steps being taken by Boeing, the airlines and some pilots:

-- Eight unsolved 737 crashes around the world in the last five years, including the March 3, 1991, crash of a United Airlines 737 at Colorado Springs and the Sept. 8, 1994, crash of a USAir 737 near Pittsburgh. The two U.S. crashes killed 157 in all.

-- Numerous other incidents, including near-accidents, in which pilots had to fight to regain control of their aircraft after sudden, violent twisting and rolling to the left or right. In several of those incidents, pilots regained control only after intuitively or desperately turning off the yaw damper.

-- A National Transportation Safety Board statement after the Colorado Springs crash. Although it never determined what caused the crash, the safety board said "the interaction of the yaw damper and the observed PCU operation is not fully understood."

A Seattle Times survey of FAA service-difficulty reports, one-page documents that airlines file to report minor problems, found 22 yaw-damper malfunctions and 21 PCU failures reported by U.S. airlines from 1974 to 1994 - incidents that have never been analyzed by safety authorities for similarities.

It is widely known in aviation circles that airlines typically report only a fraction of the problems discovered by pilots and mechanics to the FAA, and that the agency rarely conducts comprehensive analyses of problems that are reported.

"We found that FAA had not effectively collected and analyzed data that are needed to target its inspection resources to the areas of greatest risk," Kenneth Mead, GAO's director of transportation issues, told the Committee on Commerce, Science and Transportation.

Much of the reporting about 737 rudder and yaw-damper problems is anecdotal. Safety critics say that is part of the problem.

"These problems have been pretty well-known all along," said Leo Janssens, president of Aviation Safety Institute, a Worthington, Ohio, advocacy group. "But the information isn't being passed on."

An example of the kind of incident only spottily reported occurred on a clear morning over North Dakota more than 20 years ago. On Aug. 22, 1973, a Frontier Airlines 737 departed from Bismarck for Rapid City, S.D., with R.M. "Mac" Schow in the captain's seat. Shortly after takeoff, Schow noticed the jet flying with its nose "skidding" slightly to the right. Schow straightened out the airplane by depressing the left rudder pedal. As the jet climbed higher, Schow applied more left rudder to keep the jet on course.

Schow checked to see if both engines were putting out equal thrust and that his fuel tanks were full and even. Instruments showed everything properly balanced. As he climbed to cruising altitude, Schow dialed a "rudder trim" knob to deflect - and hold - the rudder slightly to the left. The jet then flew straight. Schow turned on the autopilot and settled in.

About seven minutes later, flight attendant Cathy Colombi was approaching the cockpit with coffee for Schow and first officer Don Straus. One second the jet was cruising smoothly at 17,000 feet, the next it rolled violently to the left. "I hit my head on the galley door and started to fall, but caught myself on the assist handle," Colombi wrote in a company report.

Schow quickly disengaged the autopilot and righted the aircraft, then dialed the rudder-trim knob to zero. He did not switch off the yaw damper. Colombi walked to the rear of the cabin and found other attendants hurt, sprawled on the galley floor.

A Frontier investigation revealed that the violent jet roll was caused by a type of yaw-damper malfunction which Frontier and United Airlines had been trying to eliminate for several years. An almost identical incident had occurred less than a week earlier near Bozeman, Mont., on the same airplane, with the same result: injured cabin attendants.

As early as 1969, Boeing had warned Frontier that stray electrical signals in the area where the yaw damper connects to the PCU could result in uncommanded movement of the rudder. A stray electrical signal could even hold the rudder at a deflected angle for a time. When the signal disappeared, the rudder would be released.

When Frontier mechanics examined Schow's plane, they discovered such a defect. Boeing service letters indicated the problem was caused by defective electrical components supplied by subcontractors. Other Boeing documents suggested problems could be caused by fluids seeping into the electronics-and-equipment bay, just beneath the forward galley, where the yaw damper and other electronics are housed.

Frontier determined that a defective electrical circuit caused Schow's rudder to "creep" 4 degrees to the right, the largest deflection a yaw damper could command on early-model 737s. (A full 737 rudder deflection is 26 degrees.)

Though Schow didn't know the yaw damper was holding his rudder deflected to the right, he compensated by "trimming" the rudder to the left.

As Colombi was bringing Schow coffee, the stray signal disappeared. In a company memo, E.G. McMillan, then Frontier's avionics-engineering manager, described what happened next: "The rudder suddenly returned to the neutral position, now displaced by the amount of trim which had been added. This action caused a sudden yaw in the aircraft."

Boeing addressed the problem highlighted by Schow's flight by recommending that airlines within two years reduce the yaw damper's authority - the extent to which it could adjust the rudder - to 2 degrees from 4 degrees.

Boeing engineers theorized an uncommanded 2-degree deflection would not be enough to disrupt flight.

The FAA did not feel the safety implications of Schow's flight were serious enough to order airlines to make the change in yaw-damper authority. It was left to the airlines' discretion, and the FAA did not track cooperation.

But Frontier didn't wait two years. The airline reduced yaw-damper authority to 2 degrees on its entire fleet within two weeks of receiving the Boeing recommendation, said former Frontier pilot Keith Sleater.

Nevertheless, he said, Frontier pilots continued to report 737s briefly veering out of control, even on airplanes limited to 2 degrees of yaw-damper authority.

"I've never personally had it happen to me, but I knew that it could give you a real sudden, violent swerve and that you'd need some room to recover," Sleater said.

In June 1986, one of the modified Frontier jets - not Schow's airplane - was sold to United Airlines and assigned tail No. N999UA.

On Feb. 25, 1991, N999UA, the airplane United had purchased from Frontier five years earlier, was leveling off at 12,000 feet. It suddenly yawed to the right for a few seconds, then returned to its normal heading. Before landing, the pilots switched off the yaw damper, and, as an extra measure of protection, pulled the yaw-damper circuit-breaker, removing power to the device.

Two days later, on Feb. 27, N999UA was climbing through 10,000 feet when the airplane jerked rapidly several times. The pilots continued to fly the jet past 25,000 feet, then felt a sharp, uncommanded yaw to the right lasting five to 10 seconds. After regaining control, the pilots switched off the yaw damper and pulled its circuit-breaker.

Four days later, on March 3, N999UA took off from Denver as Flight 585 and proceeded to Colorado Springs, where the jet, with Capt. Harold Green and First Officer Patricia Eidson at the controls, made a left turn on final approach to the runway.

Descending at about 500 feet, with its landing gear lowered, N999UA suddenly rolled sharply right. Green and Eidson reacted by revving the engines to full thrust and partially deploying wing panels, called flaps, in attempt to lift the airplane. In less than 10 seconds N999UA crashed, killing all 25 aboard.

The investigation that followed brought in an NTSB-directed committee of experts from Boeing, United, the Air Line Pilots Association and the FAA. Early in the probe, investigators found a loose wire in an electromagnetic switch, called a solenoid, used to transmit signals between the yaw damper and rudder PCU.

The NTSB cited this loose wire as evidence to explain both the Feb. 25 and Feb. 27 yaw-damper malfunctions on N999UA - incidents handled safely by the pilots at 12,000 and 25,000 feet, respectively - and to rule out the yaw damper as a probable cause in the low-altitude crash.

The NTSB said the loose connection created a stray, intermittent signal that could have caused erratic rudder movement.

But the NTSB agreed with Boeing investigators that such rudder deflections would have had "little or no effect on airplane controllability" since N999UA's yaw-damper authority was limited to 2 degrees.

When the NTSB issued its final report 22 months after the crash, no one pointed out that the same 2-degree yaw-damper deflection might have created what were described as "sudden" and "sharp" yaws in N999UA six and four days before the crash. In one case, the uncommanded yaw lasted 5 to 10 seconds - about the time in which N999UA went out of control and crashed.

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