

Log 2359



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: May 14, 1992

In reply refer to: A-92-31 through -35

Honorable Barry Harris
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20591

On December 12, 1991, about 0520 Eastern Standard Time (EST), a Boeing 747-100, operated by Evergreen International Airlines under contract to Japan Airlines, experienced an in-flight upset. The airplane, loaded with cargo and a crew of five, had departed Kennedy International Airport, New York, and was bound for Tokyo, Japan, with an intermediate stop in Anchorage, Alaska. When the airplane was approximately 150 nautical miles northeast of Thunder Bay, Ontario, in cruise at flight level (FL) 310, the crew noted that the inertial navigation system (INS) FAIL lights had illuminated. When the crew crosschecked the instrument panel, they determined that the airplane was in a steep right-wing-down bank. The flight lost approximately 10,000 feet of altitude, and the airplane approached supersonic speeds (0.98 Mach) before the recovery could be completed. The flight subsequently diverted to Duluth, Minnesota, and made a successful landing. There were no injuries.

The National Transportation Safety Board is assisting the Transportation Safety Board of Canada in the investigation of the incident. A report of the findings has not been released; however, the investigation has revealed safety issues that should be addressed by the Federal Aviation Administration.

At the time of the incident, the airplane was operating at 31,000 feet, at night, with the autopilot engaged. The crew did not notice the initiation of the roll and first noted a problem when the INS warning lights illuminated. They then noted that attitude reference instruments indicated a roll to the right with a bank angle in excess of 90 degrees. At the time the crew first noted the bank, there had been no navigational course change input that would have accounted for any turn. External visibility was limited at the time of upset because of darkness.

5708

Examination of flight data recorder information indicates that the airplane continued to roll right until a bank angle of approximately 95 degrees was attained. The airplane began to lose altitude and gain airspeed from approximately a 310 knot indicated airspeed (KIAS) cruise to 420 KIAS at recovery. Although the autopilot remained engaged during the event and was still controlling the airplane during the upset, the crew initiated the recovery by disengaging the autopilot, rolling the airplane to wings level, and initiating an approximate 3-g pullup. The crew jettisoned fuel to a level below the maximum approved landing weight while diverting to Duluth, Minnesota.

The airplane sustained structural damage during the event. A section of the forward inboard lower surface skin panel of the right wing had separated, and the leading edge of the right horizontal stabilizer was damaged by impact with departing wing debris. There was other damage involving the upper surface and trailing edge flaps of the right wing and minor left wing damage.

During the investigation of the Evergreen incident, the Canadian investigator leading the investigation learned of similar Boeing 747 in-flight upsets. On September 1, 1990, the flight crew of a Boeing 747-200, operated by Air Canada, reported an uncommanded roll of approximately 71 degrees bank angle while at cruise with a recovery pullup recorded at 1.8 g. Although the airplane encountered high speed buffet, the upset did not result in damage to the airplane or injury to passengers. Testing after the event determined that an autopilot roll computer had failed.

On April 30, 1989, a British Airways Boeing 747-136, while cruising at 31,000 feet en route from Miami to London, began a slow uncommanded roll that approached 52 degrees bank angle before the crew disengaged the autopilot. The airplane was not damaged, and no passengers were injured. The flight continued to its destination operating on the other channel of the autopilot. The autopilot failure was traced to a defective roll computer.

Following the Evergreen incident, the airplane's autopilot system was examined and tested. At the time of the upset, the crew reported that they were operating on the "A" channel of the system. Testing of the system on the airplane disclosed no anomalies. Subsequent testing of system components, including the roll actuator, roll computers, inertial navigation unit, airplane wiring, and connectors, indicated that the most likely cause of the upset was the "A" channel roll computer. Maintenance records at the roll computer manufacturer's facility indicated that the suspect computer had been returned for repair on three occasions. Two of the discrepancies were for faults described as uncommanded roll inputs. Testing is continuing to determine the cause of the uncommanded roll system upsets.

During the examination of the Boeing Model 747 autopilot system, it was determined that a failure in the autopilot system could cause the airplane to slowly roll into a bank. A roll rate induced from a failure of the autopilot system may be barely perceptible to the crew and may be difficult to detect without external visual attitude references or continuous close monitoring of

flight attitude instruments. Both the Evergreen and Air Canada events occurred while outside visual references were limited.

The Boeing 747-100, -200, and -300 series airplanes have similar autopilot system designs. The 747-400 model autopilot system was not evaluated during this investigation. The 747-400 autopilot design incorporates differences in design and may not be susceptible to the same failure modes.

Federal Aviation Administration certification standards address the autopilot systems in Title 14 Code of Federal Regulations (CFR) Part 25.1329. FAA Advisory Circular (AC) 25.1329-1A also sets forth acceptable means of compliance with the intended certification requirements. AC 25.1329-1A states, in part, that:

A three-second delay between airplane response and pilot corrective action has been considered acceptable in certification demonstrations. The first indication a pilot has of a malfunction is the deviation of the airplane from the intended flight path, abnormal control movements, or a reliable failure warning system. Present operating procedures require that at least one pilot monitor the behavior of the airplane and associated autopilot performance at all times. The three-second delay applied in normal climb, cruise, descent, [is a] reasonable delay [time], provided that pilot recognition of the malfunction is the basis of these time delays.

The Safety Board is concerned that the slow onset of the roll induced by the autopilot system failure may go undetected by the flightcrew beyond the 3-second recognition time and ultimately result in the airplane exceeding normal flight attitude bank angles that may result in loss of control. The recognition of the fault may be exacerbated by limited visibility for external attitude reference. Further, it is apparent that under long-range cruise conditions, flightcrews might relax their vigilance and not recognize and react to the slow roll onset in sufficient time to prevent loss of control. Although the known reported upsets have not resulted in injuries to passengers or crew, the Safety Board believes that the upsets noted above and the damage sustained by the Evergreen B-747 indicate that the potential exists for loss of an airplane as a result of undetected autopilot system failures.

Therefore the National Transportation Safety Board recommends that the Federal Aviation Administration:

Review the Boeing 747 series autopilot system designs and installations to identify all possible failure modes that could generate autopilot flight control commands that would cause the airplane to initiate an uncommanded roll. Following the completion of the review, implement design changes to prevent or limit excursions of the airplane as a result of any

autopilot system malfunctions or failures. (Class II, Priority Action)(A-92-31).

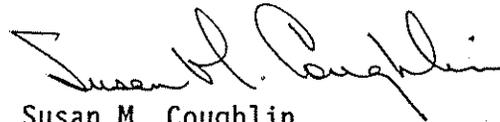
Issue an airworthiness directive to require the installation of devices in Boeing 747 series airplanes that provide aural and visual warnings of bank angles that exceed normal flight attitudes. (Class II, Priority Action)(A-92-32).

Issue an air carrier operations bulletin to principal operations inspectors to advise Boeing 747 operators of the potential for a slow roll input in the event of an autopilot system failure. (Class II, Priority Action)(A-92-33).

Review in-flight incident data for all transport-category airplanes in an effort to determine if similar potential autopilot failure conditions exist with other airplanes and issue the appropriate directives. (Class II, Priority Action)(A-92-34).

Revise Advisory Circular 25.1329-1A to add guidance regarding autopilot failures that can result in changes in attitude at rates that may be imperceptible to the flightcrew and thus remain undetected until the airplane reaches significant attitude deviations. (Class II, Priority Action)(A-92-35).

COUGHLIN, Acting Chairman, and LAUBER, HART, HAMMERSCHMIDT, and KOLSTAD, Members, concurred in these recommendations.



By: Susan M. Coughlin
Acting Chairman