National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation 2718

Date: March 15, 1990

In reply refer to: A-90-12 through -15

Honorable James B. Busey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On May 21, 1988, a McDonnell Douglas Corporation DC-10-30 (American Airlines flight AA70, N136AA) overran runway 35L during a rejected takeoff (RTO) at the Dallas-Fort Worth International Airport, Texas. No fire occurred, but the airplane was damaged beyond economical repair. The first officer and flight engineer sustained serious injuries, and the captain sustained minor injuries during the accident. An inspector with the Federal Aviation Administration (FAA), who occupied the jumpseat, and 11 flight attendants were not injured. Of the 239 revenue passengers, 5 sustained minor injuries during the emergency evacuation.

The captain of the airplane executed the RTO following the sounding of a takeoff warning horn and the illumnation of the slat disagree light. The warning occurred almost simultaneously with the V1 (takeoff decision speed) call, and the crew responded immediately to reject the takeoff.

In response to the RTO procedures followed by the flightcrew, the airplane decelerated normally for 5 to 6 seconds, slowing from a 178-knot maximum ground speed to about 130 knots ground speed. The deceleration then decayed rapidly, and the loss of decelerative force resulted in the airplane departing the end of the runway at about 97 knots. The nose gear collapsed in soft ground, and the plowing action of the nose slowed the airplane to a stop about 1,000 feet beyond the end of the runway.

The National Transportation Safety Board determined that the cause of the accident was total brake failure in 8 of the 10 wheel brakes as a result of inadequate certification and test procedures. The Safety Board also determined that the slat disagree warning contributed to the accident of AA70; the leading edge slats, contrary to what the warning system indicated, and trailing edge flaps were symmetrical and properly configured for the takeoff. The reason for the slat disagree warning has not been positively determined; the Safety Board believes, however, that it was a nuisance warning and resulted from an overly restrictive tolerance of the position monitoring switch sensor combined with air loads imposed on the left outboard leading edge slat.

A takeoff warning indication during the high speed portion of a takeoff roll, whether or not it occurs near the V1 call, can prompt a pilot to reject a takeoff with potentially critical results. The Safety Board therefore believes that the slat disagree logic of the DC-10 airplane takeoff warning system should be redesigned as necessary to reduce, to the extent possible, the probability of a nuisance warning. Consequently, the Safety Board issued the following Safety Recommendation to the FAA on July 11, 1988:

A-88-77

Require that McDonnell Douglas Corporation redesign the flap/slat disagree logic of the DC-10 airplane (all models) takeoff warning system as necessary to eliminate the probability of a nuisance warning.

In a letter to the Safety Board on December 22, 1988, the FAA responded to the Safety Recommendation A-88-77 by stating, in part:

> The slat rigging, proximity switches, and proximity switch targets (from AA70) were checked and all were found to be installed properly within specified tolerances.
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> In June 1984, Douglas Service Bulletin 27-195 (and subsequently Airworthiness Directive AD 85-17-02) was released and intended to reduce the probability of nuisance slat disagree indications during takeoff because of rigging variations or proximity switch target tolerances.
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> In the 3 years prior to the release of the service bulletin, 69 cases of slat disagree lights were reported to Douglas. Subsequent to the issuance of AD-85-17-02, i.e., between November 1985 and June 1988, there have been six reports of slat disagree lights. Four of the reports were due to improper control system rigging; one was due to wiring; and the cause of the sixth case (the subject accident) is currently unknown. Nuisance warnings could come from problems in wiring, connectors, computers, or sensors.

On May 23, 1989, the Safety Board responded, in part:

> In spite of the FAA use of the AD as a solution, the Safety Board continues to believe that a redesign is necessary. One of the six incidents referenced in the FAA letter resulted in the loss of a DC-10 airplane, and prompted the Safety Board's safety recommendation. McDonnell Douglas Corporation has proposed that the master caution and warning system logic for slat disagreement for the new MD-11 airplanes be designed to preclude non-critical warnings during the high speed portion of the ground run and initial climb phase of take off. Such logic probably would have prevented the subject accident. Although the Safety Board would like the FAA to reexamine this issue, the Safety Board has classified Safety Recommendation A-88-77 as "Closed--Unacceptable Action" based on the FAA's response that it plans no further action on the safety recommendation.

The Safety Board remains concerned that nuisance slat disagree warnings continue to occur, even though the McDonnell Douglas service bulletin and the FAA airworthiness directive have cut the rate of the nuisance warnings. The increase in the tolerances of the warning devices, however, has not eliminated the nuisance warnings attributed to rigging or tolerance errors. As recently as January 11, 1990, a DC-10 airplane had a series of slat disagree nuisance warnings. In addition, after extensive review of the hardware from AA70, an out-of-tolerance condition remains a prime suspect in that nuisance warning.

The Safety Board believes that an additional substantial increase in the tolerance of slat disagree warning system can further reduce the probability of nuisance warnings without affecting the airplane's safety in flight. According to McDonnell Douglas, flight tests and simulations indicate that the airplane would have been controllable with asymmetrical outboard slats if the flightcrew had continued the takeoff. The inboard slats are cable bussed to assure symmetrical motion.

McDonnell Douglas states that either set of outboard slats could have fully deployed or retracted asymmetrically from the takeoff slat position and the airplane would have been controllable from V1 through climbout as long as the trailing edge flaps were properly extended and the wing-mounted engines were developing symmetrical thrust. The chief test pilot at McDonnell Douglas stated that controlling an asymmetric outboard slat condition is much less difficult than maintaining control with a loss of thrust from a wing-mounted engine. In other words, asymmetric outboard slat movement would not affect the safety of the takeoff. Tolerances in the slat disagree warning system could be greatly expanded or even eliminated for the short period of time at the critical high speeds immediately prior to takeoff.

As a result of its investigation of AA70, the Safety Board again recommends that the slat disagree logic of the DC-10 takeoff warning system be redesigned.

The Safety Board also realizes that DC-10 pilots probably are not aware of the performance of the airplane with asymmetric leading edge slat extension and that the pilots may believe that the airplane would be uncontrollable during the takeoff with asymmetric slats. This belief might be a result of their knowledge of a specific accident 1/ in which other circumstances combined with asymmetric slats resulted in a loss of control.

As a result of several accident or incident investigations, the Safety Board has attempted to examine the history of RTOs. However, RTOs that result in accidents are rare and, therefore, the limited data base precludes a meaningful examination of the event. In addition, comprehensive data are not gathered for RTOs that are successful because reports of the event are not required.

1/ Aircraft Accident Report: American Airlines, Inc. DC-10-10, N110AA, Chicago, Illinois, May 25, 1979, NTSB-AAR-79-17.

The Safety Board believes that a high speed, high energy RTO is a dangerous maneuver and that a comprehensive data base on RTOs would be a useful source of information that could provide a clearer understanding of the degree of risk associated with RTOs. The current requirement for reporting engine failures has proven to be valuable by promoting timely corrective actions to various problems.

In the absence of a comprehensive data base of RTOs and nuisance warnings, the Safety Board believes that a review of the relationship between nuisance warnings in the takeoff warning system and RTOs is warranted for turbojet transport category airplanes. Therefore, it recommends that the FAA undertake a directed engineering study of the takeoff warning systems and the relationship to RTOs of all turbojet transport category airplanes currently in service. In addition, the Safety Board recommends that the FAA establish reporting requirements for high energy RTOs involving turbojet category airplanes and establish an appropriate data base for the information.

As a result of its investigation of AA70, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require that McDonnell Douglas Corporation redesign the flap/slat disagree logic of the DC-10 airplane (all models) takeoff warning system as necessary to reduce the probability of a nuisance warning. (Class II, Priority Action) (A-90-12)
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> Review and revise, as necessary, takeoff warning system designs and design guidelines to reduce the potential for nuisance and noncritical alarms at high speeds to reduce the number of unnecessary high speed rejected takeoffs of turbojet transport category airplanes. (Class III, Longer Term Action)(A-90-13)
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> Establish reporting requirements, a reporting system, and a data base on successful and unsuccessful high energy rejected takeoffs of transport category airplanes. (Class III, Longer Term Action)(A-90-14)
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> Confirm that the DC-10 airplane is flyable during a takeoff with asymmetric outboard leading edge slats; if valid, require air carrier operators to implement a training program for all DC-10 pilots that emphasizes that the DC-10 airplane is flyable with asymmetric outboard leading edge slats. (Class II, Priority Action)(A-90-15)

KOLSTAD, Chairman, COUGHLIN, Acting Vice Chairmin, BURNETT and LAUBER, Members, concurred in these recommendations.

By: James Kolstad
Chairman