



# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

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Date: January 9, 1990

In reply refer to: A-89-121 thru -130

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

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About 0901 central daylight time on August 31, 1988, Delta Air Lines, Inc., flight 1141, crashed shortly after lifting off from runway 18L at the Dallas-Fort Worth International Airport, Texas. The airplane, a Boeing 727-232, U.S. Registry N473DA, was a regularly scheduled passenger flight and was en route to Salt Lake City, Utah.

The flightcrew reported that the takeoff roll appeared to be normal in all respects, with no warning lights, audible warnings, or unusual engine instrument conditions. The captain stated that the rotation was initially normal, but as the main gear wheels left the ground he heard "two explosions." He said it felt as though the airplane was experiencing "reverse thrust." The captain stated that the airplane began to "roll violently."

The airplane struck the instrument landing system (ILS) localizer antenna array approximately 1,000 feet beyond the end of runway 18L, and came to rest about 3,200 feet beyond the departure end of the runway. The flight was airborne approximately 22 seconds from liftoff to the first ground impact near the ILS localizer antenna. The airplane was destroyed by impact forces and the postcrash fire. Of the persons on board flight 1141, 12 passengers and 2 crewmembers were killed, 21 passengers and 5 crewmembers were seriously injured, and 68 passengers sustained minor or no injuries.<sup>1</sup>

The Safety Board's investigation determined that the flightcrew did not properly configure the wing flaps and slats prior to the attempted takeoff. With the wing flaps and slats in the retracted or 0° position, the airplane did not develop sufficient lift to climb and maintain flight.

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<sup>1</sup>For more detailed information, read Aircraft Accident Report--"Delta Air Lines, Inc., Boeing 727-232, N473DA Dallas/Fort Worth International Airport, Texas, August 31, 1988" (NTSB/AAR-89/04).

The investigation found that the takeoff warning system did not function during the attempted takeoff. Inspection of the takeoff warning system switch, mounted to the No. 3 engine autothrottle clutch assembly, noted a corrosion-type substance surrounding the switch terminals. Additionally, the tab to which the switch actuation button was attached was bent such that it might be possible for the actuator button to slide past the switch plunger.

The investigation noted that the Boeing service manual and Boeing service bulletin 727-31-30 are not consistent regarding adjustment of the switch. Revision 4 of the service bulletin, which was applicable at the time of the accident, stated that the tab adjustment of the switch may be bent to adjust for the correct switch operating point. There is no limit given for the amount of bending adjustment possible. The maintenance manual, dated January 20, 1985, states not to bend the actuator tab more than  $\pm 1/4^\circ$  from the plane of the actuator arm and that adjustments are to be made by moving the switch body in the slotted switch support mount.

The investigation noted that it is possible to bend the adjustment tab without visually checking that the actuator button and the switch plunger are making contact over the majority of their surfaces. Thus it is possible for maintenance personnel, who are not aware of the limitations stated in the maintenance manual, to bend the tab to the point that the button and plunger no longer make firm contact while attempting to adjust the activation of the warning system. This would explain why the tab of the switch from the accident airplane was found bent well past the limits given in the maintenance manual.

The Safety Board's investigation found that (1) the switch did not electrically close during the first two attempts at the accident site; (2) successful activations of the switch during the teardown investigation was "hit-or-miss" due to the positioning of the actuator button to the switch plunger; and (3) the internal contacts of the switch showed contamination.

Additionally, the Safety Board found that 3 weeks prior to the accident, the aural warning horn had been written up in the airplane's maintenance records in the "A2" inspection as being weak and intermittent. The corrective action taken by maintenance personnel was to replace the aural warning horn and test the system. The removed unit was taken to the repair shop where its contacts were cleaned and functionally tested. The unit was found to function properly and was sent to the spare parts inventory.

The Safety Board's investigation could not determine if, at the time that the aural warning horn was replaced, all components of the takeoff warning system were inspected to verify that indeed the warning horn was the cause of the intermittent operation. Discussions with maintenance personnel disclosed that the warning horn is readily accessible and easily replaced. Therefore, it normally is the first component of the system to be removed and replaced by a serviceable unit from the spare parts inventory. If the system then functions properly, most likely no further work or troubleshooting needs to be accomplished. While such a procedure is expedient, it does not assure that an intermittent condition has, in fact, been corrected because the other components of the system have not been checked. Therefore, the possibility exists that the aural warning horn was not the cause of the problem and because other components

in the system were not tested after the unit was replaced, the real cause of the problem may well have gone undetected.

Therefore, the evidence suggests that there was an intermittent problem in the takeoff warning system that was not detected and corrected during the last maintenance action. This problem could have manifested itself during the takeoff of flight 1141, and thus the flightcrew was not provided with the aural warning of misconfigured airplane which is the function of the takeoff warning system.

The Safety Board believes that significant problems regarding the reliability of the takeoff warning system in the Boeing 727 were discovered during the investigation. Therefore, it recommends that the FAA undertake a directed engineering study of the takeoff warning systems in the Boeing 727 series airplanes. Additionally, the Safety Board believes that modifying the Boeing 727 checklists to require testing of the takeoff warning system prior to each flight would significantly increase flight safety.

The investigation noted that as a result of a takeoff accident involving a DC-9-82,<sup>2</sup> the FAA issued Air Carrier Operations Bulletin (ACOB) No. 8-88-4. This bulletin specified action to be taken by principal inspectors to review overall takeoff warning system performance; i.e., test the systems, ensure that each carriers procedures are consistent with airplane manufacturers' current recommendations, and ensure that the checklists appropriately support required crew actions for each of their assigned carriers. The bulletin was approved by FAA headquarters in June 1988. The flight standards district office (FSDO) responsible for Delta received the bulletin on August 30, 1988. FAA official testified that the delay from the approval of the bulletin to its arrival at the district office was attributed to normal processing and publication time. The principal operations inspector (POI) for Delta testified that the bulletin reached his desk on September 5, 1988, and was put in the mail to Delta on September 14, 1988.

The Safety Board believes that if this ACOB had been processed more expeditiously, it is possible that the intermittent failure of the stall warning system would have been detected. Therefore, the Safety Board believes that the ACOB distribution procedures should be improved such that they reach the principal inspectors and airline officials in a more timely manner.

The Safety Board's investigation concluded that the accident may have been prevented if the captain had taken a more active role in running the cockpit. Additionally, the investigation found that the cockpit discipline problems noted on flight 1141 were not isolated to this cockpit. These problems were previously observed and reported to Delta in FAA inspection reports. However, neither FAA nor company management initiated sufficient corrective action. In its report of the DC-9-82 accident, previously cited, the Safety Board observed almost identical cockpit management shortcomings. As a result of that accident, the Safety Board observed that the FAA should require its operations inspectors and

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<sup>2</sup>For more detailed information, read Aircraft Accident Report--"Northwest Airlines, Inc., McDonnell-Douglas DC-9-82, N312RC, Detroit Metropolitan Wayne County Airport, Romulus, Michigan, August 16, 1987" (NTSB/AAR-88/05).

designated check airmen to emphasize the importance of disciplined application of operating procedures and rigorous adherence to prescribed checklist procedures (Safety Recommendations A-88-69 and A-88-71). Based upon the accident involving flight 1141, the Safety Board reiterates its conviction of the need for rigorous FAA surveillance of training programs that emphasize cockpit management procedures and the use of Cockpit Resource Management programs.

With respect to the issue of checklist discipline, there is no evidence that the intent, presentation, and execution of checklists at Delta were significantly different than at any other airline company in the industry. Procedures were in place that provided for an orderly execution of all required items; i.e., the captain was required to ask for the appropriate checklist to be completed and the first and second officers were expected to accomplish the items on the checklist or verify that they had been accomplished. Because of the repetitive nature of checklist accomplishment and the fact that the required response to checklist items is most often the same (i.e., flaps are usually set at 15° for takeoff; there always is a green light associated with the slat setting), it is very easy for crewmembers to fall into a habit of reciting checklist challenge and response items by rote and providing a response to a challenge on the basis of what should be the proper response rather than the actual condition of the system that was queried. Examples of such mistakes were brought out at the public hearing when both the first and the second officers recounted instances of responses to flap position challenges being given on the basis of expectations rather than reality. The Safety Board believes that this accident once again points out the paramount importance of cockpit discipline in the accomplishment of checklists. Because there is no ideal way for management to monitor individual performances of crewmembers in a cockpit, standard operating procedures and checklists are developed as a means for crewmembers to self-monitor their performance.

Therefore, principal operations inspectors should review the operations manual of their assigned carriers and ensure that the manuals clearly state the roles of each flight crewmember in visually confirming the accomplishment of all operating checklist items, especially those checklist items considered "critical" to flight.

The Safety Board's investigation into FAA surveillance of Delta sought to identify existing boundaries of responsibility of the POI regarding the level of regulatory compliance and the quality of operations demonstrated by the assigned air carrier. During this investigation, evidence of accountability of the POI and the district office for the performance of the assigned carrier(s) was not apparent. Evidence suggests that FAA surveillance and inspection programs and the in-house evaluation of POI performance have no relationship to each other. The POI's performance seems to be related only to the quantity of work and the ability to handle approvals smoothly and directly. The Safety Board is concerned that the POI has the authority to approve critical areas of air carrier operational programs without being held responsible for those approvals. There does not appear to be a recurring qualitative assessment of POI approvals by FAA management.

The FAA's followup of the 1986 National Aviation Safety Inspection Program (NASIP) inspection is also indicative of a lack of POI accountability. The negative findings of an airline operational inspection become the responsibility of the POI to promote and monitor corrective action. Thus, the POI, in effect, becomes the arbiter of his own shortcomings, with no assessment being made by outside interests of the quality of the corrective action. Therefore, the accountability for the ongoing quality of the POI's work performance does not appear to exist.

It appears that the current surveillance system can lead to rubber stamp approvals of an air carrier's operations and maintenance programs. Improvements are needed to encourage and support the POI's efforts to secure compliance and to promote upgraded levels of performance by the assigned air carrier in both pilot training and crew coordination areas. Without such improvements, the system of program approval can be driven by the momentum and interests of the air carrier. It appears the present system is sustained by the personal motivation and dedication of the concerned FAA inspector personnel rather than by an FAA system that includes internal oversight of itself and its inspection workforce. It is apparent that the need exists for a program of FAA management emphasis on the accountability of its POIs. In addition, there is a need for a program which standardizes the approvals of air carrier operations programs in order to promote a uniform and acceptable level of safety performance in the current competitive air carrier industry.

Though not causal to the accident, the Safety Board is concerned about the procedures used in refueling flight 1141. The investigation found that the No. 1 main fuel tank quantity indicator was inoperative and that the airplane was dripstick and level checked in order to determine the amount of fuel to add to each tank. The airplane was not dripstick after refueling. After the airplane was fueled, it would have been prudent to have had the fuel tanks dripstick once again and the level of the airplane verified. The Safety Board is concerned that with an inoperative fuel gauge it is possible that the airplane could have been incorrectly fueled, i.e., too much or too little fuel in the No. 1 fuel tank. Such a situation could cause the airplane to be laterally unbalanced or not have sufficient fuel for the flight. Therefore, it is recommended that the FAA require that whenever an airplane operating under 14 CFR Parts 121 or scheduled 135 is allowed to fly with an inoperative fuel quantity gauge, that dipstick, dripstick, or other appropriate measurements of fuel quantity are taken, and that the level of the airplane is taken into consideration.

As part of the Safety Board's investigation of this accident, it examined the issue of airline flight safety programs. This issue was explored primarily during testimony at the Safety Board's public hearing. The purpose of this effort was to elicit industry views about the purpose of, the need for, and the conceptual framework for an airline flight safety program. No attempt was made to compare Delta Airlines' program with other airlines or with any other standard. Further, no correlation was drawn between the events that led up to the accident involving flight 1141 and the viability of Delta's safety program. In general, the Safety Board's objective was to raise an awareness about the issue of airline flight safety programs as a starting point for possible improvements in the future.

The Safety Board believes that an accident or other unsafe incident is really a symptom of a failure somewhere in the system. It is traditionally reported from airline accident statistics that about 80% of airline accidents result from flightcrew errors. For this reason alone, it seems appropriate that the flight operations department needs an audit or redundant organizational function responsible for flight safety. It is easily recognized that the person(s) responsible for flight safety within the flight operations department, such as the Chief Pilot, the Director of Training, and the Director of Flight Operations, may not be able to recognize or admit personal or organizational shortcomings within his/her own programs. There is a real possibility that objectivity may suffer. However, an independent safety officer, who reports to the top manager of the airline, would be in an excellent position to provide objective views of possible safety problems within the flight operations department.

The Safety Board believes that the FAA should initiate a joint airline industry program to develop guidelines and regulatory provisions for airline flight safety programs. It seems logical that the same rationale that requires the separation of maintenance and inspection departments and the quality assurance ("second set of eyes") function in airline maintenance should be applied to flight operations. Similarly, the provisions for specific management positions and qualifications of those managers contained in the extant regulations should be developed for flight safety. That is, the regulations should specify the need for a qualified safety officer and flight safety program at airlines, and separation of management oversight of these two important functions. Further guidance by means of an FAA Advisory Circular, which outlines the structure, functions, and responsibilities of such a program, should be developed. The guidance and regulatory provisions would then provide a means by which the FAA could evaluate an airline's safety performance other than by accidents and incidents.

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

Require that principal operations inspectors review the operations manuals of their assigned carriers and ensure that the manuals clearly state the roles of each flight crewmember in visually confirming the accomplishment of all operating checklist items, especially those checklist items considered "critical" to flight. (Class II, Priority Action) (A-89-121)

Direct all principal operations inspectors to review the training and operations manuals of their assigned air carriers and ensure that the verification of flap position during stall recognition and recovery procedures is a part of those procedures. (Class II, Priority Action) (A-89-122)

Modify National Aviation Safety Inspection Program inspection procedures to ensure that following safety inspections of Part 121 air carriers, deficiencies are corrected expeditiously and that the leader of the inspection team is made part of the evaluation of the proposed actions. (Class II, Priority Action) (A-89-123)

Require 14 CFR Part 121 operators to develop and use Cockpit Resource Management programs in their training methodology by a specified date. (Class II, Priority Action) (A-89-124)

Perform a directed engineering study of the takeoff warning system(s) in the Boeing 727 model airplanes, with special emphasis on the takeoff warning system throttle switch installation. The study should evaluate the reliability, maintainability, and methods to improve the design of the system. (Class II, Priority Action) (A-89-125)

Issue an Airworthiness Directive to require modification of the takeoff warning system in the Boeing 727 model airplanes based upon the results of the directed engineering study. (Class II, Priority Action) (A-89-126)

Modify the Boeing 727 checklists to require flightcrews to check the operation of the takeoff warning system prior to each flight. (Class II, Priority Action) (A-89-127)

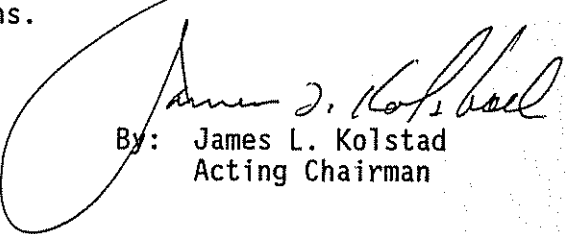
Modify Air Carrier Operations Bulletin (ACOB) distribution procedures to expedite the approval and transmission of ACOB's to the principal inspectors and airline officials. (Class II, Priority Action) (A-89-128)

Direct principal operations inspectors to inspect their air carriers operating under 14 CFR Parts 121 or scheduled 135 as to procedures for refueling with an inoperative fuel quantity gauge and require, as necessary, that these air carriers modify their refueling procedures to require dipsticking, dripsticking, or have other appropriate measurements of fuel quantity taken, with consideration given to the level of the airplane. (Class II, Priority Action) (A-89-129)

Initiate a joint airline industry force to develop a directed approach to the structure, functions, and responsibilities of airline flight safety programs with the view toward advisory and regulatory provisions for such programs at all Part 121 airlines. (Class II, Priority Action) (A-89-130)

Also, the National Transportation Safety Board issued Safety Recommendations A-89-131 and -132 to the American Association of Airport Executives and the Airport Operations Council International, Inc., and A-89-133 and -134 to the National Fire Protection Association.

KOLSTAD, Acting Chairman, BURNETT, LAUBER, NALL, and DICKINSON, Members, concurred in these recommendations.

  
By: James L. Kolstad  
Acting Chairman