



# National Transportation Safety Board

Washington, D.C. 20594  
Safety Recommendation

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Date: June 3, 1993

In reply refer to: A-93-57  
through -60

Mr. Joseph M. Del Balzo  
Acting Administrator  
Federal Aviation Administration  
Washington, D.C. 20591

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On August 2, 1992, a McDonnell Douglas MD-11, operated by Delta Airlines, sustained damage to the underside of the aft fuselage as a result of contact with the runway when the aircraft pitched nose up after landing at Los Angeles International Airport. There were no injuries to the occupants of the airplane. Examination of the airplane revealed that the aft pressure bulkhead lower left and right-hand caps were bent and the lower centerline web was buckled. The airplane was later ferried to Atlanta for repairs, where it again pitched nose up after landing. The pitching moment was corrected before the tail contacted the runway.

In both cases, the crews reported that the aircraft nose pitched up suddenly after main gear contact and that they believed that this was a result of full ground spoiler deployment before nose gear contact.<sup>1</sup> However, data from the flight data recorders (FDRs) from both incidents indicate that the ground spoilers functioned properly and that pilot elevator control inputs made after the nose gear contacted the runway resulted in the aircraft pitching up excessively. McDonnell Douglas records indicate that there have been 21 DC-10 tail strike landing incidents reported over 18 years and 3 MD-11 tail strike landing incidents reported over 1 and 1/2 years. Several of the incidents resulted in structural damage to the tail section and aft pressure bulkheads of the aircraft. More than 90 percent of the incidents were attributed to pilot over-rotation of the aircraft as a result of

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<sup>1</sup>The MD-11 and the McDonnell Douglas DC-10 are configured with spoilers on the upper surface of the wing which serve as ground spoilers during landing. The MD-11 ground spoilers are designed to deploy to approximately 30° when the main gear wheel speed reaches 80 knots and to deploy to approximately 60° when the nose gear touches the ground. The DC-10 ground spoilers are designed to deploy partially to approximately 22° in the first .4 seconds after main gear contact, pause .4 seconds, then deploy fully to approximately 60° in the next .4 seconds (with the exception of some late model DC-10s that were built with the MD-11 spoiler logic). The MD-11 and DC-10 both experience a nose-up pitching moment during landing when the ground spoilers partially deploy. Full deployment of the ground spoilers induces a significantly greater nose-up pitching moment in both airplanes.

improper elevator control inputs after touchdown. Although both the DC-10 and MD-11 have the propensity for tail strikes, the damage to the structure may be more significant on the MD-11 due to the length of its aft fuselage and the location of the aft pressure bulkhead where it could be damaged by tail strikes.

The Safety Board believes that the large number of DC-10 and MD-11 tail strike incidents indicates inadequate pilot training. The Safety Board has reviewed the landing procedure portion of the McDonnell Douglas MD-11 Flight Crew Operating Manual (FCOM) and has found that the only flying techniques described between main gear touchdown and nose gear contact is, "Fly the nose to the runway." The Delta MD-11 Pilot's Reference Manual (PRM) has a flight training section that contains landing roll procedures similar to those in the McDonnell Douglas FCOM and a brief description of the MD-11 spoiler deployment sequence after touchdown. However, the Delta MD-11 PRM does not discuss the associated nose-up pitch tendencies or related control inputs.

Discussions with McDonnell Douglas and Delta MD-11 instructor pilots revealed that although the FCOM contains no written description of the ground spoiler-induced nose-up pitch tendency or specific procedures to be used during the landing, instructors normally inform pilots training on the MD-11 of the ground spoiler-induced nose-up pitching tendency of the airplane and instruct pilots about more specific landing procedures. Safety Board investigators were told by McDonnell Douglas and Delta that their MD-11 and DC-10 pilots are taught that slight nose-down elevator inputs must be made after main gear contact in order to develop the proper nose-down pitch rate and that sufficient nose-down elevator inputs must be made after nose gear contact and full spoiler deployment to keep the nose on the ground during the high speed portion of the rollout. The above procedure is not described in the MD-11 FCOM.

The landing roll portion of the McDonnell Douglas DC-10 FCOM contains a brief note describing the nose-up pitching tendency induced by the ground spoilers and the fact that nose-down elevator control inputs can counter the tendency. The DC-10 FCOM is not specific in terms of when the tendencies might be encountered. The Safety Board believes that a more accurate and complete description of the ground spoiler-induced nose-up pitch tendency and the specific procedural requirements for a hand-flown landing should be included in both the DC-10 and MD-11 FCOMs and not reserved for dissemination only during classroom, simulator, or in-flight training. McDonnell Douglas has indicated its intent to revise the MD-11 FCOM accordingly.

In their current configurations, the MD-11 and DC-10 permit partial ground spoiler deployment regardless of pitch angle and permit full ground spoiler deployment as soon as the nose gear strut compression is sensed without requiring a period of continuous nose gear strut compression.

McDonnell Douglas has informed the Safety Board that its in-house motion-based simulator of the MD-11 has recently been modified to include the pitching moment characteristics of the airplane with ground spoiler deployment. Similarly, this software modification was expected by McDonnell Douglas to be added to all MD-11 simulators in the first quarter of 1993.

The FDR data from the two Delta MD-11 incidents discussed above and from several previous incidents suggest that the number of MD-11 and DC-10 tail strikes during the landing phase might be significantly reduced if the ground spoiler deployment logic were revised such that if the aircraft touches down at a pitch angle close to the tail strike pitch angle, initial partial ground spoiler deployment should not occur until the pitch angle falls below a specified angle. In addition, nose gear strut compression status<sup>2</sup> should be maintained long enough to ensure that the nose wheel is firmly on the ground and has not just momentarily touched the ground before full deployment of ground spoilers occurs.

The Safety Board recognizes that landing/braking performance and other issues need to be considered before effecting any of the ground spoiler logic revisions discussed above.

The Safety Board has found that several DC-10 and MD-11 landing and takeoff<sup>3</sup> tail strike incidents were not reported or even noticed by the flightcrew until ground maintenance personnel observed damage to the tail structure of the airplanes. Because substantial structural damage can be incurred during a tail strike without flightcrew knowledge, the Safety Board is concerned that an airplane that is damaged during landing (and that possibly sustains damage to the aft pressure bulkhead) could be dispatched and a catastrophic failure could occur in flight. The Safety Board believes that some positive means of tail strike indication should be made available to the flightcrew and ground maintenance personnel which would be visible, in all weather conditions, during the preflight inspection of the airplane. This could be accomplished by use of an external probe placed strategically under the tail surface. Further, a system that would provide a cockpit indication of a tail strike should be evaluated as a means of alerting the flightcrew of the possibility of damage to the aft fuselage.

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

Require McDonnell Douglas and U.S. operators of the DC-10 and MD-11 airplanes to revise their DC-10 and MD-11 Flight Crew Operating Manuals (or equivalent documents) to include an accurate and complete description of the ground spoiler-induced nose pitch-up tendencies of the airplanes and the specific pilot control techniques that may be required to counter those tendencies during landing. (Class II, Priority Action) (A-93-57)

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<sup>2</sup>Nose gear strut compression status indicates whether or not nose gear strut compression has occurred. The flight control computer uses this status to determine when to command full spoiler deployment.

<sup>3</sup>A tail strike on takeoff might cause significant damage, yet be undetected by a crew in flight. At least three incidents of tail strikes during takeoff involving DC-10 and KC-10 with moderate damage to the underside of the aircraft have been recorded by McDonnell Douglas.

Advise foreign airworthiness authorities of the ground spoiler-induced pitch-up tendencies of the DC-10 and MD-11 airplanes and advise them to include in Flight Crew Operating Manuals, or equivalent documents, an accurate and complete description of the ground spoiler-induced nose pitch-up tendencies of the airplanes and the specific pilot control techniques that may be required to counter those tendencies during landing. (Class II, Priority Action) (A-93-58)

Require McDonnell Douglas to study possible revisions to the DC-10 and MD-11 ground spoiler deployment logic to reduce the possibility of landing tail strikes. The revisions should include, but not be limited to, the following general concepts: if the aircraft touches down at a pitch angle close to the tail strike pitch angle, initial partial ground spoiler deployment should not occur until the pitch angle falls below a specified angle; and, nose gear strut compression status should be maintained long enough to ensure that the nose wheel is firmly on the ground, and has not just momentarily touched the ground, before full deployment of ground spoilers occurs. (Class II, Priority Action) (A-93-59)

Require McDonnell Douglas to develop and install a positive means of tailstrike indication to alert flightcrews and maintenance personnel to the possibility of tailstrike damage during the preflight inspection of DC-10 and MD-11 airplanes. In addition, evaluate cockpit warning systems that would alert flightcrews to the possibility of tail strike damage to prevent continued operation of the airplane following such damage. (Class II, Priority Action) (A-93-60)

Chairman VOGT, Vice Chairman COUGHLIN, and Members LAUBER, HART, AND HAMMERSCHMIDT concurred in these recommendations.

  
By: Carl W. Vogt  
Chairman