



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: September 4, 2003

In reply refer to: A-03-41 through -44

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

Background

On November 17, 2002, at 1800 eastern standard time, a Canadair CL-600-2B19 (CRJ-2), N868CA, operated by Comair as Delta Connection flight 5109, a scheduled passenger flight from Atlanta, Georgia, to Washington, D.C., encountered severe turbulence while in a descent near Rockville, Virginia. There were no injuries to the crew or passengers. The airplane was returned to revenue service on November 18, 2002, after it was visually inspected for damage in accordance with the procedures for severe turbulence or extreme maneuvers outlined in the Canadair Regional Jet (CRJ) Aircraft Maintenance Manual (AMM).

The National Transportation Safety Board's examination of information from the flight data recorder (FDR) indicated that large vertical accelerations occurred during the turbulence event. Further analysis by Canadair indicated that during the event, the wing, pylon, and horizontal stabilizer to vertical stabilizer attachment structure experienced loads outside their certificated design envelopes. Specifically, this analysis revealed that the airplane experienced vertical accelerations ranging from 4.3 G¹ positive to 1.9 G negative, resulting in internal loads well in excess of the certificated limit load² for these structural components. The inspection procedures in the CRJ AMM define a minimum positive G threshold, depending on the airplane's gross weight, above which a visual inspection for damage is required in order to return the airplane to service. For an airplane at the approximate gross weight of the incident airplane, the AMM requires that inspections be performed if the vertical acceleration exceeds 2.5 G positive.³ No minimum threshold or inspection criteria are provided for negative G excursions, nor is any minimum threshold provided for lateral G excursions.

¹ A G is a unit of measurement of force on a body undergoing acceleration as a multiple of its weight. The normal load factor for an airplane in straight and level flight is about 1 G.

² Structures are required to be designed to withstand the highest loads expected in service, referred to as limit load. See *14 Code of Federal Regulations* (CFR) 25.301(a). The structure is required to be designed to sustain these loads without detrimental permanent deformation and any deformation may not interfere with safe operation. See 14 CFR 25.305(a).

³ 2.5 G positive is the threshold for inspection at an approximate operating weight of 46,000 lbs. The operating weight of the aircraft at the time of the incident was estimated to be 45,519 lbs.

On December 20, 2002, as a result of its engineering and loads assessment, Canadair determined that inspections in addition to those already specified in the CRJ AMM were required to ensure the airplane's structural integrity. As a result, the operator performed a more detailed series of supplemental inspections, but no damage was identified.

On May 12, 1997, an Airbus Industrie A300 B4-600R series airplane, N90070, operated by American Airlines as flight 903, was involved in an upset event. During the upset, the stall warning system activated, the airplane rolled to extreme bank angles left and right, and rapidly descended more than 3,000 feet. One passenger sustained serious injuries. After the event, the airplane was visually inspected for damage in accordance with the procedures for excessive turbulence or large vertical G excursions in the Airbus A300-600 AMM, which specified threshold criteria for positive and negative vertical, but not lateral G excursions. During this inspection, damage to the engine pylons and engines was noted and repaired and the airplane was returned to service.

In March 2002, approximately five years after the American flight 903 incident, as a result of the Safety Board's ongoing investigation of the accident involving American Airlines flight 587,⁴ further analysis of FDR data from American flight 903 indicated that the airplane experienced external and internal loads outside its certificated design envelope. The airplane's vertical stabilizer was removed and the composite attachment lugs were subjected to ultrasonic nondestructive inspection (NDI). The results of the NDI of the right-hand aft attachment lug indicated a delamination in the composite material. This type of damage can be caused by extreme loading conditions such as those associated with the upset. Based on these findings, the vertical stabilizer has been permanently removed from service.

Inspection Procedures Following High Load Events

The investigations of American flights 903 and 587 revealed that those airplanes experienced lateral accelerations in excess of 0.4 G,⁵ resulting in internal loads well in excess of the certificated ultimate loads⁶ for the vertical stabilizer attachment structure. However, until recently the A300 AMM contained no inspection procedures for high lateral load events. As a result of the American flight 587 investigation, the Federal Aviation Administration (FAA) issued Airworthiness Directive 2002-06-09, for Airbus model A300, A300-600, and A310 series airplanes, which contains inspection procedures applicable to lateral accelerations exceeding 0.3 G but not exceeding 0.35 G. If lateral accelerations exceed 0.35 G, the aircraft is not

⁴ On November 12, 2001, an Airbus Industrie A300-605R, N14053, operated as American Airlines flight 587, crashed into a neighborhood in Belle Harbor, New York, several minutes after taking off from Kennedy International Airport. During the accident event, the vertical stabilizer and rudder departed the airplane in flight. Two pilots, seven flight attendants, 251 passengers, and five persons on the ground were fatally injured. The cause of the accident is still under investigation. Information to date indicates that the vertical stabilizer was subjected to large aerodynamic structural loading during the accident event.

⁵ Data gathered as part of the Federal Aviation Administration operational loads monitoring program indicates that 0.2 G lateral accelerations are rarely encountered. See American Airlines flight 587 Public Hearing Exhibit 7F.

⁶ Structures are required to be designed to withstand limit load multiplied by a safety factor (referred to as ultimate load) without failure for at least 3 seconds. (See 14 CFR 25.301.) The minimum safety factor is 1.5. (See 14 CFR 25.303.)

permitted to return to flight without direct oversight and intervention by the manufacturer. Operators of the affected airplanes have incorporated these inspection procedures in their AMMs.

Following the American flight 903 and the Delta Connection flight 5109 events, the operators performed the required inspections as specified in the applicable AMM. However, neither the CRJ nor the A300 AMM included inspections for damage caused by high loads due to extreme lateral accelerations, such as those encountered by American flight 903, and the Canadair AMM did not include inspections for damage caused by extreme negative vertical accelerations, such as those encountered by Delta Connection flight 5109. A review of several AMMs from other manufacturers revealed similar deficiencies. Extreme lateral accelerations and both positive and negative vertical accelerations can occur as a consequence of severe turbulence, system failures, or pilot-induced yaw, pitch, or roll maneuvers. Because encounters with such conditions could result in reduced structural integrity of the airplane, the Safety Board is concerned about these inspection procedure deficiencies. Therefore, the Board believes that the FAA should require all manufacturers of transport-category airplanes to review and, if necessary, revise their maintenance manual inspection criteria for severe turbulence and extreme in-flight maneuvers to ensure that loads resulting from positive and negative vertical accelerations, as well as lateral accelerations, are adequately addressed.

The CRJ and A300 AMMs established only a single, minimum threshold for high load events that would require an inspection for damage before the airplane could be returned to service. Implicit in this high load and inspection formulation was the presumption that the specified inspections would be adequate to identify and address damage caused by any such high load event, regardless of the degree to which the threshold was exceeded. However, Canadair and Airbus determined, after engineering reviews of the internal loads, that their published inspection criteria were inadequate to ensure safety after the high load events encountered by Delta Connection flight 5109 and American flight 903, and that additional broader and more detailed inspections were required to ensure safety. In light of these determinations, the Safety Board is concerned that the successful accomplishment of currently prescribed inspections following high load events that greatly exceed the manufacturer's threshold may be inadequate and that, as a result, airplanes that have encountered such high loads may be returned to service in an unairworthy condition. Further, in light of the circumstances surrounding the high load events discussed in this letter, the Safety Board is concerned that airplanes may be exceeding design and certification standards more frequently than was previously known or expected and, therefore, recommends that all such events be tracked and evaluated.

Therefore, the Safety Board believes that the FAA should require all manufacturers of transport-category airplanes to establish and validate maximum threshold values for positive and negative vertical and lateral G accelerations beyond which direct manufacturer oversight and intervention is required as a condition for returning the airplane to service. The Safety Board also believes that the FAA should require all operators of airplanes that have experienced accelerations exceeding these threshold values (or that the operator has reason to believe might have exceeded those thresholds), as determined from FDR and other available data, to notify the FAA immediately of such high loading events and provide all related loads assessment and inspection results. The Safety Board also believes that the FAA should require manufacturers of transport-category airplanes to immediately notify the appropriate certification authority of any

event involving accelerations exceeding the threshold values (or that the manufacturer has reason to believe might have exceeded those thresholds) necessitating the intervention of the manufacturer, and provide all related loads assessment and inspection results.

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

Require all manufacturers of transport-category airplanes to review and, if necessary, revise their maintenance manual inspection criteria for severe turbulence and extreme in-flight maneuvers to ensure that loads resulting from positive and negative vertical accelerations, as well as lateral accelerations, are adequately addressed. (A-03-41)

Require all manufacturers of transport-category airplanes to establish and validate maximum threshold values for positive and negative vertical and lateral G accelerations beyond which direct manufacturer oversight and intervention is required as a condition for returning the airplane to service. (A-03-42)

Require all operators of airplanes that have experienced accelerations exceeding the threshold values established as a result of Safety Recommendation A-03-42 (or that the operator has reason to believe might have exceeded those thresholds), as determined from FDR and other available data, to notify the FAA immediately of such high loading events and provide all related loads assessment and inspection results. (A-03-43)

Require manufacturers of transport-category airplanes to immediately notify the appropriate certification authority of any event involving accelerations exceeding the threshold values (or that the manufacturer has reason to believe might have exceeded those thresholds) necessitating the intervention of the manufacturer, and provide all related loads assessment and inspection results. (A-03-44)

Chairman ENGLEMAN, Vice Chairman ROSENKER, and Members CARMODY, GOGLIA, and HEALING concurred with these recommendations.

Original Signed

By: Ellen G. Engleman
Chairman