



# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

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**Date:** August 31, 2005

**In reply refer to:** A-05-21 through -23

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

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On May 8, 2003, about 1228 eastern daylight time, the flight crew of Atlantic Southeast Airlines (ASA) flight 4690, a Canadair CL-600-2B19, N829AS, reported an uncommanded roll during climb after departure from Atlanta, Georgia. The flight crew declared an emergency and diverted to Chattanooga, Tennessee, where the airplane landed safely. Visual meteorological conditions prevailed and an instrument flight plan was filed for the 14 *Code of Federal Regulations* Part 121 scheduled domestic/international passenger flight. No injuries were reported.

In postincident interviews, the first officer, who was the pilot flying, reported that he felt several vibrations in the control column after takeoff. He stated that the vibrations lasted about 30 seconds each time they occurred and that, as the airplane climbed through 17,000 feet, it experienced an uncommanded 45° roll to the right. The first officer reported that he disconnected the autopilot and regained control of the airplane. The flight crew reported that a series of airframe vibrations and uncommanded rolls continued during the descent and emergency landing.<sup>1</sup>

The National Transportation Safety Board's investigation found that the airframe vibrations and uncommanded rolls occurred because of wear in the output linkages that connect each of the airplane's two ailerons<sup>2</sup> to their respective power control units (PCU).<sup>3</sup> Output linkage components, which consist of an attach bolt, bushings, and washers, can wear over time allowing an increase in aileron freeplay. If the linkage wear is allowed to continue, the freeplay will increase and can result in uncommanded displacement of the aileron, severe vibration, and/or flutter of the aileron.

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<sup>1</sup> The description for this incident, ATL03IA090, can be found on the National Transportation Safety Board's Web site at <<http://www.nts.gov>>.

<sup>2</sup> An aileron is an aerodynamic control surface that is attached to the trailing edges of each wing to provide roll control.

<sup>3</sup> Each aileron is connected to two PCUs. When commanded, the PCUs cause the ailerons to rotate up or down.

Because inadequate flutter damping in the aileron system was identified as a potentially catastrophic in-flight condition, Bombardier calculated the risk of inadequate flutter damping using a fault tree model in their certification safety assessment. This model evaluated the failure modes of all aileron system components (except for linkage wear) that, individually or combined, could result in inadequate flutter damping. Bombardier's analysis considered that certain component failure modes in the fault tree could go undetected in normal operation. Using the fault tree, Bombardier derived a periodic inspection interval of 3,224 flight hours<sup>4</sup> for susceptible elements affecting PCU stiffness and damping to ensure that the potentially catastrophic in-flight flutter condition remained extremely improbable (that is, less than  $1 \times 10^{-9}$ /flight hour). Based on Bombardier's analysis, operators were recommended to perform a freeplay check<sup>5</sup> every 3,224 flight hours on each aileron to ensure that freeplay is less than the maximum limit. If the aileron freeplay exceeds the maximum limit, the operator is required to return the freeplay to within accepted limits, usually by replacing the output linkage.

When Bombardier's aileron freeplay check was performed on N829AS after the emergency landing at Chattanooga, the freeplay on the left and right ailerons was found to be greater than the limit.<sup>6</sup> As a result, ASA replaced all four aileron PCU output linkages before the airplane was returned to service. The airline's records indicated that the incident airplane had accumulated 2,973 flight hours since the last aileron freeplay check was performed in March 2002. Although the records noted that the airplane passed the check, the test procedure did not require that the measured values be recorded or retained; therefore, the freeplay values at the time of the last check are not known. After the Chattanooga, Tennessee, incident, ASA performed aileron backlash checks on 11 other Canadair CL-600-2B19s in its fleet. ASA reported that, of the 44 PCU output linkages tested, 41 had freeplay measurements that exceeded the maximum limit.

Because Bombardier did not collect or monitor freeplay check data, the manufacturer was unable to determine whether these data accurately reflected the status of the entire fleet. To gain a more accurate assessment, Bombardier issued Service Letter RJ-SL-27-061, "Sampling and Data Gathering Program for Aileron Backlash and PCU Interconnect Link Bolt Torque Values," dated July 11, 2003, to operators of the CL-600-2B19, requesting that freeplay check measurements be recorded and submitted to Bombardier for further analysis. The results of Bombardier's aileron freeplay data-gathering program (provided to the Safety Board in May 2004) showed that, of the 79 airplanes for which Bombardier received information,

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<sup>4</sup> This inspection interval value is interdependent upon the failure modes (single and combined), failure rates, and exposure times of all other components in the aileron system.

<sup>5</sup> The aileron freeplay test includes two elements: a test of the aileron PCU stiffness (backlash) and a bearing backlash test, which tests the hardware linkages ("backlash" and "freeplay" are different terms used to describe the same test. Bombardier uses the term "backlash"). Each element of the aileron freeplay check requires measurement of the up and down displacement of each aileron's trailing edge when the PCU is maintained in a fixed position. Although linkage wear was not included in Bombardier's fault tree analysis, the bearing backlash test element was added to the PCU stiffness check to ensure that aileron rotational freeplay remained within specifications and was subject to the 3,224-flight-hour test interval.

<sup>6</sup> The linkage bearing freeplay limit is .070 inch. The linkage bearing freeplay on the event airplane was measured as .135 inch on the right-hand aileron and .093 inch on the left-hand aileron.

49 percent had at least one aileron freeplay measurement that exceeded the limit.<sup>7</sup> In all, 19 percent of the sampled linkages had freeplay measurements that exceeded limits.

In March 2000, Bombardier determined that the failure rates of hydraulic system components (which includes aileron PCUs) as measured in-service were better than the rates estimated at certification. Applying these better rates to the fault tree, Bombardier was able to increase the interval for the PCU portion of the freeplay check from 3,224 to 4,000 flight hours without increasing the calculated risk of inadequate flutter damping. Although this analysis is consistent with the guidance provided in Advisory Circular (AC) 25-19, "Certification Maintenance Requirements,"<sup>8</sup> for the PCU portion of the freeplay check, the Safety Board is concerned that Bombardier incorrectly applied the resulting interval extension to the bearing backlash element of the aileron freeplay check, as well.

In addition, Bombardier failed to supplement the conclusions with actual in-service aileron freeplay inspection results from Canadair CL-600-2B19 operators. The Safety Board concludes that, because Bombardier did not consider aileron linkage wear as a failure mode in the fault tree model, linkage wear was not a determining factor in establishing the original freeplay inspection interval. Further, because Bombardier did not collect in-service freeplay exceedance data, the effectiveness of the original freeplay check interval was never considered in the extension analysis. As a result, the freeplay interval extension potentially exacerbated the magnitude of the wear condition on in-service aircraft and permitted more aircraft to continue flying with linkages worn well past established limits.

Based on the findings in the investigation of the incident involving ASA flight 4690, the high percentage of PCU output linkages in the ASA fleet with aileron freeplay measurements that exceeded limits, and the findings of Bombardier's fleet campaign, the Safety Board is concerned that the 4,000-flight-hour aileron freeplay check interval is too long, allowing airplanes to operate with aileron linkages that exceed limits. In fact, because the incident discussed in this letter occurred 2,973 flight hours after the last aileron freeplay check was performed, an interval shorter than 2,973 hours should be determined so that out-of-limits ailerons can be identified earlier. The Safety Board considers any airplane operation with excessive wear in the aileron PCU output linkage to be an unsafe condition. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require Bombardier to revise the maintenance procedures for the Canadair CL-600-2B19 so that the aileron freeplay check is accomplished at an appropriate interval that is less than 2,973 flight hours to prevent flight with aileron freeplay greater than the maximum limit. Also, the FAA should require operators of the Canadair CL-600-2B19 to record and retain aileron freeplay check measurements and report the results to the manufacturer.

Finally, the Safety Board notes that Bombardier does not currently provide guidance to flight crews on properly diagnosing and responding to the effects (such as uncommanded rolls and airframe vibrations) of an out-of-tolerance aileron linkage. A Bombardier representative

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<sup>7</sup> The maximum value for aileron linkage bearing freeplay submitted to Bombardier was .190 inch.

<sup>8</sup> Paragraph 13a in AC 25-19 states, in part, "A...task change or interval escalation could only be made if world fleet service experience indicates that certain assumptions regarding component failure rates made early during the engineering analysis were overly conservative, and a recalculation of system reliability with revised failure rates of certain components reveals that the task or interval may be changed."

indicated during a meeting with Safety Board staff that flight crews are expected to use basic airmanship to correctly resolve these situations. Although the flight crew of ASA flight 4690 reacted appropriately to the uncommanded roll and airframe vibrations, the Safety Board is concerned that the crew did not declare an emergency sooner given that Bombardier identified inadequate flutter damping as a potentially catastrophic in-flight condition. Flight crews of Canadair CL-600-2B19s should be informed about the potential effects of out-of-tolerance aileron linkages and would benefit from a set of procedures or guidance materials from Bombardier detailing proper flight crew recognition of and response to this in-flight situation. Therefore, the FAA should require Bombardier to develop and provide guidance to Canadair CL-600-2B19 operators that instructs flight crews in the proper recognition of and response to the effects of out-of-tolerance aileron PCU output linkages.

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

Require Bombardier to revise the maintenance procedures for the Canadair CL-600-2B19 so that the aileron freeplay check is accomplished at an appropriate interval that is less than 2,973 flight hours to prevent flight with aileron freeplay greater than the maximum limit. (A-05-21)

Require operators of the Canadair CL-600-2B19 to record and retain aileron freeplay check measurements and report the results to the manufacturer. (A-05-22)

Require Bombardier to develop and provide guidance to Canadair CL-600-2B19 operators that instructs flight crews in the proper recognition of and response to the effects of out-of-tolerance aileron power control unit output linkages. (A-05-23)

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS and HERSMAN concurred with these recommendations.

By: Mark V. Rosenker  
Acting Chairman

*Original Signed*