National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 17, 2008

In reply refer to: A-08-50

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The National Transportation Safety Board is an independent United States Federal agency charged by the U.S. Congress with investigating transportation accidents, determining their probable cause, and making safety recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendation in this letter. The Safety Board is vitally interested in this recommendation because it is designed to prevent accidents and save lives.

On February 2, 2005, about 0718 eastern standard time, a Bombardier Challenger CL-600-1A11, N370V, ran off the departure end of runway 6 at Teterboro Airport, Teterboro, New Jersey. The aircraft continued through an airport perimeter fence, across a six-lane highway (where it struck a vehicle), and into a parking lot before hitting a building. The two pilots and two occupants in the vehicle were seriously injured. The cabin aide, eight passengers, and one person in the building received minor injuries. The airplane was destroyed by impact forces and postimpact fire. The National Transportation Safety Board determined that the probable cause of the accident was the flight crew's attempt to take off with the center of gravity (c.g.) well forward of the forward takeoff limit, which prevented the airplane from rotating at the expected rotation speed.[1]

During the Safety Board's investigation, vehicle performance engineers conducted simulator tests to study takeoff rotation characteristics of the CL-600, as configured at the time

[1] National Transportation Safety Board, *Runway Overrun and Collision, Platinum Jet Management, LLC, Bombardier Challenger CL-600-1A11, N370V, Teterboro, New Jersey, February 2, 2005*, Aviation Accident Report NTSB/AAR-06/04 (Washington, DC: NTSB, 2006).

of the Teterboro accident, as well as for a normal takeoff and a mistrim-takeoff.[2] They found that in the mistrim scenario, with the c.g. at the most forward limit and with the horizontal stabilizer at the nose-down limit of the takeoff green band,[3] the airplane did not rotate, even with full nose-up elevator control, until it was significantly above the nominal rotation speed (V_R, that is, the speed at which the pilot applies elevator control to rotate the airplane for takeoff).[4] The Safety Board is concerned that the delayed rotation characteristics of this condition may cause pilots to believe that their airplanes will not fly, leading them to abort takeoff at a speed well above the takeoff-decision speed (V_1),[5] with possible catastrophic results.

Mistrim takeoffs, at both forward c.g. and aft c.g., are required maneuvers during the certification testing of an airplane. Federal Aviation Regulation (FAR) 25.107, "Takeoff Speeds," paragraph (e)(4), requires the following:

> Reasonably expected variations in service from the established takeoff procedures for the operation of the airplane (such as over rotation of the airplane and out of trim conditions) may not result in unsafe flight characteristics or in marked increases in the scheduled takeoff distances established in accordance with § 25.113(a).

The associated guidance for meeting this FAR is provided in Advisory Circular (AC) 25-7A, which states the following:

> 10b(6)(iii)(C) For reasonably expected out-of-trim conditions with all engines operating and as near as practicable to the maximum weight allowed under sea level standard day conditions, it should be shown that there will not be a "marked increase" in the scheduled AFM [airplane flight manual] takeoff distance when rotation is initiated in a normal manner at the scheduled V_R speed … The amount of mistrim should be the maximum mistrim that would not result in a takeoff configuration warning, including taking into account the takeoff configuration warning system-rigging tolerance. It is permissible to accept an analysis in lieu of actual testing if the analysis shows that the out-of-trim condition would not present unsafe flight characteristics or "marked increase" in the scheduled AFM field lengths.

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[2] A "mistrim takeoff" refers to a takeoff configuration in which the c.g. is at one limit of its allowable range, but the stabilizer position is set at the green band limit corresponding to the opposite c.g. limit (the stabilizer green band is defined below). In an "aft-c.g. mistrim," the c.g. is at the aft limit, but the stabilizer is set at the most nose-up limit of the green band, which risks making the airplane rotate early. In a "forward-c.g. mistrim," the c.g. is at the forward limit, but the stabilizer is set at the most nose-down limit of the green band, which risks making the airplane hard to rotate at the nominal rotation speed.

[3] The "takeoff green band" refers to a range of indications on the cockpit display of the horizontal stabilizer position, highlighted in green. The highlighted cockpit display range represents a range of horizontal stabilizer incidence settings. The range of stabilizer settings represented by the green band is chosen by design to ensure acceptable takeoff rotation and climb handling qualities throughout the allowable longitudinal range of travel of the center of gravity (see additional information below).

[4] This scenario is similar to the accident scenario, except that in the accident, the stabilizer trim was near the middle of the green band, and the airplane's c.g. was well forward of the forward c.g. limit. In both scenarios, however, the airplane would not rotate properly.

[5] V_1 means the maximum speed in the takeoff at which the pilot must take the first action (for example, apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. V_1 also means the minimum speed in the takeoff, following a failure of the critical engine, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance.

AC 25-7A also states the following:

> 21b(7) Longitudinal control, extreme out-of-trim, takeoff conditions, §§ 25.107(e)(4) and 25.143(a)(1).
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> (i) Configuration:
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> (A) Critical combinations of takeoff weight and forward and aft c.g. limits.
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> (B) Wing flaps in all takeoff positions.
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> (C) All engines operating at maximum takeoff power or thrust.
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> (ii) The airplane should be loaded to weight and c.g. combinations representing critical corners of the takeoff envelope for both forward and aft c.g. limits. The longitudinal trim should be set for the extreme opposite c.g. (e.g., load to forward c.g. limit at a given weight and set the longitudinal trim for the aft c.g. limit at that weight) as presented in the takeoff trim "green-band" including the takeoff warning system rigging tolerance. Accomplish a takeoff at normal operating speeds and evaluate the control forces and airplane responses to control inputs. In accordance with § 25.107(e)(4), this out-of-trim takeoff configuration must not result in any unsafe flight characteristics.

The simulator testing done during the Teterboro investigation indicated that the delay between the V_R callout and the actual rotation of the airplane in the forward-c.g. mistrim condition lasts several seconds. This was comparable to the delay that was experienced by the pilot in the Teterboro accident and caused him to reject his takeoff. In its final report on the Teterboro accident, the Safety Board concluded that the pilot's decision to abort was reasonable, given the failure of the airplane to rotate at V_R. There is a real possibility that other pilots, if surprised by a similar delay, might also decide to perform an unnecessary high-speed rejected takeoff. For this reason, a delay of this length in the most adverse trim condition is an excessive delay that constitutes an "unsafe flight characteristic." However, FAR 25.107 and the associated guidance in AC 25-7A do not state explicitly that an excessive delay in rotation during the mistrim takeoff is an "unsafe flight characteristic" to be evaluated during certification testing.

The European Joint Aviation Regulations (JAR),[6] and the associated guidance material in the Advisory Material Joint, contain similar language to the Federal Aviation Administration (FAA) documents concerning mistrim takeoff conditions. In an effort to harmonize the flight-test guidance material from various European Joint Aviation Authorities (JAA) documents with an update to AC 25-7A (covering all areas of flight tests, not specifically mistrim-takeoff conditions), the JAA formed a working group[7] to establish a JAA Flight Test Guide (FTG). The working group was composed of members from the JAA National Authorities and European aircraft manufacturers, with representation from the FAA, Transport Canada, and North American aircraft manufacturers.

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[6] In July 2002, the European Parliament produced regulations (EC 1592/2002) establishing a European Aviation Safety Agency (EASA). Aircraft certification and maintenance responsibilities for European Union member States were transferred from JAA to EASA on September 28, 2003.

[7] The Flight Test Guide Sub Group of the JAA Flight Study/Steering Group.

Regarding the mistrim-takeoff condition, the working group agreed, on the basis of service experience with some airplanes, that the existing guidance in AC 25-7A was inadequate. Transport Canada suggested additional guidance, including quantitative requirements on the allowable delay in rotation. These quantitative requirements were opposed strongly by the aircraft manufacturers, and the group agreed upon non-quantitative requirements based on the Transport Canada proposal. The JAA published Noticed of Proposed Amendment (NPA) 25B-335 for its FTG Proposal in June 2002,[8] which contained the following wording (additional to AC 25-7A) concerning the mistrim takeoff condition:

> (D) JAR 25.107(e)(4) also states that reasonably expected variations in service from the established take-off procedures for the operation of the aeroplane such as out-of-trim conditions may not result in unsafe flight characteristics. For example, for an aeroplane loaded to obtain a forward c.g. position and mis-trimmed for an aft c.g. loading, it may not be possible to rotate at the normal operating speeds due to excessive control force or lack of primary pitch control authority. This may result in an excessive delay in time for rotation. Such a condition would be considered an unsafe flight characteristic…. Qualitative assessments should be made by the test pilot in the following take-off tests with all engines operating:
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> 10b(6)(iii)(D)(1) The test pilot should determine that no unsafe characteristics exist with the aeroplane loaded to the forward c.g. limit and the stabiliser mis-trimmed in the aeroplane nose-down direction. The amount of mis-trim should be the maximum mis-trim that would not result in a configuration warning (including taking into account take-off warning system tolerances). Rotation should be initiated at the most critical scheduled rotation speed for the aeroplane weight and ambient conditions. Unsafe characteristics include: an excessive pitch control force to obtain normal aeroplane response or an excessive time to achieve perceptible rotation.

The FAA is working to update AC 25-7A, and the current draft, AC 25-7C,[9] contains the material quoted above from JAA NPA 25B-335. For future airplane designs, paragraph 10b(6)(iii)(D)(1) of the NPA would address the forward-c.g. mistrim-takeoff concern identified during the investigation of the Teterboro accident. However, AC 25-7C is still in draft form, and there is a risk that the mistrim-takeoff material in JAA NPA 25B-335 may be removed from the final version. To ensure that the mistrim-takeoff certification requirements contained in JAA NPA 25B-335 are applied to future airplane designs, the Safety Board is recommending that the FAA include language that accomplishes the intent of JAA NPA 25B-335, Paragraph 10b(6)(iii)(D)(1), in the final version of AC 25-7C.

Although draft AC 25-7C would address mistrim-takeoff rotation delays for airplanes certified in the future, the concern regarding the mistrim-takeoff characteristics of the CL-600

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[8] JAA NPA 25B-335, "JAR-25 Flight Test Guide," was published for comment on June 1, 2002. Although a draft final version of the JAR-25 Flight Test Guide (FTG) was developed, including considerations of the comments received, EASA took over responsibility for European certification and rulemaking from the JAA before the JAR-25 FTG could be issued. The FTG has not yet been published as a final rule.

[9] The update to AC 25-7 is comprehensive, covering much more than just the mistrim-takeoff issue discussed here. AC 25-7 is the primary source of guidance for flight test methods and procedures to show compliance with almost all of the Part 25 certification requirements for which compliance must be shown by flight test. The current version, AC 25-7A Change 1, consists of over 500 pages of material.

airplane remains. Pilots are less likely to attempt a takeoff with a mistrimmed stabilizer if they are made aware of the importance of the proper takeoff stabilizer trim setting on these particular airplanes and have directly experienced the delay in rotation associated with mistrim-takeoff conditions in a flight simulator. Accordingly, the Safety Board is recommending that the FAA encourage operators of the Bombardier Challenger series of airplanes to provide training to their pilots that emphasizes the importance of the proper takeoff stabilizer trim setting and that informs pilots about the mistrim-takeoff characteristics of the airplane, including demonstration of these characteristics in a flight simulator.

The Canadair Challenger AFM lists recommended takeoff stabilizer settings based on the c.g. range of the airplane. During the Teterboro investigation, Safety Board staff discovered that this information was not contained in the FlightSafety Canada Pilot Training Manual used by the pilots or in the FlightSafety International Canadair Challenger Quick Reference Handbook (QRH) carried in the cockpit. This information should be made available to pilots through training manuals and the QRH, thereby permitting a more precise setting for trim based upon different c.g. values. Therefore, the National Transportation Safety Board is issuing the following recommendation to Transport Canada, Civil Aviation:

> Encourage Bombardier Aerospace to revise its Challenger 600/601 Quick Reference Handbook to include detailed instructions for setting the takeoff stabilizer trim as described in the airplane flight manual, to ensure that the pages containing these procedures are clearly referenced on any checklist pages that direct pilots to set or check takeoff stabilizer trim, and to inform all operators of CL-600 airplanes about these changes. (A-08-50)

The Safety Board is also issuing two recommendations to the Federal Aviation Administration.

In response to the recommendation in this letter, please refer to Safety Recommendation A-08-50. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us at the same address asking for instructions on how to use our Tumbleweed secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman ROSENKER, Vice Chairman SUMWALT, and Members HERSMAN, HIGGINS, and CHEALANDER concurred in this recommendation.

[*Original Signed*]

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Chairman

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