National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: June 26, 2012

In reply refer to: A-12-24 and -25

The Honorable Michael P. Huerta
Acting Administrator
Federal Aviation Administration
Washington, D.C. 20590

On January 27, 2009, about 0437 central standard time, an Avions de Transport Régional (ATR) Aérospatiale Alenia ATR 42-320 (ATR 42), N902FX, operating as Empire Airlines flight 8284, was on an instrument approach when it crashed short of the runway at Lubbock Preston Smith International Airport, Lubbock, Texas. The captain sustained serious injuries, and the first officer sustained minor injuries. The airplane was substantially damaged. The airplane was registered to FedEx Corporation and operated by Empire Airlines, Inc., as a 14 *Code of Federal Regulations* (CFR) Part 121 supplemental cargo flight. The flight departed from Fort Worth Alliance Airport, Fort Worth, Texas, about 0313. Instrument meteorological conditions prevailed, and an instrument flight rules flight plan was filed.[1]

The National Transportation Safety Board (NTSB) determined that the probable cause of this accident was the flight crew's failure to monitor and maintain a minimum safe airspeed while executing an instrument approach in icing conditions, which resulted in an aerodynamic stall at low altitude. Contributing to the accident were 1) the flight crew's failure to follow published standard operating procedures in response to a flap anomaly, 2) the captain's decision to continue with the unstabilized approach, 3) the flight crew's poor crew resource management, and 4) fatigue due to the time of day in which the accident occurred and a cumulative sleep debt, which likely impaired the captain's performance.

Additional review of the stall protection system in the accident airplane and the events leading to the stall in this accident prompted the NTSB to make the following recommendations.

[1] See *Crash During Approach to Landing, Empire Airlines Flight 8284, Avions de Transport Régional Aérospatiale Alenia ATR 42-320, N902FX, Lubbock, Texas, January 27, 2009,* Aircraft Accident Report NTSB/AAR-11/02 (Washington, D.C.: National Transportation Safety Board, 2011) <http://www.ntsb.gov>.

Stick Pusher Activation

For a clean wing with no ice contamination, the ATR 42 stall protection system provides an aural warning and stick shaker to alert pilots that a stall is imminent, and, if the angle of attack (AOA) is further increased, a stick pusher activates to automatically limit or reduce the AOA. For a clean wing with no ice contamination, the ATR 42 is expected to stall at 14.4° AOA, and the stick pusher activates at an angle lower than the clean-wing stall AOA. Wind tunnel testing conducted by ATR determined that the ATR 42 will stall at 8.4° AOA with Part 25 Appendix C ice contamination (cruise ice shapes), which is significantly lower than the 14.4° stall AOA of a clean wing. To address the reduction in stall AOA in icing conditions, when the ice protection system is turned on, activation of the stick shaker is reduced from 11.6° AOA to 7° AOA. However, the stick pusher's activation AOA does not change when the ice protection system is turned on, and, therefore, it may not offer stall protection when the airplane encounters icing conditions.

Following the Lubbock investigation, the NTSB completed a study of the aerodynamic events that led up to the stall. The study revealed that the airplane, which was operating in icing conditions, experienced an asymmetric stall that initiated as the AOA increased to 8°. The stall resulted in an uncommanded roll response about 1 second after stall. The uncommanded roll angle reached 34°, which exceeded the stall response certification standards.[2] Examination of the data found that the pilot only received a stick shaker warning 1 second before the stall occurred. The stick pusher did not activate because its minimum activation AOA was 11.5°.

The NTSB is aware that, under the certification icing conditions in which the ATR 42 was tested, ATR was not required to reduce the stick pusher's minimum activation AOA. However, the NTSB has long recognized that the certification standards do not capture real-world icing conditions.[3] Based on the data derived from the Lubbock accident, it appears that the certification process did not detect the post-stall roll characteristics of the airplane that can occur in certain icing conditions. Large, uncommanded roll angles can develop quickly and without natural cues[4] in the presence of airframe ice accretions, especially when operating in icing

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[2] Title 14 CFR 25.203(b) requires that, "for level wing stalls, the roll occurring between the stall and the completion of the recovery may not exceed approximately 20 degrees."

[3] Safety Recommendation A-96-54 asked the Federal Aviation Administration (FAA) to "revise the icing criteria published in 14 *Code of Federal Regulations* (CFR), Part 23 and 25, in light of both recent research into aircraft ice accretion under varying conditions of liquid water content, drop size distribution, and temperature, and recent development in both the design and use of aircraft. Also, expand the appendix C icing certification envelope to include freezing drizzle/freezing rain and mixed water/ice crystal conditions, as necessary." Safety Recommendation A-96-54 was classified "Open—Acceptable Response" on January 27, 2012. Safety Recommendation A-07-16 asked the FAA to "when the revised icing certification standards (recommended in Safety Recommendations A-96-54 and A-98-92) and criteria are complete, review the icing certification of pneumatic deice boot-equipped airplanes that are currently certificated for operation in icing conditions and perform additional testing and take action as required to ensure that these airplanes fulfill the requirements of the revised icing certification standards." Safety Recommendation A-07-16 was classified "Open—Unacceptable Response" on September 12, 2011.

[4] The NTSB recognizes that manufacturers often use natural indicators such as airframe buffet and uncommanded pitch down with minor roll excursions instead of a stick pusher to define stall.

conditions not examined in icing certification.[5] The data indicate that a revised stick pusher activation system would enhance the stall protection of the ATR 42 in the presence of real-world icing conditions.

The NTSB notes that, in this accident, stick pusher activation would not have prevented ground contact. Further, there were no natural cues in this accident that the flight crew could have used to identify the impending stall before a large roll off occurred. However, for ATR 42-series airplanes operating at altitudes only a few hundred feet higher than the accident airplane, a stick pusher design that accounts for and activates before the reduced stall AOA in icing conditions would enhance the safety of the flight while operating in icing conditions. Several airplanes, including the ATR 72, lower the trigger AOA for both stick shaker and stick pusher in the presence of ice to preserve the AOA margin between stick shaker and stick pusher. The NTSB concludes that, in icing conditions, lowering the stick pusher's activation AOA on the ATR 42 would provide an increased safety margin against stall, similar to that achieved by lowering the stick shaker activation AOA when operating in icing conditions. Therefore, the NTSB recommends that the Federal Aviation Administration (FAA) require that ATR 42-series airplanes operating in the United States incorporate a revised stick pusher activation AOA, such that the stick pusher activates before the stall AOA in the presence of airframe ice accretions.

Stall Protection in Icing Conditions

The NTSB has investigated other accidents and incidents in which an uncommanded roll occurred in icing conditions either before or during a stall with no preceding natural cues.[6] As a result of the January 9, 1997, in-flight icing encounter and uncontrolled collision with terrain of an Embraer EMB-120RT, operating as Comair flight 3272,[7] the NTSB issued Safety Recommendation A-98-96, which asked the FAA to "require the manufacturers and operators of all airplanes that are certificated to operate in icing conditions to install stall warning/protection systems that provide a cockpit warning (aural warning and/or stick shaker) before the onset of stall when the airplane is operating in icing conditions." In response to this recommendation, the FAA revised the stall warning requirements for newly type-certificated transport-category airplanes (14 CFR 25.207) to require that the warning systems provide sufficient margin to prevent stall in both icing and nonicing conditions.

Also in response to Safety Recommendation A-98-96 and the March 19, 2001, Embraer EMB-120 intercycle ice accretion accident[8] in which the airplane lost roll control following a

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[5] Icing can be highly variable, and the effects cannot always be fully defined during limited research and flight testing.

[6] Some past accidents and incidents that have involved an uncommanded roll during a stall in icing conditions are NTSB case numbers DCA08WA038, NYC07RA064, LAX06IA076, DCA05MA037, DEN05MA029, DCA05RA010, CHI04IA056, DCA02WA050, DCA01MA031, DCA97MA017, DCA98RA012, and FTW93MA143, which can be found online at <http://www.ntsb.gov/aviationquery/index.aspx>, and Australian Transport Safety Board accidents 200402415 and 199805068.

[7] See *In-Flight Icing Encounter and Uncontrolled Collision with Terrain, Comair Flight 3272, Embraer EMB-120RT, N265CA, January 9, 1997*, Aircraft Accident Report NTSB/AAR-98/04 (Washington, D.C.: National Transportation Safety Board, 1998) <http://www.ntsb.gov>.

[8] See NTSB case number DCA01MA031 at <http://www.ntsb.gov/aviationquery/index.aspx>.

stall and sustained substantial damage to the horizontal tail during recovery, the FAA issued Airworthiness Directive (AD) 2007-26-21 on January 16, 2008, for all Embraer EMB-120 airplanes to install an upgraded stall warning computer that includes new settings for stick shaker activation angles to preserve the margin between stall warning/stall protection and aerodynamic stall when operating with intercycle ice accretions.

The FAA did not apply the revised standards to all in-service airplanes but indicated that it would take action on specific models if it became aware of an unsafe condition. On October 26, 2009, the FAA informed the NTSB that it believed the collective actions it had taken to improve safety for flight in icing conditions provided an acceptable level of safety for the existing fleet and that, because it had addressed the risk of inadvertent stalls in icing conditions, no further action was necessary. The FAA also indicated that reassessing stall warning margins in icing conditions for existing airplanes to identify whether any additional airplanes' stall warning systems needed to be modified would require a comprehensive study, and the costs associated with such an effort exceeded any potential safety benefits. On April 27, 2010, because the FAA did not take the recommended action for all in-service airplanes, Safety Recommendation A-98-96 was classified "Closed—Unacceptable Action."

Following the NTSB's investigation of the January 2, 2006, American Eagle Saab SF340 stall upset in icing incident,[9] on July 10, 2006, the NTSB issued Safety Recommendation A-06-49, which asked the FAA to "require the installation of modified stall protection logic in Saab SF340 series airplanes certified for flight into known icing conditions." In its letter to the FAA, the NTSB cited the Transport Canada requirement for an "ice speed" switch on the Saab SF340, which lowered the trigger AOA for both the stick shaker and the stick pusher. On September 22, 2011, the FAA stated that design of a stall warning modification was complete, that the European Aviation Safety Agency (EASA) intended to mandate the modification (it did so in EASA AD 2011-0219 issued November 11, 2011), and that the FAA would issue an AD requiring the modification following EASA's mandate. Safety Recommendation A-06-49 is currently classified "Open—Acceptable Response," pending the issuance of an AD to mandate stall protection modifications on Saab SF340 airplanes.

The presence of ice on the wings, which may be accreted or shed in an asymmetric fashion and accreted between deicing boot activations, has not been adequately examined during initial icing certification, as demonstrated by the contrast between the benign stalls in flight test and the sharp roll off at stall in this accident. These untested ice accretions can impart additional flight control challenges as an airplane approaches natural aerodynamic stall. As demonstrated in the above events and in the final seconds of the Lubbock accident flight, uncommanded roll departures often occur at or just after the airplane stalls without the benefit of a stick pusher system designed to account for icing conditions.

In response to prior incidents and accidents, the FAA changed its regulations for newly type-certificated aircraft to require that stall warning systems maintain sufficient margins in icing conditions. As noted, current guidance emphasizes reducing the AOA as the primary means to stall prevention, and the stick pusher is intended to aid the pilot in that action. However, the

[9] See NTSB case number LAX06IA076 at <http://www.ntsb.gov/aviationquery/index.aspx>.

NTSB is concerned that, for in-service stick pusher-equipped transport-category airplanes, if the activation angle of the stick pusher is not reduced in icing conditions, its benefit in reducing the airplane's AOA prior to stall and during recovery efforts is lost. The NTSB concludes that a lower stick pusher activation AOA would enhance safety in icing conditions and provide stall protection before an uncommanded roll develops during stall. Therefore, the NTSB recommends that the FAA evaluate all U.S.-certificated transport-category airplanes equipped with stick pushers to ensure that the stick pusher activates at an AOA that will provide adequate stall protection in the presence of airframe ice accretions.

Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Require that Avions de Transport Régional (ATR) 42-series airplanes operating in the United States incorporate a revised stick pusher activation angle of attack (AOA), such that the stick pusher activates before the stall AOA in the presence of airframe ice accretions. (A-12-24)
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> Evaluate all U.S.-certificated transport-category airplanes equipped with stick pushers to ensure that the stick pusher activates at an angle of attack that will provide adequate stall protection in the presence of airframe ice accretions. (A-12-25)

The National Transportation Safety Board made two complementary recommendations to the European Aviation Safety Agency.

In response to the recommendations in this letter, please refer to Safety Recommendations A-12-24 and -25. We encourage you to submit updates electronically at the following e-mail address: correspondence@ntsb.gov. If a response includes attachments that exceed 5 megabytes, please e-mail us at the same address for instructions. To avoid confusion, please do not submit both an electronic copy and a hard copy of the same response.

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman