



# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

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**Date:** May 18, 2011

**In reply refer to:** A-11-39 through -47

The Honorable J. Randolph Babbitt  
Administrator  
Federal Aviation Administration  
Washington, DC 20591

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On January 27, 2009, about 0437 central standard time,<sup>1</sup> an Avions de Transport Régional (ATR) Aerospatiale 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 (LBB), Lubbock, Texas.<sup>2</sup> 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 (IFR) flight plan was filed.

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 (SOP) 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 (CRM), 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.

### Background

During the accident approach, the first officer was flying using the autopilot. When she called for the approach flap setting of 15°, a flap asymmetry occurred in which the right flaps did not extend and the left flaps extended partially. About 40 seconds later, when the airplane was at

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<sup>1</sup> All times in this letter are central standard time (unless otherwise noted) and based on a 24-hour clock.

<sup>2</sup> The National Transportation Safety Board's full report, *Crash During Approach to Landing, Empire Airlines Flight 8284, Avions de Transport Régional Aerospatiale Alenia ATR 42-320, N902FX, Lubbock, Texas, January 27, 2009*, Aircraft Accident Report NTSB/AAR-11/02 (Washington, DC: National Transportation Safety Board, 2011) will be available online at <[http://www.nts.gov/publicn/A\\_Acc1.htm](http://www.nts.gov/publicn/A_Acc1.htm)>.

an altitude of about 1,400 feet above ground level (agl) and just outside the locator outer marker (which serves as the final approach fix), the captain stated, “we have no flaps.” The captain’s observation that the airplane had no flaps was an inaccurate assessment of the problem (the airplane had a flap asymmetry); however, the inaccuracy was irrelevant because the same procedure in the quick reference handbook (QRH) applied for both a no-flaps condition and a flap asymmetry.

Both the captain and the first officer had been trained to perform a go-around maneuver and reference the QRH if a flap problem occurred during an approach. However, neither flight crewmember immediately called for a go-around maneuver or performed the QRH procedure for addressing flap anomalies. The captain, without discussing any plan of action with the first officer, instead began a nonstandard response to try to troubleshoot the flap problem; the first officer continued to fly the approach. Neither flight crewmember adequately monitored the airplane’s airspeed, which decayed to the extent that the aural stall warning and tactile stick shaker activated multiple times (stick-shaker activation is indicative of an unstabilized approach and is another criteria for performing a go-around maneuver). At one point, the first officer asked the captain if she should perform a go-around maneuver, but he dismissed her request.

The captain took over the controls when the airplane was about 700 feet agl, and he continued the unstabilized approach even though he received additional stick-shaker activations and a terrain awareness and warning system (TAWS) “pull up” warning. At the time that the stick shaker and TAWS warning occurred, the airplane was about 500 feet agl, just below the cloud ceiling (the first officer had the runway in sight), and descending at a rate of 2,050 feet per minute. About 2 seconds after the TAWS warning, the flaps returned to a symmetric state, and control input to counteract the flap asymmetry was no longer required.

Procedures for responding to either the stick shaker or the TAWS warning require the immediate application of maximum engine power. However, the captain did not apply maximum engine power until 17 seconds after the TAWS warning. If the captain had responded appropriately to the concurrent stall and TAWS warnings by immediately initiating a go-around maneuver, he likely would have been able to arrest the airplane’s descent, increase its airspeed, and avoid the aerodynamic stall that occurred a few seconds before impact. When the stall warning occurred, the airspeed was about 124 knots (kts), approximately 19 kts below the minimum safe airspeed for the approach of 143 kts. About 2 seconds after the stall warning occurred, the airplane experienced an uncommanded roll followed by a series of roll, yaw, and pitch oscillations, which continued until ground impact.

Empire Airlines had dispatched the airplane into icing conditions (including freezing drizzle) that were outside the airplane’s certificated icing envelope. Although the airplane accumulated airframe ice during the approach that degraded the airplane’s performance, the degradation never exceeded the airplane’s thrust performance, nor would it have exceeded the airplane’s flight control capabilities if the minimum safe airspeed had been maintained.

### **Crew Resource Management Training on First Officer Assertiveness**

The accident captain had about 13,935 total flight hours (2,052 hours of which were in the ATR 42) and extensive experience flying in icing conditions. He had previously served as a

check airman on Empire Airlines' single-pilot Cessna 208 airplanes. The captain had been with Empire Airlines for more than 20 years. Thus, he should have been very familiar with the company's SOPs, and the accident flight crew should have benefitted from the captain's extensive experience with the company, in ATR 42 airplanes, and with flying in icing conditions. However, the captain failed to command control of the situation and follow SOPs. After identifying the flap anomaly, the captain did not communicate to the first officer his intentions for managing the situation. Instead, the captain pursued his own plan of action without providing any guidance to the first officer or performing the duties required of him as the pilot monitoring, which could have helped the first officer manage the airplane during the approach.

The first officer had about 2,109 total flight hours (130 hours of which were as second-in-command in the ATR 42) and very limited experience flying in icing conditions. The large disparity between the captain's and the first officer's flying experience, their experience in the ATR 42, and their experience in icing conditions likely created a steep authority gradient in the cockpit. The issue of cockpit authority gradient has been examined since the late 1970s and has been evident in a number of major aviation accidents, including the March 27, 1977, collision of two Boeing 747s at Tenerife Airport, Los Rodeos, Spain.<sup>3</sup> Evidence has suggested that too steep of an authority gradient can reduce flight crew performance, hinder communication, and increase errors. For example, a review of U.S. Navy mishaps between 1980 and 1990 revealed that flight crews with an authority gradient of one rank or more between flight crewmembers had 21 percent more errors than flight crews in which the crewmembers were of the same rank.<sup>4</sup> In a study of 249 airline pilots in the United Kingdom, nearly 40 percent of first officers stated that they failed to communicate safety concerns to their captains on more than one occasion for reasons that included a desire to avoid conflict and deference to the captain's experience and authority.<sup>5</sup>

The poor CRM observed in this accident is similar to that which the NTSB found during its investigation of the February 19, 1996, crash of Continental Airlines flight 1943 in Houston, Texas.<sup>6</sup> During the event sequence leading to the accident, the captain rejected, without any discussion, the first officer's go-around request, and the first officer failed to challenge his decision. The flight crew failed to complete multiple checklists and continued an unstabilized approach below 500 feet<sup>7</sup> against company procedures to go around in such situations. As a result of this accident, the NTSB issued Safety Recommendations A-97-05 and -06, which asked the Federal Aviation Administration (FAA) to require all principal operations inspectors of 14 CFR Part 121 carriers to (1) ensure that the carriers establish a policy and make it clear to their pilots that there will be no negative repercussions for appropriate questioning in accordance

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<sup>3</sup> See *KLM B-747, PH-BUF, and Pan Am B-747, N736PA, Collision at Tenerife Airport, Los Rodeos, Spain, on 27 March 1977*, Aircraft Accident Report (Spain: Subsecretaría de Aviación Civil, 1978).

<sup>4</sup> R.A. Alkov and others, "The Effect of Trans-Cockpit Authority Gradient on Navy/Marine Helicopter Mishaps," *Aviation, Space, and Environmental Medicine*, vol. 63, no. 8 (1992), pp. 659-661.

<sup>5</sup> J. Wheale, "Crew Coordination on the Flight Deck of Commercial Transport Aircraft," *Proceedings of the Flight Operations Symposium, October 1983* (Dublin: Irish Air Line Pilots Association/Aer Lingus, 1983).

<sup>6</sup> See *Wheels-Up Landing, Continental Airlines Flight 1943, Douglas DC-9-32, N10556, Houston, Texas, February 19, 1996*, Aircraft Accident Report NTSB/AAR-97/01 (Washington, DC: National Transportation Safety Board, 1997). <<http://www.nts.gov/publictn/1997/AAR9701.pdf>>.

<sup>7</sup> A ground proximity warning system alert continued below 200 feet above field elevation.

with CRM techniques of another pilot's decision or action and (2) ensure that CRM programs provide pilots with training in recognizing the need for, and practice in presenting, clear and unambiguous communications of flight-related concerns.

On October 30, 1998, the FAA issued Advisory Circular (AC) 120-51C (currently AC 120-51E), which emphasized the importance of all levels of management to support a safety culture that promotes communication by encouraging appropriate questioning and that does not allow negative repercussions for appropriate questioning of one pilot's decision or action by another. Based on the FAA's lack of action to issue a flight standards information bulletin, on February 23, 2000, the NTSB classified these recommendations "Closed—Unacceptable Action." Thirteen years after the FAA issued AC 120-51C, the NTSB continues to investigate accidents in which one pilot does not question the actions or decisions of another pilot.

To overcome steep authority gradients, AC 120-51E suggests that assertiveness be included in CRM training programs. FlightSafety's CRM training materials for Empire Airlines' flight crewmembers included two presentation slides that encouraged pilots to speak up with "appropriate persistence until there is a clear resolution." However, the accident first officer could not recall what was trained during the 2-day CRM training course, including whether or not assertiveness was addressed.

According to Empire Airlines' ATR 42 pilot handbook, if a go-around maneuver is required, the pilot flying should call out "go around" and initiate the go-around procedures. During the accident flight, the first officer instead asked the captain, "should I go around?," rather than directly asserting her concern about the unstabilized approach, even though she was aware that company policy was to go around in the event of stick-shaker activation. The first officer indicated that asking was her way of saying that she wanted to go around "without stepping on toes." Captains who had previously flown with the first officer stated that, although she did not seem to have a problem standing up for something in the cockpit, she asked a lot of questions when flying that were related to skills that she already knew.

The first officer stated that, after the captain responded "no" to her go-around inquiry, she felt that he had a good reason for not wanting to go around and that she trusted that he was making the right decisions. The first officer stated that, after the captain took control of the airplane, she was still concerned with the approach and felt that she should have called again for a go-around maneuver but that she did not know why she did not say anything. The NTSB concludes that the first officer's failure to assert herself to the captain and initiate a go-around maneuver when she recognized the unstabilized approach likely resulted from the steep authority gradient in the cockpit and the first officer's minimal training on assertiveness; further, the captain's quick dismissal of the first officer's go-around inquiry likely discouraged the first officer from voicing her continued concerns and challenging the captain's decision to continue the unstabilized approach. The NTSB notes that the first officer's CRM training did not include any role-playing activities in which pilots could practice developing assertiveness skills. Practice allows pilots to bridge the gap between their knowledge of assertiveness and the actions needed in the cockpit to effectively be assertive.<sup>8</sup> The NTSB concludes that role-playing exercises are

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<sup>8</sup> R.L. Beard, E. Salas, and C. Prince, "Enhancing Transfer of Training: Using Role Play to Foster Teamwork in the Cockpit," *International Journal of Aviation Psychology*, vol. 5, no. 2 (1995), pp. 131-143.

essential for effective assertiveness training because such exercises provide flight crews with opportunities for targeted practice of specific behaviors and feedback that a lecture-based presentation format lacks. Therefore, the NTSB recommends that the FAA require that role-playing or simulator-based exercises that teach first officers to assertively voice their concerns and that teach captains to develop a leadership style that supports first officer assertiveness be included as part of the already required CRM training for 14 CFR Part 121, 135, and 91 subpart K pilots.

### **Dispatch into Freezing Drizzle Conditions**

The flight release for the accident flight contained weather information that indicated that IFR conditions with light freezing drizzle and mist were reported at LBB and that such conditions were forecast to continue beyond the flight's estimated time of arrival. During the flight's descent toward LBB, the controller informed the flight crew that light freezing drizzle and mist were reported at the airport.

Although supercooled large droplet (SLD) conditions like freezing rain or freezing drizzle are outside the ATR 42's certification icing envelope as specified in 14 CFR Part 25, Appendix C, the FAA does not specifically prohibit operators from dispatching or operating airplanes in such weather conditions. For the ATR 42, the airplane flight manual (AFM) states that a flight crew must immediately exit severe icing conditions when they are encountered. According to Empire Airlines' General Operations Manual (GOM), "when light freezing rain, light or moderate freezing drizzle, or light, moderate, or heavy snow is falling, aircraft may land." The GOM also stated that, "when light freezing rain, light to moderate freezing drizzle, or light, moderate snow is falling, [an ATR] aircraft may take off, provided it is prepared in accordance with approved deicing procedures."

After the accident, on February 27, 2009, Empire Airlines issued a flight operations bulletin to supersede the icing information in the GOM and to inform flight crews and flight followers that freezing rain and freezing drizzle are not covered by the icing certification envelope and that takeoff or landing operations in known or reported freezing rain or freezing drizzle of any intensity are prohibited. An informal review of other 14 CFR Part 121 and 135 operators' icing guidance revealed that the operators' guidance for dispatching their turbine-powered, pneumatic deice boot-equipped airplanes into freezing rain and freezing drizzle conditions varied widely; some operators prohibited dispatch into such conditions, and others permitted it.

As this accident shows, moderate icing conditions due to light freezing drizzle can increase a flight crew's workload and degrade the performance of the airplane. Although Empire Airlines and the other FedEx feeder operators developed "no-go" weather guidance (after the accident) that prohibits takeoff or landing operations in known or reported freezing rain or freezing drizzle, these actions were not required by the FAA, and other operators may not adopt such safety measures. The NTSB concludes that dispatching and operating an airplane in known icing conditions for which the airplane is not certificated and has not demonstrated the ability to operate safely has the potential to reduce or eliminate safety margins. Therefore, the NTSB recommends that the FAA prohibit all 14 CFR Part 121, 135, and 91 subpart K operators of pneumatic deice boot-equipped airplanes from dispatching or deliberately operating these

airplanes in known freezing rain or freezing drizzle of any intensity, unless the airplane manufacturer has demonstrated that the airplane model can safely operate in those conditions.

According to Empire Airlines' director of operations, the GOM information in place before the accident (which permitted dispatching and operating airplanes in light freezing rain; light or moderate freezing drizzle; or light, moderate, or heavy snow) was developed based on information from the aircraft deicing program (ADP) holdover tables. However, the NTSB notes that holdover tables are references that are used for ground deicing operations and are not intended to be used to address the in-flight icing environment.

Interviews with Empire Airlines' flight followers and the dispatch manager revealed that their perceptions about dispatching into freezing drizzle conditions were based on this GOM and ADP information. However, such guidance based on ground deicing operations did not emphasize the potential dangers of in-flight encounters with freezing rain and freezing drizzle that are described in airplane-specific flight operations publications. For example, the AFM for the airplane (which is a flight publication provided by ATR) contained the following warning:

Severe icing may result from environmental conditions outside of those for which the airplane is certificated. Flight in freezing rain, freezing drizzle, or mixed icing conditions (supercooled liquid water and ice crystals) may result in ice buildup on protected surfaces exceeding the capabilities of the ice protection system.

Also, ATR's *Cold Weather Operations* publication<sup>9</sup> stated that in-flight icing is a major concern for commuter airplanes (which are typically pneumatic deice boot-equipped airplanes) in particular because they fly at altitudes where icing conditions are most likely to occur. Neither of these flight publications was used in developing dispatch guidance.

Based on information obtained during interviews with flight crewmembers and dispatch personnel, the NTSB found that many were not sufficiently aware of the dangers of operating in freezing drizzle precipitation and lacked a thorough understanding of the weather phenomena associated with SLD conditions. On March 16, 2010, the FAA issued Safety Alert for Operators (SAFO) 10006, which referenced several of the NTSB's safety recommendations that resulted from its investigation of the October 31, 1994, accident in Roselawn, Indiana,<sup>10</sup> to encourage all operators to review and amend, if necessary, their flight crewmember and dispatcher training programs to ensure that their programs address SLD icing conditions. However, the actions recommended in a SAFO are not mandatory. Also, as noted previously, other operators' dispatch guidance varied, and Empire Airlines erroneously relied on ground deicing guidance as the basis for dispatch decisions, which resulted in assumptions that led to the dispatch of flights into

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<sup>9</sup> ATR Flight Operations Services, *Cold Weather Operations: Be Prepared for Icing* (2008). This publication was updated in March 2011, and the current edition can be obtained from ATR's website <[http://www.atraircraft.com/content/media/downloads/coldweatheroperations\\_2011\\_20.pdf](http://www.atraircraft.com/content/media/downloads/coldweatheroperations_2011_20.pdf)> (accessed April 14, 2011).

<sup>10</sup> See *In-flight Icing Encounter and Loss of Control, Simmons Airlines, d.b.a. American Eagle Flight 4184, Avions de Transport Regional (ATR) Model 72-212, N401AM, Roselawn, Indiana, October 31, 1994; Volume 1: Safety Board Report (Revision 9/13/02)*, Aircraft Accident Report NTSB/AAR-96/01 (Washington, DC: National Transportation Safety Board, 1996). <<http://www.ntsb.gov/publictn/1996/AAR9601.pdf>>.

freezing drizzle without adequate consideration for the in-flight hazards associated with the conditions.

The NTSB is concerned that disparity exists between operators' and airplane manufacturers' guidance materials and between the guidance materials of operators of similar airplanes regarding flight operations in SLD conditions, particularly after the NTSB issued numerous safety recommendations on the topic resulting from its investigation of the October 31, 1994, accident in Roselawn, Indiana.<sup>11</sup> Dispatch personnel like Empire Airlines' flight followers who authorize each flight release, provide preflight weather products, and perform flight following share an integral role with flight crews in ensuring that each flight safely reaches its destination. The NTSB concludes that, to most effectively ensure the safety of flight operations in icing conditions, pilots, dispatchers, and flight followers must understand how the dangers of freezing drizzle and freezing rain can affect their airplanes and must understand the differences between ground deicing considerations and in-flight icing operations. Therefore, the NTSB recommends that the FAA review the approved pilot, dispatcher, and flight follower training programs and procedures for all 14 CFR Part 121, 135, and 91 subpart K operators and require revisions to the programs and procedures, as necessary, to include standardized training and aircraft-specific information to educate pilots, dispatchers, and flight followers of the dangers of flight operations in freezing precipitation and of the differences between ground deicing considerations and in-flight icing operations.

## **Emergency Response**

### *Lack of Occupant and Hazardous Materials Information Available to First Responders*

The aircraft rescue and firefighting (ARFF) station was notified of the accident when the air traffic control tower (ATCT) controller lifted the direct-line radio receiver in the tower, resulting in the automatic sounding of a tone in the station. According to procedure, following the tone, the ATCT controller can provide information about the level of the alert, the type of aircraft, the nature of the emergency, the runway to be used, and any other information as time permits. In the case of the accident flight, other than the accident location, the only information about the flight that the ATCT controller could convey was that the airplane was an ATR. ARFF personnel did not know that it was a cargo airplane and that they could expect two or three occupants until they began suppressing the fire and saw the FedEx logo on airplane's tail. Further, the ARFF responders were initially unaware of the airplane's hazardous materials (HAZMAT) cargo.

The captain and the first officer opened the forward cargo door without difficulty and exited the airplane. Both the captain and the first officer then left the scene and ran to the FedEx hangar before the first responders arrived. A FedEx employee subsequently notified the Lubbock Fire Department and emergency medical services personnel when they arrived at LBB that the flight crew was at the FedEx hangar; however, by that time, the ARFF responders were already on scene and looking for survivors.

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<sup>11</sup> NTSB/AAR-96/01.

As a result of the confusion regarding the flight crewmembers' whereabouts, at least two ARFF personnel unnecessarily accessed the airplane to look inside the cockpit and cabin area, and other personnel also unnecessarily interrupted their fire suppression activities to participate in the search. After the arriving fire department personnel conveyed to ARFF personnel that the flight crew was safe, the search was stopped but then was resumed briefly after the ATCT controller relayed information (which was apparently old) that a pilot was walking around on the ramp looking for assistance. In addition, the ARFF personnel were initially unaware of the airplane's HAZMAT cargo. Operators that transport HAZMAT cargo are required to make specific HAZMAT cargo information available during an emergency response, and Empire Airlines' procedures complied with the requirements. The ARFF captain indicated that, if they had the information, the ARFF response to the scene would have been similar with the exception that all responding firefighters would have worn full personal protective equipment.

Although the flight crewmembers acted appropriately by ensuring their own safety following the accident, the situation highlights that a lack of information from the flight crew can hinder the response team's ability to safely and most efficiently prioritize their on-scene activities. The NTSB notes that a similar situation occurred on June 28, 2008, during a cargo airplane ground fire in which the flight crew evacuated the airplane and left the scene before first responders arrived, but no information about their safe egress was immediately provided to first responders. In this accident, a firefighter unnecessarily entered the burning wreckage to look for survivors and encountered a dangerous situation in the cockpit, including heavy smoke in which he lost his radio, confined spaces that pulled off some of his equipment, and a "wall of fire" behind the cockpit door. The firefighter indicated that, in hindsight, he should not have entered the cockpit but that he did it because he did not know if anybody was in there and because he thought that he could put the fire out.<sup>12</sup>

The NTSB concludes that, because flight crews cannot always immediately communicate with air traffic control after an accident, it is important that another method be developed to communicate information, such as the number of occupants on board and the presence of hazardous materials, to ARFF personnel upon initial notification of an accident. Therefore, the NTSB recommends that the FAA develop a method to quickly communicate information regarding the number of persons on board and the presence of HAZMAT to emergency responders when airport emergency response or search and rescue is activated.

#### *Inoperative Emergency Response and Mutual Aid Gate*

The airport's emergency plan indicated that units that respond from outside of the airport should "respond to Gate 6 and Gate 48 or at a location prescribed by the command post." However, the emergency response unit that arrived at Gate 48 could not access the airport at that location because the gate was inoperative due to ice in its operating mechanism. The remaining response units diverted to another gate for airport access, which minimally delayed their response time.

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<sup>12</sup> See the Survival Factors Group Chairman's Factual Report in the public docket for *Ground Fire Aboard Cargo Airplane, ABX Air Flight 1611, Boeing 767-200, N799AX, San Francisco, California, June 28, 2008*, Aircraft Accident Summary Report NTSB/AAR-09/04/SUM (Washington, DC: National Transportation Safety Board, 2009). <<http://www.nts.gov/Dockets/Aviation/DCA08MA076/407654.pdf>>.



The LBB snow and ice removal plan did not address checking or ensuring the operability of the airport gates. A survey of several other 14 CFR Part 139 airports with operations affected by winter weather revealed that none of the airports' snow and ice operations plans addressed checking or ensuring the operability of emergency response and mutual aid gates. Also, AC 150/5200-30C, "Airport Winter Safety and Operations," did not address the issue.

The NTSB notes that airport snow and ice removal plans already require airport operations personnel to conduct periodic inspections of the routes used by emergency response vehicles. Therefore, the checking of mutual aid gates for operability could easily be added as an item to be performed during these inspections. Further, following the accident, LBB voluntarily added the checking of mutual aid gates for operability to its snow and ice operations plan. The NTSB concludes that an iced and inoperable mutual aid gate could extend the response time of mutual aid, which could delay the delivery of medical attention to accident survivors and result in further fire damage to property. Therefore, the NTSB recommends that the FAA amend AC 150/5200-30C to include guidance on monitoring and ensuring the operability of emergency response and mutual aid gates during winter operations.

### **Aircraft Performance Monitoring System**

ATR developed the aircraft performance monitoring (APM) system, which has been installed on new production ATR 42 and ATR 72 airplanes since November 2005, to enhance a flight crew's ability to detect the effects of severe icing conditions on the airplane. The APM is a condition-specific, low-air-speed alerting system because it is designed to provide specific alerts in icing conditions only (level 2 or 3 icing protection must be engaged or an icing signal must be provided by the icing detector). The APM calculates and compares the airplane's actual performance (with respect to airspeed and drag) with its expected performance, computes the actual minimum icing and severe icing airspeeds, and provides alerts to the flight crew when low airspeed or performance degradation is detected. These alerts prompt the flight crew to perform the specified QRH procedures (depending upon the type of alert) to respond to the effects of icing on the airplane's performance.

Although the APM is intended to help flight crews recognize and respond to performance degradations developed while operating in severe icing encounters, the APM alerts are an important safety enhancement for flights operating even in moderate icing conditions, like the accident flight. For example, if the accident airplane had been equipped with an APM, the blue "CRUISE SPEED LOW" annunciator lights would have illuminated about 70 seconds before the flap anomaly, and the amber "DEGRADED PERF" annunciator lights and a single chime would have activated about 40 seconds before the flap anomaly. An APM would not have provided any further alerts after the flight crew selected flap extension because the system requires a flaps-up configuration.

According to ATR, the appropriate flight crew response to the "DEGRADED PERF" alert includes maintaining the minimum airspeed for an approach with 0° flaps in icing conditions plus 10 kts. The NTSB notes that, although the accident flight's hazardous low-air-speed situation resulted from the flight crew's inadequate airspeed management rather than the performance degradation from the moderate icing encounter, if the accident airplane had

been equipped with an APM, the APM would have provided icing-related alerts that may have alerted the flight crew of the need to be more attentive to airspeed management during the approach. The NTSB concludes that the APM system is a valuable low-air-speed alerting tool that can enhance safety in all icing conditions.

APM retrofits for older ATR 42 (like the accident airplane) and ATR 72 airplanes have been available since June 2006, and, effective August 24, 2009, the European Aviation Safety Agency (EASA) required that all EASA-participating operators (operators in the European Community, its Member States, and the European third countries) of ATR 42 and 72 airplanes not originally equipped with the APM system retrofit their airplanes with the system within 72 months or by the second “C” check, whichever occurs first. The FAA did not take similar action. As a result, APM system retrofits are optional for U.S. operators.

In a January 14, 2011, letter responding to a query from NTSB investigators, the FAA stated that its decision not to require APM retrofits for U.S. operators was based, in part, on its finding that, in five of the ten icing-related events that were cited by EASA when mandating the APM, the flight crewmembers were aware that they were in severe icing conditions but did not follow mandatory operating limitations. Thus, the FAA reasoned that, although the APM would have provided alerts in four of these five cases, “it cannot be determined if the flight crew would have acted any differently in response to an APM alert than they did to observing the severe icing cues.” The NTSB notes that, in times of high workload, an alert even a few seconds earlier than an ice accretion has crossed the line from “normal” to severe would be beneficial because it would allow the flight crew to take immediate action. Because the APM warns of performance degradations when they begin to occur, even if the autopilot is on and the flight crew is unable to detect degradation in performance, the APM can provide warnings to flight crews that a hazardous low-air-speed situation is developing well before the icing conditions become severe. The NTSB does not concur with the FAA’s position that APMs would not help flight crews in icing conditions and believes that the FAA should reexamine its decision not to require APM retrofits for U.S. operators. Therefore, the NTSB recommends that the FAA require all operators of ATR 42- and ATR 72-series airplanes to retrofit the airplanes with an APM system if they are not already so equipped.

### **Flap Asymmetry Light**

During the accident flight, the flap asymmetry was not quickly or accurately identified by either flight crewmember despite several available cues, including the cockpit flap position indicator, the exterior wing flap position fairings, the left control wheel input by the autopilot (and the resulting 5° heading change of the airplane), the airplane’s failure to decelerate as expected, and the “RETRIM ROLL L WING DN” and “AILERON MISTRIM” messages on the advisory display unit (ADU). Although it is possible that the flight crewmembers did not detect all of the cues (both the captain and the first officer stated that they did not see any messages on the ADU), the cues they did observe were not rapidly interpreted as indicative of a flap problem.

The NTSB notes that the ATR 42-320 (the accident airplane model) is one of only a few models of transport-category airplanes certificated without a flap malfunction light (either a light to indicate any flap malfunction or a specific asymmetry light) in the cockpit (other models are the ATR 42-200 and -300 and the Cessna 500, 550, 553, 560, and 560XL airplanes). Certification

testing for these airplanes demonstrated that a cockpit light was not required because a flap malfunction (including an asymmetry) did not constitute an unsafe flight condition.

If the accident airplane had been equipped with a flap malfunction light in the cockpit, the light would have illuminated amber in response to the flap asymmetry and would have provided the flight crew with an immediate, definitive indication of a flap problem. The NTSB concludes that, if the accident aircraft had been equipped with a flap asymmetry light, as many other ATR 42- and ATR 72-series airplanes are equipped, the illumination of that light would likely have made the nature of the malfunction more salient to the flight crew and may have triggered a more appropriate crew response. Therefore, the NTSB recommends that the FAA require all ATR 42-series airplanes to be equipped with a flap asymmetry annunciator light if they are not already so equipped.

### **Simulator Training for Icing Encounters**

During the accident flight, both the flap asymmetry and the airframe ice accretion adversely affected the airplane's performance. Aerodynamic coefficient extraction indicated that drag beyond the level expected for an uncontaminated airframe was present during cruise and the final minutes of the flight. ATR estimated that, by the time that the flap asymmetry occurred, a drag increase (due to ice) corresponding with about 23 percent of total power was present. The flight simulator provided by ATR and used by investigators to conduct qualitative testing to assess pilot workload and to evaluate the airplane's handling qualities could not reproduce the accident airplane's drag levels from ice accretion without introducing unrealistic lift and pitch, roll, and yaw moments; therefore, the full extent of the performance degradations could not be determined or duplicated in the simulator. No requirements exist for simulators to be qualified with validated data, such as flight test and flight data recorder (FDR) data, for the effects of airframe ice accumulation.

In this accident, the airplane's stall warning system operated as designed and warned the flight crew of the airplane's proximity to the stall. However, other accidents and incidents have occurred in which airframe ice accumulation has resulted in airplanes entering an aerodynamic stall without any warning to the flight crews. For example, on January 2, 2006, a Saab SF340 operated by American Eagle Airlines, Inc., encountered icing conditions during the en-route climb and departed controlled flight at an altitude of about 11,500 feet mean sea level, losing about 5,000 feet of altitude before the pilots recovered control of the airplane.<sup>13</sup> The flight crew was using the autopilot in vertical speed mode when airplane control was lost, and information from the FDR showed that the upset began before the stall warning activated.

The performance degradations associated with airframe ice accretion can result in an aircraft slowing down much faster than normal and stalling at a much higher airspeed than normal. Both conditions require pilot vigilance to recognize and react to the performance degradations; however, both the American Eagle incident flight crew and this accident flight crew failed to properly monitor and manage the airplanes' airspeed. Although flight crews are

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<sup>13</sup> The report for this incident, NTSB case number LAX06IA076, is available online at <<http://www.ntsb.gov/aviationquery/index.aspx>>.

trained to use higher airspeeds during icing conditions, the effects of performance degradations resulting from ice accretion are not realistically duplicated in a simulator.

The NTSB concludes that simulator-based training scenarios that realistically reflect aircraft performance degradations that result from airframe ice accretion can better prepare flight crews to effectively respond to decaying airspeed situations and other situations that can occur during in-flight icing encounters. Therefore, the NTSB recommends that the FAA define and codify minimum simulator model fidelity requirements for aerodynamic degradations resulting from airframe ice accumulation. These requirements should be consistent with performance degradations that the NTSB and other agencies have extracted during the investigations of icing accidents and incidents.

The NTSB further recommends that the FAA, once the simulator model fidelity requirements requested in Safety Recommendation A-11-46 are implemented, require that flight crews of all aircraft certificated for flight in icing conditions be trained in flight training simulators that meet these fidelity requirements. Such simulation training should emphasize the following: (1) cues for recognizing changes in the aircraft's flight characteristics as airframe icing develops; (2) procedures for monitoring and maintaining appropriate airspeeds in icing conditions, including the use of icing airspeed reference indices; and (3) procedures for responding to decaying airspeed situations, stall protection system activation, and early stalls that can occur without stall protection system activation.

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

Require that role-playing or simulator-based exercises that teach first officers to assertively voice their concerns and that teach captains to develop a leadership style that supports first officer assertiveness be included as part of the already required crew resource management training for 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K pilots. (A-11-39)

Prohibit all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators of pneumatic deice boot-equipped airplanes from dispatching or deliberately operating these airplanes in known freezing rain or freezing drizzle of any intensity, unless the airplane manufacturer has demonstrated that the airplane model can safely operate in those conditions. (A-11-40)

Review the approved pilot, dispatcher, and flight follower training programs and procedures for all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators and require revisions to the programs and procedures, as necessary, to include standardized training and aircraft-specific information to educate pilots, dispatchers, and flight followers of the dangers of flight operations in freezing precipitation and of the differences between ground deicing considerations and in-flight icing operations. (A-11-41)

Develop a method to quickly communicate information regarding the number of persons on board and the presence of hazardous materials to emergency responders when airport emergency response or search and rescue is activated. (A-11-42)

Amend Advisory Circular 150/5200-30C to include guidance on monitoring and ensuring the operability of emergency response and mutual aid gates during winter operations. (A-11-43)

Require all operators of Avions de Transport Régional Aerospatiale Alenia ATR 42- and ATR 72-series airplanes to retrofit the airplanes with an aircraft performance monitoring system if they are not already so equipped. (A-11-44)

Require all Avions de Transport Régional Aerospatiale Alenia ATR 42-series airplanes to be equipped with a flap asymmetry annunciator light if they are not already so equipped. (A-11-45)

Define and codify minimum simulator model fidelity requirements for aerodynamic degradations resulting from airframe ice accumulation. These requirements should be consistent with performance degradations that the National Transportation Safety Board and other agencies have extracted during the investigations of icing accidents and incidents. (A-11-46)

Once the simulator model fidelity requirements requested in Safety Recommendation A-11-46 are implemented, require that flight crews of all aircraft certificated for flight in icing conditions be trained in flight training simulators that meet these fidelity requirements. Such simulation training should emphasize the following: (1) cues for recognizing changes in the aircraft's flight characteristics as airframe icing develops; (2) procedures for monitoring and maintaining appropriate airspeeds in icing conditions, including the use of icing airspeed reference indices; and (3) procedures for responding to decaying airspeed situations, stall protection system activation, and early stalls that can occur without stall protection system activation. (A-11-47)

In response to the recommendations in this letter, please refer to Safety Recommendations A-11-39 through -47. 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](mailto:correspondence@ntsb.gov). If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. 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 HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations. Vice Chairman HART filed a dissenting statement, Member ROSEKIND filed a concurring statement, and Member WEENER filed a concurring and dissenting statement. These statements were published in the final report for this accident investigation.

*[Original Signed]*

By: Deborah A.P. Hersman  
Chairman