**NATIONAL TRANSPORTATION SAFETY BOARD**
**Public Meeting of September 13, 2016**
**(Information subject to editing)**

**Runway Excursion During Landing, Delta Air Lines Flight 1086, Boeing MD-88, N909DL**
**New York, New York, March 5, 2015**
**NTSB/AAR-16/02**

This is a synopsis from the NTSB's report and does not include the Board's rationale for the conclusions, probable cause, and safety recommendations. NTSB staff is currently making final revisions to the report from which the attached conclusions and safety recommendations have been extracted. The final report and pertinent safety recommendation letters will be distributed to recommendation recipients as soon as possible. The attached information is subject to further review and editing to reflect changes adopted during the Board meeting.

# EXECUTIVE SUMMARY

On March 5, 2015, at 1102 eastern standard time, Delta Air Lines flight 1086, a Boeing MD-88, N909DL, was landing on runway 13 at LaGuardia Airport (LGA), New York, New York, when it departed the left side of the runway, contacted the airport perimeter fence, and came to rest with the airplane's nose on an embankment next to Flushing Bay. The 2 pilots, 3 flight attendants, and 98 of the 127 passengers were not injured; the other 29 passengers received minor injuries. The airplane was substantially damaged. Flight 1086 was a regularly scheduled passenger flight from Hartsfield-Jackson Atlanta International Airport, Atlanta, Georgia, operating under the provisions of 14 *Code of Federal Regulations* Part 121. An instrument flight rules flight plan had been filed. Instrument meteorological conditions prevailed at the time of the accident.

The captain and the first officer were highly experienced MD-88 pilots. The captain had accumulated about 11,000 hours, and the first officer had accumulated about 3,000 hours, on the MD-88/-90. In addition, the captain was previously based at LGA and had made many landings there in winter weather conditions.

The flight crew was concerned about the available landing distance on runway 13 and, while en route to LGA, spent considerable time analyzing the airplane's stopping performance. The flight crew also requested braking action reports about 45 and 35 minutes before landing, but none were available at those times because of runway snow clearing operations. The unavailability of braking actions reports and the uncertainty about the runway's condition created some situational stress for the captain, who was the pilot flying.

After runway 13 became available for arriving airplanes, the flight crews of two preceding airplanes (which landed on the runway about 16 and 8 minutes before the accident landing) reported good braking action on the runway, so the flight crew expected to see at least some of the runway's surface after the airplane broke out of the clouds. However, the flight crew saw that the runway was covered with snow, which was inconsistent with their expectations based on the braking action reports and the snow clearing operations that had concluded less than 30 minutes before the airplane landed. The snowier-than-expected runway, along with the relatively short runway length and the presence of Flushing Bay directly off the departure end of the runway, most likely increased the captain's concerns about his ability to stop the airplane within the available runway distance, which exacerbated his situational stress.

The captain made a relatively aggressive reverse thrust input almost immediately after touchdown. Reverse thrust is one of the methods that pilots use to decelerate the airplane during the landing roll. Reverse thrust settings are expressed as engine pressure ratio (EPR) values, which are measurements of engine power (the ratio of the pressure of the gases at the exhaust compared with the pressure of the air entering the inlet). Both pilots were aware that 1.3 EPR was the target setting for contaminated runways.

As reverse thrust EPR was rapidly increasing, the captain's attention was focused on other aspects of the landing, which included steering the airplane to counteract a slide to the left and ensuring that the spoilers had deployed (a necessary action for the autobrakes to engage). The maximum EPR values reached during the landing were 2.07 on the left engine and 1.91 on the right engine, which were much higher than the target setting of 1.3 EPR. These high EPR values likely resulted from a combination of the captain's stress; his relatively aggressive reverse thrust input; and operational distractions, including the airplane's continued slide to the left despite the captain's efforts to steer it away from the snowbanks alongside the runway. All of these factors reduced the captain's monitoring of EPR indications. The high EPR values caused rudder blanking (which occurs on MD-80 series airplanes when smooth airflow over the rudder is disrupted by high reverse thrust) and a subsequent loss of aerodynamic directional control. Although the captain stowed the thrust reversers and applied substantial right rudder, right nosewheel steering, and right manual braking, the airplane's departure from the left side of the runway could not be avoided because directional control was regained too late to be effective.

Delta issued MD-88/90 fleet bulletins in November 2014 and February 2015 indicating that, for the MD-88, 1.3 EPR was the target setting on runways that are not dry and that 1.6 EPR was the target on dry runways. These targets were also emphasized in revisions to the MD-88/90 *Flight Crew Training Manual*. The November 2014 bulletin further stated that, according to line check data, "many pilots accept reverser settings far below the target." However, the National Transportation Safety Board (NTSB) evaluated flight data from Delta MD-88 airplanes and found other flights that involved maximum EPR levels above those targets. Unlike the accident flight, none of those flights resulted in any adverse outcomes. Because the EPR exceedances were likely the result of human factors issues associated with the high workload during landing operations, flight crews at other air carriers that operate MD-80 series airplanes might also experience such exceedances.

The NTSB identified the following safety issues as a result of this accident investigation:

- **Use of excessive engine reverse thrust and rudder blanking on MD-80 series airplanes.** The NTSB's evaluation of flight data from Delta MD-88 airplanes showed that, despite company training and procedures on EPR targets, more than one-third of the landings captured by the data involved an EPR value of 1.6 or above, indicating the need for strategies to preclude excessive EPR use that could lead to rudder blanking. Such strategies, which could benefit all pilots of MD-80 series airplanes, include (1) identifying industry-wide best practices that have been shown to be effective in reliably preventing EPR exceedances during actual high-workload and high-stress operating conditions, (2) implementing a procedure in which the pilot monitoring would make a callout whenever reverse thrust power exceeded an operator's EPR settings, and (3) exploring the possibility that an automated alert could help flight crews avoid EPR exceedances.

- **Subjective nature of braking action reports.** Even though the flight crew received two reports indicating that the braking action conditions on the runway were good, postaccident simulations showed that the braking action at the time that the accident airplane touched down was consistent with medium (or better) braking action. The flight crew's landing performance calculations indicated that the airplane could not meet the requirements for landing with braking action that was less than good, but the flight crew proceeded with the landing based on, among other things, the reports indicating good braking action on the runway.

  As part of its investigation of the 2005 Southwest flight 1248 accident at Chicago Midway International Airport, the NTSB issued safety recommendations to the Federal Aviation Administration (FAA) that addressed runway surface condition assessment issues, including the inherently subjective nature of pilot braking action reports. One recommendation—to outfit transport-category airplanes with equipment that routinely calculates, records, and conveys the airplane braking ability required and/or available to slow or stop the airplane during the landing roll and develop related operational procedures—has not yet been implemented because these systems are still under development and evaluation. The NTSB continues to encourage the FAA to develop the technology for these systems because they are expected to provide objective, reliable, real-time information that flight crews of arriving airplanes could use to understand the extent of runway surface contamination.

- **Lack of procedures for crew communications during an emergency or a non-normal event without operative communication systems.** Damage to the airplane during the accident sequence resulted in the loss of the interphone and public address system as methods of communication after the accident. As a result, the flight attendants in the aft cabin left their assigned emergency exits to obtain information from the flight crew and the lead flight attendant in the forward cabin. Also, the lead flight attendant left her assigned emergency exit to check on a passenger in the mid-cabin. However, because the airplane was not at a normal gate location or a normal attitude, an emergency evacuation was possible, but the flight attendants were not in a position to immediately open their assigned exits if necessary. Delta's flight attendant manual and training curriculum did not address communicating during an emergency or a non-normal situation without operative communication systems. In addition, Delta did not have guidance instructing flight attendants to remain at their assigned exits during such a situation.

- **Inadequate flight and cabin crew communication, coordination, and decision-making regarding evacuations for an emergency or a non-normal event.** Postaccident interviews with the flight attendants indicated that the captain did not convey a sense of urgency to evacuate the cabin. The first officer stated, during a postaccident interview, that emergency response personnel requested, and the captain subsequently commanded, the evacuation. Postaccident videos provided by a passenger showed that the lead flight attendant announced the plans to evacuate about 6 minutes after the airplane came to a stop. The videos also showed that the flight attendants were confused about the timing of the evacuation, which did not begin until about 6 minutes after the evacuation announcement. In addition, the videos showed that more than 17 minutes had elapsed between the time that the airplane came to a stop and the time that all of the passengers were off the airplane.

The NTSB has a long history of investigating accidents involving inadequate evacuation communication, coordination, and decision-making and has made numerous safety recommendations, including requests for joint evacuation exercises for flight and cabin crews, to resolve these issues. However, FAA efforts to fully address the issues have so far been insufficient. A multidisciplinary effort that focuses on analyzing data involving airplane evacuations and identifying ways to improve flight and cabin crewmember performance could be an effective way to resolve recurring evacuation-related issues.

- **Inaccurate passenger counts provided to emergency responders.** After the accident, the passenger count provided by the flight and cabin crews to air traffic control personnel and emergency responders (125) did not fully reflect the total number of passengers (127) aboard the airplane because two lap-held children were not included in the total passenger count. Delta reported the actual number of passengers to LGA airport operations staff several hours after the accident. However, flight and cabin crews involved in an accident or incident should be able to provide emergency responders with an accurate passenger count (including lap-held children) upon exiting the airplane and without contacting company personnel for further information.

- **Unclear policies regarding runway friction measurements.** LGA and other airports operated by the Port Authority of New York and New Jersey were not using continuous friction measuring equipment (CFME) to assess runway friction after snow removal operations. However, LGA's *Airport Certification Manual* and Port Authority's letter of agreement with the LGA air traffic control tower stated that airport operations staff used CFME to conduct friction assessments when conditions either required trend analysis or might result in degraded runway surface friction. As a result, Port Authority's policies regarding CFME use during winter operations need clarification, especially given that the FAA promotes CFME as a valuable tool for airport operators to detect trends in runway conditions during winter operations.

- **Unclear policies regarding runway condition reporting.** According to the FAA's advisory circular (AC) on airport winter safety and operations, notices to airmen (NOTAM) describing runway surface conditions must be "timely" and need to be updated any time a "change to the runway surface condition" occurs. However, the NOTAM that was current at the time of the accident had been issued 2 hours beforehand, and a new NOTAM was not issued after runway snow clearing operations had completed (27 minutes before the accident). If the FAA clarified the guidance in the AC to specifically describe what constituted a "timely" NOTAM and what types of "change to the runway surface condition" needed to be reported, airport operations personnel could issue more effective NOTAMs, and flight crews could have more updated information regarding runway surface conditions.

## FINDINGS

1. The flight crew was properly certificated and qualified in accordance with federal regulations and company requirements. Flight crew fatigue was likely not a factor in this accident. The airplane was properly certificated, equipped, and maintained in accordance with federal regulations. No evidence indicated any preimpact structural, engine, or system failures.

2. The flight crewmembers' uncertainty about the runway conditions at LaGuardia Airport led to some situational stress for the captain.

3. The flight crew was well prepared for the approach and established landing requirements that were consistent with company policies.

4. Even though the flight crewmembers' observations of snow on the runway were inconsistent with the expectations that they formed based on the field condition information that they received, their decision to continue the approach was not inappropriate because the landing criteria had been met.

5. Although the runway was contaminated with snow, runway friction when the accident airplane landed was sufficient for stopping on the available runway length.

6. The circumstances associated with the landing, including the snowier-than-expected runway, short runway length, and body of water off the departure end of the runway, likely exacerbated the captain's situational stress and prompted him to make an aggressive input on the thrust reversers.

7. The captain was unable to maintain directional control of the airplane due to rudder blanking, which resulted from his application of excessive reverse thrust.

8. Even though the first officer promptly identified rudder blanking as a concern and the captain stowed the thrust reversers in response, the airplane's departure from the left side of the runway could not be avoided because directional control was regained too late to be effective.

9. A solution to reliably limit reverse thrust engine pressure ratio values could benefit all pilots of MD-80 series airplanes.

10. A callout when reverse thrust exceeds 1.3 engine pressure ratio during landings on contaminated runways could help avoid rudder blanking and a subsequent loss of directional control.

11. An automated alert could help minimize the possibility of reverse thrust engine pressure ratio exceedances during the landing rollout.

12. This accident demonstrates the continuing need for objective, real-time, airplane-derived data about runway braking ability for flight crews preparing to land with runway surface conditions that are worse than bare and dry.

13. The flight and cabin crews did not conduct a timely or an effective evacuation because of the flight crew's lack of assertiveness, prompt decision-making, and communication and the flight attendants' failure to follow standard procedures once the captain commanded the evacuation.

14. The flight attendants were not adequately trained for an emergency or unusual event that involved a loss of communications after landing, and the flight attendants' decision to leave their assigned exits unattended after the airplane came to a stop resulted in reduced readiness for an evacuation.

15. This and other accidents demonstrate the need for improved decision-making and performance by flight and cabin crews when faced with an unplanned evacuation.

16. Aircraft rescue and firefighting personnel would likely have arrived at the accident scene sooner if they had received more timely and precise information about the accident and its location.

17. Even though the initial uncertainty regarding the total number of passengers aboard the flight, including lap-held children, did not lead to any adverse outcomes, such uncertainty could be detrimental under other accident circumstances, especially if search and rescue efforts are needed.

18. By not using its continuous friction measuring equipment during winter operations, LaGuardia Airport did not take advantage of a tool that would allow the airport to objectively assess the effectiveness of snow removal operations on contaminated runways.

19. The Federal Aviation Administration's airport winter operations safety guidance is not sufficiently clear about the timing and need for updated runway condition reports, which could result in flight crew uncertainty about possible runway contamination.

## PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the captain's inability to maintain directional control of the airplane due to his application of excessive reverse thrust, which degraded the effectiveness of the rudder in controlling the airplane's heading. Contributing to the accident were the captain's (1) situational stress resulting from his concern about stopping performance and (2) attentional limitations due to the high workload during the landing, which prevented him from immediately recognizing the use of excessive reverse thrust.

## RECOMMENDATIONS

### New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

**To the Federal Aviation Administration**:

1. Collaborate with Boeing and US operators of MD-80 series airplanes to (1) conduct a study to examine reverse thrust engine pressure ratio (EPR)-related operational data, procedures, and training and (2) identify industry-wide best practices that have been shown to be effective in reliably preventing EPR exceedances to mitigate the risks associated with rudder blanking.

2. Encourage US operators of MD-80 series airplanes to (1) implement the best practices identified in Safety Recommendation [1] and (2) participate in an industry-wide monitoring program to verify the continued effectiveness of those solutions over time.

3. Require operators of MD-80 series airplanes to revise operational procedures to include a callout when reverse thrust power exceeds 1.3 engine pressure ratio during landings on a contaminated runway.

4. Continue to work with industry to develop the technology to outfit transport-category airplanes with equipment and procedures to routinely calculate, record, and convey the

airplane braking ability required and/or available to slow or stop the airplane during the landing roll.

5. If the systems described in Safety Recommendation [4] are shown to be technically and operationally feasible, work with operators and the system manufacturers to develop procedures that ensure that airplane-based braking ability results can be readily conveyed to, and easily interpreted by, arriving flight crews, airport operators, air traffic control personnel, and others with a safety need for this information.

6. Require 14 *Code of Federal Regulations* Part 121 operators to provide (1) guidance that instructs flight attendants to remain at their assigned exits and actively monitor exit availability in all non-normal situations in case an evacuation is necessary and (2) flight attendant training programs that include scenarios requiring crew coordination regarding active monitoring of exit availability and evacuating after a significant event that involves a loss of communications.

7. Develop best practices related to evacuation communication, coordination, and decision-making during emergencies through the establishment of an industry working group and then issue guidance for 14 *Code of Federal Regulations* Part 121 air carriers to use to improve flight and cabin crew performance during evacuations.

8. Clarify guidance to all 14 *Code of Federal Regulations* Part 121 air carriers to reinforce the importance of (1) having precise information about the number of passengers aboard an airplane, including lap-held children, and (2) making this information immediately available to emergency responders after an accident to facilitate timely search and rescue operations.

9. For airports certificated under 14 *Code of Federal Regulations* Part 139, direct airport certification safety inspectors to ensure, before or during the airports' next scheduled annual inspection, that policies and procedures for friction measurement during winter operations are accurately and adequately described in the airports' *Airport Certification Manual* and Snow and Ice Control Plan.

10. Revise Advisory Circular 150/5200-30D, Airport Field Condition Assessments and Winter Operations Safety, to provide more precise guidance regarding (1) the need to issue notices to airmen (NOTAM) in a timely manner and (2) the specific changes to runway surface conditions that would prompt the issuance of updated NOTAMs.

**To Boeing**:

11. Collaborate with the Federal Aviation Administration and US operators of MD-80 series airplanes to (1) conduct a study to examine reverse thrust engine pressure ratio (EPR)-related operational data, procedures, and training and (2) identify industry-

wide best practices that have been shown to be effective in reliably preventing EPR exceedances to mitigate the risks associated with rudder blanking

12. Explore the possibility of incorporating an alert in MD-80 series airplanes to aid pilots in preventing engine pressure ratio exceedances.

**To US operators of MD-80 series airplanes**:

13. Collaborate with the Federal Aviation Administration and Boeing to (1) conduct a study to examine reverse thrust engine pressure ratio (EPR)-related operational data, procedures, and training and (2) identify industry-wide best practices that have been shown to be effective in reliably preventing EPR exceedances to mitigate the risks associated with rudder blanking.

**To The Port Authority of New York and New Jersey**:

14. After consultation with the Federal Aviation Administration, clarify your policies regarding continuous friction measuring equipment use during winter operations and ensure that this information is included in the *Airport Certification Manual* and Snow and Ice Control Plan for each airport operated by the Port Authority.

## Previously Issued Recommendation Reiterated in This Report

The National Transportation Safety Board reiterates the following recommendation to the Federal Aviation Administration:

> Revise Advisory Circular 120-48, "Communication and Coordination Between Flight Crewmembers and Flight Attendants," to update guidance and training provided to flight and cabin crews regarding communications during emergency and unusual situations to reflect current industry knowledge based on research and lessons learned from relevant accidents and incidents over the last 20 years. (A-09-27)

## Previously Issued Recommendations Classified in This Report

Safety Recommendation A-07-63 is classified "Open—Acceptable Response."

> Establish a minimum standard for 14 *Code of Federal Regulations* Part 121 and 135 operators to use in correlating an airplane's braking ability to braking action reports and runway contaminant type and depth reports for runway surface conditions worse than bare and dry.

Safety Recommendation A-07-64 is reclassified "Closed—Acceptable Action/Superseded." This recommendation is superseded by Safety Recommendations [4] and [5].

> Demonstrate the technical and operational feasibility of outfitting transport-category airplanes with equipment and procedures required to routinely calculate, record, and convey the airplane braking ability required and/or available to slow or stop the airplane during the landing roll. If feasible, require operators of transport-category airplanes to incorporate use of such equipment and related procedures into their operations.

Safety Recommendation A-09-27 is reclassified "Open—Unacceptable Response."

> Revise Advisory Circular 120-48, "Communication and Coordination Between Flight Crewmembers and Flight Attendants," to update guidance and training provided to flight and cabin crews regarding communications during emergency and unusual situations to reflect current industry knowledge based on research and lessons learned from relevant accidents and incidents over the last 20 years.