Submission of Delta Air Lines, Inc. to the National Transportation Safety Board

Delta Air Lines Flight 1086
Boeing MD-88, N909DL
Runway Excursion
LaGuardia, New York
March 05, 2015
DCA15FA085

DELTA SKYTEAM

Table of Contents

1.0 SYNOPSIS

1.1 Incident Details

On March 5, 2015, about 1102 Eastern Standard Time (EST), a Boeing MD-88, N909DL, operating as Delta flight 1086, was landing on runway 13 at LaGuardia Airport, New York, New York (LGA), and exited the left side of the runway, contacted the airport perimeter fence, and came to rest with the airplane nose on an embankment next to Flushing Bay. The 129 passengers received either minor injuries or were not injured, and the 3 flight attendants and 2 flight crew were not injured. The airplane was substantially damaged. Flight 1086 was a regularly scheduled passenger flight from Hartsfield-Jackson Atlanta International Airport (ATL) operating under the provisions of 14 Code of Federal Regulations (CFR) Part 121. Instrument meteorological conditions (IMC) prevailed, and an instrument flight rules (IFR) flight plan was filed.

1.2 Executive Summary

As a party to the investigation Delta Air Lines is submitting facts, conditions, and circumstances about the accident for consideration as the final report is developed. The content of the submission attempts to communicate the following: 1) The field condition reporting process at LaGuardia airport. 2) The aircraft's motions and forces experienced during landing. 3) The effect of high EPR and rudder blanking. 4) The post-accident crew actions and evacuation.

2.0 ANALYSIS

2.1 Meteorology

As noted in the Meteorology Group Chairman's Factual Report, precipitation (snow and rain mix) began at 0412 EST. According to the report "total snow on the ground from previous storms was noted at 3 inches based on an observation at 0651 EST. At 0657 EST moderate snow began with 1 inch of new snowfall reported at 0751 and again at 0851 with a total of 5 inches on the ground. Moderate snow continued through the time of the accident." Based on estimations using surface visibility, the snow accumulation rate exceeded ¾ inch per hour and approximately 1 inch per hour in the immediate time surrounding the accident.

According to the Airport Operations Group Factual Report:

> The FAA contractors at MAT [Marine Air Terminal] used "a thin, metallic ruler provided by their weather service to measure the snow… typically in the MAT courtyard on pavement and the grass (location selected depends on varying conditions, namely the wind)." They did this on an hourly basis, or as requested." On the day of the accident, "they chose to do so in the [MAT] courtyard for a more accurate measurement which they wouldn't get on the roof."

A review of the five minute Automated Surface Observing System (ASOS) information revealed that freezing fog was present from at least 1030 EST and persisted after the accident. Additionally, a review of the ASOS information between 0850 EST to 1150 EST revealed that liquid water equivalent measurements of hourly snowfall accumulation were:

> 0851 EST - 0950 EST = 0.03 inch
> 0951 EST - 1050 EST = 0.06 inch
> 1051 EST - 1150 EST = 0.05 inch

The liquid water equivalent as reported by the ASOS for the 1 hour period prior to the accident was 0.06 inches, which is the greatest amount reported in any one hour preceding the accident. The use of liquid water equivalent precipitation measurements could have aided in runway clearing operations by influencing the removal of runway contaminants prior to the accident.

2.2 Airport

2.2.1 Field Condition Reports

On November 22, 2011, the Port Authority of New York and New Jersey issued a memorandum titled "Winter Operations Friction Testing and Snow and Ice Control Plans" to airport managers. The memorandum noted that following the 2008 revisions of the Federal Aviation Administration (FAA) Advisory Circular (AC) 150/5200-30C, the "Port Authority Aviation Department sought further clarification of the changes from the Director of the FAA's Office of Airports Safety and Standards." Based on the FAA's response[1], the Port Authority's law department recommended that a standard procedure for reporting friction testing be used by all airports when practicable. The Port Authority developed the following policy:

> During Snow removal Operations friction testing may be conducted to provide trend data (Mu values) for Airport Operation staff. Mu values will not be transmitted via NOTAM or communicated to the Air Traffic Control Tower.
>
> Runway friction test results may be provided to interested parties upon request.

Approximately 20 minutes after the accident, Delta requested that a post event friction assessment be performed. The Port authority did not accomplish the friction assessment. Following the accident, Delta requested that the port authority share friction testing results (Mu) during times of active precipitation. This request was denied by the Port Authority.

[1] The FAA stated "we continue to believe operational testing under winter conditions can be a valuable tool to airport operators in providing information on changing runway conditions." The FAA also supported sharing trend information with interested parties (aircraft operators' dispatchers).

According to the Airport Operations Group Factual Report, "LGA's chief operations supervisor stated that LGA had CFME[2] vehicles, but that it was not used during snow removal operations – only to examine runway friction as it related to rubber removal during the summer months." In reference to runway assessments and clearing, the factual report includes references from a January 20, 2016 email from the LGA aeronautical operations manager. The factual report states:

> LGA does not allow "snow to collect on the runway past the point of 'thin' or to the point [they] need to measure it. It is a visual assessment from the teams constantly monitoring the conditions on the field." With regard to specific "triggers" that require the beginning of plowing operations, he stated that the triggers were "braking action reports, visual inspection, weather forecast data, [and] surface temps."

According to the Airport Operations Group Factual Report, runway clearing operations at LGA is performed using "hot runways" during a "gap" in arrivals or departures. It was noted that at the time of the accident, Team Blue was staged on taxiway DD. *See Figure 1.* At approximately 1051 EST (approximately 11 minutes before the accident), a request was made to the air traffic control tower to provide a gap in arrivals to allow for another clearing of runway 13/31. The LGA snow coordinator stated that they wanted to perform a runway clearing every 10-20 minutes. Prior to the accident, the last clearing operation on runway 13/31 was completed at 1035 EST (approximately 27 minutes prior to the accident).

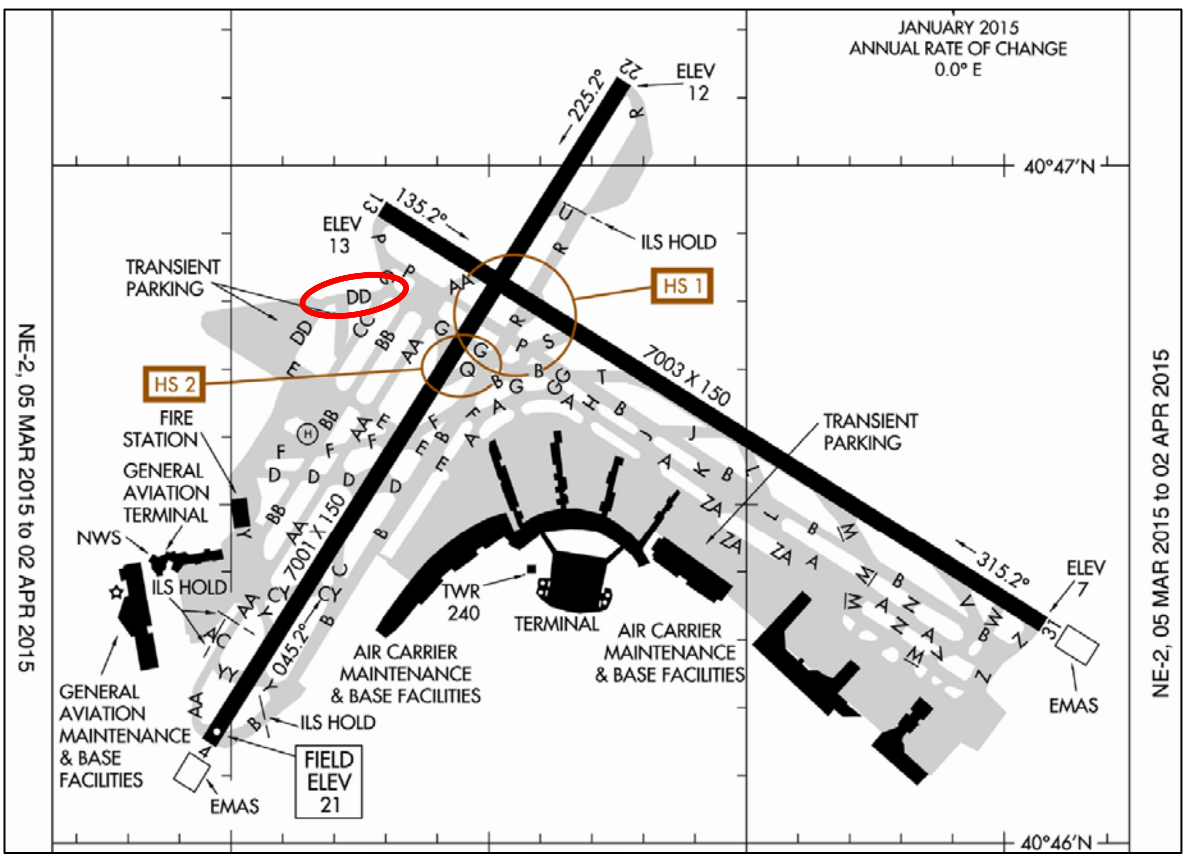

Figure 1: FAA LGA Airport Diagram (excerpt).
Note: Red circle highlights taxiway DD.

According to FAA AC 150/5200-30C "Runway condition reports must be updated any time a change to the runway surface condition occurs." The AC notes that this includes the application of chemicals or sand as well as runway clearing operations. Additionally, the AC states "airport

[2] CFME is defined as continuous friction measuring equipment.

operators should not allow airplane operations on runways after such activities until a new runway condition report is issued reflecting the current surface condition(s) of affected runways."

The Airport Operations Group produced a timeline of events that included runway clearing operations and runway condition reports. According to the timeline, the runway was last cleared at 1035 EST and the last NOTAM was issued at 0903 EST. Additionally, the Airport Operations Group noted that the 0738 EST NOTAM indicated that the runway had been chemically treated even though the runway had not been chemically treated. In an interview with the LGA operations manager, it was stated that NOTAMs will only be issued when conditions change and that a new NOTAM will not be issued after clearing operations if the runway conditions are comparable to the conditions previously reported. This practice is not in accordance with FAA AC 150/5200-30C.

In an interview with the FAA airport certification inspector, who completed the annual airport inspection at LGA for the previous three years, the inspector was asked about information in AC 150/5200-30C. In response to a question noting that airports are required to comply with the AC, the inspector stated "an advisory circular is just that, advisory." The APPLICATION section of the AC states: "

> Certificated airports are required to follow the requirements of paragraphs 5-6 [Requirements For Runway Closures] and 5-7 [Continuous Monitoring] as of the effective date of this AC. In addition, all certificated airports must submit revised Snow and Ice Control Plans to the FAA no later than April 30, 2009 for approval. At that time, certificated airports will be required to comply with the remaining portions of this AC. The AC is advisory for non-certificated airports."

2.2.2 Delta Air Lines Special Winter Operations Airport Program

Based on Delta Flight Safety investigations from previous runway excursion events during winter conditions and several visits with airport management at northern tier airports, a Special Winter Operations Airport (SWOA) program was established. Flight Safety introduced a SWOA program to mitigate the risks associated with the difficulty in standardizing runway treatment, clearing, and friction testing, as well as addressing environmental factors which increase an aircraft's risk of runway excursions during winter conditions. Additionally, the program was designed to assist airports in upgrading snow plans, equipment, and facilities. The use of the SWOA program extends to the Delta Connection partners (regional carriers) who also participate in the SWOA program.

SWOA airports are identified through a matrix that accounts for several elements including: incident history, frictions testing equipment used, vertical guidance availability, runway lighting, runway length, field elevation, and surrounding terrain. Airports that have been identified through the SWOA program will be scheduled for a bi-annual visit to foster conversations to enact changes to improve safety. Additionally, SWOA airports are subject to operating restrictions when frozen precipitation is falling and accumulating or the runway is contaminated with frozen precipitation.

In addition to an annual SWOA airport survey (Airport Operations Attachment 6), Delta contacted 13 airports[3] to assess their use of surface friction testing during winter events. The review found that all airports conduct surface friction testing during winter events.

2.2.3 Emergency Response

A review of the emergency response, revealed that the Red Team (east taxiway snow clearing team) leader notified the LGA snow coordinator of the accident. The coordinator responded at 1103:10 EST (18 seconds after the aircraft came to a stop). At 1104 EST the coordinator informed the air traffic control tower controller that the runway was closed. At 1104:48 EST a second airport official responded to the aircraft, requested Aircraft Rescue and Firefighting (ARFF), and informed the controller that the airport was closed.

[3] DTW / MSP / MDW / BOS / GRR / SLC / SYR / BDL / FNT / IND / CLE / PHL / ORD

The coordinator arrived at the aircraft at 1105:11 EST and observed a fuel leak. At that time, the airport manager, deputy manager, and ARFF deputy chief were conducting a meeting in the airport administrative offices. During the meeting the deputy manager received a phone call notification of the event. Subsequently, the ARFF deputy chief dispatched ARFF personnel via phone, noting that the incident had not been announced via the emergency notification system. This call was the first indication received by ARFF of an aircraft accident. Airport Operations Group noted that at 1110:12 EST the ARFF crews were unclear about the location of the aircraft until they observed it on the embankment at approximately 1111 EST. ARFF personnel arrived at the aircraft approximately 8 minutes after the aircraft came to a stop.

2.3 Aircraft Performance

2.3.1 Vehicle Performance

According to the NTSB Performance Study, the aircraft touched down in the touchdown zone at 133 knots, approximately 600 feet from the runway threshold. The nose landing gear touched down approximately 1,200 feet from the runway threshold. Approximately 1,600 feet from the runway threshold, a left yawing moment began and the flight crew applied right rudder. During that time, the reverse thrust engine pressure ratio (EPR) exceeded 2.0 and 1.9 for the left and right engines, respectively. Subsequently, the thrust reversers were stowed and manual braking was applied. The aircraft exited the paved surface 3,200 feet from the runway threshold, approximately 14 seconds after main landing gear touchdown.

As noted in the Performance Study, test data indicated that the rudder has limited directional authority for reverse thrust EPR values above 1.6 at airspeeds below 146 knots. Additionally, below 108 knots the rudder has limited directional authority above 1.3 EPR. The Performance Study noted that the high EPR values resulted in rudder blanking and the rudder's reduced effectiveness during the left yaw and heading deviation. The study also noted that manual braking and nose wheel steering contributed to reducing the left yaw but were insufficient to correct the aircraft's path with the rudder blanked. The Aircraft Performance Group was unable to determine the circumstances that contributed to the heading deviation.

An analysis of quick access recorder (QAR) data for 78 landings from the accident aircraft and prior landing aircraft indicated that EPR value above 1.6 were common, including during times of reported precipitation. It was noted that none of the 78 landings exhibited a significant deviation in heading or resulted in a runway excursion. The analysis indicated that rudder input was "more strongly correlated" to asymmetrical reverse thrust EPR than to crosswind direction. It was noted that of all of the reviewed landings, the accident landing had the highest recorded EPR value as well as the shortest time to rise from 1.3 EPR to 1.6 EPR. Based on this information, aircraft routinely experience reverse thrust above 1.3 EPR without degradation of lateral control; indicating that the conditions of the runway at the time of touchdown likely contributed to the loss of directional control and inability to recover.

Simulations were performed using data from the flight recorder, to estimate the wheel braking coefficients for the accident aircraft and the prior landing aircraft (an MD-88). The simulations estimated the wheel braking coefficient to be approximately 0.16 or better[4] which is less than GOOD. With the exception of Flight UAL462, who reported braking action as MEDIUM at touchdown and POOR at rollout, other landing aircraft reported GOOD braking action. This points to the subjectivity of pilot braking action reports as it relates to actual runway friction assessment. Had the flight crew been provided with a more accurate runway condition assessment, they would have diverted as discussed during approach due to the need for GOOD or better braking action.

[4] A wheel braking coefficient of 0.16 is within the range for MEDIUM pilot-reported braking action as defined by FAA AC 25-32, dated December 22, 2015, page 14.

2.3.2 MD-88 Rudder Effectiveness

In response to a Delta request for MD-88 rudder blanking information, Boeing provided the following information in January 2016:

> There are no single rudder effectiveness factors available for different MD-80 reverse thrust EPR settings. The NTSB report NTSB-AAR-81-16 cites rudder effectiveness values that are valid at a nominal airspeed of 100 knots. The report's "Maximum Rudder Effectiveness Available" values are the percentages of yawing moment available with full rudder deflection in reverse thrust, as compared to full rudder deflection with forward thrust at a 100 knots.
>
> For cases where symmetrical reverse thrust is utilized and the rudder power is ON:
>
>> When utilizing idle reverse thrust and full rudder deflection, the resultant rudder moment will be at least 65% of the full rudder moment experienced while utilizing forward thrust, regardless of the airspeed.
>>
>> When utilizing 1.3 EPR reverse thrust and full rudder deflection, the resultant rudder moment varies from 57% at 150 kts to 16% at 80 kts, when compared to the rudder moment experienced when utilizing forward thrust and full rudder deflection. The rudder effectiveness in this condition will continue to decrease as speed decreases.
>
> The effectiveness of the MD-80's rudder was determined under different reverse thrust settings during flight testing. This flight testing including cases where the nose wheel steering was disconnected, to show aircraft yaw accelerations that result from rudder moments when operating on wet or contaminated runways. Rudder effectiveness at different airspeeds and runway conditions were taken into account when Boeing's MD-80 FCOM was created and provided to the operators. Therefore, the MD-80 can be safely operated on the runway conditions covered in the MD-80 FCOM and Boeing continues to recommend the landing procedures found within Volume II of the FCOM.

Data relating to the rudder's specific effectiveness was not included in Delta's manuals; as Delta's manual content is based on those produced by Boeing.

2.4 Operations and Human Performance

During interviews conducted by the Operational Factors Group and in conversations captured on the cockpit voice recorder, the flight crew stated that they required braking action reports of GOOD or better to land. The cockpit voice recorder revealed that the flight crew requested braking action reports or runway status updates to determine if they needed to divert.

The Operations Group Factual Report stated that on final approach "both pilots stated they saw the runway centerline lights but the runway was white in color and appeared to be covered in snow, which they did not expect." The runway conditions were captured in a passenger's photograph (Survival Factors Attachment 12, picture 2). After touchdown and the application of reverse thrust the captain noted that he "did not hear the normal braking sound or feel the usual deceleration and he did not look at the EPR indicators." According to the flight data, approximately 3.5 seconds after main gear touchdown, and while still established on runway centerline, the reverse thrust EPR values exceeded 1.3. Reverse thrust EPR reached peak values shortly after the aircraft began to drift left. Approximately 3 second later, reverse thrust was stowed. Delta FCTM policy states that "Reverse thrust above 1.3 EPR may blank the rudder and degrade directional control effectiveness. However, as long as the aircraft is aligned with runway track, reverse thrust may be used as necessary (up to maximum), to stop the aircraft. Do not attempt to maintain directional control by using asymmetric reverse thrust". Additionally, the captain noted that the first officer called out "watch your reverse, you're drifting left." The first officer's notation of reverse thrust is in accordance with the MD88/90 Flight Crew Training Manual

(FCTM) policy that the pilot monitoring should call out an engine operational limit being approached or exceeded.

On May 29, 1996, Boeing issued Service Bulletin MD80-78-068 which implemented an improved thrust reverser cam support assembly. The new assembly provided the flight crew with a throttle lever detent for 1.3 EPR. Due to reports of excessive EPR split with the new assembly, the bulletin was rescinded by Service Bulletin MD80-78-070 on May 29, 1997.

The MD-88 is equipped with a bucket type thrust reverser that is comprised of two canted deflector doors on each engine that direct fan and exhaust gases above and below the nacelle. The MD-90 is equipped with a cascade thrust reverser that is comprised of cold-ducts, translating sleeves, blocker doors, and cascades on each engine that direct fan air around the nacelle. The B717-200 is equipped with non-canted bucket type thrust reverser comprised of two deflector doors on each engine that direct fan and exhaust gases above and below the nacelle. Both the MD-90 and the B717-200 are thrust limited and are equipped with a reverse thrust detent and an emergency reverse thrust detent. Additionally, both the MD-90 and B717-200 engine are full authority digital engine control (FADEC) equipped.

In reference to unplanned evacuations, the MD88/90 FCTM, page 8.14, states “the captain needs to analyze the situation carefully before initiating an evacuation order. Quick actions in a calm and methodical manner improve the chances of a successful evacuation.” Additionally the FCTM states “when there is a need to evacuate passengers and crew, the captain has to choose between commanding an emergency evacuation using the emergency escape slides or less urgent means such as deplaning using stairs, jetways, or other means.” The FCTM notes that all available sources of information should be used to determine the safest course of action. This includes the use of reports from the cabin crew, other aircraft, and air traffic control. With the aircraft’s radios and interphone inoperative, the flight crew communicated with the cabin crew directly and used a mobile phone to contact dispatch and LGA operations. After being informed of a fuel leak by ARFF personnel, the captain commanded an evacuation of the aircraft. The flight crew’s methodical analysis of the situation and initiation of an evacuation was in accordance with policy and resulted in a successful evacuation.

2.5 Survival Factors

After the aircraft came to a stop, the cabin crew began to shout commands to “stay seated, stay calm.” The 2L flight attendant noted that they attempted to use the PA system to deliver their commands; however, the PA system did not work. At that time, the cabin crew noted that the passengers were calm and that there were no injuries. Subsequently, the flight deck door opened and the captain exited the flight deck and spoke to the flight leader about the status of the exits. Subsequently, the cabin crew observed ARFF personnel signaling to open the over wing exits. The cabin crew advised the passengers to remain seated as an evacuation command had not been provided by the flight crew. Subsequently, the evacuation command was given, using a megaphone, to use the right over wing exits and the tail cone exit.

Emergency procedures for the cabin crew are contained in the In-Flight Service Onboard Manual (OBM) and covers planned and unanticipated emergencies. The OBM states that “in an unanticipated Emergency, there is no time for preparation. It usually occurs during taxi, takeoff, or landing with little warning.” For unplanned emergencies, the OBM directs the cabin crew to return to their jumpseats, secure the aircraft for landing, shout commands, and follow evacuation instructions. The OBM cabin crew evacuation procedures contain a note that states “If there is no immediate danger after 30 seconds, do not evacuate; Purser/FL contacts flight deck crew and advises FAs.” The Survival Factors Group Factual Report states “if the PA becomes inoperable during the flight, the flight leader is required to notify the captain and to establish alternate methods of communication. Individual briefings, small group briefings, or the use of the megaphone were examples of alternate methods of communication.” The cabin crew’s analysis of the situation and communication with each other, as well as the flight crew was in accordance with policy and resulted in a successful evacuation.

After the completion of the evacuation, the cabin crew was approached by law enforcement who requested a passenger count. The cabin crew provided a portion of the departure report which contains passenger count information. The Survival Factors Group Factual Report states that "The reports contained specific information pertaining to the flight including, but not limited to, the expected totals of passengers, lap-held infants, unaccompanied minors, special assist animals, and special assist passengers." The departure report is generated approximately 15 minutes before scheduled departure and is provided to the cabin crew.

3.0 FINDINGS

- The snow accumulation rate exceeded ¾ inch per hour and approximately 1 inch per hour in the immediate time surrounding the accident.
- The Port Authority does not conduct runway friction testing at LGA.
- Runway clearing operations at LGA are performed using "hot runways" during a "gap" in arrivals or departures.
- The last clearing operation on runway 13/31 prior to the accident was completed at 1035 EST (approximately 27 minutes prior).
- At LGA, a new NOTAM will not be issued after clearing operations if the runway conditions are comparable to the conditions previously reported; NOTAMs are issued when airport surface conditions change.
- The flight crew identified the threat of degraded braking action due to runway contamination at LGA.
- The flight crew identified the need for a braking action of GOOD or better in order to land.
- The cockpit voice recorder revealed that the flight crew requested braking action reports or runway status updates to determine if they needed to divert.
- With the exception of one aircraft, who reported braking action as MEDIUM at touchdown and POOR at rollout, other prior landing aircraft reported GOOD braking action.
- On final approach both pilots observed the runway centerline lights and observed that the runway was white in color and appeared to be covered in snow, which was not expected.
- The aircraft touched down in the touchdown zone of runway 13.
- The pilot flying applied reverse thrust in excess of 1.3 EPR.
- The reverse thrust EPR exceeded 2.0 and 1.9 for the left and right engines, respectively.
- The pilot monitoring recognized the excessive reverse thrust EPR and called for a reduction in reverse thrust.
- The aircraft experienced a left yawing moment.
- The pilot flying stowed the thrust reversers, applied right rudder, and right manual braking but was unable to arrest the left drift in order to recover and remain on the paved surface due to the rudder being blanked.
- After the aircraft stopped, the captain directly spoke to the flight leader about the status of the exits as the intercom did not function.
- Aircraft Rescue and Firefighting personnel arrived at the aircraft approximately 8 minutes after the aircraft came to a stop.
- The evacuation was performed in accordance with policy.
- Aircraft performance simulations estimated the wheel braking coefficient to be approximately 0.16 or better, which correlates to less than GOOD.
- Quick access recorder data indicated that MD-88 aircraft routinely experience reverse thrust above 1.3 EPR without degradation of lateral control; indicating that the conditions of the runway at the time of touchdown likely contributed to the loss of directional control and inability to recover.

4.0 SAFETY RECOMMENDATIONS/ SAFETY ACTIONS

4.1 Safety Recommendations

Delta Air Lines is proposing that the NTSB consider issuing recommendations for the following topics:

1. The development of a technological solution for improved runway friction assessments.
2. Consider the development of a standard to utilize liquid water equivalent precipitation measurements in runway condition assessments as an additional factor to influence the timing of runway contaminant removal.
3. The development of a regulatory standard for the issuance of field condition reports at a minimum of once per hour when the surface condition is other than dry.

4.2 Safety Actions

- Flight Crew Communication
    - Flight Safety Electronic Bulletin discussing contaminated runway awareness sent to all MD-88 pilots.
    - Flight Operations published MD-88 Fleet Bulletins highlighting the use of reverse thrust during landing.
    - Flight Operations published awareness articles concerning reverse thrust usage.
- MD-88 Reverse Thrust Usage
    - A Safety Management System (SMS) Safety Risk Assessment (SRA) to review reverse thrust usage on the MD-88 was completed.
    - As of 18 May 2016, MD-88 landing distances are calculated using idle reverse.
        - For dry runways, flight crews will use 1.3 EPR.
        - For non-dry runways, flight crews will initially select idle reverse thrust. After reverse thrust symmetry is verified and the aircraft is aligned with the runway track, it is permissible to methodically and gradually increase reverse thrust to no greater than 1.3 EPR if required to reduce stopping distance.
- Special Winter Operations Airport Program
    - The LGA airport was identified as a Special Winter Operations Airport (SWOA) airport for the 2015-2016 winter season.
    - The Senior Vice President – Corporate Safety, Security, and Compliance issued a letter to LGA port authority, urging that they adopt a more robust friction assessment program.
    - LGA committed to the issuance of hourly Field Condition Reports (FICONS).
- Adoption of TALPA recommendations
    - The FAA accepted the TALPA ARC recommendations but subsequently decided to implement them as advisory guidance rather than regulatory changes.
    - Improved runway condition reporting was identified as a key component of landing runway assessment at time of arrival, and the recommended reporting changes using Runway Condition Codes will be implemented with AC150/5200-30D this fall.
    - Delta has aligned its Braking Action Table with the TALPA ARC recommendations and has implemented an automated calculation of landing distances via ACARS using the Runway Condition Code.
- Runway Friction Assessments
    - Delta is currently participating and partially sponsoring two demonstration studies of aircraft-based technology that have the potential of becoming runway friction assessment tools for next generation contaminated runway guidance.