NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, DC 20594

AIRPORT OPERATIONS GROUP CHAIRMAN'S FACTUAL REPORT

May 20, 2016

I. ACCIDENT

Operator	:	Delta Air Lines
Airplane	:	Boeing MD-88 [N909DL]
Location	:	New York, NY
Date	:	March 5, 2015
Time	:	1102 eastern standard time (EST)[1]
NTSB #	:	DCA15FA085

II. AIRPORT OPERATIONS GROUP[2]

Group Chairman	:	Jason T. Fedok National Transportation Safety Board Washington, DC
Member	:	Capt. Steve Jangelis Air Line Pilots Association Herndon, VA
Member	:	Eric Pricco Delta Air Lines Detroit, MI
Member	:	Kelly Slusarski Federal Aviation Administration Boston, MA
Member	:	Chris Rhoads The Port Authority of NY & NJ New York, NY

III. SUMMARY

On March 5, 2015, about 1102 eastern standard time (EST), a Boeing MD-88, N909DL, operating as Delta Air Lines flight 1086, was landing on runway 13 at

[1] All times are reported in local time unless otherwise noted.

[2] Not all group members were present for all activities.

LaGuardia Airport, New York, New York, 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 127 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.

IV. DETAILS OF THE INVESTIGATION

1.0 Airport Information

LaGuardia Airport (LGA) was located approximately 4 statute miles east of New York City, NY, and was operated by The Port Authority of New York and New Jersey under a lease with the City of New York. The airport property encompassed approximately 680 acres at an elevation of 20.6 feet above sea level. In 2014, LGA had approximately 360,834 total aircraft operations. The FAA certified LGA as a 14 CFR Part 139 airport with Index D aircraft rescue and firefighting (ARFF) capabilities.[3] FAA airport certification inspection reports for LGA for years 2013 – 2016 were examined. No deficiencies related to winter operations were noted, and all other deficiencies were corrected.

LGA had two runways that were certificated under 14 CFR Part 139 for use by scheduled air carriers operating aircraft designed for 10 or more seats, and unscheduled air carriers operating aircraft designed for 31 or more seats – runway 13/31 and runway 04/22 (see figure 1). Runway 13/31 consisted of grooved concrete that was 7,003 feet in length and 150 feet wide. Runway 04/22 consisted of a grooved concrete surface that was 7,001 feet in length and 150 feet wide. Both were precision instrument runways with ILS approach procedures, with the exception of the approach to runway 31 which was only equipped with a localizer. Runways 13 and 04 were equipped with a 1,400-foot medium intensity approach lighting system with runway alignment indicator lights system (MALSR).

At the approach end of runway 22 the runway safety area (RSA) was 250 feet in length and 500 feet in width. At the approach end of runway 4, the RSA was 310 feet in length and 500 feet in width. A 275-foot-long by 170-foot-wide Engineered Materials Arresting System (EMAS) was in place beyond the southwest end of runway 4/22.

[3] 14 *CFR* 139.315 described the criteria for determining an airport's ARFF index. Based on the size of aircraft operating at LGA with five or more average daily departures, LGA fell into the category of Index C. However, based on the airport's existing and forecast fleet, LGA maintained a higher index (Index D) than required by the FAA. An Index D airport was required to operate with at least three ARFF vehicles. One vehicle was required to carry 500lbs. of sodium-based dry chemical or Halon 1211 OR 450 lbs. of potassium-based dry chemical with a commensurate amount of Aqueous Film-Forming Foam (AFFF) to total 100 gallons. The other two vehicles were required to carry an amount of water and the commensurate quantity of AFFF so the total quantity of water for foam production carried by all three vehicles was at least 4,000 gallons.

At the approach end of runway 13 the RSA was 250 feet in length by 500 feet in width. At the approach end of runway 31 the RSA was 363 feet in length by 500 feet in width. A 327-foot-long by 170-foot-wide EMAS was in place beyond the southeast end of runway 13/31.

In 1964 the runways were extended to their current length by the construction of an L-shaped, pile supported, concrete structure (or deck) ranging in width from 700 to 900 feet. The northerly 2,000 foot extension to runway 4/22, which incorporated a parallel taxiway and holding pad, was built in Rikers Island channel and opened to air traffic in 1966. The westerly 1,035-foot-long by 700-foot-wide extension to runway 13/31, which also incorporated a taxiway, was also extended into the channel and opened to air traffic in November 1966. Three thousand foot long piers were constructed beyond the ends of the runway extensions to support approach lighting systems installed and maintained by the FAA.

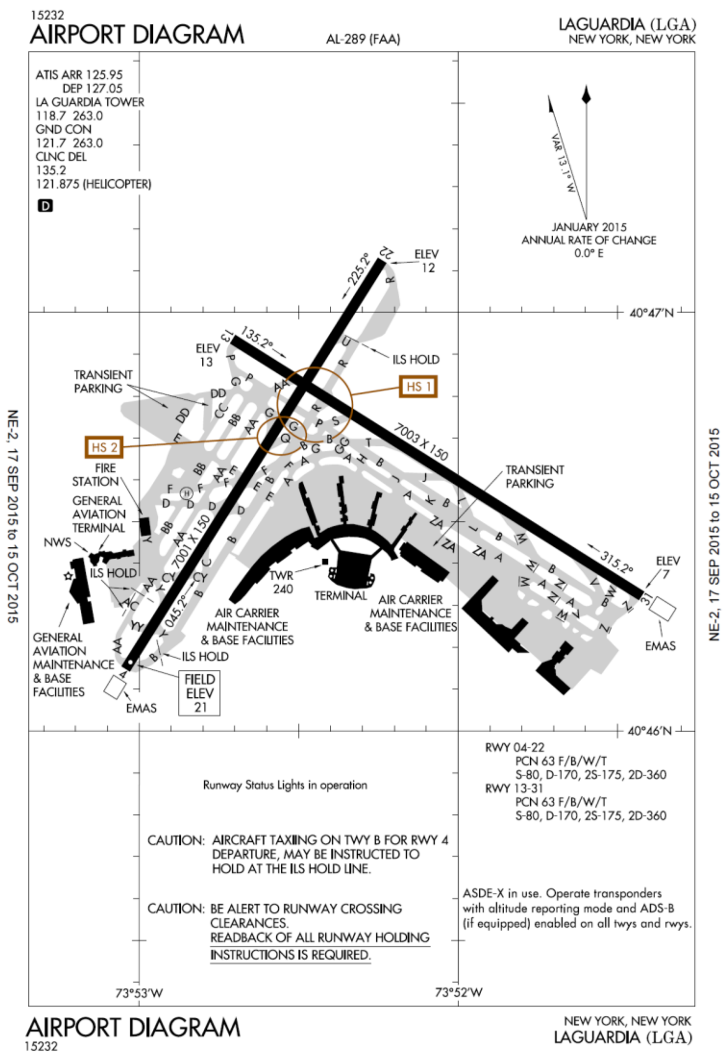

Figure 1. LGA airport diagram.

2.0 Winter Operations and Snow Removal

2.1 Pre-Accident Narrative

Based on the weather forecast and predicted snowfall, the LGA airport manager and operations staff met at 1800 on March 4, 2015 and made a decision to activate a "snow condition 5" as of 0600 on March 5th. Snow condition 5 was the highest level of snow operation readiness at LGA and was activated when freezing or frozen precipitation with substantial accumulation and/or high intensity was expected. All maintenance field personnel were called in to assist with snow removal operations. They were supplemented with additional personnel from a snow removal contractor and the airport's sign shop, totaling approximately 33 equipment drivers per 12-hour shift.[4] This allowed LGA to operate 15 pieces of snow equipment including multi-function vehicles, brooms, plows, and blowers. Additionally, LGA's operations supervisors and support staff were called in. LGA airport operations documented the snow removal activity on the airport in a snow log that this included as attachment 1.

LGA was regularly scheduled to be closed for air traffic operations between 0000-0600 each day. During the overnight shift, the runway and taxiways were treated with solid chemicals[5] and sanded in preparation for snowfall to begin. The field condition report issued at 0444 reported only wet runway conditions and at 0557 there was no accumulation on the paved surfaces when the airport opened for the day's operations.[6] One hour later there was 0.4 inches of accumulation and at 0751 a total of 1.1 inches of precipitation had fallen.[7] By 0851, another 0.7 inches had fallen (for a total of 1.8 inches) and Notices To Airmen (NOTAMs) issued a short time later (at 0902 and 0903) indicated that there was ¼ inch wet snow on the runways. These were the last NOTAMs issued prior to the accident.

The snow removal personnel and equipment were divided into five color-coded teams. Team Blue was assigned to clear runway 13/31, Team Green was assigned runway 4/22, Team Red was assigned east side taxiways, Team White was assigned to the west side taxiways, and Team Amber was assigned the high-speed taxiways of both runways. LGA did not routinely close runways during snow removal; but rather, LGA worked with "hot runways," meaning the snow removal coordinator worked with the Air

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[4] Day shift hours were 0600-1800, while the night shifted lasted from 1800-0600.

[5] The Port Authority used Cryotech NAAC Solid Runway Deicer (Sodium Acetate) manufactured by Cryotech Deicing Technology. Based on the manufacturer's specs, the Port Authority applied the product in uniform patterns at a rate of 100 lbs/100,000 sq ft. The product was applied when temperatures approached 32°F and was designed to work at a temperature as low as -18°F.

[6] For a detailed timeline of the events surrounding the accident and field condition reports, please see attachment 2.

[7] See section 2.9 of this report for more information about where and how these values were obtained.

Traffic Control Tower (ATCT) to get "gaps" in arrivals and departures[8] so that they could perform snow removal on the runways.

On the morning of March 5th Team Blue was operating with four multifunction vehicles - each containing a plow, a broom, and a blower. The 26-foot-wide plow would push accumulated snow to the right while the 26-foot-wide broom would sweep the runway behind it, also moving any residual snow to the right. Finally, a blower on the back of the vehicle would blow the snow toward the runway edge. The four vehicles worked in a staggered formation from the centerline to the edge of the runway and, in doing so, could clear half of the runway in one pass. The vehicle formation would then turn around and complete clearing the runway by doing another staggered pass on the other side of the centerline going in the opposite direction. Each pass took approximately 5 to 6 minutes; therefore, the runway could be completely cleared by one team in approximately 10-12 minutes.

At 1006 Team Blue was given permission by the local controller to proceed onto runway 31 for snow removal. The team completed two and a half clearings (up and back) of runway 13/31 between 1006 and 1035 when they exited at taxiway Papa so that arrivals could begin. Three minutes later the local controller asked the LGA airport snow coordinator[9] (call sign 100 – also the chief operations supervisor on duty) about the "official" runway conditions. The snow coordinator, who was traveling with Team Blue, responded, "we're advertising with the NOTAMs a quarter inch of wet snow and snow banks up to a foot... and the runways have not been treated. We're just brooming and plowing."[10]

The first arrival, United Airlines (UAL) flight 462 (an A319), landed about 1043:27 - approximately eight minutes after the runway had been cleared. When exiting the runway at taxiway Mike, the flight crew reported that the braking action was "medium at touchdown" and "poor [on the runway] down here where we're coming off at Mike." The next arrival, UAL flight 694 (also an A319), touched down about 2 minutes and 37 seconds after UAL flight 462 and reported braking action to be good. The pilot also specifically made an unsolicited comment that braking action was also good near taxiway Mike. Team Amber had responded to taxiway Mike and then completed an up-and-back complete pass of the high speed taxiway immediately after UAL 694 cleared the area.

Envoy Airlines flight 3647, a Canadair Regional Jet (CRJ-701), landed about 1053:57 – approximately 8 minutes after the previous arrival – and also reported good

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[8] The ATCT, in turn, worked with the Terminal Radar Approach Control (TRACON) controller to provide these "gaps."

[9] On March 5th, the airport snow coordinator position was being staffed by the chief operations supervisor at LGA. The LGA airport duty manager (call sign 90) was riding in the same vehicle as the snow coordinator at the time of the accident.

[10] The snow coordinator was referring to the NOTAMs issued at 0902 and 0903. New NOTAMs were not issued at this time. Also in his vehicle was the '90,' or assistant chief operations supervisor (airport duty manager).

braking action. DAL flight 1526 landed about 1059:30 and did not provide a braking action report (nor was one requested by the local controller). Finally, DAL flight 1086 touched down about 2 minutes and 50 seconds later (1102:20) and departed the left side of the runway. The accident flight arrived about 27 minutes after the runway had been last cleared. It was the fifth arrival in that time and there was no pilot braking action report less than "good" in the 18 minutes prior to the accident. At no point in the 27 minutes was there a pilot braking report of less than "medium" at the touchdown zone of the runway.

According to the snow coordinator, at the time of the accident Team Blue was staged on taxiway DD and monitoring pilot braking action reports. About 1051 he made a request (via radio with LGA Airport Operations) that the ATCT provide a gap in arrivals so that they could clear runway 13/31 again.[11] He stated that, even though airplanes were reporting good conditions, he wanted to get on the runway to "maintain the good." He believed that the snowfall rate was about ¼ inch per hour and he wanted to do a clearing every 10-20 minutes to maintain the good conditions. He was also monitoring the status of 6 sensors on the airport that provided information about surface temperatures, type of contamination and atmospheric conditions such as wind speed.[12] This information, particularly the surface temperatures, was useful in determining trends about the runway conditions and could be accessed via the Internet.

When asked if they were applying any chemicals to the runway, the snow coordinator replied that they were not at the time of the accident because "it would have been a waste. It would have been broomed right off." He added that if they had material in the plow and the braking action reports were less than good they would have begun treating the runway. When asked why 0738 NOTAM stated that the runways had been chemically treated during active plowing and brooming, he replied that, "if we know we're going to get off… if we have the plows with us, we'll drop chemicals and sand." He added that "sometimes plow operators do it on their own" but that it was ultimately his decision to make. He stated that it was not standard operating procedures to apply chemicals and/or sand during the last runway clearing prior to arrivals.

[11] The LGA Airport Operations office had a direct ringdown line with the ATCT, who would, in turn, work with the TRACON controller to hold arrivals and provide a gap for snow removal on the active arrivals runway.

[12] The sensors were manufactured by Vaisala and embedded in the pavement by epoxy with a cable that ran to one of several remote processing units (RPU). One in-pavement sensor was on the "deck" of runway 13, another was on the runway 22 "deck," a third was on runway 4/22 at taxiway Papa, a fourth was at the approach end of runway 4, a fifth was on runway 13/31 at taxiway Romeo, and the sixth was on runway 13/31 near taxiways Mike and Whiskey. Information such as surface temperatures, chemical composition, the presence of ice accretion, wet/dry conditions were recorded and sent via monitors to the RPUs. The snow coordinator stated that the information was stored for trend analysis and particular attention was paid to the deck sensors because they would typically be lower because they were over water. Additionally, sensors connected to RPU #1 recorded atmospheric conditions, wind, wind direction, and air temperature. The RPUs sent information to the Airport Operations computer system and could also be accessed directly by the snow coordinator via the Internet.

LGA's aeronautical operations manager stated that there were two instances in which chemicals would be applied during snow operations. The first was as a preventative measure prior to the start of precipitation. The second was to "change the condition of the runway." For example, if they were having difficulty removing stubborn areas of thin patchy ice, they would apply chemicals. Finally, he added that the use of chemicals during a normal snowfall/removal scenario can create a "gumbo"-like condition on the runway that can slow the removal process and make it more difficult.

2.2 FAA Regulations and Guidance

14 *CFR* Part 139.313 *Snow and Ice Control* required airports certificated by the FAA under 14 *CFR* Part 139 to prepare, maintain, and carry out a Snow and Ice Control Plan (SICP). The plan had to include procedures for the prompt removal (as completely as practical) of snow, ice, and slush on each movement area. It also required certificate holders to promptly notify all air carriers when any portion of the movement area was less than satisfactorily cleared for safe operation by their aircraft.[13] FAA Advisory Circular (AC) 150/5200-30C *Airport Winter Safety and Operations* (issued 12/09/08) contained the methods and procedures for snow and ice control that were deemed acceptable to the FAA and compliance with it was mandatory for certificated Part 139 airports. The AC stated that the snow removal goal of the airport should be to maintain the runways, high-speed turnoffs, and taxiways in a "no worse than wet" condition, realizing that it was not always possible. While most FAA ACs are advisory in nature, the cover page of AC 150/5200-30C stated that compliance with all sections was mandatory for all certificated airports at the time of the accident. However, according to the FAA, the means of compliance did not always have to follow the AC exactly. The AC provided only one means of compliance.

2.3 Runway Condition Assessment

Chapter 5 of AC 150/5200-30C contained information about how airport operators should assess the conditions on runways. It stated that "assessing and reporting the surface condition of a runway poses a particular challenge for an airport operator and is of the utmost importance to airport users. Pilot braking action reports are the source of braking action information most accepted by pilots, but they can vary significantly, even when reporting on the same contaminated surface conditions, and obviously only apply to the portion of the runway where braking occurred. The use of a truck or automobile to estimate airplane braking action is also subjective."

Section 5-6 noted that "when previous PIREPs have indicated GOOD or MEDIUM (FAIR) braking action, two consecutive POOR PIREPS should be taken as evidence that surface conditions may be deteriorating and require the airport operator to conduct a runway assessment."

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[13] This was to be accomplished in accordance with 14 *CFR* Part 139.339 *Airport Condition Reporting* by the use of NOTAMs.

Section 5-3 stated that "FAA-approved friction measuring equipment may be employed to help in determining the effects of friction-enhancing treatments, in that it can show the trend of a runway as to increasing or decreasing friction. Airport operators must not attempt to correlate friction readings (Mu numbers) to Good/Medium (Fair)/Poor or Nil runway surface conditions, as no consistent, usable correlation between Mu values and these terms has been shown to exist to the FAA's satisfaction."[14]

Although the FAA no longer recommended providing friction values to pilots, the AC stated that "some airport users still consider runway friction measurement values to be useful information for tracking the trend of changing runway conditions. Therefore continued transmittal of Mu values is permissible with the understanding that the particular numerical value has no particular significance other than to provide changing runway condition trend information when associated with previous or subsequent runway friction measurement values. Airport operators are cautioned against using Mu values as their sole indicator of winter runway slipperiness."[15]

Section 5-4 identified two types of devices that were approved for conducting friction surveys on runways during winter operations: continuous friction measuring equipment (CFME) and decelerometers. CFME were recommended for "measuring friction characteristics of pavement surfaces covered with contaminants, as they provide a continuous graphic record of the pavement surface friction characteristics with friction averages for each one-third zone of the runway length. They may be either self-contained or towed." Decelerometers were recommended for "airports where the longer runway downtime required to complete a friction survey is acceptable, and may actually be preferred at some busy airports where it is difficult to gain access to the full length of a runway crossed by another runway. Decelerometers should be of the electronic type due to the advantages noted below. Mechanical decelerometers may be used, but should be reserved as a backup." It also noted that decelerometers did not provide a continuous graphic record of friction for the pavement surface condition. "They provide only a spot check of the pavement surface. "

The data obtained from such runway friction surveys were only considered to be reliable when the surface was contaminated under any of the following conditions.[16]

> **(1)** Ice or wet ice. Wet ice is a term used to define ice surfaces that are covered with a thin film of moisture caused by melting. The liquid water film deposit is of minimal depth of 0.04 inch (1 mm) or less, insufficient to cause hydroplaning.

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[14] This represented a philosophy change within the FAA, whereas, prior to the 12/09/08 AC revision, the FAA had accepted the idea of correlating friction reading (Mu values) to runway surface conditions.

[15] The AC noted the U.S. movement to the use of the ICAO term "medium" instead of the term "fair." Until the transformation to ICAO terminology was complete, this AC expressed the term as "medium (fair)."

[16] The AC stated that it was "not acceptable to use decelerometers or continuous friction measuring equipment to assess any contaminants outside of these parameters."

(2) Compacted snow at any depth.

(3) Dry snow 1 inch or less.

(4) Wet snow or slush 1/8 inch or less.

The AC also provided guidance to airport operators on when to conduct runway friction assessments. **"**The airport operator should conduct runway friction assessments whenever it is thought that the information will be helpful in the overall snow/ice removal effort, and the conditions are within the limits above. Within those conditions, runway friction assessments should be conducted:

(1) When the central portion of the runway, centered longitudinally along the runway centerline, is contaminated over a distance of 500 feet (152 m) or more.
(2) Following all snow clearing, anti-icing, deicing, or sanding operations.
(3) Immediately following any aircraft incident or accident on the runway, recognizing that responding ARFF or other circumstances may restrict an immediate response."

2.4 Runway Condition Assessments at LGA

The airport operations group interviewed the chief operations supervisor on duty at the time of the accident, as well as the LGA operations manager, and the LGA airport duty manager for certification and training. (See attachment 3 for transcripts of the interviews.) During his interview, LGA's chief operations supervisor stated that LGA had CFME 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.[17] He believed that the decision not to use the CFME for winter operations was related to the FAA's 2008 revision to AC 150/5200-30C, when the FAA stated that airports could no longer correlate Mu values to runway friction conditions. He understood that the CFME could be used as a tool for snow removal trend analysis but stated that, on the day of the accident, they were evaluating the runway based on their observations and snowfall rate.

In a January 20, 2016 email, LGA's aeronautical operations manager stated that 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."

LGA's Airport Certification Manual (ACM) stated that "LGA utilizes a CFME type friction tester to conduct friction readings when conditions require trend analysis on a frozen or contaminated surface." The ACM also contained a letter of agreement (LOA) with the LGA Air Traffic Control Tower (ATCT) that stated:

[17] LGA's CFME vehicles were a 2000 Saab 9-5, and a 2008 Ford F350.

> When it becomes apparent that conditions may result in degraded runway surface friction, Airport Operations may conduct friction assessments using whatever techniques the Airport Duty Manager or Snow Coordinator deem appropriate, to include tactile feel, vehicle braking and/or use of continuous friction measurement equipment (CFME). If CFME is used, Airport Operations will not report Mu values.

The Port Authority provided two additional documents related to this issue (see attachment 4). The first was a letter from the FAA's director of Airports, Safety and Standards, dated January 13, 2010. The letter, to the general manager of the Port Authority's aviation department, was in response to two questions the Port Authority posed to the FAA on November 20, 2009:

- Does the FAA recommend that airports conduct runway friction surveys? The guidance is unclear as to whether or not the FAA is recommending that airport operators conduct runway friction surveys, and whether these surveys are optional or required under certain weather conditions.
- Does the FAA recommend that airports publish (report) the Mu values to interested parties if runway friction surveys are conducted?

The FAA responded that "while we have not been able to correlate runway friction survey data with aircraft performance, we continue to believe operational testing under winter conditions can be a valuable tool to airport operators in providing information on changing runway conditions. However, there is no requirement to conduct operational friction surveys." Additionally, the FAA stated that it was permissible to provide friction measurements to interested parties (such as aircraft dispatchers) but they were prohibited from providing the values to pilots.

On November 22, 2011, the director of the Port Authority's aviation department issued a memorandum to the airport managers at LGA, John F. Kennedy International Airport (JFK), Newark International Airport (EWR), and Teterboro Airport (TEB). The memo "Winter Operations Friction testing and Snow and Ice Control Plans" provided a new Aviation Department Policy Statement (1-2011). It explained that a snow task force comprised of staff from all Port Authority airports "recognized an inconsistency among the way our airports conduct and report friction testing." As a result, the aviation department sought further clarification from the FAA, as was discussed above. As a result of the FAA's response, the Port Authority Law Department recommended that the aviation department "develop a standard procedure for reporting friction test results to be used at all of our airports when practicable."

The new policy stated that:

- During snow removal operations, friction testing may be conducted to provide trend data (Mu values) for airport operations staff. Mu values will not be transmitted via NOTAM or communicated to the ATCT.

- Runway friction test results may be provided to interested parties upon request.

The policy statement also stated that "runway friction measurement values can be useful information for tracking the trend of changing runway conditions. Airport Operations personnel may use supplied Continuous Friction Measurement Equipment (CFME) as they deem necessary to assess runway surface conditions during winter operations."

In a February 2016 email he noted that the operations managers at LGA, JFK, and EWR had discussed the PA policy "several times over the past 18 months and we are following the FAA guidance – 'The FAA has stated that Vehicle Friction Testing results do not correlate to aircraft braking performances. The FAA no longer requires airport operators to conduct friction testing.'" When asked whether any of the PA airports used a friction measuring device to provide trend data for airport operations staff, he replied that none of three airports did so. He added that the operations managers and certification managers at the three airports "got together to ensure we had a unified decision on providing or not providing the trend data. We made the decision and recommended it to our GMs who concurred with our recommendation. Reason behind a unified decision – Could not have one airport doing operations one way and the other two doing it a different way. It was an easy decision and easy recommendation. We were just following the FAA guidance."

In his interview, LGA's airport operations manager stated that if the airport operations staff received one nil or two (consecutive) poor braking actions reports, they would have immediately "taken" the runway, which would have affected flights in the entire region. He stated that the decision to close a runway was a "fine line" because their job was to "keep the airlines and the pilots, as best we can, flying… because their job's to keep the passengers happy. But it's also, we got to keep the runway open."

LGA did not perform a runway friction assessment of runway 13 after the accident as described in AC 150/5200-30C. When asked about that decision, LGA's operations manager stated that the Port Authority policies had been discussed and that everyone believed they were correct and based on the guidance provided by the FAA. In a January 20, 2016 email, LGA's aeronautical operations manager stated that LGA "would not use the CFME after an accident, because the information would be as relevant as recording MU readings during a snow event. We follow the policy of the Aviation Department Director."

Delta Air Lines provided a statement from their systems operations manager who stated that a request to LGA Airport Operations for a runway friction assessment of runway 13/31 approximately 20 minutes after the accident (see attachment 5). According to the statement, LGA Airport Operations staff denied the request for two reasons. First, "Port Authority Airport Operations personnel no longer conducted runway friction tests." Second, PA Airport Operations staff "did not believe their vehicle … was still calibrated to do so."

In his interview, the LGA airport operations manager stated that he believed Delta Air Lines requested a friction test of runway 4/22 after the accident. He stated that they did not do so because of the standing PA policies and that it had been "standard policy for years" for PA to offer to take any airline personnel out to the runway to perform a visual inspection. The LGA aeronautical operations manager recalled some airline personnel making use of the policy in the past, but "not recently." He stated that the policy was emphasized at chief pilots' meetings and had been in place for at least 5 years.

2.5 Runway Condition Assessments At Other Airports

On February 25, 2016, DAL provided NTSB staff with the results of a 2015-2016 survey conducted of DAL's "special winter operations airports" (SWOA). A summary spreadsheet of a portion of the data is included as attachment 6. According to DAL, the survey data was collected from airport operations management, as well as station management using an Internet survey website. The accuracy of the survey data had not been verified and "any inaccuracies for 2014-2015 season SWOA airports were not corrected in this document, as they were contacted via telephone."

Of the 142 airports surveyed, about 17% did not use friction measuring devices during winter operations. Many of the 17% were from southern states such as Florida, Georgia, and Texas. LGA was also included in this group, but EWR was not. EWR responded to the survey and stated that CFME was used during winter operations to obtain friction measurements. When asked about this discrepancy, the LGA operations manager stated in a March 3rd email that he spoke with the operations manager at both EWR and JFK and confirmed that neither airport used CFME to obtain friction measurements in winter operations for internal trend analysis or otherwise. He added that TEB did perform friction measurements with CFME during winter operations but that Mu values obtained from the measurements were not reported by NOTAM or provided to that ATCT.

2.6 Runway Condition Reporting

Chapter 5 of AC 150/5200-30C stated that "the goal in reporting runway surface conditions is to provide pilots with the best information available to ensure safe operations. Currently, there is no objective type of measurement of runway surface condition that has been shown to consistently correlate with airplane performance in a usable manner to the satisfaction of the FAA. Pilots and airplane operators are expected to use all available information, which should include runway condition reports as well as any available pilot braking action reports, to assess whether operations can be safely conducted." Section 5-2 of the AC described how airport operators should report runway conditions.

> "The [airport's snow control center] needs to carefully monitor changing airfield conditions and disseminate information about those conditions in a timely manner to airport users… In addition, [snow and ice control plans] must contain provisions for informing all airplane operators of any

> pavement condition that is worse than bare and dry. It is imperative that the field condition report contain accurate and timely information. For example, the type and depth of contaminant is critical information to airplane operators. Also, the determination of dry versus wet snow or slush condition is another key element in the report because of its potential for significant impact on an airplane's takeoff and landing performance capabilities.
>
> Because runway surface conditions can change quickly, either due to weather conditions or corrective actions taken to mitigate such conditions, NOTAMs describing the runway surface conditions must be *timely*. [emphasis in original] The FAA recommends that airport operators review their reporting method and procedures so their SICP procedures are conducive to timely reporting."

It further stated:

> "Runway condition reports must be updated any time a change to the runway surface condition occurs. Changes that initiate updated reports include weather events, the application of chemicals or sand, or plowing or sweeping operations. Airport 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. At certificated airports, such changes to the runway surface condition must be updated and appropriately disseminated so airplane operators are aware of the current conditions before continuing with their operations. During active snow events or rapidly changing conditions (e.g., increasing snowfall, rapidly rising or falling temperatures) airport operators are required to maintain a vigilant runway inspection process to ensure accurate runway condition reports. While pilot reports (PIREPs) of braking action provide valuable information, these reports may not apply to the full length of the runway as such evaluations are limited to the specific sections of the runway surface in which the airplane wheel braking was used."

2.7 Runway Condition Reporting at LGA

When asked if LGA airport operations staff routinely issued updated field condition reports after each clearing event, LGA's chief operations supervisor stated "No… only if the conditions have changed.[18] Because when we… make a pass with the equipment, we're actually less than what was reported; it's a thin covering… but at no point did it go above a quarter of an inch." He added that he felt that keeping the 0903 NOTAM in place (that stated the runway conditions were ¼ inch wet snow) was "being

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[18] He described the precipitation on the morning of the accident as a "light to moderate… very fine…dry snow." The LGA airport operations manager also stated in his interview that it was changing to a dry snow during the hour prior to the accident.

conservative" and "safer" than reporting a thin covering prior to allowing arrivals to begin to land. He stated that "if you can see the runway grooves, it's a thin covering… based on my experience." He further stated that "I wanted to report what I knew to be the conditions out there most extreme… so that I could communicate to the airport community so that they can, you know, do whatever they had to adjust whatever they needed to land safely."

LGA's airport operations manager agreed and added that "I'd rather tell someone I got a quarter inch and I just cleaned it, it went to blacktop, and the snow's coming down and 5 minutes, 10 minutes later it's going to be back to a quarter of an inch, than to say to someone it's blacktop and a pilot's coming in and I'm putting the pilot in harm's way… I think it's a smart move." He added that "if you keep on giving NOTAMs out every 30 minutes, every 45 minutes -- you know, you're constantly changing the environment that those at the receiving end aren't getting it. So it's something that, if you were out there and, you know, you've taken it down to thin-patchy, or whatever the NOTAM is at the time, and then we have a quarter inch of snow come back out there, and we go clean it off, you know, it's back to the original. So we don't need to give a new NOTAM that says, you know, it's the same as before."

LGA's aeronautical operations manager summarized this viewpoint by saying that "we don't like NOTAMs to swing in the breeze out there for, like, 3, 4 hours… so occasionally… we will reissue the NOTAM, and say it's sustained. But when we're out there in snow condition plowing, brooming, we're going to keep it down to the condition that the NOTAM was initially issued for… and we'll sustain that condition. For as long as we do that, that NOTAM stays."

Minutes from the December 10, 2015 chief pilots' meeting at LGA provided by DAL and LGA indicated that there were two significant changes to winter operations at LGA for the 2015-2016 winter season. First, a "warning order" notice was provided to ATCT (approximately 15 in advance) if LGA Operations staff needed to occupy a runway for more than 20 minutes. A runway closure NOTAMs was then issued by LGA Operations and snow clearing operations commenced until a predetermined 'stop' time when the runway was reopened. Second, at the request of the airline community, LGA issued runway conditions NOTAMs hourly, once conditions warranted. Runway conditions were updated more frequently as needed, but, at a minimum, they were updated once every hour.

The LGA snow coordinator stated that the new procedures worked well during the 2015-2016 snow season. He recalled that it was a relatively quiet winter and be believed LGA only closed a runway once for snow removal. He added that they did "religiously issue surface condition reports on the hour as requested. We had our post season AAR and there were no complaints."

2.8 Automatic Terminal Information Service (ATIS) Broadcasts

ATIS information Oscar was issued at 0951 and reported a temperature of -3°C with snow and freezing fog conditions and ¼ mile visibility. Winds were 030 at 10 knots. It stated that "all runways are wet and have been sanded and deiced with solid chemical" and that breaking action advisories were in effect.

ATIS information Papa (special) was issued at 1024 and reported a temperature of -3°C with snow and freezing fog and ¼ mile visibility. Winds were 040 at 7 knots. It stated that "all runways are wet and have been sanded and deiced with solid chemical." It also stated that "all runway field conditions ¼ inch wet snow observed at 1404Z" and that breaking action advisories were in effect.

ATIS information Quebec was issued at 1051 and current at the time of the accident. It reported a temperature of -3°C with snow and freezing fog and ¼ mile visibility. Winds were 030 at 11 knots. It stated that "all runways are wet and have been sanded and deiced with solid chemical" and that breaking action advisories were in effect. It also stated that "all runway field conditions ¼ inch wet snow observed at 1404Z."

2.9 Snow Accumulation Measurement at LGA

Personnel contracted by the FAA maintained a weather observation service at LGA's Marine Air Terminal (MAT). According to LGA personnel, the contractors had varying experience in the fields of weather forecasting/observation/meteorology and received their weather reports from weather monitoring equipment at Brookhaven National Laboratory (BNL).[19] The FAA contractors at MAT 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."

2.10 LGA/FAA Letter of Agreement

At the time of the accident LGA had a letter of agreement (LOA) with the FAA-operated ATCT regarding braking action reports (see attachment 7). The LOA, effective October 1, 2012, established the responsibilities for both the ATCT and LGA Airport Operations. The following are two excerpts from the LOA outlining those responsibilities:

[19] One of ten national laboratories overseen and primarily funded by the Office of Science of the U.S. Department of Energy (DOE), Brookhaven National Laboratory conducts research in the physical, biomedical, and environmental sciences, as well as in energy technologies and national security. Brookhaven Lab also builds and operates major scientific facilities available to university, industry and government researchers. Brookhaven is operated and managed for DOE's Office of Science by Brookhaven Science Associates, a limited-liability company founded by the Research Foundation for the State University of New York on behalf of Stony Brook University, the largest academic user of Laboratory facilities, and Battelle, a nonprofit applied science and technology organization

A. LaGuardia Airport Air Traffic Control Tower Responsibilities:

1. Solicit braking action reports (PIREPS) from pilots when weather or other conditions are conducive to deteriorating or rapidly changing runway surface conditions.

2. Promptly relay to Airport Operations all braking action reports that indicate runway braking conditions have deteriorated to FAIR, POOR or NIL. Also promptly relay reports indicating that conditions have improved to GOOD.

3. Cease aircraft operations to the effected runway upon receipt of a NIL braking action report or if requested by Airport Operations.

B. Port Authority Airport Operations Responsibilities:

1. Airport Operations shall conduct continuous monitoring of runway surface conditions during deteriorating weather or other conditions conducive to a loss of traction.

2. Airport Operations shall continuously monitor ATCT Tower frequency for PIREP braking action reports. If no reports are forthcoming, Airport Operations may request that ATCT solicit pilots for braking action reports.

3. When it becomes apparent that conditions may result in degraded runway surface friction, Airport Operations may conduct friction assessments using whatever techniques the Airport Duty Manager or Snow Coordinator deem appropriate, to include tactile feel, vehicle braking and/or use of continuous friction measurement equipment (CFME). If CFME is used, Airport Operations will not report Mu values.

4. Upon receipt of a NIL braking action report or an assessment if NIL braking, Airport Operations shall immediately close the effected runway before the next flight operation to conduct a surface assessment and corrective action. The runway will remain closed until Operations is satisfied that the NIL condition no longer exists.

5. When previous PIREPs have indicated GOOD or FAIR braking action, two consecutive PIREPs of POOR braking action indicate conditions have deteriorated, which may require ATCT to immediately cease aircraft operations to the effected runway. Upon receipt of two POOR braking action reports, Airport Operations shall conduct a surface assessment. If Operations has been conducting continuous monitoring, Operations shall coordinate with ATCT to conduct this assessment as soon as air traffic volume permits. If Operations has not been continuously monitoring surface conditions, Operations shall coordinate with ATCT to conduct this assessment before the next flight operation.

6. Immediately coordinate all runway closures with ATCT via the most expeditious means available (radio or telephone). Airport Operations will also immediately inform airport users any time a runway is closed via:

   a) Primary: the Notice to Airman (NOTAM) system;

   b) Secondary: the web-based LGA Operations Network (OPSnet) system and the High-Speed Notification System (Vortex).

2.11 LGA Snow & Winter Operations Annual Training

The Airport Operations Group reviewed training records for the airport operations staff[20] as well as the computer-based annual training course relating to snow and winter operations. One portion of the training course instructed LGA operations personnel on

[20] All required airport operations staff was found to have completed the winter training within the past 12 months.

the use of NOTAMS in winter conditions (termed SNOWTAMS) as well as the use of friction measurement equipment. A video clip of a portion of this module can be found as attachment 8. The group made the following observations:

- The training video stated that the interval between friction tests in winter conditions could vary from "hourly in rapidly changing conditions" to "every 8 hours in more stable conditions." It continued "if pilot reports are consistent with favorable braking action the interval can be extended."
- The training video stated that certain other conditions triggered a need for friction testing including: when the closed runway was reopened after snow removal operations, a pilot braking action report of nil, two consecutive pilot braking action reports of poor, or "after any aircraft incident or accident on the runway."

In a January 20, 2016 email, the LGA aeronautical operations manager stated that the training module viewed by the group dated "from around 2005." He added that the audio script had been revised after the accident to state - "to help determine the best timing for de-ice or anti-ice application or snow removal, instruments that detect pavement conditions and friction measuring equipment can be very helpful."

2.12 FAA Oversight of LGA

On February 18, 2016, the airport operations group interviewed the FAA Airport Certification Safety Inspector (ACSI) for LGA. A summary of that interview can be found in attachment 9.

2.12 NTSB Recommendation A-07-062

On October 16, 2007 the NTSB issued safety recommendation A-07-062 asking the FAA to "develop and issue formal guidance regarding standards and guidelines for the development, delivery, and interpretation of runway surface condition reports." In response the FAA established a Takeoff and Landing Performance Assessment (TALPA) Aviation Rulemaking Committee (ARC) that developed a matrix (known as the Runway Condition Assessment Matrix or RCAM) that correlated runway contaminants to a numerical code.

In June 2013, the FAA published a document titled *Takeoff and Landing Performance Assessment Validation Effort of the Runway Condition Assessment Matrix.* This document examined the RCAM's processes to determine if it could be implemented at airports nationwide in order to disseminate runway surface condition information to pilots prior to landing. An industry team, along with the FAA, airport operators, and air carrier representatives, reviewed the evaluation approach, analysis, and results. Based on the results of the validation efforts, the industry team recommended that the FAA work to implement the RCAM and its processes into aviation operations.

After the committee delivered its recommendations to the FAA, the FAA worked with two airlines and 29 airports to validate the runway condition codes[21] of the contaminants on the RCAM and the feasibility of obtaining an accurate rating of the runway surface condition from airport operations personnel using the TALPA ARC recommended methods. This validation testing lasted two winter seasons (2009-2010 and 2010-2011). After the first season of validation testing, the validation team made modifications to the original RCAM based on the data collected from the airports and correlated pilot braking action reports. These modifications were re-validated the second winter season. The TALPA ARC then used this data as the basis for its final recommended RCAM (see figure 2).

On December 22, 2015 the FAA published Advisory Circular 25-32 *Landing Performance Data for Time-of-Arrival Landing Performance Assessment* that included the RCAM and defined 6 categories of pilot-reported braking actions.[22]

- *Good* – Braking deceleration is normal for the wheel braking effort applied, and directional control is normal.
- *Good to Medium* – Braking deceleration or directional control is between good and medium braking action.
- *Medium* – Braking deceleration is noticeably reduced for the wheel braking effort applied, or directional control is noticeably reduced.
- *Medium to Poor* – Braking deceleration or directional control is between *medium* and *poor*.
- *Poor* - Braking deceleration is significantly reduced for the wheel braking effort applied, or directional control is significantly reduced.
- *Nil* - Braking deceleration is minimal to non-existent for the wheel braking effort applied, or directional control is uncertain.

[21] The runway condition code was a number from 0 to 6 that was used to denote the category of slipperiness of a designated portion of a runway (that is, a specific one-third of the runway), with 0 being extremely slippery and 6 being a dry runway. Since runway condition code reflected only the runway slipperiness (that is, any effect of contaminant drag is not included), the runway condition code could be directly correlated with a pilot-reported braking action.

[22] There had previously been four categories: Good, Fair, Poor, and Nil. At the time of the publication of AC 25-32, the term “fair” was in the process of being replaced with “medium” and continued use of “fair” was permitted until the FAA officially published the change.

**Table 2. Runway Surface Condition—Pilot-Reported Braking Action—
Wheel Braking Coefficient Correlation Matrix**

Runway Condition Code	Runway Surface Condition Description	Pilot-Reported Braking Action	Wheel Braking Coefficient
6	• Dry	—	90% of certified value used to comply with § 25.125[1].
5	• Frost • Wet (includes damp and ⅛″ (3 mm) depth or less or water) ⅛″ (3 mm) depth or less of: • Slush • Dry snow • Wet snow	Good	Per method defined in § 25.109(c).
4	-15 °C and colder outside air temperature: • Compacted snow	Good to Medium[2]	0.20[3]
3	• Wet ("Slippery When Wet" runway) • Dry snow or wet snow (any depth) over compacted snow Greater than ⅛″ (3 mm) depth of: • Dry snow • Wet snow Warmer than -15 °C outside air temperature: • Compacted snow	Medium[2]	0.16[3]
2	Greater than ⅛″ (3 mm) depth of: • Water • Slush	Medium[2] to Poor	(1) For speeds below 85% of the hydroplaning speed[4]: 50% of the wheel braking coefficient determined in accordance with § 25.109(c), but no greater than 0.16[3]; and (2) For speeds at 85% of the hydroplaning speed[4] and above: 0.05[3].
1	• Ice	Poor	0.08[3]
0	• Wet ice • Water on top of compacted snow • Dry snow or wet snow over ice	Nil	Not applicable. (No operations in Nil conditions.)

Figure 2. The runway condition assessment matrix (RCAM) from AC 25-32.

According to the FAA, AC 150/5200-30 was scheduled be updated with this information and the NOTAM Joint Order 7930.2 would likely need to be updated simultaneously.[23] As of the date of this report, NTSB recommendation A-07-062 was classified "Open – Acceptable Response."

3.0 Emergency Response

After DAL 1086 departed the runway and came to a stop about 1102:52,[24] the first individual to see the airplane was the Team Red leader who notified the LGA snow coordinator that a DAL aircraft had hit a fence. The snow coordinator was unable to see the airplane from his location at taxiway DD and was initially uncertain about what had occurred, but he was monitoring the tower frequency and noted that ATC had lost communications with DAL 1086. Realizing something was likely wrong with the airplane, the snow coordinator began responding at about 1103:10 and requested permission to cross runway 4 on taxiway Papa a short time later. The request was

[23] The updates were estimated for spring 2016 with the information being operational in October 2016.

[24] This time was obtained from a playback of LGA's ASDE-X radar data included in the docket as attachment 10.

approved and a playback of LGA's Airport Surface Detection Equipment. Model X (ASDE-X) radar showed the vehicle entering runway 4 from taxiway Gulf, turning northbound, and turning onto runway 13.

At 1104 the snow coordinator notified the ATCT that "runway 1-3 is closed" but no response was received. Twelve seconds later the snow coordinator attempted to confirm that the tower controller had received the information to which the controller replied, "you said runway 1-3 is closed?" The snow coordinator confirmed that it was closed and Team Red radioed a short time later that there was an aircraft off the runway. The tower controller then immediately instructed DAL 1999 to go around at 1104:33. Five seconds later snow coordinator notified the tower controller that the airport was closed and that "we've got a 3-4!" The controller responded, "say again?" and a second LGA operations staff member responded at 1104:48, "you have an aircraft off 3-1 on the north vehicle service road. Please advise crash/rescue. LaGuardia Airport is closed at this time." After arriving at the site at 1105:11, the snow coordinator exited his vehicle and noted to the ATCT that the airplane's left wing was ruptured and that "fuel was pouring out at a very high rate."

About the same time, the airport operations manager was in the LGA operations office in Hangar 7 having an in-person discussion with the LGA deputy manager and Aircraft Rescue and Firefighting (ARFF) deputy chief. The deputy general manger received a phone call that an airplane had gone off the runway but nothing had been announced on the Emergency Alert Notification System (EANS).[25] The airport operations manager told the ARFF captain to launch the ARFF crews even though an alert had not been received. At 1104:35 the ARFF deputy chief made a phone call to the on-duty ARFF crew chief and launched ARFF units to the accident, although he did not know the precise location. That phone call was the first indication to ARFF personnel that there was an accident on the airport.[26]

An ASDE-X radar data playback showed a group vehicles appearing in the vicinity of the ARFF station (see figure 1) about 1106:45.[27] Eventually those vehicles

[25] LGA used a variety of communications systems on the airport. EANS was designated as the primary method of communicating an emergency on the airport. Activated by the ATCT, EANS provided audible tones to the ARFF station, Airport Operations Office, and Port Authority Police Department (PAPD). In addition, the system allowed the ATCT controller to provide a verbal description of the emergency and its location.

[26] According to the LGA Airport Emergency Plan (AEP) the primary responsibility of the ATCT in an emergency was to "immediately notify ARFF, PAPD, and Airport Operations and provide ARFF vehicle operators with "the last known position of the aircraft" and all other pertinent information such as the type of aircraft and the number of people and fuel on board. The EANS was activated by the ATCT at 1106:25. See attachment 11 for an audio recording of the alert.

[27] This time is approximate and based on a visual playback if ASDE-X data and should not be understood as the time the ARFF vehicles began responding to the accident. Additionally, according to email communication from the LGA airport operations manager, "ARFF crews initially had no reported incident location information other than an aircraft had hit a fence. ARFF began searching fence areas beginning with the closest fenced area… ARFF continued searching fence area in the vicinity of Echo parking, then near the approach of Runway 13. After not finding the aircraft, the search resumed on to Taxiway Papa, crossing 4-22 running parallel to Runway 13 on Taxiway Delta where they eventually came

made their way to the accident via taxiways Papa, Bravo, and Mike with radio communications indicating that ARFF crews were still unclear of the location of the accident as of 1110:12. They finally saw the airplane on the embankment and arrived at the accident site at about 1111:02 – more than 8 minutes after the accident.

While those vehicles were responding, the snow coordinator climbed the berm to the copilot's window and attempted to get the flight crew's attention to open the right side overwing exit. After failing to do so, he went back toward the overwing exit and attempted to get the attention of someone inside to realize that "there was a sense of urgency to get them off." Eventually, the overwing exits were opened and he and others helped people off the back of the wing. He also noticed at some point that passengers were coming out of the tailcone. The forward, right door of the airplane was never opened.[28]

The initial ARFF response consisted of 14 personnel in 4 firefighting vehicles and a stair truck, in addition to the ARFF deputy chief. Statements from responding personnel are included as attachment 12. Radio communications from the arriving firefighters indicated that an evacuation had not yet begun at the time of their arrival.[29] Three ARFF vehicles positioned themselves at the tail of the airplane and two used turrets to apply a foam blanket to the left wing area where fuel was leaking. When the evacuation began, numerous ARFF personnel assisted passengers off the right wing and tailcone of the airplane.

Classifications. The aircraft incident/accident classification system developed for LGA includes five emergency conditions (See Table A-1, Emergency Conditions 1-5):

	Description
Alert 1	A malfunction on an aircraft reported to tower by pilot or company in which emergency equipment is ***not*** requested. Only part of the emergency equipment will respond to a stand-by position. The Crew Chief, depending on weather conditions or other factors may upgrade to an Alert 2.
Alert 2	A malfunction on an aircraft reported by the pilot or company with a request for emergency equipment will cause a full response by the emergency crews.
Alert 3	An actual or impending crash and/or major aircraft accident or fire and/or aircraft in dire emergency will cause the aircraft emergency plan to go into effect.
Alert 4	A bomb scare on an aircraft. The Tour Commander (IC) will determine the amount of equipment to respond. An isolated aeronautical location will be designated by the IC and ADM at the time of the incident for the unloading of passengers and crew and for processing the threat.
Alert 5	A hijack threat on an aircraft. An isolated location will be designated by the IC and ADM as a staging area at the time of incident for the processing of aircraft under actual hijack threat. The Tour Commander (IC) will determine the amount of equipment to respond guided by the established procedures relating to this form of threat. (A copy of the LaGuardia Airport Hijack Plan is on file and available for inspection by authorized individuals or agencies at the Police Emergency Garage.)

Table A-1. Alert Conditions

Figure 3. LGA Incident/Accident Classification System from the Airport Emergency Plan.

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upon incident… the ARFF crews did not hear the EANS alert as they were already in the trucks searching for incident at the time of activation."

[28] See the Survival Factors Group Chairman's factual report for more information about the evacuation.

[29] See the Survival Factors Group Chairman's factual report for more information about the timing of the evacuation.

Alert 3 (Major accident, fire, or other actual emergency on the airport / an aircraft

1. Port Authority Emergency Trucks (ARFF) respond.
2. Port Authority Operations personnel response on minor incident.
3. Port Authority Police Desk notifies all mutual aid responders for immediate response. To include, but not limited to: FDNY, NYPD, EMS, Coast Guard, NYCDOC
4. Port Authority Police Desk notifies New York State Police.
5. The Port Authority Police Desk and Operations Office make other internal and external notifications as necessary.

Figure 4. Response Description to an Alert 3 at LGA.

Jason Fedok
Survival Factors Investigator

Attachments

1.) LGA snow log
2.) Timeline of events
3.) NTSB interview transcripts
4.) FAA letter and PA memorandum
5.) DAL request
6.) Summary of data from DAL airport survey
7.) LGA/FAA ATCT letter of agreement
8.) Video clip of LGA training course
9.) NTSB interview summary
10.) ASDE-X video playback
11.) Audio recording of EANS alert
12.) ARFF statements