National Transportation Safety Board

Office of Research and Engineering

Washington, DC 20594

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FDR AND ADS-B STUDY

Aircraft Performance Study

By

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A. INCIDENT

Location: Queens, New York
Date: January 13, 2023
Time: 20:44 Eastern standard time (EST)
Airplane 1: Boeing 777-200, N754AN
Airplane 2: Boeing 737-900ER, N914DU

B. SUMMARY

On January 13, 2023, about 2044 local time, American Airlines (AA) flight 106, a Boeing 777-200, crossed runway 4L without air traffic control (ATC) clearance at John F. Kennedy International Airport (JFK), Queens, New York causing Delta Air Lines (DAL) flight 1943, a Boeing 737-900ER, to abort its takeoff on runway 4L. Of the 6 crew and 153 passengers on DAL 1943, and 12 crew and 137 passengers on AA 106, there were no injuries. There was no damage to either aircraft. AA 106 was a 14 *Code of Federal Regulations* (CFR) Part 121 scheduled international passenger flight from JFK to London Heathrow International Airport, London, United Kingdom (LHR). DAL 1943 was a CFR Part 121 scheduled international passenger flight from JFK to Santo Domingo, Dominican Republic (SDQ).

C. PERFORMANCE STUDY

1.0 Airplanes

1.1 Boeing 777-200

The Boeing 777-200 is a wide-body jet aircraft, which is 209 ft 1 in (63.7 m) long, has a wingspan of 199 ft 11 in (63.7 m), and is 60 ft 9 in (18.5 m) tall at the tail. Figure 1 is a photograph of the American Airlines aircraft involved in the runway incursion, N754AN. The airplane will be referred to as AA106 in this report.

Figure 1. American Airlines flight 106 (AA106), a Boeing 777-200, N754AN.

1.2 Boeing 737-900ER

The Boeing 737-900ER is a narrow-body jet aircraft, which is 138 ft 2 in (46 m) long, has a wingspan of 117 ft 5 in (35.8 m), and is 41 ft 2 in (12.5 m) tall at the tail. Figure 2 is a photograph of the Delta aircraft involved in the runway incursion, N914DU. The airplane will be referred to as DAL1943 in this report.

Figure 2. Delta Air Lines flight 1943, (DAL1943), a Boeing 737-900ER, N914DU.

2.0 Weather

Weather was recorded at 19:51. The temperature was 41°F (5°C), the dew point was 30°F (-1°C), and the barometric setting was 29.69 inHg. Conditions were clear on the ground with night lighting conditions. Winds were 18 kts from 320°.

3.0 Available Data

Both airplanes were equipped with Flight Data Recorders (FDRs) [1] and Cockpit Voice Recorders (CVRs). The FDR data for the incident was obtained for both airplanes, but the incident was overwritten on both airplanes' two-hour CVRs. FDR data included airplane attitude, accelerations, altitude, airspeed, control inputs, control surfaces, engine parameters, avionic settings, and other parameters.

Some communications between the two airplanes and the JFK air traffic control tower (ATCT) are included in this report [2].

The latitude and longitude parameters on the FDRs of both airplanes were not recorded with enough precision to accurately determine the airplane's location. Therefore, Automatic Dependent Surveillance-Broadcast (ADS-B) data provided by the FAA was used to determine the airplanes' locations. ADS-B broadcasts an airplane's Global Positioning System (GPS) position and other data to the ground where it is recorded. The GPS position has an accuracy of approximately 20 meters (65 ft) in both the horizontal and vertical dimensions.

Also provided was a playback video of the airplane locations and runway surface lights using the Airport Surface Detection System – Model X (ASDE-X). ASDE-X is a surveillance system using radar, multilateration, and satellite technology that allows air traffic controllers to track surface movement of aircraft and vehicles. It was developed to help reduce critical Category A and B runway incursions[1]. Position accuracy of ASDE-X is ± 20 ft [3].

4.0 Airport Information

The event occurred where taxiway J crosses runway 4L at JFK. Figure 3 shows a portion of the airport diagram with the runway crossing circled in orange. DAL1943 (blue arrow) was taking off from runway 4L when AA106 (red arrow) crossed from west to east on taxiway J. Figure 4 shows a satellite image of runway 31L, runway 4L, and taxiways B, K, and J.

Runway 4L is 12,079 ft long and 200 ft wide from edge marking to edge marking. Taxiway J is 4,500 ft from the threshold of 4L. The hold short line on taxiway J for runway 4L is 175 ft from the edge of runway 4L.

[1] According to the FAA, a Category A incursion is a serious incident in which a collision was narrowly avoided. A Category B incursion is an incident in which separation decreases and there is a significant potential for collision, which may result in a time critical corrective or evasive response to avoid collision.

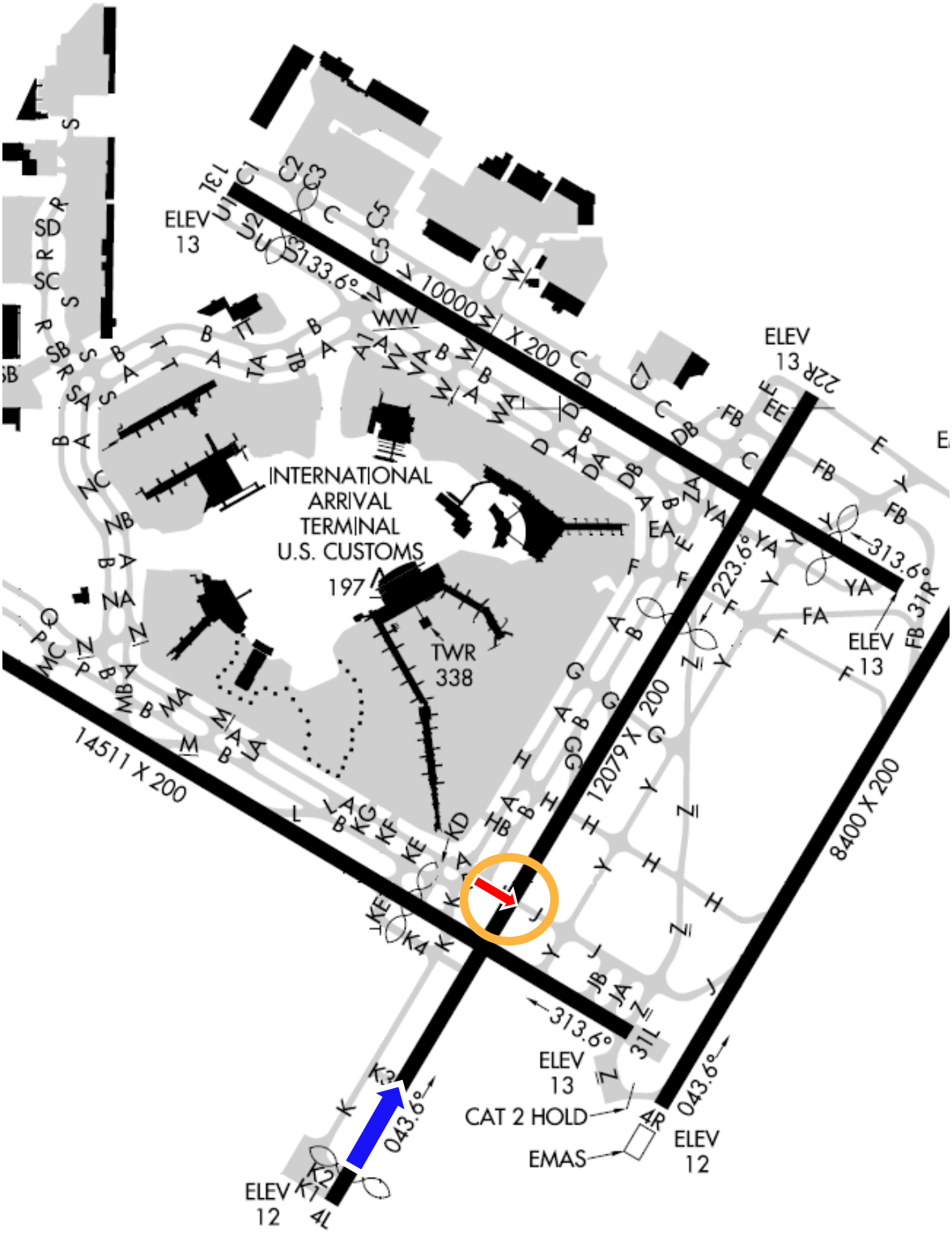

Figure 3. JFK airport diagram. The intersection of interest is circled in orange. AA106's direction is highlighted with a red arrow and DAL1943's direction with a blue arrow.

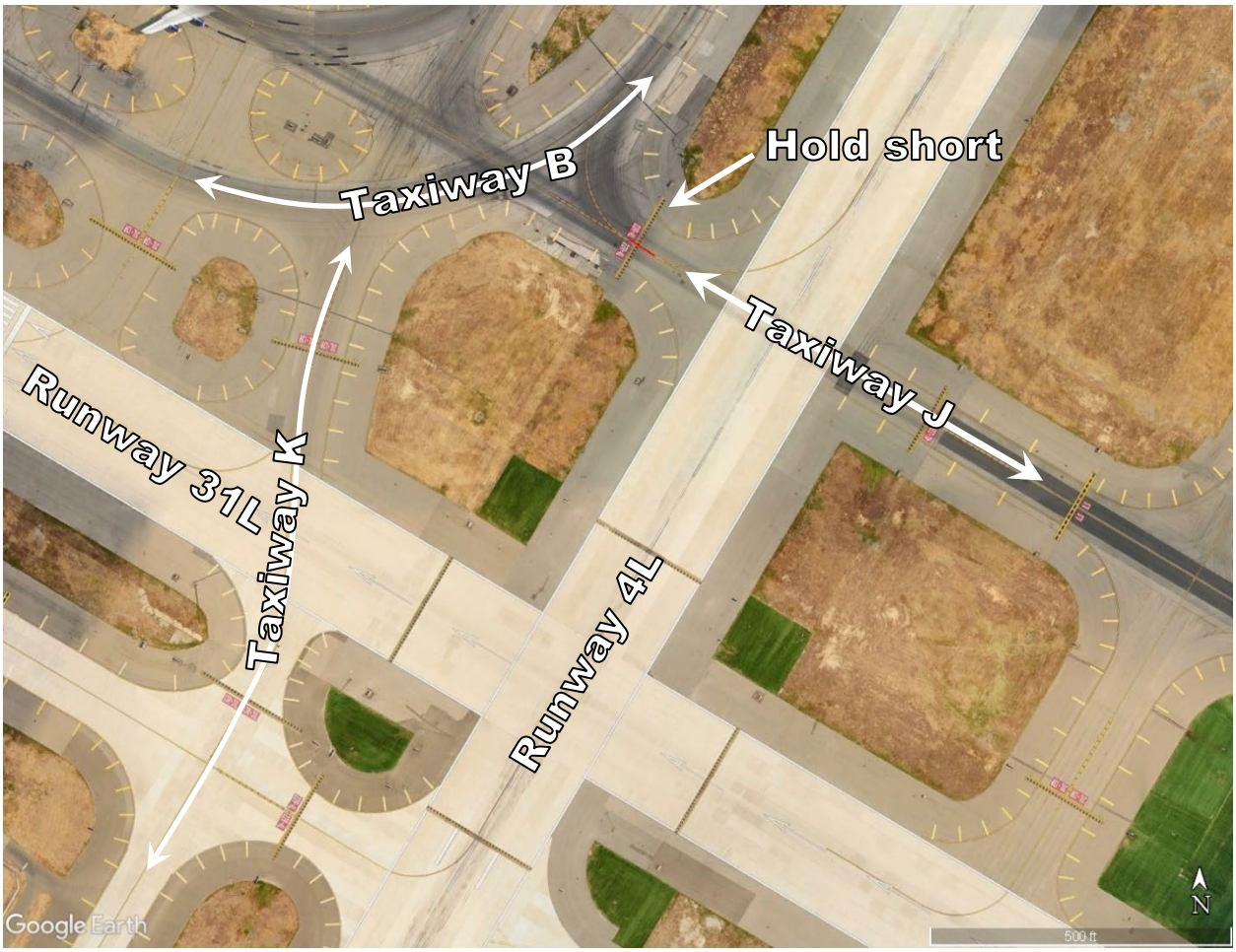

Figure 4. Satellite image of the area of interest. Taxiways B, K, and J and Runways 4L and 31L are labeled as is the hold short line on taxiway J before runway 4L.

5.0 Airplane Separation Calculations

The airplanes' ADS-B location data was reflective of the location of the GPS antenna. On AA106, a B-777, the GPS antenna is on the top of the airplane, 46 feet aft of the nose. On DAL1943, a B-737, the GPS antenna is on the top of the airplane, 33 feet aft of the nose. The separation calculations made in this report reflect the distance between the two GPS antennas and do not account for the wingspan of AA106 or the forward fuselage of DAL1943. Additionally, as discussed in 3.0 Available Data, there is uncertainty in the GPS data which should be kept in mind for the separation calculations.

6.0 Taxi Path from ADS-B Data

As reported in the Operations and Human Performance Factual Report for this event, the AA106 crew originally briefed take-off from runway 31L, taxiing Tango-

Alpha, left on Bravo, hold short at Juliet. However, at 2013:07, the crew received a message that departure would be from runway 4L and briefed "the same taxi route up until Bravo short of Kilo."

AA106 left the ramp area and entered taxiway TA (Figure 3) at 20:34:45 (Figure 5). At this time, DAL1943 was in line on taxiway K for departure on runway 4L. AA106 turned left on taxiway B and followed it for several minutes. At 20:40:13, ATC contacted AA106 and said "American 106 heavy, cross 31Left at Kilo". The crew responded, "Cross 31Left at Kilo for American 106 heavy."

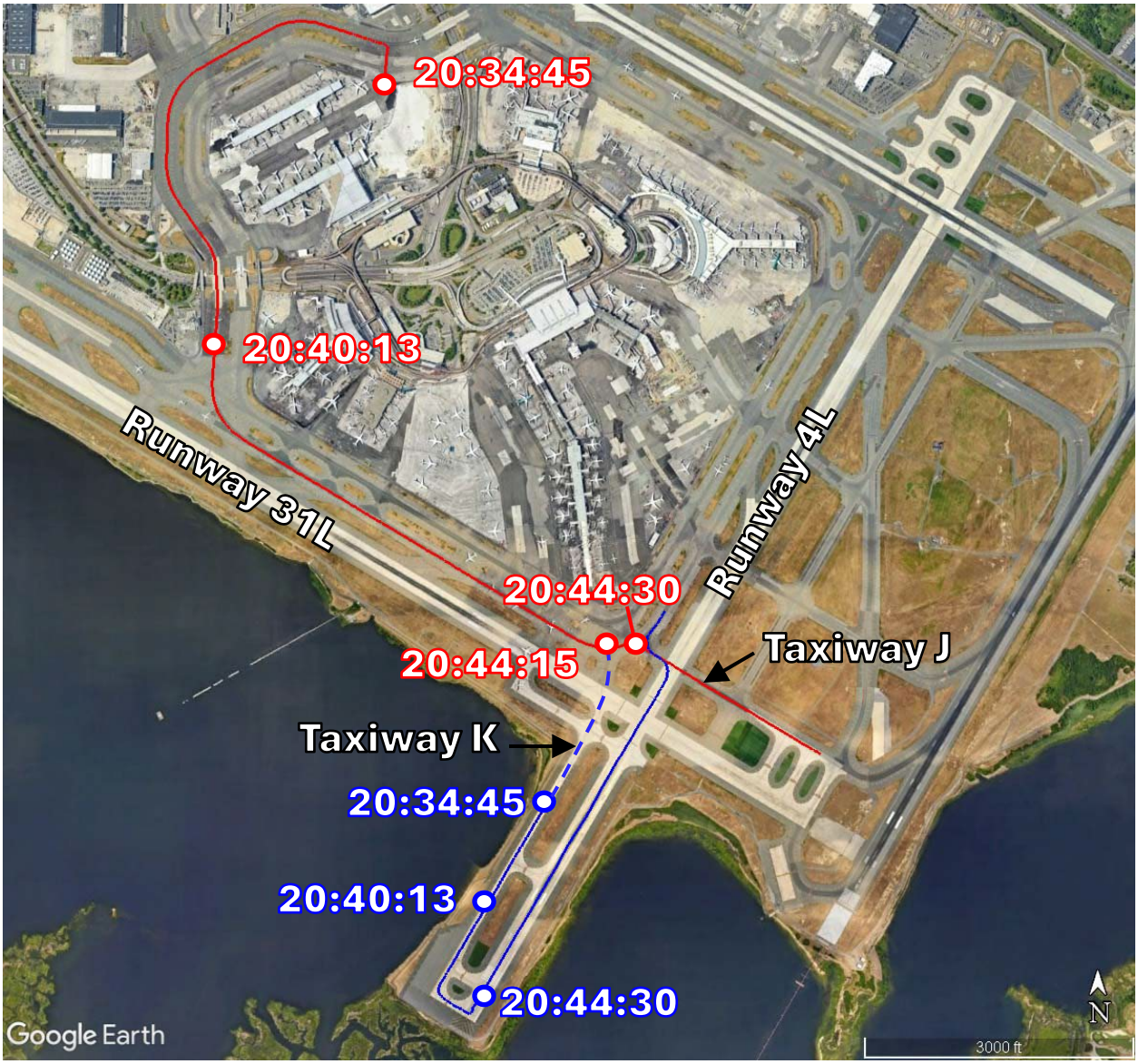

Figure 5. B-777 taxi in red and B-737 in blue with selected times annotated.

AA106 slowed from 15 kts groundspeed to 10 kts as it approached and passed taxiway K (Figure 6). At 20:44:30, AA106 turned onto taxiway J as DAL1943 began its

take-off roll (Figure 9). Airplane groundspeeds shown in Figure 6 and Figure 7 display the FDR recorded groundspeed, which were consistent with groundspeed calculated from the airplanes' respective ADS-B taxi tracks. The airplane was considered to be crossing runway 4L from the time its nose was over the runway surface until its tail cleared the opposite runway edge.

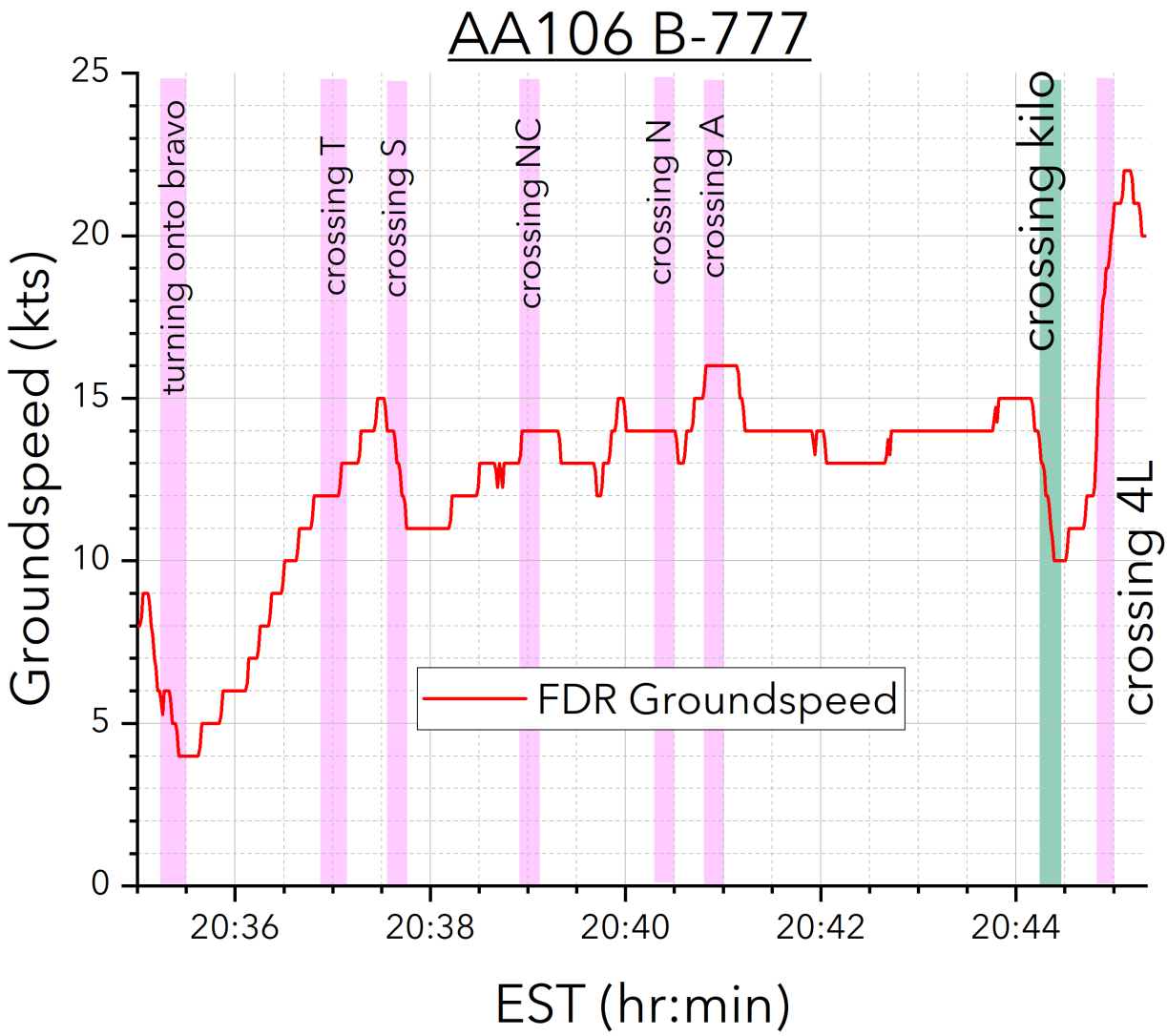

Figure 6. B-777 FDR recorded groundspeed during taxi.

By 20:44:40, AA106's nose was passing the hold short line for runway 4L at a groundspeed of about 11 kts. DAL1943 was 3,900 ft from the intersection of 4L and taxiway J at 47 kts groundspeed and accelerating (Figure 8).

At 20:44:45, AA106's nose was 100 ft from the edge of runway 4L. DAL1943 was 3,400 ft from the intersection of 4L and taxiway J at 72 kts groundspeed and accelerating.

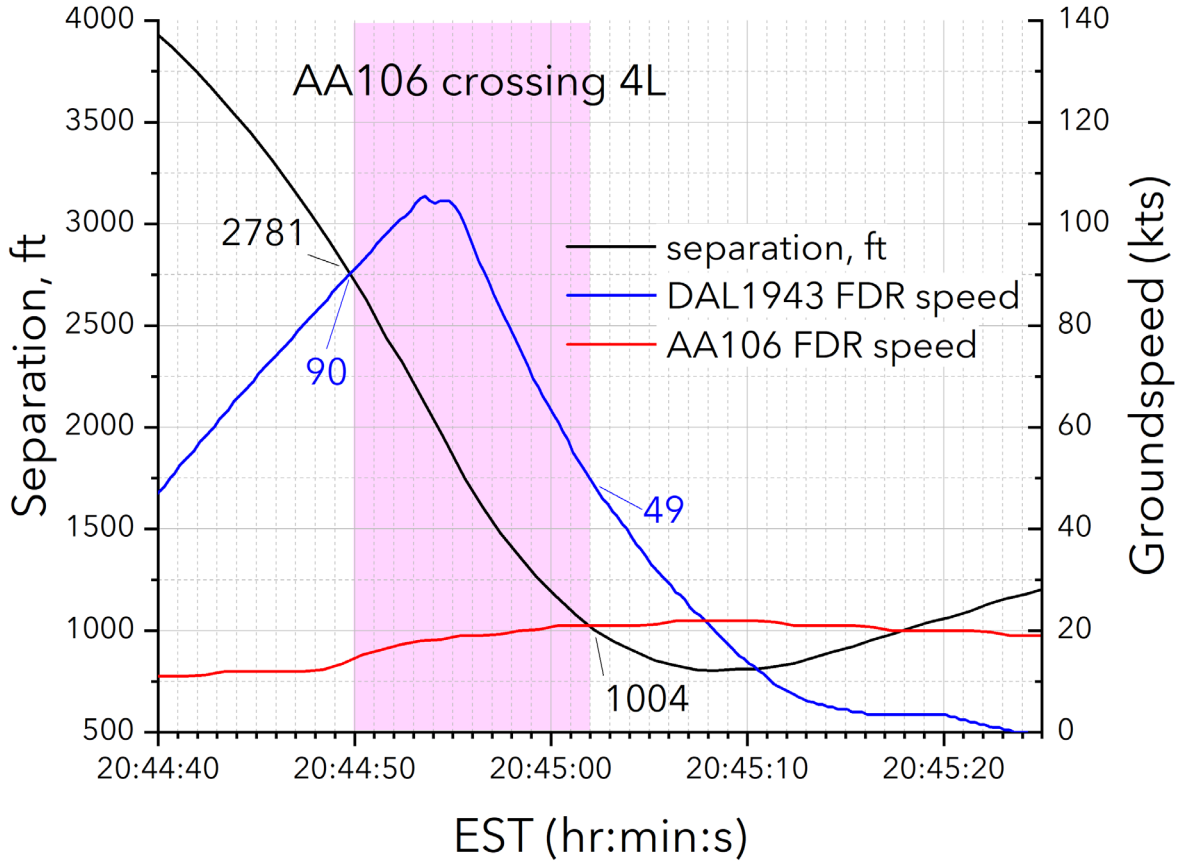

Figure 7. Airplane separation and FDR groundspeeds.

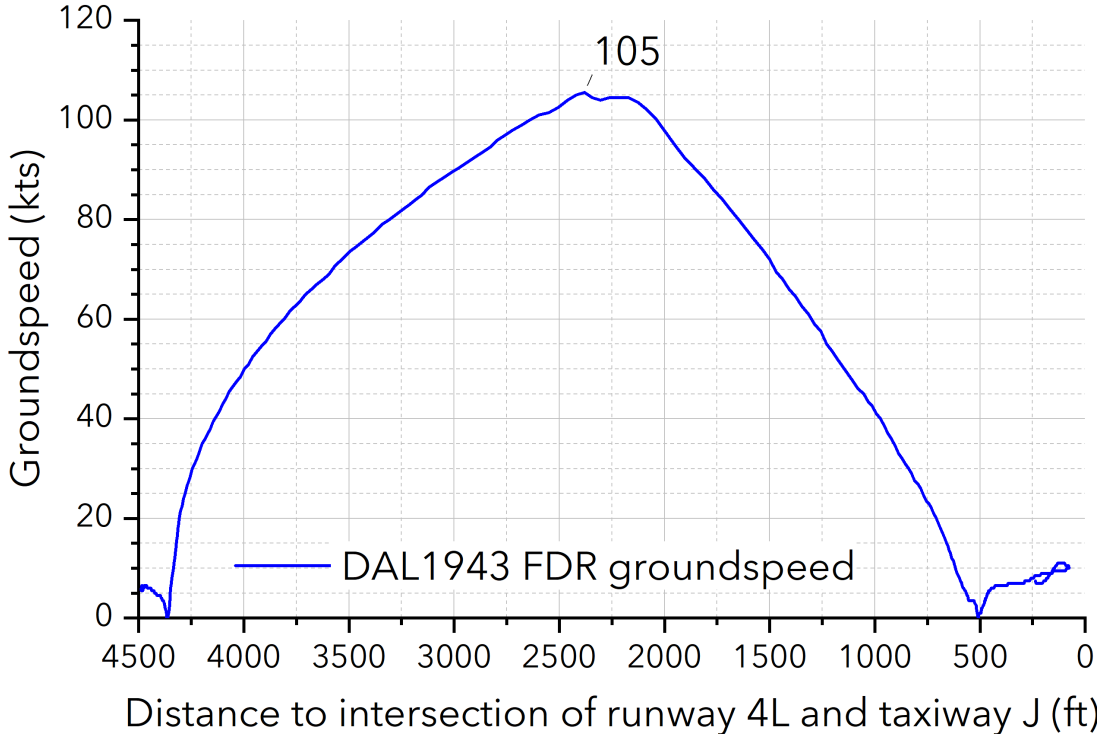

Figure 8. DAL1943 FDR groundspeed versus distance to intersection of runway 4L and taxiway J.

At 20:44:50 (Figure 10), the nose of AA106 entered onto runway 4L at a groundspeed of about 15 kts. DAL1943 was 2,700 ft from the intersection of 4L and taxiway J at 94 kts groundspeed and accelerating.

At 20:44:48, the local controller told DAL1943 their take-off clearance was canceled [4]. On DAL1943, the throttle moved to idle and autobrakes were triggered at 20:44:51. Speedbrakes were deployed at 20:44:52 and thrust reversers at 20:44:55. DAL1943 reached a maximum groundspeed of 105 kts at 20:44:53 (Figure 11), when it was 2,300 ft from the intersection of 4L and taxiway J. The nose of AA106 was just passing over the centerline of runway 4L at a groundspeed of 18 kts.

By 20:45:02 (Figure 12), AA106 was clear of runway 4L and traveling at a groundspeed of 21 kts. DAL1943 had decelerated to 49 kts and was 1,000 ft from AA106.

DAL1943 came to a stop on runway 4L at 20:45:23, 500 ft from the intersection of 4L and taxiway J. It then exited the runway turning left onto taxiway J.

Figure 9. Locations and groundspeeds of both airplanes when AA106 turned onto taxiway J at 20:44:30.

Figure 10. Locations and groundspeeds of both airplanes when AA106 entered runway 4L at 20:44:50.

Figure 11. Locations and groundspeeds of both airplanes when DAL1943 was at its maximum speed at 20:44:53.

Figure 12. Locations and groundspeeds of both airplanes when AA106 clears runway 4L at 20:45:02.

7.0 Runway Status Lights System

A Runway Status Lights (RWSL) system was installed at the taxiway J/ runway 4L intersection. The lights are embedded in the pavement and automatically turn red when traffic should not enter a runway or begin takeoff. The lights are intended to provide an immediate alert directly to pilots without controller input. According to the FAA, Runway Entrance Lights (RELs) will illuminate on crossing taxiways when a departing aircraft has 1) reached a speed of 29.9 kts coupled with an acceleration of 1.20 m/s^2 or 2) reached a speed of 49.9 kts [3].

Six RELs were installed at the taxiway J/runway 4L intersection. Figure 13 shows a photograph of these lights when activated. The first five lights are approximately equidistant apart while the 6th light is farther away. The first light is just beyond the runway designation at the hold short line and the 5th appears even with the edge of the runway.

Figure 13. Photograph of activated REL lights from taxiway J crossing runway 22R-4L at night. [Source: Port Authority of NY & NJ]

Figure 14 shows the location of the RELs on a Google Earth image of taxiway J and runway 4L. The lights are visible in the pavement as white marks, more easily seen on the dark taxiway than the lighter surfaced runway.

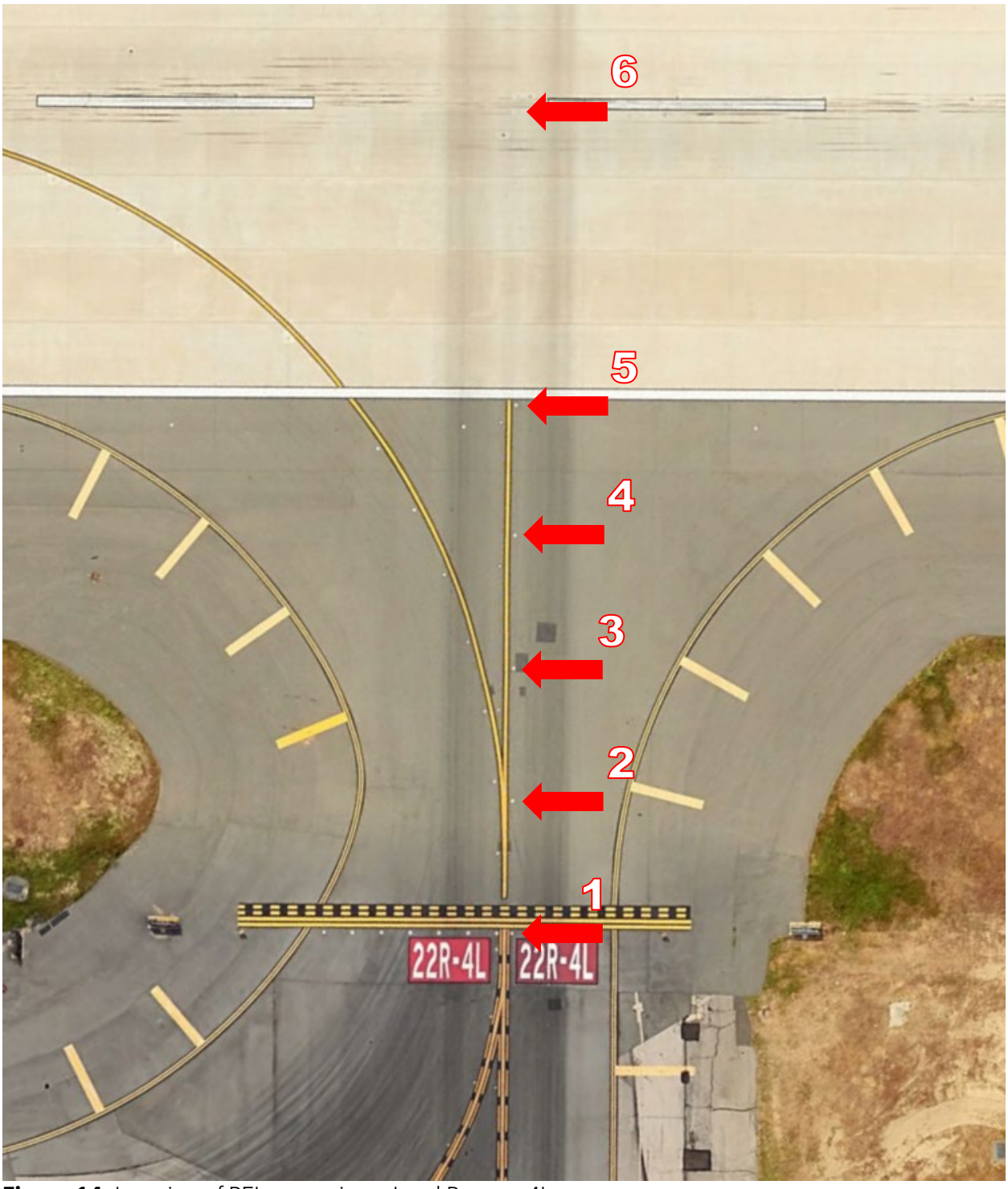

Figure 14. Location of RELs on taxiway J and Runway 4L.

8.0 ASDE-X Replay and RWSL

The FAA provided a playback file of the ASDE-X taxi paths for the two airplanes of interest. The ASDE-X point locations of the airplanes appeared consistent with the

ADS-B locations. However, it was determined that the airplane icons shown in the ASDE-X replay centered the wings over the point locations rather than the location of the GPS antenna, so the noses of the airplanes appeared slightly more forward than they likely were. Additionally, it was determined that the groundspeed displayed in the playback for DAL1943 was not reflective of the actual groundspeed of the airplane as recorded by its FDR. The ASDE-X calculated its own predictive velocity values [3] that exceeded the recorded speeds by over 30 kts at times.

According to the ASDE-X replay, the RELs illuminated at 20:44:40 coincident with DAL1943 accelerating from 47 kts through 49 kts groundspeed. Figure 15 shows a scaled drawing of AA106 with the GPS antenna location positioned at the ADS-B GPS position point. At 20:44:40, the nose of AA106 was just crossing the hold short line and REL 1 was beneath the airplane.

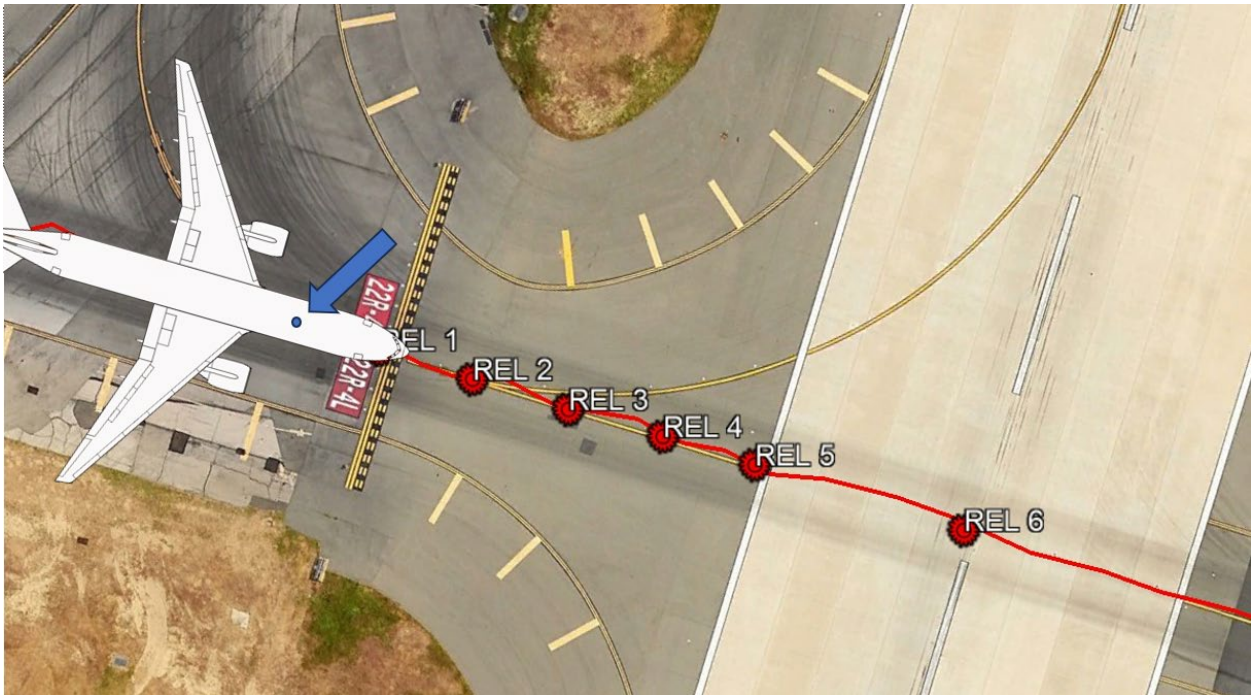

Figure 15. Google Earth image showing the illumination of the RELs at 20:44:40 and the location of AA106. Note, the plane icon displayed with the GPS antenna position.

The eye position of the crew of a B-777 is 89 inches aft of the nose of the airplane and the closest point on the ground that the crew can see is 582 inches ahead of their eye position [2]. This means crew can see the ground 41 ft ahead of the nose of the airplane or approximately 90 ft ahead of the recorded point location. However, the location of the airplane has an uncertainty of ± 20 ft with ASDE-X multilateration.

By 20:44:39, the hold short line and REL 1 would have been out of view of the crew. At 20:44:40, REL 2 was 100 ft forward of the point location of AA106. Therefore, when the RELs illuminated, REL 2 may have been within view of the crew of AA106 while REL 3, 4, 5, and 6 were within view. As AA106 continued forward, subsequent

RELs would have passed out of view beneath the airplane. REL 6 would have passed out of view at about 20:44:52. The RELs turned off at 20:45:07 as DAL1943 slowed below 25 kts.

D. SUMMARY

AA106 turned onto taxiway J at 20:44:30. It passed the hold short line for runway 4L at 20:44:40 at a groundspeed of about 11 kts as the RELs illuminated, four of which would have been viewable by the crew. AA106 entered runway 4L at 20:44:50 at a groundspeed of 15 kts and continued accelerating as it crossed the runway. DAL1943 was 2,700 ft from the intersection of 4L and taxiway J at 94 kts groundspeed and accelerating.

After take-off clearance was canceled at 20:44:48 due to AA106 entering the runway, DAL1943 initiated a rejected take-off at 20:44:51 and began decelerating at 20:44:53. AA106 cleared runway 4L at 20:45:02 at 21 knots groundspeed when DAL1943 was 1,000 ft away at a speed of 49 kts.

E. REFERENCES

1. Flight Data Recorder – Specialist's Factual Report, DCA23LA125, National Transportation Safety Board, 2023.
2. Operations and Human Performance Factual Report, DCA23LA125, National Transportation Safety Board, 2023.
3. NTSB JFK RWSL Array Response letter
4. Air Traffic Control, Group Chair's Factual Report, DCA23LA125, National Transportation Safety Board, 2023.