

May 29, 2024

Aviation Investigation Report AIR-24-01

Runway Incursion and Rejected Takeoff

American Airlines Flight 106

Boeing 777-200, N754AN, and

Delta Air Lines Flight 1943

Boeing 737-900, N914DU

Queens, New York
January 13, 2023

Abstract: This report discusses the January 13, 2023, runway incursion incident involving American Airlines (AAL) flight 106, a Boeing 777-200, and Delta Air Lines (DAL) flight 1943, a Boeing 737-900, at John F. Kennedy International Airport (JFK), Queens, New York. The flight crew of the AAL airplane was instructed to taxi to runway 4L for departure and cross runway 31L; however, the crew crossed runway 4L, where the DAL airplane had just begun its takeoff roll. The local controller cancelled the DAL airplane's takeoff clearance, and the DAL flight crew rejected the takeoff. Safety issues discussed in this report include (1) the need for additional risk mitigation strategies to prevent flight crew surface navigation errors that result in runway incursions; (2) the need for a procedural crosscheck that requires flight crews to verbalize the number of a runway they are about to cross as indicated by runway signs; and (3) the lack of flight deck technology to detect potential traffic conflicts. As a result of this investigation, the National Transportation Safety Board issues eight new safety recommendations to the Federal Aviation Administration (FAA), reiterates one previously issued recommendation to the FAA, and supersedes two recommendations.

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Acronyms and Abbreviations

AAL	American Airlines
AC	advisory circular
ACARS	aircraft communications addressing and reporting system
ADS-B	automatic dependent surveillance-broadcast
AIM	<i>Aeronautical Information Manual</i>
ASDE-X	airport surface detection equipment, model X
ASSC	airport surface surveillance capability
ATC	air traffic control
ATCT	airport traffic control tower
ATIS	automated terminal information service
ATP	airline transport pilot
<i>CFR</i>	<i>Code of Federal Regulations</i>
CRM	crew resource management
CVR	cockpit voice recorder
DAL	Delta Air Lines
FAA	Federal Aviation Administration
FB	relief first officer
FDR	flight data recorder
FMS	flight management system
FO	first officer
FOM	flight operations manual
JFK	John F. Kennedy International Airport
LHR	London Heathrow International Airport

NOTOC	notification to captain
NTSB	National Transportation Safety Board
NWS	National Weather Service
REL	runway entrance light
RSAT	runway safety action team
RWSL	runway status light system
SDQ	Las Américas International Airport
SMS	safety management system
TAF	terminal aerodrome forecast
TPS	takeoff performance system

Executive Summary

What Happened

On January 13, 2023, about 2044 local time, American Airlines (AAL) flight 106, a Boeing 777-223, N754AN, crossed runway 4L on taxiway J 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, N914DU, to abort its takeoff roll on runway 4L. None of the 6 crew and 153 passengers on DAL1943, nor the 12 crew and 137 passengers on AAL106, were injured, and there was no damage to either aircraft. AAL106 operated as a Title 14 *Code of Federal Regulations* (CFR) Part 121 scheduled international passenger flight from JFK to London Heathrow International Airport (LHR), London, United Kingdom. DAL1943 was a CFR Part 121 scheduled international passenger flight from JFK to Santo Domingo (SDQ), Dominican Republic. Night visual meteorological conditions prevailed at the airport at the time of the incident.

The flight crew of AAL106 was instructed to taxi to runway 4L for departure via taxiway B to taxiway K. During the taxi, they were instructed to cross runway 31L. The airplane approached the intersection of taxiways B and K, and rather than turning right onto K as instructed, the captain continued along taxiway B, which curved to the left. The captain subsequently turned right onto taxiway J before crossing runway 4L, from which DAL1943 had just begun its takeoff roll. Airport surface detection equipment, model X (ASDE-X) alerted the tower controller to the conflict, and the controller cancelled DAL1943's takeoff clearance. The crew of DAL1943 rejected their takeoff, reaching a maximum groundspeed of about 105 knots, about 2,300 ft from the taxiway J intersection. AAL106 continued across runway 4L and DAL1943 came to a stop before taxiing off the runway onto an adjacent taxiway without further incident.

What We Found

The National Transportation Safety Board (NTSB) found that the flight crew of AAL106 deviated from the instructions given by air traffic control and inadvertently crossed runway 4L due to a surface navigation error that likely stemmed from several factors, including the timing of the instruction provided to the crew to cross runway 31L; interruptions and multitasking as the crew performed required crosschecks of their takeoff performance calculations; the captain's prospective memory error, which resulted in his forgetting to turn right onto taxiway K; and environmental capture, which prompted the captain to proceed along a familiar, but incorrect, taxi route.

The ASDE-X functioned as designed and alerted the air traffic controller to the conflict between AAL106 and DAL1943, which resulted in the controller's timely cancellation of DAL1943's takeoff clearance; however, additional risk mitigation strategies are needed to reduce the likelihood that flight crew surface navigation errors will result in runway incursions. These might include procedural crosschecks that would require a flight crew to verbalize the runway they are about to cross, flight deck displays of airport traffic with aural and visual conflict alerting capability, and as-of-yet undeveloped strategies for reducing likelihood of surface navigation errors caused by the need to perform multiple concurrent operational tasks during taxi. Such strategies can be developed and tailored to the characteristics of an operator's unique constraints as part of an operator's safety management system.

The taxiway/runway intersection where the incident occurred was equipped with a runway status light system that included runway entrance lights (RELs), which comprised red lights embedded in the surface that illuminated to signal to approaching aircraft that the runway was in use. The RELs illuminated during this incident as designed; however, they illuminated as the nose of AAL106 was crossing the runway hold short markings, which was too late for the crew to perceive them and stop the airplane in a safe area. As a result, this system did not serve as an effective safeguard for alerting the crew that they were about to cross an active runway.

Finally, cockpit voice recorder (CVR) information was not available for this incident because the data were overwritten. As a result, the NTSB had to rely exclusively on flight crew recollections about the incident; however, these were not documented until 1 month after the incident occurred. A cockpit voice recording would likely have provided additional details about the content and timing of crew communications; shed light on the crew's minute-by-minute focus of attention; revealed any unreported, nonpertinent conversations; and potentially provided additional information about any distractions.

The NTSB determines that the probable cause of this incident was the AAL106 flight crew's surface navigation error due to distractions caused by their performance of concurrent operational tasks during taxi, which resulted in a loss of situational awareness. Contributing to the incident was the air traffic control tower team's nondetection of the AAL106 crew's deviation from taxi instructions while performing concurrent operational tasks; the timing of the runway status light system, which activated too late to prevent the AAL106 crew from crossing the runway hold short line; and American Airlines' lack of adequate risk controls to prevent concurrent flight crew tasks from leading to distraction, loss of situational awareness, and deviation from an authorized taxi clearance. Reducing the severity of the incident, and likely preventing an accident, was the activation of the ASDE-X warning in the air traffic control tower and the local controller's prompt cancellation of DAL1943's takeoff clearance.

What We Recommended

As a result of this investigation, we made eight new recommendations to the Federal Aviation Administration (FAA). We recommended that the FAA encourage Title 14 *Code of Federal Regulations* (CFR) Part 91K, 135, and 121 operators to incorporate into their standard operating procedures a procedural crosscheck that requires flight crews to verbalize the number of a runway they are about to cross, as indicated by runway signs, unless an installed automated system already provides an aural advisory.

We recommended that the FAA encourage 14 CFR Part 121 operators to use their safety management system to detect flight crew surface navigation errors resulting from the performance of concurrent tasks during taxi and use scientific knowledge from the field of human factors to develop and implement effective risk mitigation strategies.

We recommended that the FAA collaborate with aircraft and avionics manufacturers and software designers to develop the technology for a flight deck system that would provide visual and aural alerts to flight crews of traffic on a runway or taxiway and traffic on approach to land. We also recommended that the FAA require this new technology to be installed in all newly certificated transport-category airplanes, and that existing transport-category airplanes be retrofitted with the technology. These recommendations superseded a recommendation that asked the FAA to require a ground movement safety system that provided a direct warning capability to flight crews.

We recommended that the FAA evaluate the effectiveness of the activation logic for the runway status light system (RWSL) considering the circumstances of this incident. We also recommended that the FAA use the findings of this evaluation to update the RWSL activation logic as necessary to improve system effectiveness.

We recommended that the FAA require retrofit of all cockpit voice recorders (CVR) on all airplanes required to carry both a CVR and a flight data recorder with a CVR capable of recording the last 25 hours of audio. This recommendation superseded a recommendation that asked the FAA to require such recorders by January 1, 2024.

Additionally, we reiterated the following recommendation that was previously issued to the FAA:

Require all newly manufactured airplanes that must have a cockpit voice recorder (CVR) be fitted with a CVR capable of recording the last 25 hours of audio. (A-18-30)

1. Factual Information

1.1 History of Flight

On January 13, 2023, about 2044 eastern standard time, the flight crew of American Airlines (AAL) flight 106, a Boeing 777-200, N754AN, crossed runway 4L on taxiway J without air traffic control (ATC) clearance at John F. Kennedy International Airport (JFK), Queens, New York, causing the flight crew of Delta Air Lines (DAL) flight 1943, a Boeing 737-900, N914DU, to abort their takeoff roll on runway 4L. None of the 6 crew and 153 passengers on DAL1943, nor the 12 crew and 137 passengers on AAL106, were injured, and there was no damage to either airplane. AAL106 operated as a Title 14 *Code of Federal Regulations* (CFR) Part 121 scheduled international passenger flight from JFK to London Heathrow International Airport (LHR), London, United Kingdom. DAL1943 was a CFR Part 121 scheduled international passenger flight from JFK to Santo Domingo (SDQ), Dominican Republic. Night visual meteorological conditions prevailed at the airport at the time of the incident.¹

The flight crew of AAL106 comprised the captain, a first officer (FO), and a relief first officer (FB). In interviews conducted about 1 month after the incident, the flight crew reported that, before the flight, they reviewed the flight plan, weather, and new procedures contained in a two-sided company “Fleet Harmonization” quick reference page, dated January 3, 2023. The quick reference page involved some changes to flight crew responsibilities, and the FO and FB had not yet used the new procedures. The captain stated that he had operated many flights to LHR and offered the FO the option to serve as pilot flying or pilot monitoring. The FO chose to serve as pilot flying.²

Upon arrival at the airplane, which was parked at gate 18, the FB conducted an exterior preflight inspection while the captain and FO retrieved the automatic terminal information service (ATIS) information whiskey.³ Based upon the ATIS information, they anticipated and briefed a departure from runway 31L. The FO programmed the flight management system (FMS), and she and the captain briefed the taxi route. The captain recalled that his briefing included taxiway TA, left on B, and hold short at J, which he stated was the standard route to runway 31L from the

¹ Visit [ntsb.gov](https://www.ntsb.gov) to find additional information in the [public docket](#) for this NTSB incident investigation (case number DCA23LA125). Use the [CAROL Query](#) to search safety recommendations and investigations.

² Although the FO was the pilot flying, the captain performed the taxi.

³ ATIS is a continuously broadcast automated service that provides current airport information to departing and arriving aircraft. Each ATIS message is identified by a phonetic letter designation.

AAL gates at JFK. The FO stated that the airport diagram was available and was referenced during these discussions.

The captain produced a laminated copy of the Fleet Harmonization Memo quick reference page, placed it on a console for the flight crew's reference, and stated to the other pilots that they would discuss the changes while en route to LHR. The captain asked if the FO or FB were aware of any threats to the safety of the flight, and the FO stated that she was unfamiliar with the approach into LHR. The captain also recalled telling the FB to speak up if he had any safety concerns.

Recorded aircraft communications addressing and reporting system (ACARS) data revealed that at 2013:07, the crew received the flight's instrument clearance, which indicated that the flight would depart from runway 4L.⁴ The crew reported that the captain and FO obtained the updated ATIS, reprogrammed the FMS, and rebriefed the departure and taxi route. According to the FO, the captain's revised taxi briefing stated, "same taxi route up until Bravo short of Kilo." The captain recalled briefing the FO and FB that the controller would "have you come up Kilo, and then as you get closer, they'll tell you when to cross [runway 31L]." The captain stated that this was the typical route from the American Airlines gates to runway 4L. Figure 1 depicts AAL106's assigned taxi route from the gate to runway 4L (dashed orange line) and its actual taxi route (solid orange line).⁵

⁴ ACARS is a digital datalink system for transmission of short messages between aircraft and ground stations via airband radio or satellite.

⁵ AAL106's taxi route was captured by automatic dependent surveillance-broadcast information provided by the FAA.



Figure 1. AAL106's assigned (dashed orange line) and actual (solid orange line) taxi routes overlaid on a satellite image of JFK airport.

The captain subsequently briefed the passengers via the airplane's public address system, during which an airline employee provided the flight crew with a dangerous goods form.⁶ The form provided to the crew contained a handwritten annotation that the item, a load of lithium batteries, had not been loaded. The crew acknowledged their receipt of the form via the ACARS at 2017. Around this time, the crew received two ACARS messages from American Airlines dispatch advising of moderate turbulence during departure and en route. The first message requested crew acknowledgement, and the FO responded with the confirmation code.

⁶ The form was a notification to captain, or NOTOC, which informs the captain of the presence of hazardous material located in the airplane's cargo hold. The dangerous goods form, or DG, and NOTOC are used interchangeably as an industry practice.

The crew began pushback from the gate at 2028. AAL106 made initial contact with JFK air traffic control about 2033 when the FO reported that the airplane was at taxiway TA and requested taxi clearance, which the ground controller provided. The crew was initially instructed to taxi to runway 4L via a left turn onto taxiway B and to hold short of taxiway K; the FO responded, "Bravo short of Kilo American one zero six." The captain and FO stated that they each had the airport diagram displayed on their tablets, which were mounted to their respective sides of the cockpit, for reference during taxi.

The captain recalled that he began to taxi the airplane, but the crew had not yet received the ACARS load closeout, which was normally transmitted directly after pushback.⁷ The captain was concerned that the delay in receiving the load closeout was due to the handwritten notation on the dangerous goods form. The captain recalled that he slowed the airplane's taxi and asked the FO to request the load closeout via ACARS, which she did at 2034:47.

After receiving an automated reply stating, "STANDBY - LOAD AGENT NOTIFIED," the captain asked the FB to call a company operations agent via radio to receive the load closeout. The captain stated that he did not normally need to perform these tasks during taxi because the load closeout typically arrived soon after the airplane pushed back from the gate. He said that he normally made a point of crosschecking the load closeout with the FO and completing related tasks before departing the ramp area. In this case, however, he said that he decided to begin the taxi before receiving the load closeout because the flight had a third flight crewmember (the FB).

According to the ATC audio recordings, at 2040:13, the ground controller instructed AAL106 to cross runway 31L at taxiway K. The FO responded, "Cross three one left at kilo for American one oh six heavy." Airport surface detection equipment, model X (ASDE-X) information indicated that the airplane was on taxiway B approaching taxiway N at this time. About 2041:39, a company operations agent contacted the FB via radio to let him know that the load closeout would be coming shortly. The FB then relayed this information to the captain.

About 2041, the local controller (communicating on a different frequency that the crew of AAL106 was not yet monitoring) provided DAL1943 a wake turbulence advisory, instructed the crew to line up and wait on runway 4L at their discretion, then

⁷ The load closeout contained the final figures confirming number of passengers and fuel and cargo weights.

advised of traffic crossing right to left downfield.⁸ The crew acknowledged with only the instruction to line up and wait on runway 4L.

Between 2042:12 and 2042:14, when AAL106 was between taxiways M and L, the crew received three identical ACARS messages warning of moderate-to-severe turbulence affecting the departure area. The FO printed and briefed these messages to the captain, and the captain asked the FB to advise the flight attendants to remain seated after departure because of these reports. In accordance with the new Fleet Harmonization procedures, the FO made an announcement over the public address system directing the flight attendants to be seated for departure.

ACARS data indicated that the load closeout was received at 2043:06, shortly after the airplane had crossed taxiway L. The FB recalled removing the load closeout paperwork from the printer and handing it to the FO. ACARS data indicated that, over about the next 40 seconds, updated weight and balance information was transmitted to the FMS and the crew accepted these values in the flight management computer; during this time, the airplane was crossing taxiway KE. The FB recalled that, after removing the load closeout paperwork, additional paperwork remained on the center pedestal, covering his radio panel and other controls and displays. He began cleaning up this paperwork to access and adjust his radio controls, as overlapping transmissions from the ground control and company operations frequencies were "muddying up" his audio.

The FO recalled that she began performing required crosschecks of the load closeout information with takeoff performance information on her tablet, which she had previously been using to display the airport diagram. She stated that she removed the tablet from its mount and placed it on her knee for about 1 minute while discussing the performance values with the captain. The captain recalled that he was discussing these performance values with the FO as the airplane approached taxiway K.

At 2044:15, about the time the local controller cleared DAL1943 for takeoff, AAL106 crossed taxiway K and continued along taxiway B, which curved to the left. In a postincident interview, the ground controller stated that he observed AAL106 swing out to the left on taxiway B to begin what he believed to be a typical wide right turn onto taxiway K. He stated that, since the AAL106 flight crew correctly read back their taxi instructions, he expected them to adhere to the instructions and perform the taxi route as assigned.

⁸ According to the *Aeronautical Information Manual*, line up and wait is an air traffic control procedure designed to position an aircraft onto the runway for an imminent departure.

Review of JFK tower communications recordings showed that, as AAL106 passed taxiway K, the ground controller received a request from AAL107, which was located near the departure end of runway 4L, to taxi to the ramp area. The controller subsequently instructed AAL107 to taxi to the ramp. Shortly after completing his communication with AAL107, the ground controller then established communications with an airport operations vehicle and instructed them to perform a sweep of runway 31R in preparation for a runway configuration change.⁹

The ground controller recalled that, after he finished his communication with the airport operations vehicle, he attended to another task that he speculated might have involved “getting a strip or doing something.” At 2044:30, AAL106 made a right turn on taxiway J where it continued toward runway 4L. Figure 2 depicts AAL106’s missed right turn onto taxiway K and the airplane’s path toward taxiway J/runway 4L.

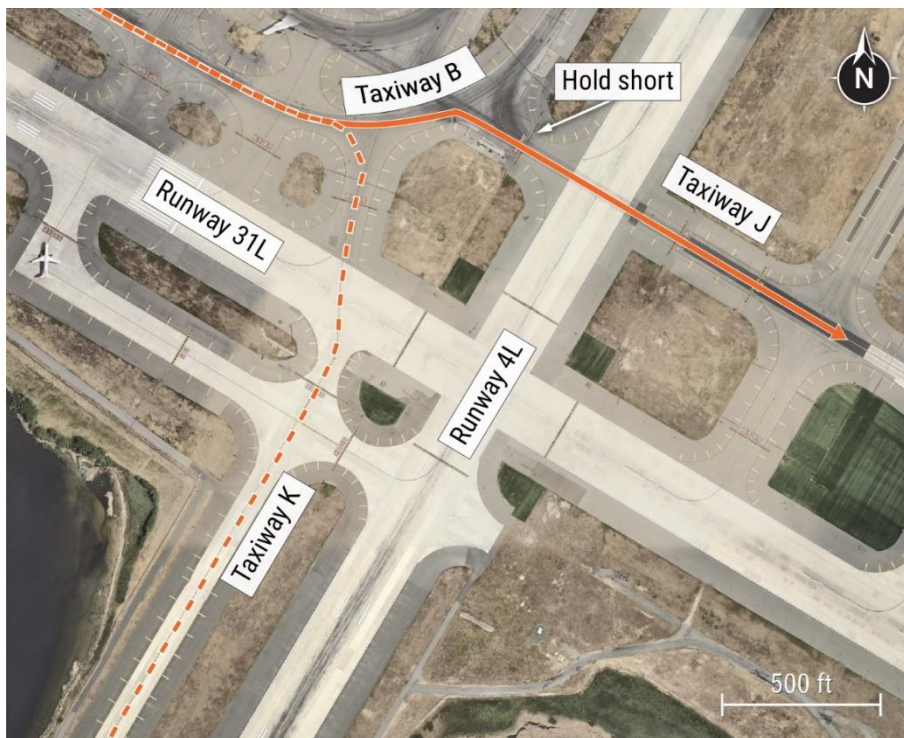


Figure 2. Satellite image of the area of taxiways B, K, and J; and runways 4L and 31L with AAL106’s assigned (dashed orange line) and actual (solid orange line) taxi routes overlaid.

⁹ In the postincident interview, the JFK tower operations supervisor indicated that the runway configuration change began about 5 minutes before the incident at the request of the New York Terminal Radar Approach Control traffic management unit. He stated that he attempted to delay this change until 2130, as they routinely reconfigured runways at JFK between around 2130 and 2230; however, the traffic management unit was “insistent” that the configuration change take place “as soon as possible.”

The FO recalled being “head-down” and talking about takeoff performance when she heard the captain say, “Cleared to cross.” She recalled looking up, leaning forward, gazing down the runway to the right, and checking the runway and final approach area for conflicting traffic. She recalled seeing no airplane on the runway. The captain recalled looking left and right to clear the runway before entering it, and he did not see an airplane on the runway. According to all three pilots, the captain stated, “clear left,” and the FO responded, “clear right.”¹⁰

The captain recalled activating the airplane’s runway turnoff lights, both landing lights, and the nosewheel light before crossing the runway. The FO stated that the taxi light was on and that before crossing the runway, the captain reached to turn on additional lights. She could not recall which lights were on but stated, “I know he had crossing lights on.” The FB recalled that the captain turned on the “taxi light, nose lights and the wing lights.” He added, “I was probably just coming up from heads down at that point.”

Automatic dependent surveillance-broadcast (ADS-B) location information indicated that DAL1943 began its takeoff roll on runway 4L at 2044:30, as AAL106 turned onto taxiway J.¹¹ At 2044:40, AAL106 reached the runway hold short line, taxiing at a speed about 11 knots (kts) as DAL1943 was 3,900 ft from the intersection between runway 4L and taxiway J and accelerating through 47 kts; according to ASDE-X information, the runway entrance lights (RELs) for runway 4L illuminated at this time. By 2044:50, the nose of AAL106 had crossed onto runway 4L. DAL1943 was 2,700 ft from the intersection and accelerating through 94 kts.

The captain of AAL106 recalled that, as the airplane crossed the runway centerline, he saw red lights illuminate on the runway but was unsure why they had illuminated and chose to add power to expedite the runway crossing. The FO also observed red lights illuminate but stated that they did so after the airplane crossed

¹⁰ According to the captain’s postincident interview, “I said, ‘clear left, clear right.’ [The FO] said, ‘clear right.’”

According to the FO’s postincident interview, the captain “started to turn to the runway, and he said ‘cleared to cross’ ... I picked my head up, looked all the way down the runway. I checked the runway and final, and I actually had to lean forward to see around. So—and he checked left. He said ‘clear left.’ I said ‘clear right.’”

¹¹ According to the Federal Aviation Administration, ADS-B uses GPS satellite signals to provide air traffic controllers and pilots with accurate information that will help keep aircraft safely separated in the sky and on runways. Aircraft transceivers receive GPS signals and use them to determine the aircraft’s precise position in the sky, which is combined with other data and broadcast out to other aircraft and air traffic control facilities.

the runway “stop lines.”¹² The FO stated that both she and the captain realized that the illumination of the red lights (runway entrance lights) indicated that something “wasn’t right,” and that the captain added power and “pushed across the runway.”

The FB recalled that his attention was focused inside the flight deck after the crew received the load closeout. He stated that he was head-down as the airplane approached the runway and “heard some confusion about crossing a runway.”¹³ When he looked up, he saw that the airplane was across the hold short line, and as the airplane straightened out to cross the runway, he saw another airplane “down to the right.”

The captain recalled that, after they crossed the runway, the FB stated that an airplane was “taxiing on the runway.” The captain looked out the right cockpit window and saw an airplane that appeared to be taxiing on runway 4L. He stated that it did not look “that close” from his perspective.

In a postincident interview, the local controller stated that he performed a visual scan before issuing DAL1943’s takeoff clearance, then began talking to the crew of another airplane. Recorded tower communications revealed that, in the 15 seconds after issuing DAL1943’s takeoff clearance, the local controller spoke with two other airplanes that were taxiing for takeoff, the first on runway 4L and the second on runway 31L. At 2044:42, the ASDE-X system annunciated a “runway occupied” alert in the control tower. At 2044:47 and again at 2044:51, the local controller advised DAL1943 that their takeoff clearance was cancelled, and at 2044:54, the DAL1943 crew responded that they were rejecting the takeoff.

The ground controller stated that he did not know if the crew of AAL106 was monitoring his frequency, but he saw that AAL106 was crossing runway 4L and decided it was best to let it continue crossing. He felt that broadcasting AAL106’s callsign may have caused the crew to slow down or stop. Shortly thereafter, the local controller asked the crew of DAL1943 whether they were able to taxi or if they needed to complete checks. The crew responded that they could clear the runway, and the local controller instructed the crew to turn left on taxiway J. The flight crew of AAL106 could not hear the transmissions between the local controller and DAL1943 because they had not yet switched to tower frequency.

¹² According to the FO’s recollection in a postincident interview, “The red lights actually came up like—if I’d be sitting on them. They were already—the lights came from behind my shoulder, but you could see the outline because they were pretty bright. So that’s how we saw the lights.”

¹³ Due to a lack of cockpit voice recorder information, conversations between the flight crew regarding the runway crossing could not be verified. Refer to Sections 1.6, Flight Recorders, and 1.9, Additional Information.

About 2046, after crossing runway 4L, the captain of AAL106 stopped the airplane on taxiway J and the flight crew of AAL106 switched to tower frequency, shortly after which the local controller advised the crew of AAL106 that they had a possible pilot deviation and to stand by for a phone number.¹⁴ The captain of AAL106 asked, "The last clearance we were given, we were cleared to cross, is that correct?" to which the controller replied, "American 106 heavy we're departing runway four left ... you are supposed to depart runway four left. You are currently holding short of runway three one left."¹⁵ The captain later said that he realized during this discussion that he had made a mistake.

After receiving the phone number, the captain called the controller and stated that the crew had briefed a runway 31L departure, but "as we were coming out along on Bravo as we taxied out we got a new ... it was runway four left and then we were told to cross at Juliet and ... or Kilo or something I don't remember exactly now exactly because we were still trying to get this closeout problem fixed and I guess then we crossed the wrong runway."¹⁶ The controller stated ATC personnel were listening to audio recordings to confirm what clearances had been issued to AAL106. The controller took the captain's name and phone number, advised that the flight should prepare to depart from runway 31L, and instructed the captain to resume communication via radio.

The AAL106 flight crew did not report the incident to American Airlines before departure, and the captain stated that, to his knowledge, no provision in the company's operations manual would have prohibited the flight's departure following the event. The FB stated that he called the pilot union hotline, and a representative confirmed that there was no prohibition on their departure. The captain conferred with the FO and FB regarding whether they "felt okay" about continuing the flight, and they stated that they did. The flight subsequently departed runway 31L and completed the trip to LHR without further incident.

In a postincident written statement, the captain of DAL1943 stated that the flight had been cleared for takeoff following a brief delay holding on the runway. Shortly after the airplane reached a speed of 80 kts, the tower controller cancelled their takeoff clearance, and the captain initiated rejected takeoff procedures. He stated that, due to the "extreme darkness" of the evening, he and his FO did not see AAL106 crossing the runway ahead until after rejecting the takeoff, and they did not

¹⁴ In Order 8020.11D, the FAA defines pilot deviation as, "an action of a pilot that results in the violation of a Federal Aviation Regulation (FAR) or a North American Aerospace Defense (Command Air Defense Identification Zone) tolerance."

¹⁵ At this time, AAL106 was on taxiway J between taxiways Y and Z.

¹⁶ The phone call between the controller and the captain was recorded.

believe that AAL106's exterior lights were illuminated. The FO recalled that only AAL106's beacon lights were visible.

1.2 Personnel Information

1.2.1 American Airlines Flight Crew

1.2.1.1 Captain

The captain had been employed by American Airlines since June 1989 and had held the position of captain on the Boeing 777 (B777) since February 2022. He had about 20,000 hours total flight experience at American Airlines and about 14,000 hours total pilot-in-command experience. He had about 9,000 hours on the B777, of which about 500 hours was pilot-in-command. The captain stated that he had been based at JFK for about 10 years and that he was "very familiar" with the airport.

The captain commuted to JFK from his home near Buffalo, New York, via airline. He served as captain on a flight from JFK to LHR on the evening of Tuesday, January 10, returning to his home on the night of January 12. He reported that he received a 2-hour nap in the crew rest area during the flight to LHR, a 5-hour nap after arriving at LHR, and more than 8 hours of sleep during the two nights before the incident.

On the day of the incident, he departed Buffalo about 1330 and arrived at JFK about 1430. He slept in a recliner in a crew rest area from about 1600 to 1800. He reported good sleep quality in the days preceding the incident and stated that he felt rested when he reported for duty. The FO and FB also reported that the captain's alertness and mood on the night of the incident seemed good.

1.2.1.2 First Officer

The FO was hired by American Airlines in April 2014 and had recently transitioned to the position of FO on the B777. She had flown out of JFK on four previous occasions. The FO reported 1,188 hours total flight experience at American Airlines, of which about 126 hours was in the B777. The FO was on reserve duty at home during the 72 hours before the incident and reported sleeping more than 8 hours per night during that time. On the evening of the incident, she commuted to JFK by car from her residence, departing about 1700 and arriving about 1830. She recalled feeling rested when she reported for duty, and the captain described her as appearing rested and in a good mood.

1.2.1.3 Relief First Officer

The FO was hired by American Airlines in September 2016 and reported about 2,800 total hours of flight experience with the company, of which about 110 hours was on the B777. He stated that he had operated “hundreds” of flights from JFK with both AAL and his previous employer. The FO was off duty for the 2 days before the incident and reported sleeping more than 8 hours per night. On the afternoon of the incident, he commuted by car from his home to JFK, departing around 1400 or 1500. He recalled feeling rested when he reported for duty, and the captain also described him as appearing rested and in a good mood.

1.2.2 Delta Airlines Flight Crew

1.2.2.1 Captain

The Delta Airlines captain was hired at Delta in February 1999. He began flying as FO on the DC-9 before transitioning to the Boeing 757/767. He upgraded to captain on the B737 in October 2018.

1.2.2.2 First Officer

The Delta Airlines FO was hired by Delta in June 2022 and had served as FO on the B737 since that time.

1.3 Airplane Information

The American Airlines Boeing 777 is configured with seating for 273 in three cabins. The airplane is about 200 ft long with a wingspan about 200 ft. The B777 is powered by two Rolls-Royce engines, each capable of producing 95,000 lbs of thrust. The Delta Air Lines Boeing 737-900 is configured with seating for 149 in two cabins. The airplane is about 138 ft long with a wingspan about 120 ft. The 737-900 is powered by two CFM-56 engines, each capable of producing 27,300 lbs of thrust.

1.4 Meteorological Information

At 1951, the automated weather observation at JFK included wind from 320° at 18 kts, 10 miles or greater visibility, an overcast cloud ceiling at 2,700 ft above ground level, temperature 5°C, dew point temperature -1°C, and an altimeter setting of 29.69 inches of mercury.

1.5 Airport Information

1.5.1 Overview

John F. Kennedy International Airport is a publicly owned entity operated by the Port Authority of New York and New Jersey (Port Authority). At the time of the incident, the airport had four runways: runway 4L/22R, runway 4R/22L, runway 13L/31R, and runway 13R/31L. The incident occurred on runway 4L, which measured 12,079 ft long and 200 ft wide.

1.5.2 Lighting, Signage, and Markings

The intersection of taxiway J and runway 4L/22R was lighted and marked with taxiway edge lights, taxiway edge markings, an enhanced taxiway centerline, both elevated and in-pavement runway guard lights, hold short markings, and two surface painted holding position markings (see figure 3).¹⁷ Additionally, the Port Authority reported that a surface painted direction sign for taxiway K had been painted on taxiway B in July 2022 (see figure 4). A lighted outbound destination sign was located on the right side of taxiway K displaying the direction of runway 4L.

¹⁷ According to the *AIM*, the enhanced taxiway centerline marking consists of a parallel line of yellow dashes on either side of the normal taxiway centerline. The taxiway centerlines are enhanced for a maximum of 150 ft before a runway holding position marking. Runway guard lights consist of either a pair of elevation flashing yellow lights installed on either side of the taxiway, or a row of in-pavement yellow lights installed across the entire taxiway, at the runway holding position marking.

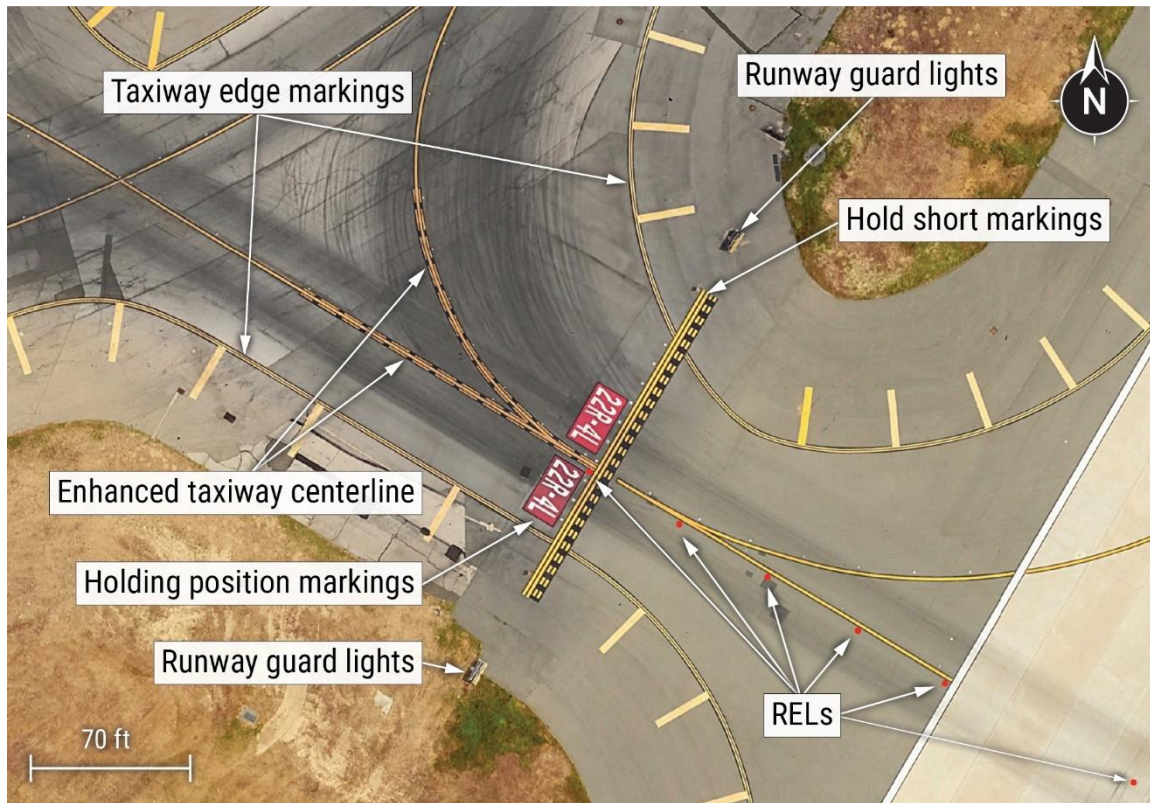


Figure 3. Satellite image of the taxiway J/runway 4L intersection showing lights and markings. (Source: Google Earth)



Figure 4. Taxiway K's surface painted taxiway direction sign located on taxiway B. (Source: Port Authority of NY and NJ)

Note: The lighted outbound destination sign for runway 4L can be seen on the right side of taxiway K.

1.5.3 Runway Status Lights System

JFK is one of 20 US airports where a runway status light system (RWSL) is installed.¹⁸ According to FAA Advisory Circular 150/5340-30J, Design and Installation Details for Airport Visual Aides, RWSLs, “display critical, time-sensitive safety status information directly to pilots and vehicle operators via in-pavement lights giving them an immediate indication of potentially unsafe situations.”

The RWSL consists of an RWSL processor and a field lighting system. The RWSL processor receives surveillance data of aircraft and vehicles on or near the airport surface from the ground surface surveillance system, ASDE-X. The RWSL processor uses these data to establish the presence and motion of aircraft and surface vehicles on or near the runways. It then determines when to activate and deactivate the runway entrance lights (RELs) and takeoff hold lights. The system illuminates red RELs if the runway is unsafe for entry or crossing and illuminates red takeoff hold lights if the runway is unsafe for departure. The system extinguishes the lights automatically as appropriate when the runway is no longer unsafe.

1.5.3.1 Runway Entrance Lights

RELs are located where a taxiway intersects a runway and only indicate a runway’s status—lack of such lights does not indicate clearance to enter or cross a runway. RELs illuminate when an aircraft is taking off or landing on a runway, just before the aircraft reaches the taxiway intersection. According to the FAA, 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 meters/second², or 2) reached a speed of 49.9 kts.

Per FAA Advisory Circular 150/5340-30J, RELs are installed parallel to the taxiway centerline and spaced laterally 2 ft from the taxiway centerline on the opposite side of the taxiway centerline lights (if installed). An REL array will typically consist of a minimum of six unidirectional lights, but may include more or fewer, depending on the distance between the runway centerline and the holding position. Six RELs were installed at the taxiway J/runway 4L intersection at JFK. Figure 5 depicts the RELs at the taxiway J/runway 4L intersection when activated (yellow runway guard lights and green taxiway centerline lights can also be seen illuminated).

¹⁸ RWSLs combine airport lighting equipment with airport surveillance systems to create an additional layer of runway safety that is intended to reduce the number and severity of runway incursions without interfering with normal airport operations.



Figure 5. Photograph of activated RELs across runway 4L at night, as seen from the hold short line on taxiway J. (Source: Port Authority of NY and NJ)

1.5.3.2 RWSL Operating Characteristics

The FAA's Runway Status Lights Pilot Reference Guide described the system as follows:

Operating Characteristics - Departing Aircraft: When a departing aircraft reaches 30 knots, all taxiway intersections with Runway Entrance Lights arrays along the runway ahead of the aircraft will illuminate. As the aircraft approaches a Runway Entrance Lights equipped taxiway intersection, the lights at that intersection extinguish approximately 2 to 3 seconds before the aircraft reaches it. This allows controllers to apply "anticipated separation" to permit air traffic control to move traffic more expeditiously without compromising safety. After the aircraft is declared "airborne" by the system, all lights will extinguish.

The NTSB requested that the FAA evaluate the operational algorithm/criteria for the RWSL installation at JFK to ensure that it was operating as described on the day of the incident. FAA Air Traffic Organization responded with a detailed analysis of the incident and concluded that, "the JFK RWSL system [was] operating within the standard algorithm/criteria for RWSL light activations."

1.5.4 Airport Surface Detection System, Model X

JFK airport was equipped with an ASDE-X system to alert air traffic controllers of potential runway conflicts by providing detailed coverage of movement on runways and taxiways. Controllers are presented this information on a color display depicting aircraft and vehicle positions as icons overlaid on a map of the airport's

runways, taxiways, and airport approach corridors.¹⁹ The map is continuously updated and can be particularly beneficial at night or in poor visibility conditions as an enhancement to controller situational awareness.

The ASDE-X system is equipped with visual and aural alarms to alert controllers of possible runway incursions or incidents. This software predicts the path of an aircraft landing or departing as well as vehicular movements on runways. Figure 6 shows a screen capture of the ASDE-X display during the runway-occupied alert for this incident. The system also annunciated an accompanying “runway occupied” aural alert.



Figure 6. Screen capture of the JFK ASDE-X system display while the runway-occupied alert was active for DAL1943 and AAL106. (Source: Federal Aviation Administration)

Note: Red-boxed text in the upper left corner identifies DAL1943 and AAL106 as the airplanes involved in the alert, with both airplanes circled in red on the airport map.

¹⁹ The airplane icons depicted on the ASDE-X display 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.

1.5.5 Hot Spots at JFK

At the time of the incident, JFK did not have any charted hot spots, which the FAA's Chart Supplement defines as a "location on an aerodrome movement area with a history or potential risk of collision or runway incursion, and where heightened attention by pilots/drivers is necessary." Typically, it is a complex or confusing taxiway or taxiway and runway intersection. According to the FAA, some factors that can contribute to a hot spot designation are airport layout; traffic flow; airport marking, signage, and lighting; and pilot situational awareness or training.

Hot spots are depicted on airport diagrams as open circles or polygons designated as "HS1," "HS2," etc., and the qualifying features of each are briefly described in the Airport Diagram Hot Spots Chart Supplement. Runway Safety Action Teams (RSATs), which comprise local airport stakeholders, meet at least once a year to identify risks to surface safety at their airport and develop plans to mitigate or eliminate those risks.

One of the topics that might be discussed during RSAT meetings is published airport hot spots, including whether additions or deletions of hot spots may be appropriate. While there are no specific criteria listed for additions and deletions, hot spots are not added to airport diagrams without concurrence from members of the local RSAT. Similarly, hot spots remain charted on airport diagrams until the RSAT determines that the increased risk posed by the area has been reduced or eliminated.

Review of JFK RSAT meeting minutes between 2004 and 2022 revealed that various hot spots were depicted at complex taxiway intersections before 2010, including the area where the incident occurred. Minutes from the 2011 RSAT meeting indicated consensus among pilots, the Port Authority, and other stakeholders that no hot spots would be charted at JFK due to updates in airport signage and markings and improvements to taxiway angles. Subsequent meeting notes indicated that "areas of concern" at the airport continuously changed due to the variety of runway configurations available.

The tower supervisor and cab coordinator on duty at the time of the incident said that tower controllers were trained that the intersections of taxiways K and J with taxiway B were a hot spot. The tower supervisor described it as the "main hotspot, because it is not just the geometry of the turn, but just the amount of traffic that goes through that intersection."

On June 15, 2023, about 6 months after and as a result of the incident, the intersection of taxiways B, K, and J at JFK was charted as hot spot 1 (HS1) on the airport diagram with the following description added in the chart supplement,

“Maint[ain] vigilance Twy K and Twy J complex int[ersection] close proximity to Rwy 04L and Rwy 31L.”

1.5.6 Air Traffic Control Tower Staffing

At the time of the incident, the ATCT was occupied by seven controllers staffing the local control, ground control, cab coordinator, flight data/clearance delivery, and operations supervisor positions. Some positions were combined due to the lower traffic level at the time of the incident. All air traffic controllers assigned to positions in the JFK ATCT were certified and qualified in accordance with federal regulations.

1.5.7 Air Traffic Control Procedures

1.5.7.1 Duty Priority

FAA Order 7110.65Z, Air Traffic Control, paragraph 2–1–2, Duty Priority, provided procedures and guidance for controllers in prioritizing their duties and stated in part:

- a. Give first priority to separating aircraft and issuing safety alerts as required in this order. Good judgment must be used in prioritizing all other provisions of this order based on the requirements of the situation at hand.

NOTE– Because there are many variables involved, it is virtually impossible to develop a standard list of duty priorities that would apply uniformly to every conceivable situation. Each set of circumstances must be evaluated on its own merit, and when more than one action is required, controllers must exercise their best judgment based on the facts and circumstances known to them. That action which is most critical from a safety standpoint is performed first.

1.5.7.2 Tower Team Positions Responsibilities

FAA Order 7110.65Z, Air Traffic Control, paragraph 2–10–3, Tower Team Position Responsibilities, described the team concept and the primary responsibilities of the tower team and stated in part:

- a. Tower Team Concept and Intent: There are no absolute divisions of responsibilities regarding position operations. The tasks to be completed remain the same whether one, two, or three people are working positions within a facility/sector. The team, as a whole, has responsibility for the safe and efficient operation of that facility/sector.

1.5.7.3 Visually Scanning Runways

FAA order 7110.65Z, Air Traffic Control, paragraph 3–1–12, Visually Scanning Runways, prescribed procedures for the local and ground controller for scanning runways, which stated:

- a. Local controllers must visually scan runways to the maximum extent possible.
- b. Ground control must assist local control in visually scanning runways, especially when runways are in close proximity to other movement areas.

1.6 Flight Recorders

Each airplane was equipped with a flight data recorder (FDR) and cockpit voice recorder (CVR). FDRs are required to record a minimum of 25 hours of data. The FDR data for the incident was obtained from both airplanes and included airplane attitude, accelerations, altitude, airspeed, control inputs, control surface positions, engine parameters, and avionics settings, among other parameters. As a result of their 2-hour recording capacity, the incident was overwritten on both airplanes' CVRs.

1.7 Tests and Research

1.7.1 Flight Data Recorder and ADS-B Study

The latitude and longitude parameters obtained from both airplanes' flight data recorders (FDRs) were not recorded with sufficient precision to accurately determine the airplanes' locations on the runway near the time of the incident. Therefore, ADS-B information provided by the FAA was used to determine airplane location. ADS-B has an accuracy of about 20 meters (65 ft) in both the horizontal and vertical dimensions. The location data are reflective of the location of the GPS antenna on each airplane. On the B777 (AAL106), the antenna is located on top of the fuselage, 46 ft aft of the nose; while the antenna on the B737 (DAL1943) is located on top of the fuselage about 33 ft aft of the nose. The separation calculations made in this report reflect the distance between the two GPS antennae and do not account for the wingspan of the B777 nor for the forward fuselage of the B737.

Figure 7 shows the taxi paths of both airplanes. AAL106 left the ramp area and entered taxiway TA at 2034:45, at which time DAL1943 was in line on taxiway K for departure from runway 4L. At 2040:13, the tower controller instructed AAL106 to cross runway 31L at taxiway K. At 2044:30, AAL106 turned onto taxiway J as DAL1943 began its takeoff roll. Airplane groundspeeds shown in figure 8 display the FDR-

recorded groundspeeds, which were consistent with groundspeed calculated from the airplanes' respective ADS-B taxi tracks, as well as the separation distance between the two airplanes. AAL106 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 7. The taxi paths of AAL106 (orange, terminal through taxiway J) and DAL1943 (blue, taxiway K and runway 4L), based on ADS-B data, with times annotated at select locations.

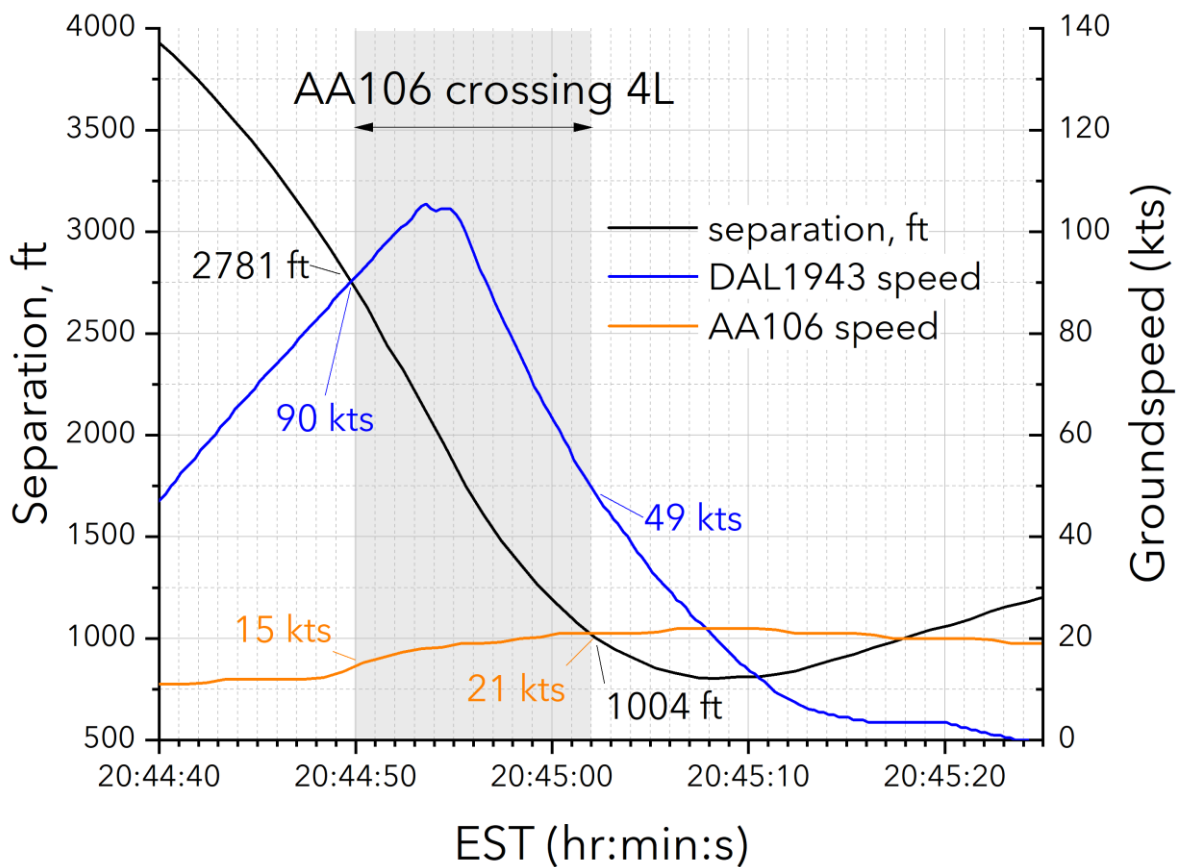


Figure 8. Airplane groundspeeds and separation distances.

By 2044:40, AAL106'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. ADSE-X recorded that the RELs for runway 4L illuminated at this time.

At 2044:47, the local controller cancelled DAL1943's takeoff clearance. At 2044:50, the nose of AAL106 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 (see figure 9).



Figure 9. Locations and groundspeeds of both airplanes when AAL106 entered runway 4L at 2044:50.

FDR data indicated that DAL1943's throttle moved to idle and the autobrakes were triggered at 2044:51. Speedbrakes were deployed at 2044:52, and the airplane reached a maximum groundspeed of 105 kts at 2044:53, 2,300 ft from the intersection of 4L and taxiway J, as the nose of AAL106 was passing over the centerline of runway 4L at a groundspeed of 18 kts (see figure 10).²⁰ DAL1943's thrust reversers deployed at 2044:55.

²⁰ Speedbrakes are high-drag devices on an airplane's wing used to assist in slowing the airplane.



Figure 10. Locations and groundspeeds of both airplanes when DAL1943 reached its maximum speed at 2044:53.

By 2045:02, AAL106 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 AAL106 (see figure 11).



Figure 11. Locations and groundspeeds of both airplanes when AAL106 cleared runway 4L at 2045:02.

DAL1943 came to a stop on runway 4L at 2045:23, 500 ft from the intersection of 4L and taxiway J. It then exited the runway, turning left onto taxiway J.

1.7.2 Ground Visibility from the Flight Deck of the B777

According to information provided by Boeing and shown in figure 12, the horizontal distance between the pilot's eye position in a B777 and the closest visible point on the ground was 582 in (48 ft, 6 in). These dimensions indicate that the horizontal distance between the closest point on the ground in front of the airplane that was visible to the pilots and the transmitted GPS location was 1,045 in (87 ft, 1 in).

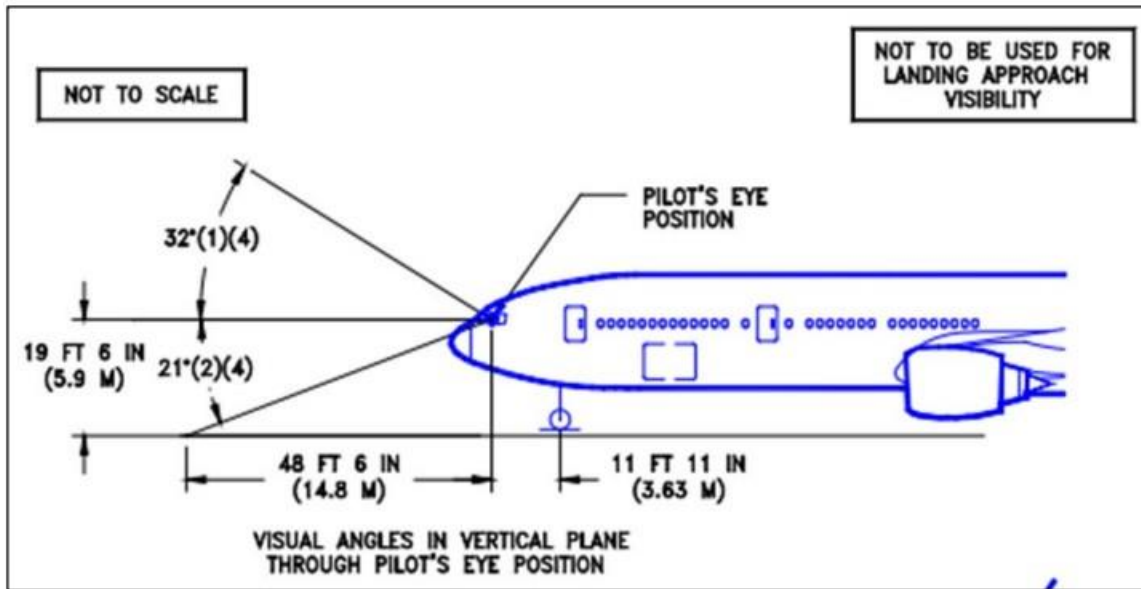


Figure 12. Sight line from the pilot's eye position to the ground for the B777. (Source: Boeing)

1.7.3 ASDE-X Replay and Runway Status Lights

The FAA provided a playback file of the ASDE-X taxi paths for the two airplanes. The ASDE-X point locations of the airplanes appeared consistent with the ADS-B locations; however, 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.

According to the ASDE-X replay, the RELs illuminated at 2044:40, coincident with DAL1943 accelerating from 47 kts through 49 kts groundspeed. Figure 13 shows a scaled depiction of AAL106 with the GPS antenna location positioned at the ADS-B GPS position point. At 2044:40, the nose of AAL106 was just crossing the hold short line at a speed of 11 kts, and REL 1 was beneath the airplane.

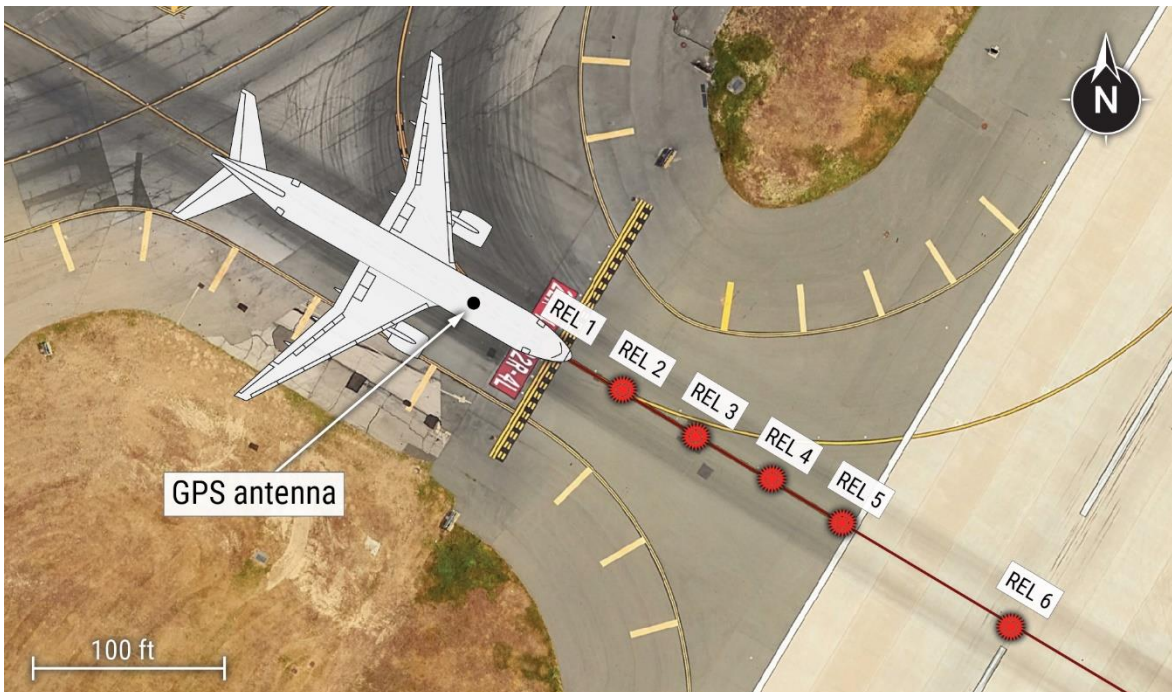


Figure 13. Satellite image of the taxiway J/runway 4L intersection showing the location of the RELs and the position of AAL106 as the airplane's nose crossed the runway hold short marking.

Note: The approximate location of the airplane's GPS antenna is shown.

As discussed in the previous section, the flight crew can see objects on the ground 87 ft in front of the airplane's transmitted GPS location; however, the ASDE-X location of the airplane has an uncertainty of ± 20 ft.

By 2044:39, the hold short line and REL 1 would have been beneath the airplane and out of the AAL106 crew's field of view. At 2044:40, REL 2 was 100 ft forward of the point location of AAL106; therefore, when the RELs illuminated, REL 2 may have been within the crew's field of view while RELs 3, 4, 5, and 6 were within the crew's view. As AAL106 continued forward, subsequent RELs would have passed out of view beneath the airplane. REL 6 would have passed out of view about 2044:52. The RELs turned off at 2045:07 as DAL1943 slowed below 25 kts.

The ASDE-X replay of the event depicted RELs 2 and 3 at the 4L/taxiway J intersection as a gray circle and a red circle, respectively, with the other four RELs in the array depicted as orange circles (illuminated). According to the FAA Air Traffic Organization, a gray circle indicated an "extinguished" lamp while a red circle indicated a "faulted" lamp. FAA Order 6850.38, Maintenance of the Runway Status

Lights (RWSL) System, states that operational tolerance/limits allow <50% of the lamps in an REL array to be inoperative.²¹

1.8 Organizational and Management Information

1.8.1 American Airlines Flight Operations Manual

The American Airlines Flight Operations Manual (FOM) defined taxiing as a critical phase of flight, during which crews shall not engage in nonessential activities, such as company communication, including completing paperwork.²² The FOM stated that, during taxi, “The flight crew’s primary task is to safely taxi the aircraft and the flight crew’s attention should not be diverted from this task.” The FOM included an additional note to “Ensure received (not expected/briefed) taxi route is followed.”

The FOM stated that both pilots should have the airport diagram readily available and reference it as necessary to ensure the taxi clearance is followed correctly, that the FO should advise the captain when accomplishing nonmonitoring tasks (e.g., FMS programming, ACARS, company radio calls, etc.), and that both pilots should be heads up to visually monitor the aircraft’s progress at critical locations on the airport (hold short, crossing runways, etc.).

The FOM gave further direction that, when approaching an entrance to an active runway, both pilots will ensure compliance with hold short and crossing clearances by discontinuing nonmonitoring tasks (e.g., FMS programming, ACARS, company radio calls, etc.).

The FOM stated that all received ACARS messages should be verified for the correct flight number, date, and aircraft nose number. Additionally, takeoff performance system (TPS) and load closeout information were to be verified against documents obtained from operations for reasonableness.²³ In addition, all subsequent TPS and/or load closeout messages were to be compared against

²¹ While paperwork obtained from the Port Authority of NY and NJ dated January 15, 2023, identified RELs 3 and 4 as being inoperative, ASDE-X playback showed the inoperative fixtures were RELs 2 and 3.

²² American Airlines clarified in a statement after the incident that tasks related to load closeout are considered essential for safety of flight and are part of the required pre-takeoff checklist that can be accomplished during taxi; the performance of such duties is not regarded as contrary to the FOM’s proscription against “completing paperwork” during the sterile flight deck period.

²³ This information included the airplane’s zero-fuel weight, takeoff gross weight, and reference speeds.

previously received messages. See appendix C for relevant excerpts of the American Airlines FOM.

1.9 Additional Information

1.9.1 Previous Related Safety Recommendations

1.9.1.1 Surface Detection Technology

The NTSB issued Safety Recommendation A-00-66 on July 6, 2000.²⁴ The recommendation asked the FAA to do the following:

Require, at all airports with scheduled passenger service, a ground movement safety system that will prevent runway incursions; the system should provide a direct warning capability to flight crews. In addition, demonstrate through computer simulations or other means that the system will, in fact, prevent incursions.

On August 25, 2017, the FAA stated that it was continuing to install runway status lights at some larger airports with scheduled passenger service to “provide a direct indication to pilots and vehicle operators when a runway is unsafe for entry, crossing, or departure ... reducing the time it takes to alert them of potentially unsafe situations.” The FAA also stated that runway status light systems require the installation of ASDE-X or the airport surface surveillance capability (ASSC).²⁵ On December 1, 2017, the NTSB stated that the recommendation remained classified as Open–Acceptable Response and expressed interest in learning about the solutions under consideration for airports that would not be receiving a runway status light system.

²⁴ Safety Recommendation A-00-66 superseded Safety Recommendation A-91-29, which was issued on June 12, 1991, and classified Closed–Unacceptable Action/Superseded on April 12, 2001. Safety Recommendation A-91-29 asked the FAA to “expedite efforts to fund the development and implementation of an operational system analogous to the airborne conflict alert system to alert controllers to pending runway incursions at all terminal facilities that are scheduled to receive Airport Surface Detection Equipment (ASDE III).” (ASDE-3 is a surface movement radar. ASDE-X and ASSC use multilateration and ADS-B in addition to a surface movement radar.)

²⁵ According to the FAA, ASSC “improves surface surveillance and situational awareness in all kinds of weather” and “is similar” to ASDE-X in that both systems allow controllers to “see aircraft and ground vehicles on the airport surface, and on approach and departure paths within a few miles of the airport.” Further, ASSC correlates flight plan information with position displays and provides surveillance data to help prevent runway incursions. With one exception (for Joint Base Andrews in the Air Force District of Washington), ASSC is no longer being implemented at airports because of the cost to install and maintain the system.

On July 2, 2021, the FAA stated that, of the 35 US airports with ASDE-X and the 8 airports with ASSC, 20 airports had runway status lights. The FAA also stated that its “Runway Incursion Prevention through Situational Awareness” initiative was working to identify different types of potential surveillance system technologies, including low-cost solutions that are suitable for smaller airports. Additionally, the FAA stated that it was further exploring technologies, including ADS-B In applications that could provide situational awareness and direct alerts to pilots; however, the avionics to implement such a system did not yet exist. On March 24, 2022, the NTSB stated that it was encouraged to learn that the FAA was exploring viable and affordable technologies that could directly warn flight crews about potential runway incursions given that ASDE-X, ASSC, and runway status light systems might not be practical at all airports. Safety Recommendation A-00-66 remained classified Open–Acceptable Response.

On October 13, 2023, the FAA reported that in June 2023 it hosted an industry event to determine how to enhance controller situational awareness of an airport surface. According to the FAA, the goal of the event was “to gain a better understanding of commercially available, production-ready, cost-effective industry solutions and capabilities that could enhance surface safety.” As a result of the event, the following three surface technology “sprints” were initiated:

- The Surface Awareness Initiative (SAI) will provide surface traffic displays to towers at airports that do not currently have a surface surveillance system. This technology will improve controller situational awareness. This sprint effort began in June 2023.
- The Approach Runway Verification ... is an aural and [a] visual alert to the air traffic controllers of aircraft alignments which will aid in the prevention of wrong runway landings. This sprint effort began in September 2023.
- The Runway Incursion Device ... is a memory aid device used by controllers for occupied and closed runways. [The device] provides a visual and [an] aural alert to controllers when a runway is not available for departing or landing aircraft. This sprint effort began in September 2023.²⁶

On February 20, 2024, the NTSB reiterated that the intent of Safety Recommendation A-00-66 was to provide flight crews with a direct warning of a potential incursion, and that the technologies described in the FAA’s October 2023

²⁶ An FAA presentation from the NTSB’s May 2023 roundtable on runway incursions showed that the FAA planned to deploy this new technology between 2025 and 2028.

letter would only assist controllers. Additionally, although the NTSB recognized the FAA's efforts to install ground surveillance and safety systems such as ASDE-X and ASSC at some large airports, it remained unclear how the FAA planned to address those airports without ground surveillance systems, particularly medium and small airports with scheduled passenger service. The NTSB classified Safety Recommendation A-00-66 as Open–Unacceptable Response.

1.9.1.2 Recording Duration of Cockpit Voice Recorders

On October 10, 2018, the NTSB issued Safety Recommendations A-18-30 and -31 as a result of the NTSB's experience with investigations that lacked access to relevant CVR data; these investigations included a July 2017 taxiway overflight event in San Francisco, California, that presented significant safety issues (NTSB 2018a, 2018b). The safety recommendations asked the FAA to take the following actions:

Require all newly manufactured airplanes that must have a cockpit voice recorder (CVR) be fitted with a CVR capable of recording the last 25 hours of audio. (A-18-30)

By January 1, 2024, require retrofit of all cockpit voice recorders (CVR) on all airplanes required to carry both a CVR and a flight data recorder with a CVR capable of recording the last 25 hours of audio. (A-18-31)

On May 23, 2023, the FAA stated that it had initiated rulemaking that proposed that newly manufactured aircraft be equipped with CVRs capable of recording 25 hours of data. Also, the FAA reported that it was launching an aviation rulemaking committee for the US aviation community to "discuss, prioritize, and provide recommendations to the FAA concerning requirements for the installation of existing, new, and upgraded investigative technologies that affect applicable airworthiness standards and operating rules."

On November 8, 2023, the NTSB responded that the rulemaking would address the intent of Safety Recommendation A-18-30 and classified the recommendation Open–Acceptable Response. The NTSB expressed concern that the rulemaking would not address the retrofit of all airplanes required to have a CVR and an FDR, as discussed in Safety Recommendation A-18-31, and classified the recommendation Open–Unacceptable Response.

On December 4, 2023, the FAA published notice of proposed rulemaking (NPRM) "25 Hour Cockpit Voice Recorder Requirement, New Aircraft Production," which proposed requiring the installation of 25-hour duration CVRs only on newly manufactured aircraft that require a CVR operating under *CFR* Parts 91, 121, 125, and 135. On January 31, 2024, the NTSB commented that it did not fully support the NPRM because it did not propose a similar requirement to retrofit existing airplanes

required to carry a CVR and an FDR. The NTSB said the FAA had inappropriately estimated the cost of retrofitting the existing fleet. The NTSB determined the retrofit requirement recommended in A-18-31 would apply to less than half the number of airplanes the FAA had estimated and could be completed during regular CVR maintenance. The NTSB urged the FAA to reconsider its position and issue a final rule applicable to both newly manufactured airplanes that must have a CVR as well as existing airplanes required to carry both a CVR and an FDR.

At the time that Safety Recommendations A-18-30 and -31 were issued in October 2018, at least 14 investigations were hampered by the lack of CVR data that were overwritten. Since the issuance of Safety Recommendations A-18-30 and -31, at least 18 additional investigations were affected by overwritten CVR data, including 8 serious runway incursions that occurred in 2023 and 2024 and a rapid decompression that occurred on an Alaska Airlines 737-9 MAX flight on January 5, 2024 (see table).

Table. NTSB investigations hampered by overwritten CVR data since Safety Recommendations A-18-30 and -31 were issued.

Date	NTSB case number	Location	Event description
April 17, 2024	DCA24FA164	Queens, New York	Runway incursion
February 10, 2024	DCA24LA097	Kelsey, New York	Turbulence
January 5, 2024	DCA24MA063	Portland, Oregon	Rapid decompression
November 30, 2023	DCA24LA034	Kahului, Hawaii	Ground collision
September 25, 2023	DCA23LA462	Caribbean Sea	Turbulence
August 11, 2023	OPS23FA010	San Diego, California	Runway incursion (delayed notification)
February 27, 2023	DCA23LA192	Boston, Massachusetts	Runway incursion (delayed notification)
February 22, 2023	DCA23LA185	Burbank, California	Runway incursion
February 16, 2023	DCA23LA179	Sarasota, Florida	Runway incursion (delayed notification)
February 4, 2023	DCA23FA149	Austin, Texas	Runway incursion
January 23, 2023	DCA23LA133	Honolulu, Hawaii	Runway incursion
January 13, 2023	DCA23LA125	New York, New York	Runway incursion
August 6, 2022	DCA22LA178	Atlanta, Georgia	Hard landing
July 7, 2022	WPR22LA284	San Francisco, California	Loss of control in flight
February 15, 2020	ENG20LA016	Sacramento, California	Electrical system malfunction
December 18, 2019	DCA20CA043	Disputanta, Virginia	Turbulence encounter
November 6, 2019	DCA20IA014	Atlanta, Georgia	Loss of control in flight
June 15, 2019	DCA19CA167	Newark, New Jersey	Hard landing

On May 16, 2024, the FAA Reauthorization Act of 2024 became law. The act included new 25-hour CVR carriage requirements for newly manufactured airplanes and a retrofit for existing airplanes within 1 and 6 years, respectively. The new requirements applied to airplanes operated by a Part 121 air carrier and other transport category airplanes type certificated with a passenger seating capacity of 30

or more, or all-cargo or cargo derivatives of such airplanes operated under other parts. The act required that the FAA update applicable regulations for the 25-hour CVR retrofit requirement for existing airplanes within 3 years.

2. Analysis

2.1 Introduction

This incident occurred when the crew of AAL106 deviated from the taxi instructions issued by the ground controller and mistakenly crossed runway 4L, where the crew of DAL1943 had just begun their takeoff roll. The ASDE-X system installed at the airport alerted the local controller to the conflict, the local controller cancelled DAL1943's takeoff clearance, and the crew aborted their takeoff. The DAL crew initiated rejected takeoff procedures about 2,500 ft from AAL106. AAL106 continued across the runway, and DAL1943 came to a stop before taxiing the airplane off the runway onto taxiway J.

The following analysis summarizes the incident (section 2.2) and evaluates the following:

- the need for additional risk mitigation strategies to reduce the likelihood that flight crew surface navigation errors result in runway incursions (section 2.3);
- the need for a procedural crosscheck that requires flight crews to verbalize the number of a runway they are about to cross as indicated by runway signs (section 2.3);
- the lack of flight deck technology to detect potential traffic conflicts on a taxiway, runway surface, or on approach to land (section 2.3); and
- the need for CVRs with a 25-hour recording capability (section 2.6).

After completing a comprehensive review of the circumstances that led to this incident, the investigation established that the following factors did not contribute to the cause of the incident:

- *Pilot and controller qualifications:* The AAL and DAL flight crews were certificated and qualified in accordance with federal regulations. All air traffic controllers assigned to positions in the JFK ATCT were certified and qualified in accordance with federal regulations.
- *Flight crew fatigue:* The AAL captain, FO, and FB had adequate sleep opportunities during the days before the incident flight. Each crewmember reported being rested and was observed to be alert on the evening of the incident.

- *Air traffic control tower staffing:* JFK tower was staffed with seven controllers staffing the eight core control positions. Some positions were combined due to the lower traffic level at the time of the incident. This staffing was normal and adequate for the time of night, complexity, and volume of traffic.

Thus, the NTSB concludes that none of the following were factors in this incident: (1) pilot and controller qualifications, (2) flight crew fatigue, and (3) ATCT staffing.

2.2 Incident Sequence

On the evening of the incident, the flight crew of AAL106 was preparing to taxi from gate 18 at JFK to runway 31L. Most of the flight's paperwork, as well as the initial taxi briefing conducted by the flight crew, anticipated a departure from runway 31L; however, upon contacting the ground controller following pushback, the crew received instructions to taxi to runway 4L. The captain and FO then conducted a revised briefing for a taxi to runway 4L.

2.2.1 American Airlines Flight Crew's Deviation from Taxi Clearance

2.2.1.1 Prospective Memory Errors

In the postincident interview, the FO and captain stated that the initial taxi route briefing for the anticipated departure from runway 31L included taxiway TA, left on B, and hold short at J, indicating that the crew would receive a subsequent clearance to proceed onto taxiway J and cross runway 4L on the way to runway 31L. The captain stated that this was the standard route from the American Airlines gates to runway 31L. The FO recalled that, after learning the flight would depart from runway 4L, the captain's revised taxi briefing stated, "Same taxi route up until Bravo short of Kilo." The captain recalled briefing the FO and FB that the controller would "have you come up Kilo, and then as you get closer, they'll tell you when to cross," implying two segments to the taxi route, with two associated clearances from the ground controller. The captain stated that this was the typical route from the American Airlines gates to runway 4L.

Human factors research indicates that, through extensive practice, experts learn to perform routine tasks, like taxiing an airplane, automatically (Wickens & McCarley 2008). This reduces attentional requirements and frees cognitive resources for other tasks. Psychological theory suggests that automatic performance is governed by sensory-motor knowledge structures known as schemas (Cooper 2016). When a goal is identified, a parent schema is established (Norman 1981). When

taxiing an airplane, a pilot's intended destination can be considered a parent schema. Subordinate schemas would address segments of the route, and lower-level schemas would govern psychomotor tasks, like controlling speed and steering the airplane along the taxiway centerline. Although schema-driven action requires little conscious attention, attention is required at key points to ensure that appropriate subordinate or lower-level schemas are activated at appropriate times.

In this case, the captain's goal was to taxi to runway 4L along the typical route, which was highly familiar to him. After AAL106 departed the gate, the taxi task required little of the captain's conscious attention for several minutes; the captain merely had to steer the airplane along the lighted centerline of taxiway B and maintain an appropriate speed. When the airplane reached taxiway K, however, the captain needed to bring his attention back to the taxi task, verify that AAL106 had received a clearance to cross runway 31L, turn right on taxiway K, and cross runway 31L.

The crew received a clearance to cross runway 31L when the airplane was about 4 minutes from arriving at taxiway K. The FO acknowledged the clearance on the radio. The captain told investigators he believed he heard and understood this clearance. Thus, he knew that he no longer needed to hold short of taxiway K and await clearance to turn right on taxiway K; however, he still needed to remember to turn right at that location where the standard routes to runways 4L and 31L diverged.

Psychologists use the term prospective memory to refer to the set of cognitive processes that govern the maintenance, retrieval, and execution of deferred tasks (Dismukes 2012). The captain's omission of the right turn at taxiway K, despite his intention to do so, was a prospective memory error. A delay between the formation of an intention to do something and the execution of that task, which occurred in this case, increases the likelihood of a prospective memory error. This occurs because intentions may be overwritten by the cognitive demands of intervening tasks (Wilson et al. 2020).

Factors associated with prospective memory errors include interruptions, multitasking, and the absence of salient cues that would normally prompt the performance of a habitual task. (Loukopoulos, Dismukes, and Barshi 2009). The NTSB explored the possible role of each in the incident.

The AAL106 crew was performing multiple tasks during the taxi. The timing of some of these tasks was determined by the crew, but the timing of others was

determined by external events.²⁷ This mix of tasks with expected and unexpected timing led to interruptions and reprioritization and interleaving of tasks, otherwise known as multitasking. In postincident interviews, all three crewmembers described an increasing workload as the taxi progressed. The captain attributed his error, in part, to this factor.

The instruction provided to the crew to cross runway 31L on taxiway K could have served as a salient cue reminding the captain to turn right at taxiway K if it had been issued closer to that intersection; however, because this clearance was issued 4 minutes before, visual indications were the primary cues of the airplane's position as the airplane approached taxiway K.

The night conditions at the time of the incident would have reduced positional cues. The airplane had passed through 17 taxiway intersections before reaching taxiway K, so the mere presence of an intersection was not sufficient to indicate arrival at a decision point. There was a surface painted taxiway K sign and an arrow pointing toward taxiway K located just before the intersection. This sign would have been visible for at least a few seconds when illuminated by the airplane's taxi lights. There was also a lighted yellow sign on the right side of taxiway K labeled "4L," which pointed the way to that runway. This sign would have been viewable as the airplane approached the intersection with taxiway K; however, it did not explicitly label taxiway K. Thus, two cues were available, but one was only temporarily visible, and the other required inference to determine that it denoted the intersection of taxiways B and K.

ACARS records indicated that the crew accepted the airplane's zero fuel weight and center of gravity in the FMC about 30 seconds before the airplane crossed taxiway K. The receipt of this information led to a cascade of other crew activities as the captain and FO reviewed and crosschecked takeoff performance calculations. These tasks, triggered by the unpredictable timing of the load closeout receipt, required at least some of the captain's visual attention and likely reduced his attention to and visual monitoring of the external environment. Thus, although salient cues to the airplane's position were present and could have reminded the captain of the need to turn right at taxiway K, they were not sufficient to break through the distraction caused by the crew's load closeout-related tasks.

²⁷ The expected tasks included obtaining the load closeout, performing follow-on tasks related to the load closeout, communicating with ATC, addressing the passengers about the departure, communicating with the cabin crewmembers, and performing the before takeoff checklist. The unexpected tasks included dealing with multiple weather advisories from dispatch via ACARS and informing crewmembers accordingly. The tasks with timing determined by external events included those tasks triggered by the receipt of weather advisories and tasks triggered by receipt of the load closeout, such as crosschecking final weights and V-speeds.

An alternative framework from the scientific literature on human error involves branching error, which can occur when a task involves an action schema that is associated with more than one possible end goal. In such situations, periodic attentional checks are needed to detect one's arrival at a choice point. This is consistent with the previous discussion about the captain's prospective memory error. In a branching error, this check does not occur, behavior becomes disconnected from intention, and actions beyond the choice point become driven by the schemas that are commonly performed in the new situational context. This latter form of a skill-based action slip is known as environmental capture (Reason 1990).

According to this framework, lower-level schemas caused the captain to continue the taxi along taxiway B after he missed the turn at taxiway K. Shortly thereafter, the airplane was directly facing taxiway J and the highly salient flashing yellow guard lights for runway 4L. A typical behavior pattern performed in that location involved taxiing onto taxiway J and crossing runway 4L (the standard route to runway 31L). In the absence of focused attention, schema theory suggests that the captain's actions may have become disconnected from his intentions and situational cues could have prompted him to continue along a common, but incorrect, route. This would explain the captain's subsequent surprise and confusion when the ground controller alerted him to the discrepancy between AAL106's clearance and the airplane's position. Thus, a branching error appears to be a good fit for the captain's continuation of the taxi onto taxiway J and across runway 4L.

The NTSB concludes that the captain's deviation from AAL106's taxi clearance likely resulted from several factors, including an early clearance to cross runway 31L, interruptions and multitasking related to the crew's delayed receipt of the load closeout, the captain's prospective memory error in forgetting to turn right at taxiway K, and environmental capture, which prompted the captain to proceed along a familiar, but incorrect, route.

2.2.1.2 American Airlines FO and FB's Nondetection of the Captain's Error

The NTSB sought to understand why neither the FO nor the FB detected the captain's error between the time the airplane passed taxiway K until the RELs activated. The FO told investigators she was head-down dealing with tasks related to the load closeout for the approximate 1.5 minutes from the time the load closeout was received until the captain began turning onto taxiway J and toward runway 4L. The missed turn at taxiway K occurred during this time that the FO's visual attention was likely focused inside the flight deck.

The FO recalled hearing the captain call out, "cleared to cross" as the captain was turning the airplane toward a runway (onto taxiway J). Based on ADS-B data, this turn occurred about 2044:29. Upon hearing the captain's callout, she looked up and visually inspected the runway as the captain did the same, in accordance with the AAL

FOM. The captain and FO then made the callouts “clear left” and “clear right,” respectively. Both pilots’ interviews indicated that this visual inspection was completed before the RELs illuminated (at 2044:40). Thus, the FO’s visual inspection occurred between 2044:29 to 2044:40, a period of about 11 seconds, while the airplane was traveling at a speed of 11 kts toward the runway.

Two types of runway signs were available in the FO’s field of view when she scanned the runway: a pair of white-on-red signs painted on the surface of taxiway J before the holding position markings, and a pair of vertical black-on-yellow lighted signs erected on either side of the runway hold short position markings. The painted signs were likely viewable for about 4 seconds and the lighted signs were likely viewable for an overlapping period of 8 seconds. One or the other type of sign was likely viewable for a period of about 10 seconds. Ten seconds is sufficient for locating and reading approaching runway signs if a viewer is specifically trying to do so; however, the FO either did not read the signs or did not notice that the numbers on the runway signs conflicted with the AAL106’s taxi clearance and that the airplane was about to cross the wrong runway. Psychological research indicates that people only perceive and remember fine details of a visual scene that receive focused attention. It is likely that the FO did not notice the lettering on the signs because she did not focus visual attention on the signs.

Visual attention is highly influenced by expectancy (Downing 1988). The FO knew the captain was very familiar with JFK; therefore, she likely expected that the odds of his making a surface navigation error were quite low. Also, her attention was divided between crosschecking the takeoff performance numbers and visually clearing the runway, reducing the amount of time she devoted to inspecting the external environment. It is likely that, due to her divided attention, she performed a cursory visual scan of the runway environment and made the associated routine callout. Thus, workload, multitasking, time pressure, and expectancy likely played a role in the FO not detecting the captain’s surface navigation errors between the time the airplane passed taxiway K and the time the airplane taxied onto runway 4L.

The FB recalled that his visual attention was focused inside the flight deck from the time the crew received the load closeout until the airplane crossed the holding position markings and entered runway 4L. During that period, he recalled handing the printed load closeout to the other crewmembers, cleaning up paperwork on the center pedestal, and adjusting his radios. He recalled hearing some confusion about crossing a runway and looking up, at which time the airplane was across the runway 4L hold short markings. As a result, he would no longer have been able to see the signs for runway 4L. Thus, the FB did not detect the captain’s deviation from AAL106’s taxi clearance because he was performing operational tasks other than looking outside and monitoring the airplane’s position.

The NTSB concludes that the FO and FB were likely distracted from their primary duty of assisting the captain in safely taxiing the airplane by other operational activities, which resulted in the crew's loss of situational awareness during a critical phase of flight.

2.2.1.3 American Airlines Crew's Nondetection of DAL1943 on Runway 4L

DAL1943 was positioned for takeoff on runway 4L for about 2 minutes before beginning its takeoff roll, and began its takeoff roll about the time AAL106 started turning onto taxiway J. As discussed in the previous section, the AAL106 captain and FO recalled visually scanning the runway, but neither recalled seeing DAL1943 on the runway.

The captain and FO recalled scanning the runway at some point during the 11 seconds between the time the captain began turning the airplane onto taxiway J and the time the airplane crossed the hold short markings and the RELs activated. The crew recalled that the captain also switched on some additional exterior lights during this time, which briefly required some of his visual attention inside the cockpit. As the airplane began to turn onto and align with taxiway J, the approach end of runway 4L was to the captain's right and may have been partially obstructed by the FO's body and aircraft structure. Thus, it is possible the captain would not have had an opportunity to see DAL1943 due to his obstructed view.

Examination of satellite images, illumination diagrams, and on-scene nighttime photographs of the airport suggest that a significant amount of airport lighting was present between the two airplanes in various colors and intensities. Due to flattening of perspective that occurs when viewing distant objects on flat terrain, DAL1943, which was around 3,000 ft away from AAL106's position, likely appeared as a small target within a dense array of surrounding lights that varied in color and brightness, including flashing yellow lights at each taxiway/runway intersection; blue taxiway edge lights; green taxiway centerline lights; green and yellow taxiway lead-on lights; yellow lighted taxiway signs; and red, white, and yellow edge lights for runway 4L. These surrounding lights would have been distractors during a visual search, making a target more difficult to identify.

Additionally, DAL1943 was moving directly toward AAL106, and would have had little apparent motion, making it less likely to attract focused visual inspection. Given the fact that the FO did not see DAL1943 before entering the runway, it is likely that she never fixated directly on the airplane. Thus, the FO's nondetection of DAL1943 likely resulted from limitations of the human visual system for detecting small stationary targets in a complex visual scene in a limited time.

Even if the crew had noticed the presence of DAL1943, it might have been difficult for them to determine whether the airplane was on runway 4L until after

AAL106 had entered runway 4L and its crew could look straight down the runway. In fact, this is when the FB first recalled seeing DAL1943. It is likely that the forward-facing white taxi/landing lights were the most salient external lights on DAL1943 when viewed from the perspective of AAL106.

Another potential explanatory factor is expectation bias, a cognitive bias that reduces the likelihood a person will notice a mismatch between what they expect to see and the actual state of things. In this event, the crew believed that the controller had cleared them to cross the runway in front of them. The AAL106 captain and FO had likely performed thousands of visual scans of runways in the past, and it is likely that most of these scans revealed no conflicting aircraft. Therefore, the crew probably did not expect another airplane to be on the runway and moving toward them, which made them vulnerable to inspecting the runway and making related callouts in rote fashion rather than systematically searching for a small target. Thus, expectation bias could explain how the captain and FO did not observe DAL1943 before entering runway 4L.

The NTSB concludes that the American Airlines flight crew's nondetection of DAL1943 on runway 4L likely resulted from night conditions, the location of DAL1943 within a complex array of airport lights, the lack of relative motion of DAL1943 in the visual field of the crew of AAL106, the distance between the two airplanes, the brief time devoted to visually scanning the runway, and expectation bias.

2.3 Operational Barriers to Runway Incursions

2.3.1 Crew Resource Management

Crew resource management (CRM) refers to the effective use of all available resources to ensure flight safety. The FAA's most recent guidance on CRM training, Advisory Circular (AC) 120-51E, outlines desired crew competencies in the areas of (a) communication processes and decision behavior, (b) team building and maintenance, and (c) workload management situational awareness. Lacking a cockpit voice recording, it was difficult for the NTSB to perform a detailed assessment of the AAL106 crew's CRM during this incident. Any insights that can be identified had to be inferred from the fact that errors occurred and from crew interviews.

FAA guidance indicates that briefings (which are primarily the captain's responsibility) should establish a team concept, establish open and interactive communications, identify potential problem areas and safety issues, provide guidelines for crew actions centered on standard operating procedures (SOPs), and address division of labor and crew workload.

According to crew interviews, the captain performed briefings, and the crew appeared to get along and adopt a team concept. The captain and the FO reported conducting two departure and taxi briefings. These occurred during a low workload period, which reflected good planning; however, the thoroughness of the taxi briefings is difficult to discern based on the limited information available from the crew interviews. Although in hindsight we know that an error occurred, it is understandable that the captain may not have been particularly concerned in advance, because the route was highly familiar to him and was not complex.

With respect to team building and maintenance behaviors, FAA guidance addresses leadership/followership and crew concern for the effective accomplishment of tasks. Specifically, this area of competency includes, among others, ensuring that all available resources are used to accomplish the job at hand, that actions are decisive when the situation requires, that the time available for tasks is well managed, and that demands on resources posed by operation of automated systems are recognized and managed.

Crew interviews indicated that the captain divided tasks among all three crewmembers to use available resources, and interviews suggested that all crewmembers were focused on effective accomplishment of their tasks. In particular, the captain's attention was focused on ensuring that there was no issue with the hand-written notation on their dangerous goods form that would result in a problem with their cargo or load closeout; the FO was highly focused on relaying advisories about potentially hazardous weather conditions and performing tasks related to the load closeout; and the FB was actively supporting the other two pilots as requested.

However, when the load closeout arrived, the captain and the FO's workload increased. Neither the captain nor the other crew members appeared to recognize how the demand on mental resources imposed by the review of takeoff performance data from the load closeout and related use of automated systems (electronic flight bag and FMS) could impact their monitoring and awareness of airplane position. Consequently, the crew did not proactively manage this threat to their awareness of the airplane's position. Actions the crew could have taken to mitigate the effect of this additional workload included delaying the completion of load closeout until the airplane could be parked or until all runways had been crossed, or by directing the FB to closely monitor the progress of the taxi while the captain's attention was divided.

In terms of workload management and situational awareness behaviors, FAA CRM guidance includes anticipating contingencies and related actions that will be required in the future, active monitoring, and avoiding "tunnel vision." In this incident, the captain was not adequately alert to the risk to monitoring posed by the concurrent performance of the load closeout-related tasks. Further, all three crewmembers probably thought it unlikely that the captain would make a surface

navigation error at an airport with which he was so familiar; however, high levels of safety require a preoccupation with failure and consistent guarding against high-consequence threats, even those that are unlikely.

FAA guidance states that CRM behaviors should be exercised in the framework of a comprehensive set of SOPs. The crew's monitoring errors suggest that the operator's monitoring SOPs, which are intended to prevent such errors, are inadequate. For example, although American Airlines SOPs required the crew to perform a visual inspection of the runway before crossing, the procedures did not require the crew to verbally crosscheck the runway number displayed on the runway signs, although this practice is recommended by the FAA.²⁸ Noticing those signs was the last opportunity for the crew to detect and correct the captain's surface navigation error before the incident occurred.

Automated systems that provide aural advisories about the number of an approaching runway have been developed but were not installed on AAL106. In this case, it is possible that reading the runway number aloud could have alerted the captain to the fact that he was not crossing the intended runway. The FO and FB told investigators that they recalled AAL106's taxi clearance throughout the taxi; therefore, a verbal crosscheck of the runway number could have alerted them to the fact that the airplane was about to cross the wrong runway. Such a procedure would be easy to perform and similar to other common safety-related checks.

The NTSB concludes that a procedural crosscheck that requires a flight crew to verbalize the number of a runway they are about to cross, as indicated by runway signs, would reduce the likelihood of future runway incursions resulting from flight crew surface navigation errors. Therefore, the NTSB recommends that the FAA encourage 14 CFR Part 91K, 135, and 121 operators to incorporate into their SOPs a procedural crosscheck that requires flight crews to verbalize the number of a runway they are about to cross, as indicated by runway signs, unless an installed automated system already provides an aural advisory.

2.3.2 American Airlines Policy on Completing the Load Closeout

The captain was ultimately responsible for verifying that the load closeout was acceptable before takeoff. The NTSB evaluated policies and procedures in the American Airlines FOM on crew performance of tasks related to the load closeout.

²⁸ FAA Advisory Circular 120-74B, Parts 91, 121, 125, and 135 Flightcrew Procedures During Taxi Operations, recommends that when approaching any hold short line, the flight crew verbalize "approaching (specific runway number) hold short line."

The FOM stated that required tasks included verifying the received messages and comparing the TPS tablet application output and load closeout numbers against documents obtained from operations for reasonableness. This was essential, in part, to ensure that the crew was using the appropriate reference speeds during the takeoff. The crew was also required to review the load closeout to determine if any restricted articles were onboard, in which case they were to ensure that they had a corresponding Notice to Captain (NOTOC). Any discrepancies were required to be corrected before takeoff. After the incident, American Airlines confirmed that tasks related to the load closeout are considered essential to the safety of flight and are part of required pre-takeoff checks that can be accomplished during taxi.

In the postincident interview, the captain said that he did not normally need to perform these tasks during taxi because load closeouts typically arrive soon after the airplane pushes back from the gate. He said that he normally made a point of crosschecking the load closeout with the FO and completing related tasks before departing the ramp area. In this case, however, he said that he decided to begin the taxi before receiving the load closeout because AAL106 had a third flight crewmember (the FB). He explained that many of the flights he operated from JFK to London had only two flight crewmembers, and he believed the presence of the FB would allow the crew to handle more tasks during the taxi while maintaining a manageable workload.

The captain delegated to the FB the duty of following up with dispatch to ensure that the load closeout was received; however, the captain could not delegate crosschecking the takeoff performance numbers with the FO. As previously discussed, load closeout-related tasks subsequently played a role in the captain's distraction and surface navigation error.

The American Airlines FOM stated that flight crewmembers should use a continuous loop process for actively monitoring and updating their progress and location during taxi. This includes knowing the aircraft's present location and mentally calculating the next location on the taxi route that will require increased attention.

Although monitoring is important, a pilot cannot continuously focus on monitoring one task while simultaneously engaging in another concurrent task, particularly one that shares the same sensory channel (that is, vision). As previously discussed, this requires multitasking, which can lead to errors. The FOM also stated that other flight deck duties and non-ATC communications should not divert attention from the safe movement of the aircraft, especially at critical times, such as runway crossings and transitioning through complex taxiway intersections. However, any time concurrent tasks are performed while taxiing, some conscious attention is diverted away from the surface navigation task.

Airline crews strive for efficiency and maintaining on-time performance; therefore, it is understandable that the crew of AAL106 opted to perform load closeout tasks during taxi. Doing so was not prohibited because these tasks are essential to the safety of the flight, and the crew likely believed it would help them avoid a delay. If American Airlines guidance had specified that the captain and FO had to complete load closeout tasks before beginning the taxi, the crew likely would have completed these tasks in the ramp area. Alternatively, if such guidance stated that load closeout-related tasks could only be performed when the airplane was parked, the crew might have delayed action on those tasks until they reached runway 4L for takeoff and parked the airplane, thereby increasing their external monitoring while the airplane was moving. Thus, a lack of guidance prohibiting the performance of load closeout related tasks during taxi increases the risk that a similar surface navigation error may occur in the future.

This incident demonstrates how interruptions and multitasking can reduce crew awareness and increase the risk of surface navigation errors, runway incursions, and accidents. Part 121 airlines are required to have safety management systems (SMS) that identify and manage risks to their operations. SMS is intended to analyze the risk of such errors and develop appropriate risk mitigation strategies. The NTSB concludes that additional risk mitigation strategies as part of an operator's SMS would reduce the likelihood that flight crew performance of concurrent tasks during taxi will lead to inaccurate navigation on the airport by reducing distractions associated with multitasking.

While it would be ideal to prohibit conducting load closeout tasks during taxi to ensure appropriate focus on taxi operations, we recognize that it is not feasible to issue such a recommendation. Some level of multitasking can be performed if pilots are aware of the risks and take steps to reduce errors, such as calling out runway crossings, as noted above. Therefore, the NTSB recommends that the FAA encourage Part 121 operators to use SMS to identify flight crew surface navigation errors resulting from the performance of concurrent tasks during taxi and develop and implement effective risk mitigation strategies considering human factors principles.

2.3.3 Flight Deck Technologies for Preventing Runway Incursions

The NTSB has long advocated the development of technologies for the prevention of runway incursions. The NTSB has, for example, recommended systems to alert air traffic controllers to the presence of traffic conflicts. This resulted in the development of ASDE-X. The ASDE-X installation at JFK likely prevented this incident from becoming an accident; however, it required adequate time for the controller to detect the warning, identify the problem, and determine the necessary action before attempting to contact the DAL1943 flight crew. Moreover, the FAA is no longer

installing ASDE-X at US airports because it considers the system too expensive to install and maintain. Therefore, many airports currently lacking this technology will not have access to it in the future.

In 2000, the NTSB recommended that the FAA require, at all airports with scheduled passenger service, a ground movement safety system that would prevent runway incursions, with the capability of providing a direct warning to flight crews (Safety Recommendation A-00-66). In the accompanying letter, the NTSB suggested that these direct warnings could be provided through such means as RELs and stop bars located at all runway/taxiway intersections, or by other means, such as a datalink. This incident highlights the limitations of RELs (which will be discussed in section 2.4) and suggests that crew positional awareness would be enhanced by a flight deck display of ground traffic with both visual and aural conflict alerts.

Flight deck technology for improving flight crew awareness of surface traffic and alerts to potential conflicts has been developed. Such systems could use ADS-B data to display the location of traffic that is on, approaching, or departing a runway, in the air or on the ground. This capability would provide a redundant means for flight crews to detect the presence of another aircraft (in addition to visually scanning the external environment).

Such systems could aurally alert and visually display to flight crews potential traffic conflicts that could prevent them from entering a runway where another airplane is departing, without pilots having to rely solely on visual scanning of the outside environment or on the intervention of a controller who has detected or received an alert about a conflict, thereby providing an additional layer of protection against runway incursions by more effectively mitigating a crew surface navigation error. It is likely that in this incident, a flight deck display of traffic information with alerting capability would have resulted in earlier action to resolve the conflict, because the warning would have been provided directly to the flight crews involved rather than relayed through the controller—and may have even prevented the conflict from occurring.

On February 4, 2023, Southwest Airlines (SWA) flight 708, a Boeing 737-700, and Federal Express Corporation (FedEx) flight 1432, a Boeing 767-300, were involved in a runway incursion at Austin-Bergstrom International Airport, Austin, Texas. The local controller had cleared the SWA airplane for takeoff and instructed the FedEx airplane to continue its approach to the same runway. The controller was unable to see the SWA airplane on the taxiway and runway because of dense fog, and the air traffic control tower did not have surface detection equipment such as ASDE-X. The airplanes came within 150 to 170 ft of each other after the FedEx flight crew realized that the SWA airplane was on the runway and performed a missed approach, thus avoiding a collision. This incident demonstrates that flight deck

alerting systems should also provide visual and aural alerts of potential conflicts involving aircraft on final approach.

The NTSB concludes that the implementation of a flight deck alerting system on transport-category aircraft that provides alerts of traffic on a runway or taxiway and traffic on approach to land would enhance safety by providing pilots with improved situational awareness and would reduce the risk of future runway-related incidents and accidents.

Therefore, the NTSB recommends that the FAA collaborate with aircraft and avionics manufacturers and software designers to develop the technology for a flight deck system that would provide visual and aural alerts to flight crews of traffic on a runway or taxiway and traffic on approach to land. The NTSB also recommends the FAA require that this technology be installed in all newly certificated transport-category airplanes and that the FAA require existing transport-category airplanes be retrofitted with this technology.

Safety Recommendations A-24-4 through -6 recommend similar actions to Safety Recommendation A-00-66; however, they specify a flight deck-based alerting system. The FAA has made efforts to reevaluate technologies and procedures to reduce and eliminate runway safety risks by deploying surface systems such as ASDE-X, ASSC, and RWSL at airports deemed highest risk, and continues to develop surface technologies to enhance air traffic controller situational awareness.

However, after 24 years, the FAA still has not required, at all airports with scheduled passenger service, a ground surveillance system that would provide timely warnings directly to flight crews of the potential for a traffic conflict. Therefore, Safety Recommendations A-24-4 through -6 are classified Open–Unacceptable Response, and Safety Recommendation A-00-66 is classified Closed–Unacceptable Action/Superseded.

2.4 Airport Measures Intended to Prevent Runway Incursions

2.4.1 Runway Status Lights

The RWSL at JFK included runway entrance lights installed at the taxiway J/runway 4L intersection. The RELs at this intersection comprised six unidirectional lights that started at the runway hold short position and extended to the runway centerline. The RELs would illuminate red to signal to aircraft approaching from the taxiway that a runway was in use. According to the FAA, 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/s² or 2) reached a speed of 49.9 kts.

Using ADS-B information, ASDE-X information, and RWSL data, a performance study was undertaken to determine when the RELs activated in relation to the positions and speeds of each airplane during the incident.

AAL106 turned onto taxiway J at 2044:30. It passed the hold short line for runway 4L at 2044:40, at a groundspeed of about 11 kts, as the RELs illuminated. At least three RELs would have been viewable by the crew given their eye position in the flight deck and evidence indicating that RELs 2 and 3 were likely inoperative. AAL106 entered runway 4L at 2044:50, at a groundspeed of 15 kts, and continued accelerating as it crossed the runway. At this time, DAL1943 was 2,700 ft from the intersection of 4L and taxiway J at 94 kts groundspeed and accelerating.

ADS-B, ASDE-X, and RWSL information indicated that the RELs illuminated as the airplane's nose crossed the hold short markings, while the crew's recollections were that the RELs illuminated when the airplane was farther past the hold short markings. Although the statements of the captain and FO did not indicate that they immediately recognized the lights as an indication that they had begun to cross an active runway, both crew members reported that the illumination of the RELs indicated an anomaly and prompted the captain's decision to expedite the runway crossing. It is likely that, had the RELs illuminated earlier, the crew would have had more time to perceive the lights and stop the airplane in a safe area.

After their takeoff clearance was cancelled at 2044:47 due to AAL106 entering the runway, the crew of DAL1943 initiated a rejected takeoff at 2044:51, reaching a maximum groundspeed of 105 kts at 2044:53. At this time, DAL1943 was 2,300 ft from the taxiway J intersection before it began decelerating. AAL106 cleared runway 4L at 2045:02 at 21 kts groundspeed when DAL1943 was 1,000 ft away at a groundspeed of 49 kts.

The NTSB requested that the FAA evaluate the operational algorithm/criteria for the RWSL installation at JFK to ensure that it was operating as described on the day of the incident. FAA Air Traffic Organization responded with a detailed analysis of the incident and concluded that, "the JFK RWSL system [was] operating within the standard algorithm/criteria for RWSL light activations."

The ASDE-X replay depicted RELs 2 and 3 at the 4L/taxiway J intersection as "extinguished" and "faulted," respectively, at the time of the event, and it is likely that both REL 2 and 3 were inoperative. However, FAA RWSL system maintenance operational tolerances allowed <50% of the lamps in an REL array to be inoperative;

therefore, even if RELs 2 and 3 were inoperative at the time of the incident, the array still met operational tolerance limitations.²⁹

The NTSB concludes that the RELs operated as designed; however, they were ineffective in preventing the crew of AAL106 from crossing the runway 4L hold short markings because they activated too late for the crew to perceive them and stop the airplane in a safe area. Therefore, the NTSB recommends that the FAA evaluate the effectiveness of the activation logic for the RWSL considering the circumstances of this incident. Using the findings of the evaluation conducted in response to Safety Recommendation A-24-7, update the RWSL activation logic as necessary to improve system effectiveness.

2.4.2 Airport Surface Detection Equipment, Model X

JFK airport was equipped with the ASDE-X system. ASDE-X alerts air traffic controllers of potential runway conflicts by providing detailed coverage of movement on runways and taxiways. Controllers are presented this information on a color display depicting aircraft and vehicle positions as icons overlaid on a map of the airport's runways, taxiways, and airport approach corridors. The map is continuously updated and can be particularly beneficial at night or in poor visibility conditions as an enhancement to controller situational awareness.

The ASDE-X system is equipped with visual and aural alarms to alert controllers of possible runway incursions or incidents. In this incident, the ASDE-X equipment generated both aural and visual alerts when AAL106 crossed Runway 4L via taxiway J while a departing aircraft, DAL1943, still occupied the runway. As a result, an aural "runway occupied" alert was voiced, and the corresponding visual text alert "RWY 4L|DAL1943, AAL106|RWY OCCUPIED" was displayed on the air traffic displays; the ASDE-X system functioned as designed. The local controller cancelled DAL1943's takeoff clearance 5 seconds after the ASDE-X aural alert was annunciated.

The NTSB concludes that the ASDE-X system at JFK was operational at the time of the incident and functioned as designed, generating both aural and visual alerts when AAL106 crossed runway 4L while DAL1943 was departing, and likely reduced the severity of the incident by preventing a runway collision.

²⁹ While paperwork obtained from the Port Authority of NY and NJ dated January 15, 2023, identified RELs 3 and 4 as being inoperative, ASDE-X playback showed the inoperative fixtures were RELs 2 and 3.

2.5 Air Traffic Control

2.5.1 Ground Controller

The ground controller instructed the crew of AAL106, from their position at taxiway TA after pushing back from the gate, to taxi to runway 4L, via a left turn onto taxiway B, and to hold short of taxiway K. As AAL106 continued to taxi on taxiway B, the ground controller instructed the crew to cross runway 31L at taxiway K. The crew read back the instruction correctly, which likely reinforced the ground controller's belief that the crew understood the taxi instructions.

The ground controller later reported in a postincident interview that he observed AAL106 swing out to the left on taxiway B to begin what he believed to be a typical wide right turn onto taxiway K. Radio communications showed that, as AAL106 passed taxiway K, the ground controller received a request from, and subsequently provided taxi instructions to, another airplane. He also established communications with an airport operations vehicle and requested that they sweep runway 31R in preparation for the runway configuration change. The ground controller recalled that, after he finished his communication with the airport operations vehicle, he looked down to attend to another task.

While the ground controller was looking down, AAL106 continued the slight left turn on taxiway B, then turned right onto taxiway J, where its nose would eventually cross active runway 4L, triggering an ASDE-X alert.

The ground controller stated that he expected the flight crew of AAL106 to adhere to their taxi instructions given that they correctly read back the instructions as issued. Believing that AAL106 was conducting the taxi as instructed, he did not ensure that the flight crew completed the right turn onto taxiway K before he began attending to other duties. FAA Order 7110.65Z, Air Traffic Control, paragraph 2-1-2, Duty Priority, stated that controllers were to give first priority to separating aircraft and issuing safety alerts as required. Therefore, the NTSB concludes that the ground controller expected the AAL106 flight crew to adhere to the assigned taxi instructions and did not detect the flight crew's surface navigation error and subsequent turn onto taxiway J because he was performing a lesser priority task that entailed looking down.

2.5.2 Local Controller

The local controller stated that he performed a visual scan before issuing the takeoff clearance to DAL1943, then he started talking to other airplanes that were taxiing to line up and wait, one on runway 4L and another on runway 31L.

Shortly after the controller provided these instructions, the ASDE-X alerted. He looked at the ASDE-X display and saw the aircraft involved were DAL1943 and AAL106. The local controller cancelled DAL1943's takeoff clearance 5 seconds after the ASDE-X alerted. He repeated the instruction a second time, and the DAL1943 crew responded that they were rejecting the takeoff. The NTSB concludes that the local controller acted in a timely and appropriate manner following the ASDE-X alert by cancelling DAL1943's takeoff clearance.

2.5.3 Air Traffic Control Tower Team

At the time of the incident, the tower was changing the runway configuration, which required some of the controllers to physically move into different positions in the tower, as well as change all their equipment to the new configuration. Airport operations was on the airfield conducting checks and switching equipment for the runway change as well. On the night of the incident, the runway configuration change was requested to be completed earlier than the time it typically took place between 2130 and 2230. Although a runway configuration change is an important priority, and, on the night of the incident, occurred at an atypical time, it is a routine event that does not always occur at prescribed times. The whole tower team has the primary responsibility of ensuring safe and effective operations in the tower and to perform continual visual scans of the runways. In this case, the cab coordinator, flight data/clearance delivery controller, and operations supervisor were busy making preparations for the runway change and were not giving their full attention to the air traffic operations at the time.

The tower team, collectively, did not effectively prioritize their duties by ensuring that the team maintained a continuous scan of the airport environment as preparations for the runway change were performed. As such, they did not meet the expectations and responsibilities as required in FAA Order 7110.65Z, Air Traffic Control, paragraph 2-10-3, Tower Team Position Responsibilities, to give first priority to the separation of traffic; and paragraph 3-1-12, to visually scan the runways to the maximum extent possible. The NTSB concludes that the JFK ATCT team had the responsibility of scanning the runways and airport environment but did not effectively prioritize their duties to ensure a continuous scan, which resulted in their nondetection of the AAL106 flight crew's deviation from taxi instructions.

2.6 Cockpit Voice Recorder Duration and Loss of Information

The overwriting of the cockpit voice recording for AAL106 resulted in a loss of useful information. As a result, the NTSB had to rely exclusively on flight crew recollections about the incident; however, these were not documented until 1 month after the incident occurred. Because memories can decay or become distorted over

time, a cockpit voice recording would have helped corroborate the crew's recollections.

CVRs are among the most valuable tools for accident investigations because they provide contemporaneous information on flight crew intentions and coordination as well as other factors, such as procedural compliance, workload, fatigue, and situational awareness (NTSB 2018b). In this case, a cockpit voice recording would likely have provided additional details about the content and timing of crew communications; shed light on the crew's minute-by-minute focus of attention; revealed any unreported, nonpertinent conversations; and potentially provided additional information about any distractions. This would have allowed the NTSB to more precisely analyze crew performance.

The NTSB recognizes that the FAA has taken action to address Safety Recommendation A-18-30 by publishing an NPRM which proposed that newly manufactured aircraft be equipped with CVRs capable of recording 25 hours of data. Further, the FAA Reauthorization Act of 2024 included new 25-hour CVR carriage requirements for some newly manufactured and existing airplanes. However, the rulemaking for 25-hour CVRs for newly manufactured aircraft and existing airplanes has not been finalized by the FAA.

The NTSB concludes that CVRs with a 25-hour recording capability are necessary because valuable information continues to be overwritten on CVRs that are designed to record only 2 hours of audio data. Therefore, the NTSB reiterates Safety Recommendation A-18-30. Because the FAA did not complete responsive action to Safety Recommendation A-18-31 by January 1, 2024, this recommendation is classified Closed–Unacceptable Action/Superseded. The NTSB recommends that the FAA require retrofit of all CVRs on all airplanes required to carry both a CVR and a flight data recorder with a CVR capable of recording the last 25 hours of audio. Safety Recommendation A-24-9 is classified Open–Unacceptable Response.

3. Conclusions

3.1 Findings

1. None of the following were factors in this incident: (1) pilot and controller qualifications, (2) flight crew fatigue, and (3) airport traffic control tower staffing.
2. The captain's deviation from American Airlines flight 106's taxi clearance likely resulted from several factors, including an early clearance to cross runway 31L, interruptions and multitasking related to the crew's delayed receipt of the load closeout, the captain's prospective memory error in forgetting to turn right at taxiway K, and environmental capture, which prompted the captain to proceed along a familiar, but incorrect, route.
3. The first officer and relief first officer were likely distracted from their primary duty of assisting the captain in safely taxiing the airplane by other operational activities, which resulted in the crew's loss of situational awareness during a critical phase of flight.
4. The American Airlines flight crew's nondetection of Delta Air Lines flight 1943 (DAL1943) on runway 4L likely resulted from night conditions, the location of DAL1943 within a complex array of airport lights, the distance between the two airplanes, the lack of relative motion of DAL1943 in the visual field of the crew of American Airlines flight 106, and expectation bias.
5. A procedural crosscheck that requires a flight crew to verbalize the number of a runway they are about to cross, as indicated by runway signs, would reduce the likelihood of future runway incursions resulting from flight crew surface navigation errors.
6. Additional risk mitigation strategies as part of an operator's safety management system would reduce the likelihood that flight crew performance of concurrent tasks during taxi will lead to inaccurate navigation on the airport by reducing distractions associated with multitasking.
7. The implementation of a flight deck alerting system on transport-category aircraft that provides alerts of traffic on a runway or taxiway and traffic on approach to land would enhance safety by providing pilots with improved situational awareness and would reduce the risk of future runway-related incidents and accidents.
8. The runway entrance lights operated as designed; however, they were ineffective in preventing the crew of American Airlines flight 106 from crossing

the runway 4L hold short markings because they activated too late for the crew to perceive them and stop the airplane in a safe area.

9. The airport surface detection equipment model-X system at John F. Kennedy International Airport was operational at the time of the incident and functioned as designed, generating both aural and visual alerts when American Airlines flight 106 crossed runway 4L while Delta Air Lines flight 1943 was departing, and likely reduced the severity of the incident by preventing a runway collision.
10. The ground controller expected the American Airlines flight 106 crew to adhere to the assigned taxi instructions and did not detect the flight crew's surface navigation error and subsequent turn onto taxiway J because he was performing a lesser priority task that entailed looking down.
11. The local controller acted in a timely and appropriate manner following the airport surface detection equipment model-X alert by cancelling Delta Air Lines flight 1943's takeoff clearance.
12. The John F. Kennedy International Airport air traffic control tower team had the responsibility of scanning the runways and airport environment but did not effectively prioritize their duties to ensure a continuous scan, which resulted in their nondetection of the American Airlines flight 106 crew's deviation from taxi instructions.
13. Cockpit voice recorders (CVRs) with a 25-hour recording capability are necessary because valuable information continues to be overwritten on CVRs that are designed to record only 2 hours of audio data.

3.2 Probable Cause

The NTSB determines that the probable cause of this incident was the American Airlines flight 106 (AAL106) crew's surface navigation error due to distractions caused by their performance of concurrent operational tasks during taxi, which resulted in a loss of situational awareness. Contributing to the incident was the air traffic control tower team's nondetection of the AAL106 crew's deviation from taxi instructions while performing concurrent operational tasks; the timing of the runway status light system, which activated too late to prevent the AAL106 crew from crossing the runway hold short line; and American Airlines' lack of adequate risk controls to prevent concurrent flight crew tasks from leading to distraction, loss of situational awareness, and deviation from an authorized taxi clearance. Reducing the severity of the incident, and likely preventing an accident, was the activation of the ASDE-X warning in the air traffic control tower and the local controller's prompt cancellation of DAL1943's takeoff clearance.

4. Recommendations

4.1 New Recommendations

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

To the Federal Aviation Administration

Encourage Title 14 *Code of Federal Regulations* Part 91K, 135, and 121 operators to incorporate into their standard operating procedures a procedural crosscheck that requires flight crews to verbalize the number of a runway they are about to cross, as indicated by runway signs, unless an installed automated system already provides an aural advisory. (A-24-2)

Encourage Title 14 *Code of Federal Regulations* Part 121 operators to use their safety management system to identify flight crew surface navigation errors resulting from the performance of concurrent tasks during taxi and develop and implement effective risk mitigation strategies considering human factors principles. (A-24-3)

Collaborate with aircraft and avionics manufacturers and software designers to develop the technology for a flight deck system that would provide visual and aural alerts to flight crews of traffic on a runway or taxiway and traffic on approach to land. (A-24-4)

Require that the technology developed in response to Safety Recommendation A-24-4 be installed in all newly certificated transport-category airplanes. (A-24-5)

Require that existing transport-category airplanes be retrofitted with the technology developed in response to Safety Recommendation A-24-4. (A-24-6)

Evaluate the effectiveness of the activation logic for the runway status light system considering the circumstances of this incident. (A-24-7)

Using the findings of the evaluation conducted in response to Safety Recommendation A-24-7, update the runway status light system activation logic as necessary to improve system effectiveness. (A-24-8)

Require retrofit of all cockpit voice recorders (CVR) on all airplanes required to carry both a CVR and a flight data recorder with a CVR capable of recording the last 25 hours of audio. (A-24-9)

4.2 Previously Issued Recommendations Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendation.

To the Federal Aviation Administration:

Require all newly manufactured airplanes that must have a cockpit voice recorder (CVR) be fitted with a CVR capable of recording the last 25 hours of audio. (A-18-30)

4.3 Previously Issued Recommendations Classified in This Report

Safety Recommendation A-00-66 is classified Closed–Unacceptable Action/Superseded in section 2.3.3 of this report. This recommendation is superseded by Safety Recommendations A-24-4 through -6, which are classified Open–Unacceptable Response.

Safety Recommendation A-18-31 is classified Closed–Unacceptable Action/Superseded in section 2.6 of this report. This recommendation is superseded by Safety Recommendation A-24-9, which is classified Open–Unacceptable Response.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

ALVIN BROWN
Member

J. TODD INMAN
Member

Report Date: May 29, 2024

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) learned about this incident on January 14, 2023. Air traffic control and operations investigative groups were formed. A specialist was assigned to conduct the readout of the flight data recorder at the NTSB's laboratory in Washington, DC, and specialists in the areas of aircraft performance, human performance, and airports participated in the investigation. Parties to the investigation were the Federal Aviation Administration, American Airlines, Delta Air Lines, Allied Pilots Association, National Air Traffic Controllers Association, and Boeing.

Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board’s collection and analysis of the specific incident investigation information most relevant to the recommendation;

(2) a description of the Board’s use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

To the Federal Aviation Administration

A-24-2

Encourage 14 *CFR* Part 91K, 135, and 121 operators to incorporate into their standard operating procedures a crosscheck that requires a flight crew to verbalize the runway number they are about to cross, as indicated by runway signs, unless a flight deck automated system already provides an aural advisory.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1, Crew Resource Management. Information supporting (b)(1) can be found on pages 41-43; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-3

Encourage 14 *CFR* Part 121 operators to use their safety management system to detect flight crew surface navigation errors resulting from the performance of concurrent tasks during taxi and use scientific knowledge from the field of human factors to develop and implement effective risk mitigation strategies.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1, Crew Resource Management, and section 2.3.2, American Airlines Policy on Completing the Load Closeout. Information supporting

(b)(1) can be found on pages 41-45; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-4

Collaborate with aircraft and avionics manufacturers and software designers to develop the technology for a flight deck system that would provide visual and aural alerts to flight crews of traffic on a runway or taxiway and traffic on approach to land.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 1.9.1.1, Surface Detection Technology, and section 2.3.3, Flight Deck Technologies for Preventing Runway Incursions. Information supporting (b)(1) can be found on pages 45-47; (b)(2) is not applicable; and (b)(3) can be found on pages 29-31 and 45-47.

A-24-5

Require that the technology developed in response to Safety Recommendation A-24-4 be installed in all newly certificated transport category airplanes.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 1.9.1.1, Surface Detection Technology, and section 2.3.3, Flight Deck Technologies for Preventing Runway Incursions. Information supporting (b)(1) can be found on pages 45-47; (b)(2) is not applicable; and (b)(3) can be found on pages 29-31 and 45-47.

A-24-6

Require that existing transport category airplanes be retrofitted with the technology developed in response to Safety Recommendation A-24-4.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 1.9.1.1, Surface Detection Technology, and section 2.3.3, Flight Deck Technologies for Preventing Runway Incursions. Information supporting (b)(1) can be found on pages 45-47; (b)(2) is not applicable; and (b)(3) can be found on pages 29-31 and 45-47.

A-24-7

Evaluate the effectiveness of the activation logic for the runway status light system considering the circumstances of this incident.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.1, Runway Status Lights. Information supporting (b)(1) can be found on pages 47-49; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-8

Using the findings of the evaluation conducted in response to Safety Recommendation A-24-7, update the runway status light system activation logic as necessary to improve system effectiveness.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4.1, Runway Status Lights. Information supporting (b)(1) can be found on pages 47-49; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-9

Require retrofit of all cockpit voice recorders (CVR) on all airplanes required to carry both a CVR and a flight data recorder with a CVR capable of recording the last 25 hours of audio.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in sections 1.1, History of Flight; 1.6, Flight Recorders; 1.9.1, Previous Related Safety Recommendations; and 2.6, Cockpit Voice Recorder Duration and Loss of Information. Information supporting (b)(1) can be found on pages 1-10, 20, 29-33, and 51-52; (b)(2) is not applicable; and (b)(3) can be found on pages 29-33 and 51-52.

Appendix C: Excerpts of American Airlines Flight Operations Manual

The following excerpts from the company Flight Operations Manual (FOM) outline procedures and pilot responsibilities for ground operations.

1g.5.4 Sterile Flightdeck Period

Source: 14 CFR 121.542; ISARP FLT 3.11.17 and 3.12.5

Definition. *Critical phases of flight include all ground operations involving taxi (when the aircraft is in motion), takeoff and landing, and all other flight operations conducted below 10,000 feet AFL, except cruise flight.*

Do not perform or engage in duties or activities during critical phases of flight that are not required for the safe operation of the aircraft or could distract other crewmembers from performing their duties.

Non-Essential Activities

Do not engage in non-essential activities such as Company communication for nonoperational related purposes, passenger connections, pointing out sights of interest, completing paperwork, eating meals, and non-essential conversations between flightdeck or cabin crewmembers.

Clearance Readback

1c.2.4 Clearance Readback

Acknowledge the following ATC clearances/instructions with the full flight number and a verbatim read back of the clearance:

– general:

- initial IFR clearance and flight plan clearance limits/amendments
- instructions to initiate contact on a specific radio frequency.

– taxi:

- taxi clearance and runway assignment
- taxi clearance involving hold short clearances restricting runway/taxiway access

- taxi clearance to cross any runway surface.

ACARS

1c.3.2 ACARS

Source: ISARP FLT 3.7.3

ACARS is the primary means of two-way communications between each aircraft and dispatch when ACARS coverage is available via either ACARS ground station or SATCOM. When away from the gate, ACARS reports:

- normal transmission of OOOI (Out, Off, On, In) times
- enroute position reports
- in-range reports
- aircraft systems performance data
- flight-to-IOC and IOC-to-flight communications
- SELCAL used to establish dispatcher-to-captain voice communication

ACARS is intended only for Company operational communication.

Note: Non-operational messages are not authorized.

Verification

Inputs. Both the captain and first officer will verify the correct flight number, origin, and destination are entered prior to departure.

Received Messages. Verify all messages for the correct flight number, date, and aircraft nose number.

TPS and Load Closeout. Besides verifying these received messages (see above), compare the TPS and load closeout against documents obtained from operations for reasonableness (e.g., ZFW, TOGW, V speeds). In addition, compare all subsequent TPS and/or load closeout messages against previously received messages.

Dangerous Goods/Hazardous Materials

1d.1.1 Dangerous Goods Definition and Classification

Dangerous goods (DGs) are articles or substances capable of posing a potential risk to health, safety, or property when transported by air. The terms dangerous goods (DGs), hazardous materials (HAZMATs), and restricted articles (RAs) are synonymous and interchangeable.

3d.2 Notifications

3d.2.1 Notification to Captain (NOTOC)

Source: 49 CFR 175.33

The notification to captain (NOTOC) requirement is satisfied by presenting a computer-generated AUTONOTOC form or a preprinted OK-333 form.

Corrections Handwritten and initialed corrections to the AUTONOTOC print-out are permitted anytime the location or quantity of dangerous goods is changed or if the DG shipment was not loaded.

Taxi

4g.1 General

Airport surface operations require strict attention and constant situational awareness. Sound flightdeck operating discipline enables the flight crewmembers to properly plan taxi operations with the same level of attention given to planning other phases of flight. For specific phase-of-flight procedures, refer to the appropriate FOM phase of flight chapters and the aircraft operating manual.

4g.1.1 Planning

Anticipate airport surface movements by performing a pre-taxi review based on ATIS and previous experience at each airport. Review the expected taxi route on the airport diagram.

4g.1.2 Control

The captain will taxi the aircraft. The flight crew's primary task is to safely taxi the aircraft and the flight crew's attention should not be diverted from this task.

4g.1.3 Communication

See paragraphs 1c.2.4 Clearance Readback for clearances requiring a read back and 4c.2.1 General for more information.

Coordination

Verbally coordinate all taxi instructions with other flightdeck crewmembers to ensure common understanding. If in disagreement, seek clarification from ATC. Do not taxi until a taxi clearance is received **and** both the captain and first officer verbally coordinate and agree on the runway assigned, any restrictions, and taxi route. Note: Ensure received (not expected/briefed) taxi route is followed.

4g.1.4 Monitoring

Source: ISARP FLT 3.12.7

Flight crewmembers should use a continuous loop process for actively monitoring and updating their progress and location during taxi. This includes knowing the aircraft's present location and mentally calculating the next location on the taxi route that will require increased attention. Consider writing down the taxiing instructions and while taxiing:

- do not allow other flightdeck duties and non-ATC communications to divert attention from the safe movement of the aircraft, especially at critical times, such as runway crossings and transitioning through complex taxiway intersections
- maintain sterile flightdeck when the aircraft is moving

Note: If uncertain as to location on the airport, taxi clear of any runway, stop the aircraft, advise the tower.

Both pilots should:

- have the airport diagram readily available and reference it as necessary to ensure the taxi clearance is followed correctly (see paragraph Taxi-Out for iPad EFB guidance)
- be *heads up* to visually monitor the aircraft's progress at critical locations on the airport (hold short, crossing runways, etc.)

When approaching an entrance to an active runway, both pilots will ensure compliance with hold short or crossing clearance by

discontinuing non-monitoring tasks (e.g. FMS programming, ACARS, company radio calls, etc.)

Operations During Flight

Taxi-Out

Airport Info charts must be readily available to ensure the taxi clearance is followed correctly. Temporarily selecting another chart (e.g. ##-7, SID, etc.) is authorized providing:

- one pilot is displaying the airport diagram
- current position is known
- aircraft is not taxiing directly toward or across an active runway

Owship.

Note: Do not use JeppFD-Pro ownship position as a primary position source, especially during low visibility taxi operations. Taxiway signs and markings outside the aircraft remain the primary reference for maneuvering the aircraft. The use of ownship position display on taxi charts is authorized to supplement situational awareness.

4g.22 Airport Markings/Lighting

Runway Entrance Lights (RELs)

The REL system is composed of flush mounted, in-pavement, unidirectional fixtures that are parallel to and focused along the taxiway centerline and directed toward the pilot at the hold line. An array of REL lights include the first light at the hold line followed by a series of evenly spaced lights to the runway edge; one additional light at the runway centerline is in line with the last two lights before the runway edge. When activated, the red lights indicate there is either high speed traffic on the runway or an aircraft on final approach within the activation area.

Operating Characteristics.

Departing Aircraft When a departing aircraft reaches 30 knots, all taxiway intersections with REL arrays along the runway ahead of the aircraft will illuminate. As the aircraft approaches an REL equipped taxiway intersection, the lights at that intersection extinguish approximately 3 to 4 seconds before the aircraft reaches it. This allows

controllers to apply anticipated separation to permit ATC to move traffic more expeditiously without compromising safety. After the aircraft is declared airborne by the system, all REL lights associated with this runway will extinguish.

Pilot Observations and Actions.

Observations

A pilot at or approaching the hold line to a runway will observe REL illumination and extinguishing in reaction to an aircraft or vehicle operating on the runway, or an arriving aircraft operating less than 1 mile from the runway threshold.

Actions

Whenever a pilot observes the red lights of the REL, the pilot will stop/remain stopped at the hold line and contact ATC for resolution if the clearance is in conflict with the lights. Should pilots note illuminated lights under circumstances when remaining clear of the runway is impractical for safety reasons (for example, aircraft is already on the runway), the crew should proceed according to their best judgment while understanding the illuminated lights indicate the runway is unsafe to enter or cross. Contact ATC at the earliest possible opportunity.

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