June 6, 2024 Aviation Investigation Report AIR-24-02

Runway Incursion and Overflight Southwest Airlines Flight 708 Boeing 737-700, N7827A, and Federal Express Flight 1432 Boeing 767-300, N297FE

Austin, Texas
February 4, 2023

Abstract: This report discusses the February 4, 2023, runway incursion and overflight incident involving Southwest Airlines (SWA) flight 708, a Boeing 737-700, and Federal Express Corporation (FedEx) flight 1432, a Boeing 767-300, at Austin-Bergstrom International Airport, Austin, Texas. The local controller assumed that the SWA airplane would depart from runway 18L before the FedEx airplane would arrive on the same runway, but the 2-mile required separation between the airplanes was not maintained. The flight crew of the FedEx airplane executed a missed approach to avoid a collision. At their closest point, the airplanes were separated by 150 to 170 ft. The 128 occupants aboard the SWA airplane and the 3 occupants aboard the FedEx airplane were not injured, and neither airplane sustained any damage. Both airplanes continued to their destinations without further incident. Safety issues discussed in this report include (1) the lack of surface detection equipment at AUS to alert controllers about potential conflicts on a taxiway or runway surface; (2) the need for flight deck technology to alert flight crews about potential conflicts on an airport surface; (3) the need to ensure, especially during low-visibility conditions, that controllers are aware when pilots, after receiving takeoff clearance, might need extra time on the runway; (4) the lack of training on the AUS airport's Surface Movement Guidance and Control System plan; (5) the need for low-visibility operations training at all airports, and (6) the need for 25-hour cockpit voice recorders. As a result of this investigation, the National Transportation Safety Board issues seven new safety recommendations to the Federal Aviation Administration (FAA) and reiterates five previously issued recommendations to the FAA.

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Acronyms and Abbreviations

AC	advisory circular
ADS-B	automatic dependent surveillance-broadcast
agl	above ground level
AIM	*Aeronautical Information Manual*
ASDE	airport surface detection equipment
ASOS	automated surface observing system
ASSC	airport surface surveillance capability
ATC	air traffic control
ATCT	air traffic control tower
ATIS	automatic terminal information system
ATP	airline transport pilot
AUS	Austin-Bergstrom International Airport
CFR	*Code of Federal Regulations*
CPAP	continuous positive airway pressure
CUN	Cancún International Airport
CVR	cockpit voice recorder
EST	eastern standard time
FAA	Federal Aviation Administration
FDR	flight data recorder
FedEx	Federal Express Corporation
HOU	William P. Hobby Airport
IFR	instrument flight rules
ILS	instrument landing system

JFK	John F. Kennedy International Airport
LOA	letter of agreement
MEM	Memphis International Airport
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
NWS	National Weather Service
PST	Pacific standard time
RA	resolution advisory
RVR	runway visual range
SAI	Surface Awareness Initiative
SMGCS	Surface Movement Guidance and Control System
SWA	Southwest Airlines
TA	traffic advisory
TCAS	traffic alert and collision avoidance system

Executive Summary

What Happened

This incident involved Southwest Airlines (SWA) flight 708, a Boeing 737-700, and Federal Express Corporation (FedEx) flight 1432, a Boeing 767-300, which were involved in a runway incursion at Austin-Bergstrom International Airport (AUS), Austin, Texas. The local controller had cleared the SWA airplane for takeoff on runway 18L 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 AUS air traffic control tower (ATCT) did not have surface detection equipment to aid the controller in monitoring ground traffic.

Federal Aviation Administration (FAA) procedures required the controller to apply a 2-mile separation between the airplanes. However, when the SWA airplane lined up with the runway 18L centerline and came to a complete stop (so that the flight crew could perform an engine run-up), the FedEx airplane was 1.5 miles away. The separation between both airplanes continued to decrease until the FedEx flight crew saw the outline of the SWA airplane through the fog and began a missed approach. At that time, the FedEx airplane had just crossed the runway 18L threshold, and the SWA airplane was 1,020 ft down the runway. The airplanes were separated at their closest point by 150 to 170 ft (which was less than the 180-ft length of the FedEx Boeing 767 airplane).

The FedEx airplane continued to climb, and the SWA airplane continued to accelerate, which increased the separation between the airplanes. The SWA airplane lifted off and continued to its planned destination. The FedEx airplane circled to the left and landed on runway 18L without further incident.

What We Found

The National Transportation Safety Board (NTSB) found that the controller had an inaccurate mental model of the SWA airplane's position on the taxiway. With the low-visibility conditions on the morning of the incident and the lack of surface detection equipment in the tower, the controller had to rely on the SWA flight crew for information about the position of the airplane on the airport surface.

On the basis of his previous experience with SWA departures at AUS, the controller expected that, when a SWA pilot said that an airplane was ready to depart, the airplane would already be at the runway 18L hold-short line (a taxiway marking that indicates where an aircraft must stop to receive clearance to enter the assigned runway if that clearance was not already provided). The controller stated that this expectation was communicated to the SWA flight crew as well as the flight crews of airplanes that departed that morning before the incident flight. However, air traffic control (ATC) recordings provided no evidence supporting the controller's statement.

Also, the controller did not verify the SWA airplane's position on the taxiway when the flight crew requested takeoff clearance and instead assumed that the SWA airplane was already at the hold-short line. However, the SWA airplane was 550 ft away from the hold-short line at that time. By the time that the SWA airplane lined up with the runway 18L centerline, the separation between the SWA and FedEx airplanes was less than the required 2 miles.

Further, the controller's inaccurate mental model also assumed that the SWA airplane would depart from runway 18L before the FedEx airplane would arrive on the same runway. This incorrect assumption set up a hazardous situation that could have resulted in an accident. If surface detection equipment had been installed in the AUS ATCT, the controller could have tracked the position of the SWA airplane while it was on the taxiway and runway, detected the inadequate separation between the SWA and FedEx airplanes, and taken action to mitigate the situation.

We also found that, although the SWA flight crewmembers were aware that traffic (the FedEx airplane) was on short final approach to the same runway, they did not inform the controller of their intention to perform an engine run-up once the airplane entered the active runway. During the engine run-up, the SWA airplane was stopped on the runway for 19 seconds, which further decreased the separation between the departing SWA airplane and the approaching FedEx airplane. Although the SWA flight crewmembers were not required to notify the controller about their plan to stop the airplane once on the active runway, it would have been prudent for them to do so given the traffic on short final approach.

Further, we found that the FAA's efforts to address a previous safety recommendation (A-00-66) were focused primarily on ATC-related technologies that were underway instead of a system to directly alert flight crews about potential runway incursions, as requested. We recognize the benefit of surface detection systems, such as airport surface detection equipment, model X (ASDE-X), and believe that airports without surface detection capability, including AUS, should be so equipped. Nevertheless, a flight deck alerting system would also help prevent runway incursions by providing timely notification to a flight crew about potential traffic conflicts that the crew might not see while visually scanning the outside environment.

In addition, we found that the controller did not have any recent training on low-visibility operations at the airport. The air traffic manager at the AUS ATCT explained that the tower had not conducted training on low-visibility operations during the 2 years before the incident. In addition, the controller could not recall details about the airport's Surface Movement Guidance and Control System (SMGCS) plan, which was intended to facilitate the safe movement of aircraft and vehicles on airport surfaces when visibility (specifically, the runway visual range) is less than 1,200 ft.

Last, we found that, if both airplanes had 25-hour cockpit voice recorders (CVR) installed (instead of CVRs with the currently required 2-hour recording capability), we would have been able to determine when the FedEx first officer saw the SWA airplane, how he communicated the need to go around to the FedEx captain, and other information that was not captured on ATC audio recordings.

We determined that the probable cause of this incident was the local controller's incorrect assumption that the SWA airplane would depart from the runway before the FedEx airplane arrived on the same runway, which resulted in a loss of separation between both airplanes. Contributing to the controller's incorrect assumption were

- his expectation bias regarding the SWA airplane's departure,
- his lack of situational awareness regarding the SWA airplane's position when the flight crew requested takeoff clearance, and
- the ATCT's lack of training (before the incident) on low-visibility operations.

Contributing to the incident was the SWA flight crewmembers' failure to account for the traffic that was on short final approach and to notify the controller that they would need additional time on the runway before the takeoff roll. Also contributing to the incident was the FAA's failure to require surface detection equipment at Austin-Bergstrom International Airport and direct alerting to flight crews.

What We Recommended

As a result of this investigation, we made seven new recommendations to the FAA. We recommended that the FAA implement, at airports that are certificated under Title 14 *Code of Federal Regulations* Part 139 and are currently not equipped with ASDE-X or airport surface surveillance capability, surface detection equipment that

- tracks the movement of arriving and departing aircraft,
- determines the proximity between those aircraft, and
- provides air traffic controllers with visual and aural cues of urface movements to aid in their decision-making processes.

We recommended that the FAA brief all air traffic controllers about the circumstances of this incident, emphasizing the importance of considering the effect certain conditions might have on a pilot's ability to begin a takeoff in a timely manner, including

- low-visibility weather conditions, such as fog;
- ambient conditions (that is, the environmental conditions in the area immediately surrounding an aircraft), such as temperature; and
- surface conditions, such as ice, snow, and other precipitation.

We recommended that the FAA amend the *Aeronautical Information Manual* so that it instructs pilots, before entering an active runway with the intent to depart, to inform controllers when they need time on the runway for any reason before a takeoff roll in low-visibility conditions. We also recommended that the FAA require air traffic controllers to

- advise pilots, through direct communication and automatic terminal information system broadcasts, when visual contact with aircraft operating on taxiways and runways cannot be established or maintained and
- instruct pilots to provide accurate position reports to aid the controller in determining an aircraft's position in such conditions.

We recommended that the FAA require all airports with a SMGCS plan to review their plans and the associated letters of agreement to ensure alignment with each other and with the stakeholder duties and responsibilities described in the related FAA advisory circular. We also recommended that the FAA direct training administrators at airports with a SMGCS plan to require initial and refresher training for all stakeholders, including air traffic controllers and airport operations personnel, on the information in the airport's plan. Further, we recommended that the FAA require training administrators at all operating ATCTs to conduct refresher training on low-visibility operations given that such conditions affect all towers.

In addition, we reiterated the following five safety recommendations that were previously issued to 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. (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)

- 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)
- 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)

1. Factual Information

1.1 History of Flight

On February 4, 2023, about 0640 central standard time, Southwest Airlines (SWA) flight 708, a Boeing 737-700, N7827A, and Federal Express Corporation (FedEx) flight 1432, a Boeing 767-300, N297FE, were involved in a runway incursion at Austin-Bergstrom International Airport (AUS), Austin, Texas.[1] The flight crew of the FedEx airplane, which was arriving on runway 18L, executed a missed approach as the SWA airplane was departing from the same runway. The 128 occupants aboard the SWA airplane and the 3 occupants aboard the FedEx airplane were not injured, and neither airplane sustained damage.[2] SWA flight 708 was a regularly scheduled international passenger flight operating under Title 14 *Code of Federal Regulations* (*CFR*) Part 121 from AUS to Cancún International Airport (CUN), Cancún, Mexico. FedEx flight 1432 was a domestic cargo flight operating under Part 121 from Memphis International Airport (MEM), Memphis, Tennessee, to AUS.[3] Night instrument meteorological conditions prevailed at the time of the incident.

The local controller at the AUS air traffic control tower (ATCT) reported for duty about 0538 and received a pre-duty weather briefing that was valid until 1300.[4] The briefing consisted of a video from the National Weather Service (NWS) that provided an overview of the weather conditions in the local area. The video showed that low-visibility conditions were occurring.

A review of Federal Aviation Administration (FAA) air traffic control (ATC) audio recordings showed that the controller received a position relief briefing from the mid-shift controller about 0545. This briefing indicated that visibility was 1/4 mile with obscuration, the runway lights were turned up to their highest intensity setting, and

[1] The Federal Aviation Administration defines a runway incursion as "any occurrence at an aerodrome involving the incorrect presence of an aircraft, vehicle or person on the protected area of a surface designated for the landing and take off of aircraft." The National Transportation Safety Board has long been concerned about runway incursions and held a runway incursion forum in 2017 and a runway incursion roundtable in 2023 to further understand the safety issue and learn about related mitigation efforts.

[2] Two flight crewmembers, 3 cabin crewmembers, and 123 passengers were aboard the SWA airplane. Two flight crewmembers and one nonrevenue FedEx pilot (who was traveling to AUS in the jumpseat) were aboard the FedEx airplane.

[3] Visit ntsb.gov to find additional information in the public docket for this NTSB incident investigation (case number DCA23FA149). Use the CAROL Query to search safety recommendations and investigations.

[4] All times in this report are central standard time unless otherwise noted.

runway visual range (RVR) values were being used to determine takeoff and landing minimums.[5] Between 0548:36 and 0628:41, the controller reported RVR values to the flight crews of the 10 aircraft that departed from AUS before the SWA incident flight; 7 of these flights departed from runway 18L, and 3 of the flights departed from runway 18R (as further discussed in section 1.8.2).

At 0634:02, the FedEx flight crewmembers contacted the controller and reported that their flight was inbound and established on a category III approach to runway 18L.[6] (The FedEx airplane was the first planned arrival at AUS that day.) The controller provided the flight crew with the RVR values for the runway (1,400 ft touchdown, 600 ft midpoint, and 1,800 ft rollout) and cleared the airplane to land. The flight crew acknowledged this information. Flight data recorder (FDR) data showed that, at 0636:55, the landing gear on the FedEx airplane was lowered to its down-and-locked position.

At 0638:47, the first officer of the SWA airplane contacted the local controller and stated that "we're short of one eight left" and "we're ready." The aircraft performance study for this incident showed that, at that time, the airplane was on taxiway B and was about 550 ft from the hold-short line (the point on a taxiway immediately adjacent to the runway where airplanes stop and wait for ATC clearance to enter the runway unless such clearance was already provided).[7] Figure 1 shows the airplane's position at that time, which the controller was unable to see due to the low-visibility conditions.[8] At that time, the FedEx airplane was 4.4 miles from the runway 18L threshold.

[5] An RVR value represents the visibility near a runway's surface, specifically, the horizontal distance that a pilot should be able to see down a runway.

[6] The FAA defines a category III approach as a precision instrument approach and landing with either no decision height or a decision height that is lower than 100 ft and an RVR that is at least 700 ft. Section 1.9.2 discusses the related FedEx procedures.

[7] Postincident interviews indicated that the SWA captain and first officer were able to see the taxiway markings leading to runway 18L with the low-visibility conditions that existed at the time.

[8] The airplane locations presented in this report were derived from automatic dependent surveillance-broadcast (ADS-B) data that were recorded by third-party ground receivers (and not FAA ground stations, which did not have adequate coverage to record an airplane's ADS-B information while at AUS). ADS-B records GPS position and other data and then broadcasts those data. The GPS position data have an accuracy within about 65 ft for both the horizontal and vertical dimensions. In addition, the latitude and longitude parameters on each airplane's FDR were not recorded with enough precision to determine the airplanes' locations as accurately as ADS-B. On the morning of the incident, the controller would not have had access to the ADS-B position information for the SWA and FedEx airplanes.

Figure 1. SWA airplane position when the flight crew reported that the airplane was short of runway 18L.

Note: The hold-short line was 200 ft from the approach end of runway 18L.

At 0638:58, the controller cleared the SWA airplane for takeoff from runway 18L, provided the RVR values for the runway (1,200 ft touchdown, 600 ft midpoint, and 1,600 ft rollout), and advised that a FedEx Boeing 767 airplane was on a 3-mile final approach. (The aircraft performance study found that the FedEx airplane was 3.9 miles from the runway 18L threshold at the time of that transmission.) Postincident statements from the FedEx flight crewmembers indicated that they heard the controller's transmission to the SWA airplane. The SWA first officer acknowledged the controller's transmission at 0639:13, and the SWA captain continued to taxi the airplane toward runway 18L. At 0639:26, the SWA airplane reached the hold-short line; the FedEx airplane was 2.8 miles from the runway threshold.

At 0639:29, the FedEx flight crew asked the local controller to confirm that their airplane was cleared to land on runway 18L because, according to the FedEx captain's postincident statement, he and the first officer were concerned about the SWA airplane's position. The controller confirmed that the FedEx airplane was cleared to land and advised the FedEx crew that a Boeing 737 would be "departing prior to your arrival." The FedEx flight crew acknowledged this information at 0639:40. FDR data showed that the SWA airplane was turning onto runway 18L at that time. At 0639:44, the FedEx airplane was 2 miles from the runway threshold at an altitude of 650 ft above ground level (agl) and descending.

The SWA airplane lined up with the runway 18L centerline and came to a complete stop at 0639:55. At this time, the distance between the SWA and FedEx airplanes was 1.5 miles. (The controller would have been unable to see that the SWA airplane had stopped on the runway because of the fog.) The SWA first officer (the pilot flying) stated that he advanced the engine power, performed a static engine run-up due to freezing fog conditions (as discussed in section 1.4), and released the brakes to begin the takeoff roll.[9]

At 0640:10, when the FedEx airplane was on a 0.8-mile final approach, the controller contacted the SWA flight crew to confirm that the airplane was “on the roll,” and the SWA captain (the pilot monitoring) replied that the airplane was “rollin’ now”; automatic dependent surveillance-broadcast (ADS-B) data showed that, at the time of the SWA crew’s transmission, the airplane was still at the runway 18L threshold.[10] The postincident statement from the FedEx first officer indicated that the FedEx airplane was at an altitude of 300 ft agl when the SWA captain stated “rollin’ now.”[11] The FedEx captain’s postincident statement indicated that the visibility was “zero” at that point. During a postincident interview, the controller reported that he was able to see a light on the FedEx airplane while it was on approach but could not see the SWA airplane due to “dense ground fog.”[12] The controller also reported that he “couldn't see the approach end of the runway.”

During a postincident interview, the FedEx first officer stated that, when the FedEx airplane was at an altitude of about 150 ft agl, he saw, about 1,000 to 1,500 ft from the approach end of the runway, the “left white position light” of the SWA airplane followed by the airplane’s “silhouette.”[13] The FedEx captain’s postincident statement indicated that he “didn’t see anything but fog” and that he executed a missed approach procedure after the first officer made a go-around callout. The time

[9] FDR data showed that the SWA airplane’s groundspeed was 0 knots for 19 seconds as engine power was advanced from 37% to 56%. The SWA engine run-up procedures are discussed in section 1.9.1.1.

[10] The airplane’s groundspeed began to increase at 0640:14 as engine power was advanced to 68%.

[11] The FedEx first officer’s postincident statement also indicated that he and the captain became concerned when they heard “now” (referring to the SWA captain’s statement “rollin’ now”) because of the possibility of a traffic conflict during the approach to landing.

[12] During postincident interviews, the operations supervisor for the incident shift reported that the weather was “very foggy…you couldn't see the ground” and “you could see above the fog layer for a while and then…you couldn't see at all,” and the controller reported that the ceilings were less than 200 ft agl and that there was “no ground visibility.”

[13] During a postincident interview, the FedEx first officer stated that, as the pilot monitoring, his attention during the approach had been focused on scanning and monitoring information on the flight deck but that he looked outside the airplane because he was concerned about the SWA airplane’s location.

of the first officer's callout could not be precisely determined because of the lack of cockpit voice recorder (CVR) data (see section 1.6), but the FDR recorded the throttles being advanced at 0640:29, which was 1 second after the FedEx airplane crossed the runway 18L threshold.[14] At 0640:31, the FedEx first officer transmitted "Southwest abort" and, 3 seconds later, "FedEx is on the go."[15] At 0640:44 and in response to the "abort" comment, the controller instructed the SWA flight crew to turn right when able. The SWA crew responded "negative" because, at that time, the SWA airplane was rolling down the runway.

In postincident statements, the SWA captain stated that he heard the FedEx pilot's go-around callout, and the SWA first officer stated that he heard both the abort and go-around callouts. (Both crewmembers noted that they heard the transmissions between the SWA captain's 80-knot and V_1 [takeoff decision speed] callouts.) Because the SWA captain did not hear the "abort" transmission or a specific instruction from the controller to discontinue the takeoff, the SWA airplane continued its takeoff roll.[16] At 0640:47, the SWA first officer rotated the airplane; 3 seconds later, the main gear lifted off the runway.

The FedEx airplane crossed the departure end of runway 18L at 0641:07. ADS-B and FDR data showed that the SWA airplane was about 1,000 ft lower than the FedEx airplane at that time. Figure 2 shows the ground and flight tracks of the SWA and FedEx airplanes in relation to runway 18L. When the FedEx airplane was climbing out of 1,900 ft, the controller instructed the FedEx flight crew to turn left onto a heading of 080° and maintain 3,000 ft. The SWA airplane then began a right turn away from the runway heading and continued with the planned flight route to CUN. The FedEx flight crew made another category III approach and landed on runway 18L about 0705 without further incident.

[14] When the FedEx airplane crossed the runway 18L threshold, the SWA airplane was 900 ft beyond the threshold.

[15] It is not standard operating procedure for a pilot of an aircraft to issue an abort instruction to another aircraft. Abort instructions are generally issued only by controllers.

[16] The SWA captain's statement also noted that "no parameters" necessitated a "high-speed rejection."

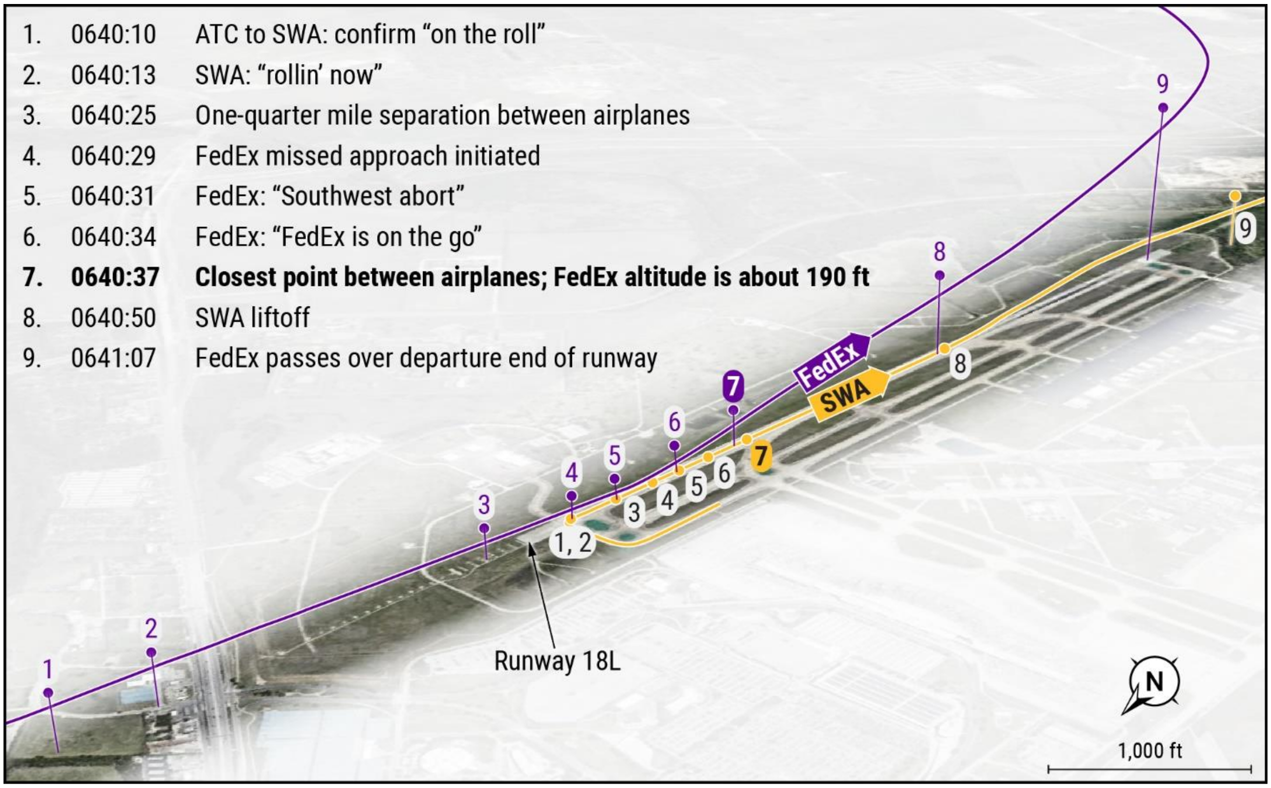

Figure 2. Ground and flight tracks for FedEx and SWA airplanes.

Note: Regarding the FedEx airplane's missed approach, the source for point 4 was the FDR on the FedEx airplane, and the source for points 5 and 6 was the ATC transcript.

The FedEx first officer stated that, during the "quick turn" associated with the missed approach, the airplane's traffic alert and collision avoidance system (TCAS) showed a target that was 700 ft below the FedEx airplane.[17] The SWA captain stated that the airplane's TCAS showed a target that was 600 ft above the SWA airplane. During a postincident interview, the SWA first officer stated that, in response to the traffic advisory, he decreased the airplane's rate of climb, which he described as "shallowing," to maintain separation from the FedEx airplane. FDR data showed that, when the SWA airplane was 8,500 ft beyond the runway threshold (about 0641:03), its climb rate decreased from about 1,400 to 500 ft per minute. The FedEx airplane maintained a climb rate between about 2,000 and 3,400 ft per minute during that time.

[17] Section 1.3 discusses TCAS, which was designed to increase pilot awareness about nearby traffic and prevent a midair collision.

1.2 Personnel Information

1.2.1 SWA Captain

The SWA captain, age 54, held an airline transport pilot (ATP) certificate with ratings for airplane single- and multiengine land and type ratings on the Boeing 737, McDonnell Douglas DC-9, and Swearingen SA-227. The captain's ratings for the 737 and DC-9 had a limitation for circling approaches in visual meteorological conditions only. He held an FAA first-class medical certificate dated August 9, 2022, with a limitation that he must use corrective lenses. The captain was hired by AirTran Airways in 2001, which merged with SWA in 2014, and he was based at William P. Hobby Airport (HOU), Houston, Texas.

According to SWA records and information that the captain provided, he had accumulated 20,600 total flight hours, 6,000 hours of which were on the Boeing 737, including 5,500 hours as 737 pilot-in-command. He had flown 60 hours in the 30 days before the incident and 6 hours in the 24 hours before the incident. The captain's last line check occurred in September 2022, and his last simulator training (a maneuvers observation and a line-oriented evaluation) occurred in August 2022. The captain satisfactorily completed a required company course on cold weather operations in October 2020.

On February 1, 2023, the captain was off from work. He awoke between 0600 and 0700 eastern standard time (EST) and went to sleep between 2100 and 2200 EST. On February 2, the captain was also off from work. He awoke between 0600 and 0700 EST and commuted to work aboard a flight that departed Miami International Airport, Miami, Florida, at 1200 EST. After the flight arrived at HOU, the captain drove to a local hotel and went to sleep between 2000 and 2100 (central standard time). On February 3, the captain awoke at 0340 and reported for duty at 0440. The captain and the incident first officer flew three legs that day, the last of which arrived at AUS. The captain's duty day ended at 1507, and he went to sleep at 2000. On the morning of the incident, the captain awoke at 0400 and reported for duty at 0540. The captain stated that he needed between 6 and 7 hours of sleep to feel rested.

1.2.2 SWA First Officer

The SWA first officer, age 41, held an ATP certificate with a rating for multiengine land; commercial privileges for airplane single-engine land; and a type rating on the Boeing 737, Beech 400, Lockheed 382, and Mitsubishi MU-300. He held a first-class medical certificate dated August 1, 2022, with no limitations. The first officer was hired by SWA in July 2016 and was based at HOU.

According to SWA records and information that the first officer provided, he had accumulated 8,907 total flight hours, 4,893 hours of which were on the Boeing 737. He had flown 79 hours in the 30 days before the incident and 6 hours in the 24 hours before the incident. The first officer's last simulator training (a maneuvers observation and a line-oriented evaluation) occurred in January 2023. The maneuvers observation included cold weather and low-visibility taxi operations.

On February 1 and 2, 2023, the first officer was off from work. On February 1, he awoke at 0500 and went to sleep at 2130. On February 2, he awoke between 0400 and 0500; drove about 4 hours from his home to HOU, arriving at a local hotel at 1500; and went to sleep at 2000. On February 3, the first officer awoke at 0330 and reported for duty at 0440. As previously stated, the first officer and the incident captain flew three legs that day, the last of which arrived at AUS. The first officer's duty day ended at 1507, and he went to sleep at 2000. On the morning of the incident, the first officer awoke at 0330 and reported for duty at 0540. The first officer stated that he normally needed 7 hours of sleep each day to feel rested.

1.2.3 FedEx Captain

The FedEx captain, age 56, held an ATP certificate with a rating for multiengine land and type ratings on the Boeing 757, Boeing 767, Beech 400, McDonnell Douglas MD-11, Mitsubishi MU-300, and Learjet. His ratings on the MD-11 and Boeing 757 and 767 included the limitation that circling approaches were to be conducted in visual meteorological conditions only. The captain also held a flight engineer (turbojet powered) certificate and an FAA first-class medical certificate dated August 19, 2022, without any limitations. He was hired by FedEx in July 2002 and was based at MEM.

According to FedEx records and information that the captain provided, he had accumulated 23,500 total flight hours, 1,324 hours of which were on the Boeing 767 as pilot-in-command. He had flown 31 hours in the 30 days before the incident and 3 hours in the 24 hours before the incident. The captain's most recent recurrent training (continuing qualification maneuvers training with a line-oriented evaluation) occurred in October 2022.

On February 1, 2023, the captain awoke about 0600 Pacific standard time (PST). He had the day off and could not recall when he went to sleep. On February 2, the captain awoke at 0500 PST and flew from Sacramento International Airport, Sacramento, California, to MEM; the flight departed at 1856 PST and arrived at 0029 (central standard time) on February 3. He went to sleep between 0115 and 0130. The captain could not recall what time he awoke that day. He then flew from MEM to AUS with the incident first officer; the flight departed at 0521 and arrived at 0705. The captain stated that he napped during the day and then flew from AUS to

MEM; the flight departed at 2223 and arrived at 0004 on February 4. The captain could not recall when he went to sleep after the flight. The incident flight departed from MEM at 0430. The captain stated that he needed between 5 and 6 hours of sleep to feel rested.

1.2.4 FedEx First Officer

The FedEx first officer, age 49, held an ATP certificate with a rating for airplane multiengine land; commercial privileges for airplane single-engine land; and type ratings on the Boeing 757, Boeing 767, and Embraer EMB-505. His type ratings for the Boeing 757 and 767 included the limitation that circling approaches were to be conducted in visual meteorological conditions only. The first officer was also a flight instructor with airplane single- and multiengine ratings, and he had commercial glider and instrument airplane endorsements. He held an FAA first-class medical certificate dated November 10, 2022, with the limitation that he must wear corrective lenses. The first officer was hired by FedEx in January 2019 and was based at MEM.

According to FedEx records and information that the first officer provided, he had accumulated 465 flight hours at FedEx, all of which were as a Boeing 767 first officer. During his postincident interview, the first officer reported a total flight time (military and civilian) of about 4,500 hours. He had flown 45 hours in the 30 days before the incident and 3 hours in the 24 hours before the incident. The first officer's most recent training (initial training on the Boeing 767 and initial operating experience) occurred in July 2022.

On February 1, 2023, the first officer was off from work. He awoke at 0830 PST, took a 1-hour nap in the afternoon, and went to sleep at 0000 PST on February 2. He awoke at 0830 PST, napped for 1 1/2 hours in the afternoon, and flew with the incident captain from Sacramento to MEM; as previously stated, the flight departed at 1856 PST and arrived at 0029 (central standard time) on February 3. The first officer went to sleep between 0115 and 0130 and awoke at 0330 because he was scheduled to fly from MEM to El Paso International Airport, El Paso, Texas, that day. The first officer "timed out" for that flight due to delays for deicing. The first officer went to a local hotel after lunch and napped from 1445 to 1745. He went to sleep between 2115 and 2130 and awoke at 0050 on February 4 to report at 0230 for the incident flight. The first officer stated that he needed between 6 and 8 hours of sleep to feel rested.

1.3 Airplane Information

The SWA airplane, a Boeing 737-79P, was manufactured in 2003. It was powered by two CFM56-7B24 engines; each could produce 24,000 pounds of thrust. The airplane was 110 ft 4 inches long with a tail height of 41 ft 2 inches. The FedEx airplane, a Boeing 767-32LF, was manufactured in 2012.[18] It was powered by two General Electric CF6-80C2B6F engines; each could produce 60,200 pounds of thrust. The airplane was 180 ft 3 inches long with a tail height of 52 ft.

The SWA airplane was equipped with a Honeywell TCAS unit. The FedEx airplane was equipped with an Aviation Communication and Surveillance Systems TCAS unit.[19] According to the FAA's booklet "Introduction to TCAS II Version 7.1," dated February 28, 2011, TCAS provides collision avoidance protection independently of ground-based ATC systems.[20] TCAS II units provide traffic advisories, which assist a pilot in visually acquiring intruder aircraft, and resolution advisories, which are recommended escape maneuvers to either increase or maintain the vertical separation between aircraft. According to the FAA's TCAS II booklet, aural alerts are inhibited below 500 ft agl ±100 ft agl. Also, if TCAS determines that an intruder aircraft is on the ground, the system would inhibit advisories about that aircraft.

The sections that follow describe each airplane's TCAS unit. Data from both TCAS units were successfully downloaded, and the information from the downloads is also discussed in the sections that follow. It is important to note that TCAS was intended to prevent midair collisions and not runway incursions.

1.3.1 SWA Traffic Alert and Collision Avoidance System

The SWA *Flight Reference Manual B-737-700/-800* stated the following about TCAS:

> TCAS alerts the Crew to possible conflicting traffic. TCAS interrogates operating transponders in other airplanes, tracks the other airplanes by analyzing the transponder replies, and predicts the flight paths and positions. TCAS provides advisory and traffic displays of the other airplanes to the Flight Deck Crew….
>
> To provide advisories, TCAS identifies a three-dimensional airspace around the aircraft where a high likelihood of traffic conflict exists. The

[18] The Boeing 737-79P and 767-32LF are the specific airplane models within the 737-700 and 767-300 airplane series, respectively.

[19] Aviation Communication and Surveillance Systems is an L3Harris and Thales Company.

[20] TCAS II version 7.1 met the requirements of FAA Technical Standard Order TSO-C119c, Traffic Alert and Collision Avoidance System Airborne Equipment. Both airplanes had TCAS II version 7.1-compliant units.

dimensions of this airspace are based upon the closure rate with conflicting traffic.

TCAS equipment interrogates the transponders of other airplanes to determine their range, bearing, and altitude. A traffic advisory (TA) is generated when the other aircraft is approximately 40 seconds from the point of closest approach. If the other aircraft continues to close, a resolution advisory (RA) is generated when the other aircraft is approximately 25 seconds from the point of closest approach.[21] The RA provides aural warning and guidance as well as maneuver guidance to maintain or increase separation from the traffic.

The manual stated the following regarding traffic and resolution advisories:

TAs are indicated by the aural "TRAFFIC, TRAFFIC" which sounds once and is then reset until the next TA occurs. The TRAFFIC annunciation appears on the navigation display. The TA symbol appears at the proper range and relative bearing of the other aircraft.[22]

RAs are indicated by one or more aural [annunciations]…. The TRAFFIC annunciation and RA symbol which depicts the traffic's relative bearing, range, altitude, and vertical motion are on the navigation display.

The TCAS on the SWA airplane recorded a traffic advisory involving the FedEx airplane, which the SWA flight crewmembers discussed in their postincident statements and interviews. When the traffic advisory was recorded, the SWA airplane was at a pressure altitude of about 39 ft and was 0.86 nautical miles from the FedEx airplane. The TCAS also calculated that the SWA airplane was 332 ft below the FedEx airplane and that the vertical altitude between the airplanes was closing at a rate of 882 ft per minute. The TCAS showed that the FedEx airplane was at a relative bearing of -178° (indicating that the FedEx airplane was behind and slightly to the left of the SWA airplane). No resolution advisory was recorded because the airplane was below 1,000 ft agl at the time.[23] Honeywell stated that the TCAS unit operated as designed with no faults at the time of the incident.

[21] The SWA manual provided example times that might occur during flight operations. These times do not apply to this incident. Section 1.8.1 provides the results of TCAS simulations for this incident.

[22] Altitude and vertical motion can also be included with the traffic advisory symbol depending on the other aircraft's transponder mode.

[23] The minimum operational performance standards for TCAS II version 7.1 required resolution advisories to be inhibited below 1,000 ft agl ±100 ft agl.

1.3.2 FedEx Traffic Alert and Collision Avoidance System

The FedEx *B767 Flight Training Manual* stated that TCAS was "designed to enhance crew awareness of nearby traffic and issue advisories for timely visual acquisition or appropriate vertical flight path maneuvers to avoid potential collisions." The manual also stated that the system was "intended as a backup to visual collision avoidance, application of right-of-way rules and ATC separation."

The downloaded TCAS data from the FedEx airplane showed that no traffic advisories or resolution advisories were recorded from the SWA airplane, but further examination found that the data for the incident flight had been overwritten.[24] The FedEx flight crewmembers discussed, in their postincident statements and interviews, receiving a TCAS advisory about the SWA airplane.

1.4 Meteorological Information

AUS had a federally installed and maintained automated surface observing system (ASOS) that was augmented by certified contract weather observers to provide surface observations through hourly meteorological aerodrome reports and special weather reports as warranted.[25] A special weather report at 0618 (22 minutes before the incident) indicated the following: wind calm; visibility 1/4 mile; runway 36R RVR 1,800 ft, variable 2,400 ft; freezing fog; vertical visibility 200 ft agl; temperature -1°C; dew point temperature -1°C; and altimeter 30.43 inches of mercury.[26] A special weather report at 0647 (7 minutes after the incident) indicated the same conditions in the previous report except that the visibility had decreased from 1/4 to 1/8 mile.

[24] TCAS was not intended to be a recording device, and no regulatory requirements address the retention of TCAS event history.

[25] The primary ASOS sensors were located in a low-lying drainage basin for a small waterway that was south of the airport. As a result, the reported overnight low temperature during the winter months under a clear sky could be up to 10°F colder at AUS than at a US Army Reserve heliport located 10 miles away.

[26] (a) For reported RVR values, "variable" describes the average 10-minute minimum and maximum values for a designated runway. Although RVR values for runway 36R were included in the observation, the RVR values provided by the controller for runway 18L were considered to be controlling because they were based on readings from visibility sensors or transmissometers every 45 seconds. (b) Fog comprises water droplets suspended in the air at the earth's surface and is reported when visibility is less than 5/8 mile. Freezing fog occurs when the water droplets freeze upon contact with exposed objects and form a coating of rime ice or glaze. Freezing fog is reported when visibility is less than 5/8 mile, the temperature is below 0°C, and the dew point is less than 2°C.

The NWS issues terminal aerodrome forecasts to provide the expected meteorological conditions within 5 statute miles of the center of an airport's runways for a specified time period (usually 24 hours). The terminal aerodrome forecast issued for AUS at 0552 on the day of the incident indicated light and variable wind at 2 knots, visibility of 1/2 mile in fog, scattered clouds at 200 ft agl, and a temporary period between 0600 and 0800 with a broken ceiling at 200 ft agl. The amended terminal aerodrome forecast issued for AUS at 0619 expected light and variable wind, visibility of 1/2 mile in fog, scattered clouds at 200 ft agl, and a temporary condition between 0600 and 0800 with a visibility of 1/4 mile in fog and a broken ceiling at 200 ft agl.

The NWS also issues in-flight advisories to notify pilots about the possibility of hazardous flying conditions that may not have been forecast at the time of a preflight briefing. The NWS Houston Center Weather Service Unit issued a center weather advisory at 0457, which was valid through 0700 for low instrument flight rules (IFR) conditions over the region (including AUS) with ceilings below 500 ft agl and visibilities at or below 1/2 mile in fog.[27] In addition, the NWS Aviation Weather Center issued a graphical AIRMET (airmen's meteorological information) that was valid at the time of the incident for a large area of IFR conditions over Texas, including the incident location.

According to astronomical data, civil twilight in Austin on the day of the incident began at 0655 (15 minutes after the incident), and sunrise occurred at 0720. NWS climate data showed that the Austin area has between 20 and 25 days of dense fog during the winter months each year.

1.5 Airport Information

AUS was located about 5 miles southeast of downtown Austin. The airport had two paved landing surfaces, which were designated as 18R/36L and 18L/36R. The incident runway,18L/36R, was 9,000 ft long and 150 ft wide. The ATCT was 3,700 ft from the approach end of runway 18L, as shown in figure 3. The airport's ATCT operated 24 hours each day. At the time of the incident, the ATCT did not have

[27] "Low IFR conditions" is defined as a ceiling below 500 ft agl or a visibility less than 1 statute mile.

surface detection technology, such as airport surface detection equipment, model X (ASDE-X).[28]

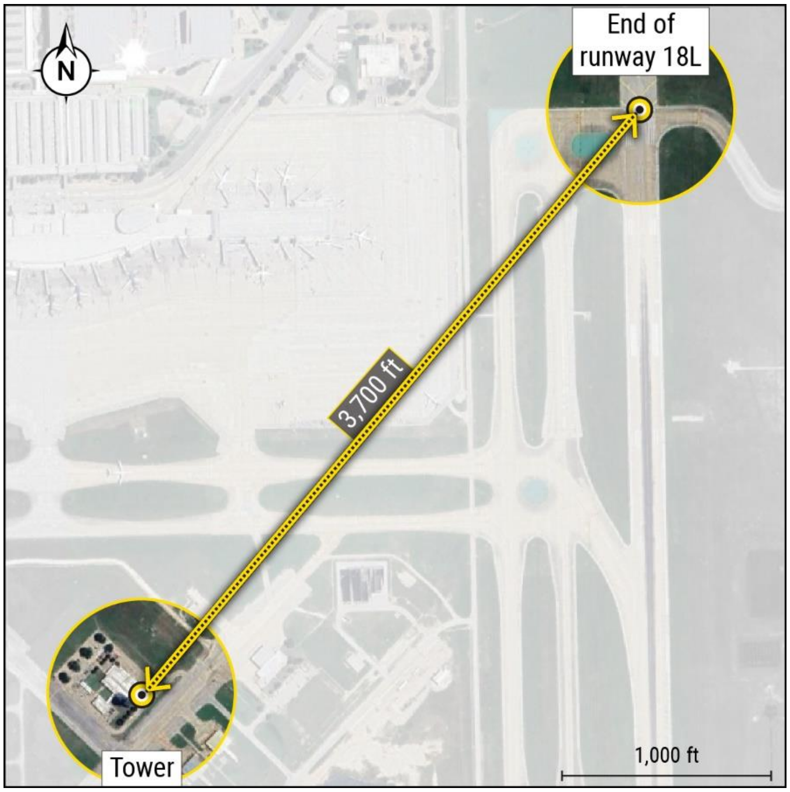

Figure 3. Distance between AUS ATCT and approach end of runway 18L.

1.5.1 Air Traffic Control Facility Staffing

According to the FAA, the ATCT at AUS was authorized to have 1 air traffic manager, 1 operations manager, 6 operations supervisors, and 42 certified controllers. As of the date of the incident, the ATCT had 1 air traffic manager, 3 operations supervisors (a fourth supervisor assigned to the tower was on an assignment outside the facility), 33 fully certified controllers, and 5 controllers in training. The operations manager position was vacant. As of January 17, 2024, the ATCT had 1 operations manager, 1 air traffic manager, 5 operations supervisors, 33 fully certified controllers, and 10 controllers in training.

[28] According to the FAA, ASDE-X is a surveillance system that allows air traffic controllers to track surface movement of aircraft and vehicles and alerts controllers about potential runway conflicts. ASDE-X is no longer being manufactured because of the cost to install and maintain this system. The FAA plans to continue maintaining the system only at ATC facilities where it is already installed.

At the time of the incident, one controller and one operations supervisor were working in the tower cab.[29] The controller was working the local control west and local control east positions, which were combined.[30] The operations supervisor was working the ground control west, ground control east, clearance delivery, and tower oversight positions, which were also combined.

1.5.2 Local Controller

The controller, age 43, began working for the FAA in 2010 and worked as a controller at several ATC facilities before transferring to AUS in March 2019.[31] The controller became fully certified on all tower positions at AUS in July 2019 and could work them under general supervisory oversight without being directly monitored. The controller held an air traffic control specialist medical clearance, dated January 4, 2023, with a waiver for obstructive sleep apnea treated with a continuous positive airway pressure (CPAP) machine. Section 1.7 discusses the controller's CPAP use.

The controller was off from work on February 1 and 3, 2023. The controller stated that he awoke at 0530 on February 2. The facility personnel log for that day indicated that the controller worked a day shift from 0645 to 1445. The controller also stated that he went to sleep at 0000 on February 3, awoke between 1100 and 1200, and went to sleep between 2030 and 2100. The time that the controller awoke on February 4 is unknown, but the controller reported that he "felt fine" that day. The controller also reported that he needed 6 hours of sleep to feel rested and that he normally slept between 6 and 8 hours each night.

[29] A Memorandum of Understanding between the National Air Traffic Controllers Association and the FAA described the basic watch schedule at the AUS ATCT from January 1, 2023, to January 13, 2024. The memorandum showed that the ATC facility (which was a combined ATCT/Terminal Radar Approach Control) was expected to be staffed with 11 controllers during the day shift. The supervisor on duty or the air traffic manager had the discretion to decide how to distribute the controllers (based on traffic and workload) during each shift, consistent with FAA Order 7210.3CC, Facility Operation and Administration, chapter 2, section 5, dated June 17, 2021 (which was in effect on the date of the incident). At the time of the incident, the tower would have been in the mid-watch hour configuration, which required two controllers in the ATC facility, one of whom was required to be in the tower cab with all tower positions combined.

[30] The controller monitored air traffic from his tower display workstation, which included a NAS (National Airspace System) information display system that showed traffic, weather, and surveillance data of en route aircraft.

[31] The other ATC facilities where the controller worked were Champaign, Illinois; Fayetteville, North Carolina; Chicago, Illinois, Terminal Radar Approach Control; and South Bend, Indiana.

Examination of the controller's cellular telephone records showed activity (phone calls and text messages) between 0603 and 1931 on February 1, between 1559 and 2228 on February 2, and between 1130 and 1529 on February 3. The records showed no activity on the day of the incident until 1251.

The controller was scheduled to work an 8-hour overtime day shift on the day of the incident.[32] The controller explained that, due to staffing shortages, ATCT personnel at AUS were scheduled for "mandatory six-day work weeks."

During a postincident interview, the controller reported that he and the operations supervisor had told departing flight crews to report when their airplanes were "holding short" and that "when they got to the [approach] end, they [were] holding short." The ATC recordings provided no evidence supporting the controller's statement. The controller also reported that the SWA flight "looked to be a safe operation" but recognized that a problem existed when the FedEx airplane was on a 2-mile final approach and he "didn't hear anything from Southwest." The controller explained that, during low-visibility conditions, he would listen for engine sounds to determine whether an aircraft was beginning its takeoff roll, but he did not hear such sounds associated with the SWA departure.

The controller stated that, if he had instructed the FedEx airplane to go around when it was inside 2 miles, the SWA airplane could have been rotating, which would have made the situation "even worse." The controller also stated that he "definitely could have held" the SWA airplane because "there was no pressure to expedite" the departure.

The controller reported that he had worked in low-visibility conditions such as those during the incident "a handful of times" but that none of those instances occurred during the year preceding the incident.[33] The controller also stated that he expected that the flight crews of all airplanes departing AUS on the morning of the

[32] The facility personnel log for that day showed that the controller's shift ended at 1338, but the controller and the operations supervisor were relieved from their positions by other controllers located in the facility about 0657, which was 17 minutes after the incident occurred.

[33] The NTSB reviewed the ATCT weather records and the controller's work schedule during the 45 days before the incident. This review showed that the controller had not worked any shifts during that timeframe with low-visibility conditions reported. The operations supervisor during the incident shift stated that the fog that occurred was "pretty rare" for AUS.

incident would report their positions (during their takeoff clearance request) as "holding short" of the runway.[34]

In addition, the controller described his experience with SWA departures during the time that he had worked at the AUS ATCT. He stated that SWA was the "most ready carrier" at AUS and that "when they [SWA pilots] call ready…they're actually holding short and they're ready. You give them the traffic and they go." The controller mentioned that he did not have the same expectation for other air carriers operating at AUS given his experience handling those carriers.

The controller noted that the AUS ATCT "could definitely use" more personnel but that ASDE-X was the "one thing" that could have mitigated this situation. The controller explained that, with ground radar, "you can see where the plane is. You can see what the plane is actually doing on the radar as opposed to making an educated guess."

The controller's supervisor (who was not the operations supervisor during the incident shift) discussed the circumstances of this incident with the controller after the event. The Performance Record of Conference, which summarized the discussion, showed that the supervisor advised the controller about actions that he could take to prevent a recurrence, including providing more space between aircraft during low-visibility conditions. The supervisor also advised the controller that "without ground radar it is extremely difficult to know exactly where an aircraft is on the ground or how fast they are moving."

1.5.3 Postincident Interviews of Operations Supervisor and Air Traffic Manager

The operations supervisor stated that she became aware of the incident when she saw the controller "stand up and start looking out" the window and that she then "looked over" and "saw [the] FedEx [airplane] climb out of the clouds and turn left." Afterward, the supervisor asked the controller what happened, and he said that the SWA airplane "never rolled."[35] The supervisor subsequently notified the air traffic manager at the ATCT, who was not in the tower at the time of the incident.

[34] ATC recordings showed that the flight crews of 9 of the 10 airplanes that departed AUS before the SWA flight used similar phraseology to request takeoff clearance. (The phraseology that one flight crew used was not available.) For example, one of the nine flight crews stated, "Ready for takeoff one eight left," and another flight crew stated, "We'll be ready at one eight left." ATC recordings also showed that flight crews of 5 of the 10 previous departures included the term "holding short" in their takeoff clearance requests.

[35] See sections 1.1 and 1.8.2 for information about the SWA airplane's takeoff roll.

The air traffic manager stated that he was notified about the event by a text message about 0715. The air traffic manager then called the operations supervisor, who reported that the controller had "tried to get a departure out in front of [an] arrival" and that a SWA flight crewmember said that "he aborted his takeoff."[36] The air traffic manager stated that he did not understand "the gravity of the situation" until he reviewed information about the incident.

The air traffic manager stated that he notified FAA district office management about the "significant event." Afterward, a teleconference was held, during which managers assessed the air traffic services associated with the event. According to FAA Order JO 1030.3B, Initial Event Response, such teleconferences can include discussions about staffing levels, weather, training, and any unusual circumstances pertaining to the event.

The air traffic manager noted that the controller was a "good guy" but that he had used "really poor judgment" in deciding to have the SWA airplane depart before the FedEx airplane arrived. The air traffic manager stated that "any type of surface surveillance with safety logic would have prevented" the incident because the technology would have produced an alarm in the tower cab to alert the controller that an aircraft would be landing on a runway that was still occupied by another aircraft.

The air traffic manager was also the training administrator at the ATCT. Training records showed that the incident controller had completed his training assignments through the end of calendar year 2022, but the air traffic manager stated that other ATCT personnel had refresher training items that were not completed.[37] The air traffic manager explained that some controller training had not been accomplished because of staffing issues at the ATCT; he added that "six-day work weeks can take a toll."

The air traffic manager indicated that the ATCT's refresher training was insufficient because the tower had not conducted, during the 2 years that he had been at AUS, training on low-visibility operations or the airport's Surface Movement

[36] As stated in section 1.1, ATC information showed that a FedEx flight crewmember told the SWA flight crew to abort the takeoff, and the SWA captain's postincident statement indicated that he knew of no reason (at the time) to abort the takeoff.

[37] The training records that the NTSB reviewed shortly after the incident showed that, as of the second quarter of calendar year 2022, the controller was missing 24 required training items. During a postincident interview, the controller stated that he had finished the training but that the facility had not documented the training as complete. Training records that the NTSB subsequently reviewed showed that the incident controller had completed the 24 training items during the third and fourth quarters of calendar year 2022.

Guidance and Control System (SMGCS) plan.[38] (See section 1.5.4 for more information about this plan.) The air traffic manager stated that the tower was "remedying that right now." (See section 1.10.4 for more information about this effort.) The air traffic manager indicated that this effort would ensure that "tower personnel are doing things we absolutely should be doing."

1.5.4 Surface Movement Guidance and Control System

FAA Advisory Circular (AC) 120-57B, which was issued on August 25, 2020, stated that a low-visibility operations/SMGCS plan "facilitates the safe movement of aircraft and vehicles on the airport by establishing…rigorous control procedures and requiring enhanced visual aids" for safely moving aircraft and vehicles on airport surfaces.[39] The AC described the standards for a SMGCS plan and provided guidance to develop the plan. Although SMGCS is a voluntary program for airports certificated under 14 *CFR* Part 139, the FAA encourages those airports to establish a SMGCS plan.

The AUS ATCT and the City of Austin Department of Aviation entered into a letter of agreement (LOA) regarding the movement of aircraft and vehicles on the airfield when visibility (the RVR) was reported to be less than 1,200 ft. The LOA, which became effective on December 9, 2013, stated that both the City of Austin Department of Aviation and the AUS ATCT were "responsible for implementing the jointly developed SMGCS Plan" in accordance with AC 120-57B.

The SMGCS plan for AUS was initially issued on June 10, 2013. (The plan was revised four times before the incident, with the latest revision dated September 30, 2021.) The SMGCS plan specified that ATC would notify airport operations "when decreasing ceiling and visibility conditions indicate that visibility less than 1200 feet RVR is imminent and that SMGCS procedures are going into effect." The LOA stated that ATC "must notify Airport Operations when conditions indicate that visibility will

[38] FAA Order 3120.4R, Air Traffic Technical Training, dated October 30, 2020, stated that refresher training was a part of proficiency training, which is conducted "to maintain and update the knowledge and skills necessary to apply ATC procedures in a safe and efficient manner." The order further stated that "all operational personnel must complete refresher training." In addition, the order stated that "each facility must develop a written annual Refresher Training plan and conduct the planned training throughout the calendar year." Among the topics that the order included for refresher training were "weather" and "tower visibility." The order required "at least two items from each topic…with a focus on items indicated by a review of local quality control data."

[39] AC 120-57B also stated that "most airports authorized for Category II/III operations already have most of the basic airport signing, lighting and marking required under a SMGCS plan. The additional requirements contained in this AC are designed to enhance the safety of low visibility operations."

decrease to and remain less than 1200 feet RVR," but the LOA did not specifically state that ATC needed to implement the SMGCS plan at that point. Airport operations was then responsible for notifying air carriers operating at the airport (among others) that SMGCS procedures were in effect.

According to the AUS SMGCS plan, ATC was responsible for ensuring that the airport's automatic terminal information system (ATIS) broadcasts stated that the plan was in effect. Because AUS did not have ASDE equipment, the SMGCS plan noted (in section 3.7 of the plan) that the ATCT used position reporting (that is, a report from a known location that an aircraft transmits to ATC) when taxiing aircraft were not visible from the tower.[40] ATC would terminate SMGCS procedures when the prevailing visibility was such that the procedures would no longer be needed.

In addition, the SMGCS plan also stated that, when the plan is in effect, "all departures will be directed to Runway 18L unless RVR values for 18R exceed 1,600 feet" and that "all landings during low visibility will be conducted on Runway 18L." The plan further stated that "only runway 18L will be served by SMGCS taxi routes," which are "a specific sequence of lighted taxiways used by aircraft during low visibility operations."[41] The plan noted that runway 18L was "the preferred calm wind runway during low visibility conditions" and that the runway was equipped with a category III instrument landing system (ILS), a high-intensity approach lighting system with sequenced flashing lights, high-intensity runway edge lighting, centerline lighting, and touchdown zone lighting.

During a postincident interview, the controller was unable to provide details regarding the content of the SMGCS plan or ATC responsibilities during SMGCS operations. (The controller added that AUS was the first ATC facility that he worked with a SMGCS plan.) The controller could not recall but stated that he was "pretty sure" that he had received training on the SMGCS plan when he began work at the ATCT and that he had not received any training on the plan since that time.[42] The

[40] AC 120-57B stated that "the FAA ground controller may use ASDE or pilot position reports to monitor the aircraft position prior to its entry into the movement area. The controller will then provide taxi instructions and traffic advisories appropriate to the route." Version B of the AC also stated that "ATC may require periodic position reports along the taxi route to confirm or supplement ASDE-3 information." Version C of the AC, which was issued on September 26, 2023, did not reference position reports. It is important to note that, when the SWA flight crew reported that the airplane was "short of one eight left," the crew was requesting takeoff clearance and was not providing a position report.

[41] The plan stated that "pilots conducting low visibility operations at AUS are required to have a copy of the low visibility taxi route chart" as "depicted on appropriate commercially available charts."

[42] The AUS ATCT's initial training on low-visibility operations included an overview of the SMGCS plan. Records indicated the incident controller successfully completed this training in 2019.

ATCT did not provide, and was not required to provide, recurrent training to personnel regarding low-visibility operations and SMGCS.[43]

During the incident shift, the operations supervisor was responsible for activating the SMGCS plan. The operations supervisor stated that she was "familiar" with the 1,200-ft RVR requirement in the SMGCS plan but could not recall a time when the plan was activated. The supervisor explained that she had not "officially" activated the SMGCS plan during the incident shift because "the RVR was not consistently below 1,200 [ft]" but that the airfield lights (including the runway centerline and edge lights and the taxiway lights) were turned up, and she was using the taxi route instructions in the SMGCS plan.

During a postincident interview, the air traffic manager stated his expectation that the SMGCS plan would be activated whenever any sensor (touchdown, midpoint, or rollout) indicated an RVR below 1,200 ft.[44] Table 1 shows the RVR values that the local controller provided to flight crews of airplanes departing from runways 18L and 18R on the morning of the incident.

Table 1. Controller-provided RVR values to departing airplanes.

Time	Touchdown RVR value (ft)	Midpoint RVR value (ft)	Rollout RVR value (ft)
0548:36	1,000	1,400	1,800
0553:50	1,200	1,200	1,200
0556:17	1,800	1,200	1,200
0559:30	1,600	1,600	1,200
0609:04	1,600	N/A	2,000
0611:35	1,200	2,000	1,400
0613:00/0615:26 (same departure)	2,800/2,400	N/A	1,600/1,600
0617:01	1,200	1,200	1,200
0622:54	2,400	800	1,600
0628:41	1,200	N/A	1,600
0638:47 (incident flight)	1,200	1,400	600

Note: All reported RVR values were for runway 18L except for those reported at 0609:04, 0613:00/0615:26, and 0628:41; those values were for runway 18R, which did not have a midpoint sensor. At 0634:14, the controller provided the FedEx flight crew with the following RVR values for runway 18L: touchdown 1,400 ft, midpoint 600 ft, and rollout 1,800 ft.

[43] The AUS ATCT included, in a June 2022 PowerPoint presentation that was used during initial tower qualification training to prepare controllers for on-the-job training, two slides that showed the departure and arrival taxi routes when the airport's SMGCS plan was in effect.

[44] The air traffic manager also stated that "a good number of people" at the ATCT did not know that SMGCS plan activation needed to be included in ATIS broadcasts.

1.5.5 Air Traffic Control Procedures

FAA Order JO 7110.65Z, Air Traffic Control, paragraph 1-1-10, Procedural Letters of Agreement, stated that LOAs supplement the requirements contained in the order. Paragraph 2-1-1, ATC Service, stated that "controllers must provide air traffic control service in accordance with the procedures and minima in this order.... Other procedures/minima are prescribed in a letter of agreement, FAA directive, or a military document."[45]

FAA Order 7110.65Z, paragraph 3-1-7, Position Determination, stated that a controller should "determine the position of an aircraft, personnel or equipment before issuing taxi instructions, takeoff clearance, or authorizing personnel, and/or equipment to proceed onto the movement area." The paragraph noted that "when ATC is unable to determine position visually or via a display system, position reports may be used."

FAA Order 7110.65Z, paragraph 3-7-2, Taxi and Ground Movement Operations, stated that controllers, when authorizing an aircraft to taxi or a vehicle to proceed on the movement area, should "specify the taxi instructions/route. If it is the intent to hold the aircraft/vehicle short of…a runway: issue the route up to the runway hold short point." The paragraph also stated the following:

> When authorizing an aircraft to taxi to an assigned takeoff runway, state the departure runway followed by the specific taxi route. Issue hold short instructions…when an aircraft will be required to hold short of a runway or other points along the taxi route.

Paragraph 3-7-2 further stated that a controller should "issue progressive taxi/ground movement instructions when…necessary during reduced visibility, especially when the taxi route is not visible from the tower." The paragraph noted that progressive taxi instructions could include step-by-step directions. The Pilot/Controller Glossary in FAA Order 7110.65Z defined progressive taxi instructions as "precise taxi instructions given to a pilot unfamiliar with the airport or issued in stages as the aircraft proceeds along the taxi route."

FAA Order 7110.65Z, paragraph 3-10-3, Same Runway Separation, instructed a controller to "separate an arriving aircraft from another aircraft using the same runway by ensuring that the arriving aircraft does not cross the landing threshold until…the other aircraft has departed and crossed the runway end." Paragraph 5-8-4 of the order, Departure and Arrival, stated that controllers are to "separate a departing

[45] Version Z of the order was dated June 17, 2021. The latest iteration of the order, version AA, was dated April 20, 2023.

aircraft from an arriving aircraft on final approach by a minimum of 2 miles if separation will increase to a minimum of 3 miles (5 miles when 40 miles or more from the radar antenna) within 1 minute after takeoff."

> Paragraph 5-8-4 also noted the following:
>
> 1. This procedure permits a departing aircraft to be released so long as an arriving aircraft is no closer than 2 miles from the runway at the time. This separation is determined at the time the departing aircraft commences takeoff roll.
>
> 2. Consider the effect surface conditions, such as ice, snow, and other precipitation, may have on known aircraft performance characteristics, and the influence these conditions may have on the pilot's ability to commence takeoff roll in a timely manner.

1.6 Flight Recorders

Both airplanes were equipped with FDRs that recorded at least 25 hours of data, as required by federal regulation. The FDR recording from the SWA airplane contained about 27 hours of data, including the entire duration of the incident flight. The FDR recording from the FedEx airplane contained about 57 hours of data, including the entire duration of the incident flight.

Both airplanes were also equipped with 2-hour CVRs, as required by federal regulation. The SWA flight from AUS arrived at CUN at 0947 EST (flight time 2 hours 28 minutes), so the CVR was overwritten before it could be quarantined for download. After landing at AUS at 0705, the FedEx airplane was on the ground with the engines running until 0823, at which time the airplane departed for MEM. The flight arrived at 1007 (3 hours 2 minutes after landing at AUS); thus, the CVR installed in the FedEx airplane was also overwritten before it could be quarantined.

1.7 Medical and Pathological Information

During the controller's September 2021 aviation medical examination, he reported the possibility of obstructive sleep apnea and noted that he was scheduled for a home sleep study. The sleep study, which was conducted in November 2021, found that the controller had mild obstructive sleep apnea. As a result, in December 2021, the FAA temporarily withdrew the controller's medical clearance. The controller began treatment with a CPAP machine. Subsequently, the FAA reviewed records related to the controller's treatment and, in March 2022, reinstated his medical clearance.

During the controller's next aviation medical examination, he provided the FAA with a CPAP use report covering the 90 days between September and December 2022. The controller also provided a December 2022 letter from his sleep medical care provider, which noted the controller's "excellent" CPAP adherence with 100% usage and an average use of 6 hours 9 minutes per day as well as "excellent" control of his obstructive sleep apnea.[46] On January 4, 2023, the FAA issued the controller a medical clearance with a waiver for obstructive sleep apnea treated with a CPAP machine; the clearance was valid through September 2023.

According to the 30-day record of his CPAP use between January 6 and February 5, 2023, the controller used his CPAP machine every day with an average use of 6 hours 51 minutes per day. Between January 28 and February 4, 2023 (the week before the incident), the controller used his CPAP machine every day with an average use of about 7 hours per day. The controller used his CPAP machine for about 3.5 hours during the overnight hours before the incident work shift.

The controller underwent employee postincident urine drug testing on the day after the incident as part of the Department of Transportation's federal workplace drug testing program. No tested-for substances (marijuana metabolites, cocaine metabolites, amphetamines, opioids, and phencyclidine) were detected. The controller did not undergo postincident alcohol testing.[47] None of the pilots underwent postincident drug or alcohol testing.[48]

1.8 Tests and Research

1.8.1 TCAS Simulations

Honeywell performed a simulation that used FDR data from both airplanes as inputs to its simulation model to determine the outputs for the SWA airplane's TCAS

[46] The FAA generally considers the target goal for effective CPAP treatment to be (1) use on at least 75% of days and (2) use for an average of at least 6 hours per day on days that the CPAP is used.

[47] In response to NTSB queries, the FAA provided documentation regarding controller testing. This documentation included an FAA email request to "please test" the local controller. The email, which was dated February 4, 2023 (the day of the incident), was sent more than 8 hours after the incident. According to Department of Transportation Order 3910.1D, Drug and Alcohol-Free Departmental Workplace Program, if a required postaccident or postincident alcohol test is not conducted "within 8 hours following the accident or incident," all attempts to conduct an alcohol test "must cease."

[48] The runway incursion and overflight event did not meet the definition of an accident under 14 *CFR* Part 120, Drug and Alcohol Testing Program, which applies to (among others) all air carriers and operators authorized to conduct operations under Part 121.

unit. The simulation showed that the SWA and FedEx airplanes likely came within about 216 ft of each other at their closest point. The simulation also showed that the SWA airplane received a visual traffic advisory about the FedEx airplane (with no aural annunciation) about 0640:02, which is when the FedEx airplane would have been about 6,400 ft behind and 400 ft above the SWA airplane. Further, Honeywell's simulation showed that the FedEx airplane likely entered the SWA airplane's near-midair-collision zone (two aircraft within 100 ft vertically and 500 ft horizontally) about 0640:33. Resolution advisories would have been inhibited on both airplanes at this time because both were below an altitude of 1,000 ft agl.

Aviation Communication and Surveillance Systems performed a TCAS simulation to determine the outputs for the FedEx airplane's TCAS unit. With the use of Flightradar24 data for position and timing, the TCAS manufacturer calculated that a visual traffic advisory (with no aural annunciation) would have been expected from the time that the SWA airplane's TCAS first transmitted an airborne status (about 0640:40) to the time that the vertical separation between the SWA and FedEx airplanes was greater than 850 ft (about 0641:04). The traffic advisory would have remained displayed for an additional 8 seconds; the TCAS unit installed on the FedEx airplane does not downgrade a potential threat to other traffic status until the advisory has been inactive for 8 seconds.

1.8.2 NTSB Aircraft Performance Study

The National Transportation Safety Board (NTSB) conducted an aircraft performance study to determine the separation between the SWA and FedEx airplanes at different times during the incident sequence. The study considered FDR and ADS-B data, ATC times and transmissions, and the weather conditions at the airport.

Two sets of airplane separation calculations were made as part of this study; both sets of calculations reflected the location of each airplane's GPS antenna.[49] The airplanes' altitudes were corrected so that, when the airplanes were on the ground, their altitudes would reflect the height of the radio altimeter.[50] One set of calculations

[49] For the Boeing 737 (the SWA airplane), the radio altimeter is on the underside of the airplane about 20 ft aft of the nose, and the GPS antenna is on the top of the airplane about 33 ft aft of the nose. For the Boeing 767 (the FedEx airplane), the radio altimeter is on the underside of the airplane about 20 ft aft of the nose, and the GPS antenna is on the top of the airplane about 44 ft aft of the nose.

[50] The radio altimeter on the Fed Ex airplane recorded a radio altitude of -7 ft when the airplane was on the ground (after the second approach to the airport), which was corrected to 9.5 ft agl. The SWA airplane's radio altitude was -5 ft when the airplane was on the ground, which was corrected to 3.5 ft agl.

consisted of the recorded GPS location and radio altimeter altitude as a single point for each airplane, and the distance between each point was determined.[51] The other set considered that information along with the geometry of both airplanes, and the separation between the bodies of the airplanes was determined.[52] The NTSB notes that GPS position data have an accuracy of about 65 ft both horizontally and vertically and that some of the study's calculated separation distances are less than the GPS uncertainty.

1.8.2.1 Performance Study Results

When the controller cleared the SWA airplane for takeoff on runway 18L, the FedEx airplane was 3.9 miles from the runway 18L threshold, and the SWA airplane was 400 ft from the hold-short line. (As previously stated, the FedEx airplane was the first arrival of the day at AUS.) When the SWA flight crew acknowledged the takeoff clearance, the FedEx airplane was 3.3 miles away, and the SWA airplane was 180 ft from the hold-short line. The FedEx airplane was traveling at a groundspeed of 126 knots and was 1 minute 15 seconds away from crossing the runway 18L threshold.

When the FedEx flight crewmembers asked the controller to confirm that their airplane was cleared to land on runway 18L, the FedEx airplane was 2.6 miles and 59 seconds from the runway threshold. When the controller confirmed that the FedEx airplane was cleared to land and advised the FedEx flight crew of the departing Boeing 737, the SWA airplane had just reached runway 18L. Four seconds after the FedEx crew acknowledged the controller's transmission, the FedEx airplane was 2 miles from the runway threshold at an altitude of 650 ft agl and a groundspeed of 137 knots; the SWA airplane was 50 ft beyond the runway threshold.

When the SWA flight crew stopped the airplane on the runway so that the crew could begin the engine run-up, the FedEx airplane was 33 seconds from the runway threshold and 8,000 ft from the SWA airplane. When the SWA airplane began its takeoff roll, the FedEx airplane was 3,400 ft from the SWA airplane, as shown in

[51] The air separation was calculated between the airplanes' altitudes, and the ground separation was calculated between the GPS locations; the total separation in the air and on the ground was the total distance between those points and the GPS location/radio altimeter altitude single point.

[52] The top of the Boeing 737 tail is more than 37 ft above the radio altimeter and 73 ft aft of the GPS antenna. The pitch angle of the Boeing 767 affected how much lower its empennage was compared with its radio altimeter altitude. (Landing gear height for the Boeing 767 was not considered for this calculation.) The air separation was the distance between the lowest part of the Boeing 767 and the top of the tail of the Boeing 737. The ground separation was the distance between the nose of the Boeing 767 and the tail of the Boeing 737.

figure 4. The FedEx airplane was at an altitude of 270 ft agl, had a groundspeed of 140 knots, and was 14 seconds from the runway threshold.

Figure 4. FedEx and SWA airplane positions at the beginning of the SWA airplane's takeoff roll.

Note: The sizes of the FedEx and SWA airplanes in this figure are scaled according to the dimensions of each airplane. The FedEx airplane was 3,400 ft from the SWA airplane at this time.

When the FedEx airplane was less than 3 seconds from crossing the runway threshold, the airplane descended below 200 ft agl, and both airplanes were within 0.25 miles of each other. When the FedEx flight crew initiated the missed approach, the airplane was 150 ft beyond the runway 18L threshold at an altitude of 70 ft agl and a groundspeed of 138 knots, as shown in figure 5. The figure also shows that the SWA airplane was 1,020 ft down the runway as the airplane traveled at a groundspeed of 67 knots. At that time, the horizontal separation (from the nose of the FedEx airplane to the tail of the SWA airplane) was 870 ft, and the vertical separation (from the lowest point of the FedEx airplane to the top of the SWA airplane's tail) was 13 ft.

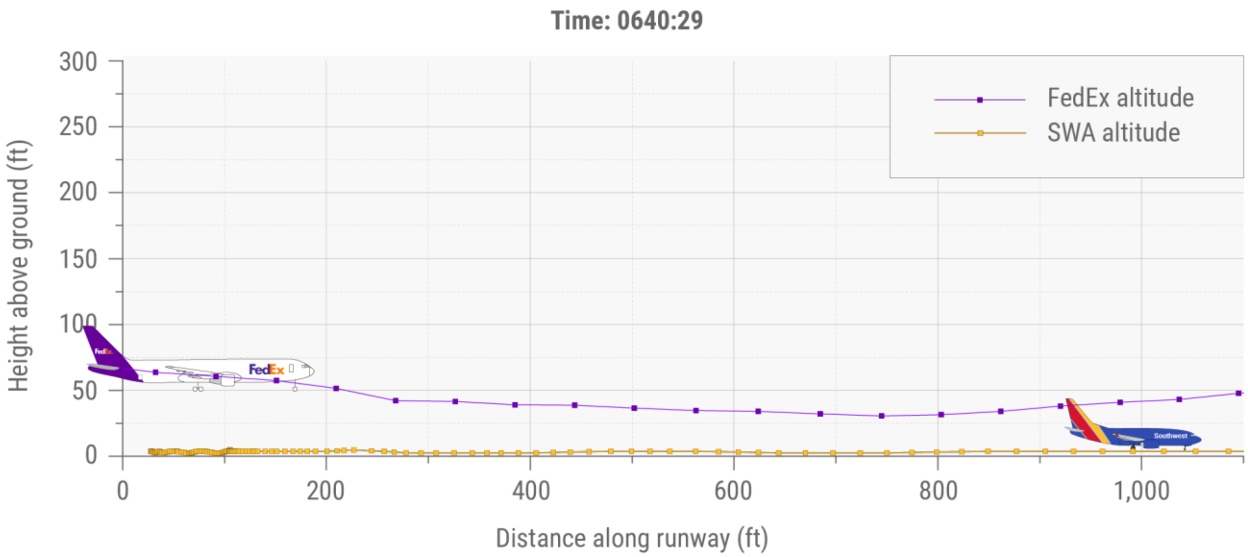

Figure 5. FedEx and SWA airplane positions when the FedEx airplane began the missed approach.

Note: The sizes of the FedEx and SWA airplanes in this figure are scaled according to the dimensions of each airplane.

The FedEx airplane continued to descend for 2.5 seconds before beginning to climb. When the FedEx flight crew transmitted "Southwest abort," the FedEx airplane had reached its lowest corrected altitude–31 ft–and was 750 ft down the runway. At that time, the SWA airplane's groundspeed was 78 knots, and the airplane was 1,350 ft down the runway. The horizontal separation between the airplanes was 480 ft, and the FedEx airplane was lower than the top of the SWA airplane's tail.

When the airplanes were at their closest point during the incident sequence, the FedEx airplane was 2,020 ft down the runway and was climbing through 190 ft at a rate of 2,000 ft per minute and a groundspeed of 138 knots, and the SWA airplane was 2,200 ft down the runway at a groundspeed of 100 knots. The separation calculation between the lowest forward point of the FedEx airplane and the highest aft point of the SWA airplane was about 115 ft; the separation between the SWA airplane's tail and the FedEx airplane's fuselage was between 150 and 170 ft. Figure 6 shows the airplanes' positions at that point.

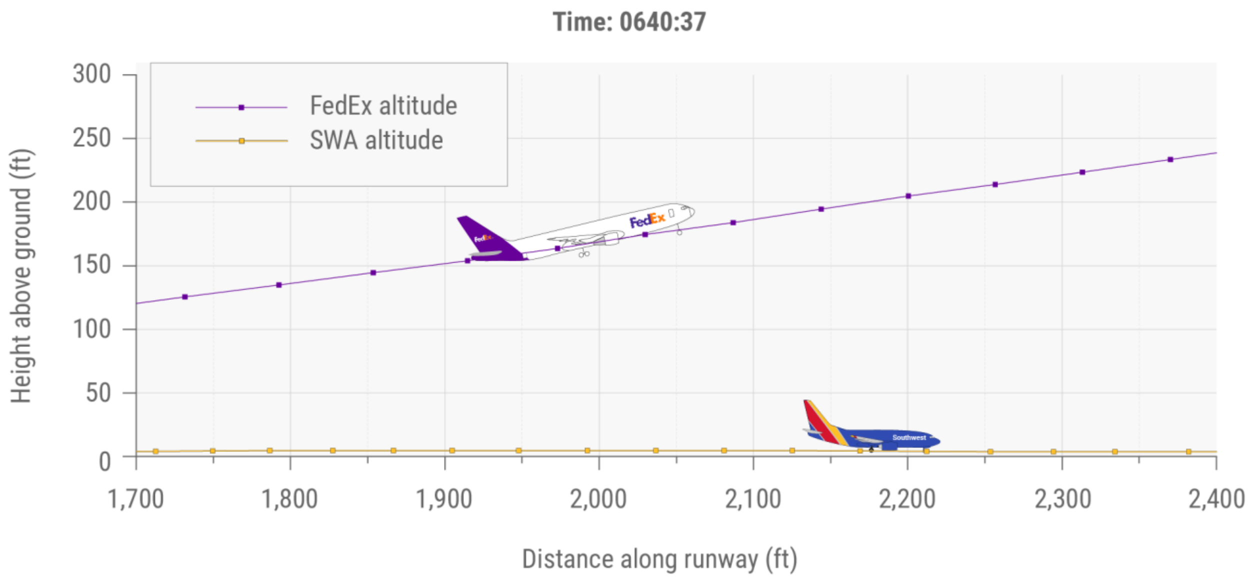

Figure 6. FedEx and SWA airplane positions when the airplanes were at their closest point.

Note: The sizes of the FedEx and SWA airplanes in this figure are scaled according to the dimensions of each airplane.

The SWA airplane rotated at an indicated airspeed of 142 knots. After main gear liftoff, the SWA airplane was 5,000 ft down the runway, and the FedEx airplane was 500 ft above it. The SWA airplane climbed at a rate of 1,400 ft per minute, and its groundspeed, which was increasing, was 7 knots faster than that of the FedEx airplane. The SWA flight crew noticed that a TCAS traffic advisory was active about this time.[53] The SWA airplane's climb decreased from 1,400 to 500 ft per minute. When the SWA airplane turned to the right of centerline, the airplane was 6,300 ft down the runway at an altitude of 80 ft, and the FedEx airplane was 6,200 ft down the runway at an altitude of 750 ft. The horizontal and vertical separation between the airplanes was 600 ft at this time.

The FedEx airplane crossed the departure end of runway 18L (the runway 36R threshold) at an altitude of 1,420 ft and then began a left climbing turn. The SWA airplane was at an altitude of 370 ft and was 500 ft beyond the departure end of the runway and 300 ft to the right of centerline. The FedEx airplane completed the left

[53] As stated in section 1.8.1, Honeywell's simulation of the SWA airplane's TCAS unit estimated that the traffic advisory would have occurred about 0640:02. The performance study calculated the time of the traffic advisory as 0640:07. Even with the 5-second difference between calculations, both showed that the TCAS advisory occurred before the SWA airplane rotated (0640:47).

turn, circled, and landed on runway 18L, and the SWA airplane completed its scheduled flight to CUN.

1.8.2.2 Departure Data on the Morning of the Incident

The SWA airplane was 550 ft from the hold-short line when the flight crew informed the controller that the airplane was short of runway 18L and ready to depart. The ADS-B data used in the performance study showed that, of the nine airplanes that departed before the incident departure (for which data were available), two of the airplanes were at the hold-short line at the time of their takeoff clearance request; the other seven departing airplanes were between 200 and 1,000 ft from the hold-short line, as shown in table 2.

Table 2. Comparison of data for departures on the morning of the incident.

Takeoff clearance time	Distance from hold-short line at time of crew's clearance request	Time from takeoff clearance to takeoff roll
0547:59	450 ft	1 minute 43 seconds
0553:50	0 ft	1 minute 29 seconds
0556:17	200 ft	0 minute 59 seconds
0559:43	0 ft	1 minute 22 seconds
0609:04	1,000 ft	1 minute 12 seconds
0611:35	600 ft	1 minute 51 seconds
0615:26	Not available	1 minute 2 seconds
0617:01	600 ft	1 minute 17 seconds
0622:54	450 ft	0 minute 49 seconds
0628:41	1,000 ft	Not available
0638:47 (incident flight)	550 ft	1 minute 20 seconds

Note: For this comparison, the takeoff roll was considered to be when the airplane's acceleration on the runway was greater than 5 knots per second. In addition to the incident flight, SWA operated the flights that were cleared for takeoff at 0556:17 and 0622:54.

As shown in table 2, the performance study also used information from the ATC recordings to compare the amount of time between the controller's clearance for takeoff and the takeoff roll. The times varied from 49 seconds to 1 minute 51 seconds; the time for the incident flight was 1 minute 20 seconds. For the nine flights for which data were available, four airplanes took more time to depart than the incident flight, and four took less time. The data also showed that the incident flight was the only airplane to fully stop on the runway.

1.9 Organizational and Management Information

1.9.1 SWA Procedures

1.9.1.1 Engine Run-up

The SWA Boeing 737 *Aircraft Operations Manual*, section 15.1.14.2, provided the following information for performing an engine run-up before takeoff when engine anti-ice is required for a flight and the outside air temperature is 3°C or below:[54]

> Accomplish a static engine run-up to a minimum of 70 percent N1 [engine fan speed] and confirm stable engine operation before the start of the takeoff roll. A 30-second run-up is highly recommended whenever possible. If airport congestion and runway surface conditions do not allow for an engine run-up, continue the takeoff normally.

Similarly, the manual's taxi-out procedure stated, "When engine anti-icing is required and the OAT [outside air temperature] is 3°C or below, an engine run-up may be required to minimize ice buildup on the fan spinner and fan blades." The manual instructed flight crews to perform a run-up "to a minimum of 70% N1 for approximately a one second duration at intervals no greater than 10 minutes" during moderate icing conditions, including freezing rain, drizzle, or fog.

The SWA *Flight Operations Manual*, section 15.5, stated that low-visibility operations "refers to the movement of aircraft on the airport when visibility is less than 1200 RVR" and that SMGCS "refers to equipment installations and control procedures at U.S. airports conducting operations when visibility is less than 1200 RVR." The manual also stated that SMGCS was "designed to minimize confusion on the ground in low visibility conditions" and that "ATC may initiate or terminate SMGCS procedures when dictated by visibility." Further, the manual stated that "specific SMGCS procedures are developed for each participating airport."

Regarding flight deck procedures in a SMGCS environment, the manual stated the following:

> The Captain and First Officer must increase their focus on safe aircraft movement, and both must monitor radio communications. It may be necessary to delay checklists and flows until the aircraft is stopped. If the

[54] The manual stated that "engine anti-ice must be on during all flight operations when icing conditions exist or are anticipated, except during climb and cruise when the temperature is below -40°C SAT [static air temperature]." The SWA flight crew stated that the airplane was deiced before taxiing for departure.

> aircraft position is in doubt, immediately stop the aircraft and notify ATC. Detailed preflight review of taxi routes and procedures will enhance operational efficiency and safety.
>
> In the SMGCS environment, all ATC clearances must be read back in their entirety. Both Pilots should fully understand each clearance.

In addition, the manual stated that, when the RVR is 1,200 ft or greater, "taxi routing is at the discretion of the control tower."

1.9.2 FedEx Procedures

Category III is one of three categories of low-visibility precision ILS approaches, each of which has specific requirements. The FedEx *Flight Operations Manual* stated that a coupled approach and the automatic landing (autoland) system were required for a category III ILS approach.[55] The manual also stated that two of the three RVR values need to be above minimums for a category III approach to continue to a landing. In addition, the manual stated the following about category III approaches:

> Category III operations are based on an approach to touchdown using the automatic landing system. Normal operations should not require pilot intervention. However, pilot intervention should be anticipated in the event inadequate airplane performance is suspected, or when an automatic landing cannot be safely accomplished in the touchdown zone.

The FedEx *767 Flight Manual* contained the operator's go-around (visual flight rules) and missed approach (IFR) procedures. Appendix C to this report shows the go-around and missed approach procedures that were current at the time of the incident.

1.10 Additional Information

1.10.1 FAA Requirements and Guidance for Pilots

Title 14 *CFR* 91.123, Compliance with ATC Clearances and Instructions, stated the following in paragraphs (a) and (b):

[55] According to the FAA's pilot/controller glossary, a coupled approach is "an instrument approach performed by the aircraft autopilot, and/or visually depicted on the flight director, which is receiving position information and/or steering commands from onboard navigational equipment."

> (a) When an ATC clearance has been obtained, no pilot in command may deviate from that clearance unless an amended clearance is obtained, an emergency exists, or the deviation is in response to a traffic alert and collision avoidance system resolution advisory.
>
> (b) Except in an emergency, no person may operate an aircraft contrary to an ATC instruction in an area in which air traffic control is exercised.

The FAA's *Aeronautical Information Manual* (AIM), which was "designed to provide the aviation community with basic flight information and ATC procedures for use in the National Airspace System," stated the following in paragraph (2) of section 4-3-14, Communications: "The tower controller will consider that pilots of turbine-powered aircraft are ready for takeoff when they reach the runway or warm-up block unless advised otherwise." [56]

The AIM stated the following in section 4-4-1, Clearance:

> a. A clearance issued by ATC is predicated on known traffic and known physical airport conditions. An ATC clearance means an authorization by ATC, for the purpose of preventing collision between known aircraft, for an aircraft to proceed under specified conditions within controlled airspace. IT IS NOT AUTHORIZATION FOR A PILOT TO DEVIATE FROM A RULE, REGULATION OR MINIMUM ALTITUDE NOR CONDUCT UNSAFE OPERATION OF AIRCRAFT [emphasis added in original].
>
> b. 14 CFR Section 91.3(a) states: 'The pilot-in-command of an aircraft is directly responsible for, and is the final authority as to, the operation of that aircraft.' If ATC issues a clearance that would cause a pilot to deviate from a rule or regulation, or in the pilot's opinion, would place the aircraft in jeopardy, IT IS THE PILOT'S RESPONSIBILITY TO REQUEST AN AMENDED CLEARANCE. Similarly, if a pilot prefers to follow a different course of action…THE PILOT IS EXPECTED TO INFORM ATC ACCORDINGLY [emphasis added in original].

The AIM, section 5-5-2, Air Traffic Clearance, stated in paragraph (a)(4) that a pilot "promptly complies with an air traffic clearance upon receipt except as necessary to cope with an emergency" and "advises ATC as soon as possible and obtains an amended clearance, if deviation is necessary.

[56] The terms "local controller" and "tower controller" are synonymous.

The AIM, section 7-7-3, Near Midair Collision Reporting, defined a near midair collision as

> an incident associated with the operation of an aircraft in which a possibility of collision occurs as a result of proximity of less than 500 feet to another aircraft, or a report is received from a pilot or a flight crew member stating that a collision hazard existed between two or more aircraft.

1.10.2 Previous Related Safety Recommendations

1.10.2.1 Surface Detection Technology

The NTSB issued Safety Recommendation A-00-66 on July 6, 2000.[57] 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

[57] 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 uses multilateration and ADS-B in addition to a surface movement radar. According to the FAA, multilateration works by deploying multiple sensors throughout an area to provide coverage of the desired airspace.)

installation of ASDE-X or the airport surface surveillance capability (ASSC).[58] On December 1, 2017, the NTSB stated that the recommendation remained classified Open—Acceptable Response and expressed interest in learning about the solutions under consideration for airports that will not be receiving a runway status light 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. 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. As a result, 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." The FAA stated that, 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 and reduce runway incursions. 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

[58] 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." ASSC is also similar to ASDE-X in that it uses multilateration and ADS-B in addition to a surface movement radar. 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, DC), ASSC is no longer being implemented at airports because of the cost to install and maintain the system.

the prevention of wrong runway landings. This sprint effort began in September 2023.[59]

- 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.[60]

On February 20, 2024, the NTSB responded by acknowledging the FAA's efforts to implement Safety Recommendation A-00-66, but we stated that the surface technologies that the FAA described did not address the intent of this recommendation because those technologies would not provide a direct warning to flight crews about a potential runway incursion. The NTSB expressed concern that the FAA had not yet implemented the recommended action even with the 15 runway incursions (including the AUS incident) that the NTSB investigated in 2023. As a result, Safety Recommendation A-00-66 was classified Open—Unacceptable Response.

On May 29, 2024, the NTSB classified Safety Recommendation A-00-66 Closed—Unacceptable Action/Superseded given the amount of time that had elapsed since the recommendation was first issued and the FAA's lack of action to implement a system that would directly alert flight crews about potential runway incursions. The NTSB took this action as part of its investigation of a runway incursion that occurred less than 1 month before the AUS incident. Specifically, on January 13, 2023, American Airlines flight 106, a Boeing 777-200, crossed runway 4L without ATC clearance at John F. Kennedy International Airport (JFK), Queens, New York; in response, Delta Air Lines flight 1943, a Boeing 737-900ER, aborted its takeoff on runway 4L. The airplanes came within 1,000 ft of each other at their closest point.

As a result of the JFK incident investigation, the NTSB issued the following recommendations to the FAA, all of which superseded Safety Recommendation A-00-66:

> Collaborate with aircraft and avionics manufacturers and software designers to develop the technology for a flight deck system that would

[59] The FAA also refers to the approach runway verification technology as the "arrival runway verification" and "airport runway verification" technology.

[60] An FAA presentation from the NTSB's May 2023 roundtable showed that the FAA planned to deploy the runway incursion device between 2025 and 2028.

> 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)

In addition, the NTSB classified Safety Recommendations A-24-4 through -6 Open—Unacceptable Response.

1.10.2.2 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, which had 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 reported that it had initiated a rulemaking effort to propose that newly manufactured aircraft be equipped with CVRs capable of recording 25 hours of data. The rulemaking effort would also propose operational rules requiring the use of such CVRs once installed. 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 was concerned 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 that recommendation Open—Unacceptable Response.

On December 4, 2023, the FAA published a notice of proposed rulemaking (NPRM) titled "25 Hour Cockpit Voice Recorder Requirement, New Aircraft Production," which proposed requiring the installation of 25-hour CVRs on newly manufactured aircraft that operate under 14 *CFR* Parts 91, 121, 125, and 135 and require a CVR (NARA 2023). On January 31, 2024, the NTSB provided comments on the NPRM, stating 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 explained that, since the time that Safety Recommendations A-18-30 and -31 were issued in October 2018, at least 14 of its investigations were hampered by overwritten CVR data, including 7 of the runway incursion events that the NTSB investigated in 2023 and a rapid decompression event that occurred on an Alaska Airlines 737-9 MAX flight in January 2024. As of April 2024, at least 18 investigations were affected by overwritten CVR data; table 3 provides details about those investigations.

Table 3. NTSB investigations hampered by overwritten CVR data since the issuance of Safety Recommendations A-18-30 and -31.

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

In addition, the NTSB commented that the FAA had inappropriately estimated the cost of retrofitting the existing fleet of aircraft covered by Safety Recommendation A-18-31. The NTSB determined the retrofit requirement in the recommendation would apply to less than one-half of the number of airplanes that the FAA had estimated and that the retrofit could be completed during regular CVR maintenance. The NTSB urged the FAA to reconsider its position and issue a final rule that would address both newly manufactured airplanes that must have a CVR as well as existing airplanes required to carry both a CVR and an FDR.

On May 16, 2024, the FAA Reauthorization Act of 2024 became law. The act required 25-hour CVRs for aircraft operated under 14 *CFR* Part 121, other transport-category airplanes that were type certificated with a seating capacity of 30 or more passengers, and cargo derivatives of such airplanes that are operated under other regulations. The act specified that newly manufactured aircraft were to be installed with 25-hour CVRs starting 1 year after the date of the act. Also, the act specified that affected operators were to retrofit their aircraft with a 25-hour CVR no later than 6 years after the date of the act. In addition, the act required the FAA, within 3 years of the date of the act, to issue a final rule to update applicable regulations to conform to the CVR retrofit requirement for existing aircraft.

On May 29, 2024, the NTSB reiterated Safety Recommendation A-18-30 in its final report for the JFK incident investigation and classified Safety Recommendation A-18-31 Closed—Unacceptable Action/Superseded because the FAA did not complete the requested action by January 1, 2024. The NTSB superseded A-18-31 with A-24-9, which asked the FAA to "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." The NTSB classified Safety Recommendation A-24-9 Open—Unacceptable Response.

1.10.3 National Airspace System Safety Review Team

As a result of the AUS, JFK, and eight other runway incursion events at US airports between October 2022 and February 2023, the FAA chartered an independent team, referred to as the National Airspace System Safety Review Team, to determine significant challenges involving the FAA's air traffic organization. The team's report was submitted to the FAA in November 2023.

The report noted the importance of surface surveillance systems in preventing runway incursions. The report indicated that the deployment of surface surveillance systems began in the 1980s and that ASDE-X was first deployed in the early 2000s. The team found that the FAA's critical ATC systems, including surface surveillance systems, were part of an aging infrastructure and that "for many components, spare parts are extremely limited and may require expensive special engineering." The team proposed recommendations to address this and other safety issues to identify "opportunities to monitor and address aviation safety risks" in the National Airspace System (National Airspace System Safety Review Team, 2023).[61]

1.10.4 Postincident Actions

On February 8, 2023 (4 days after the incident), the air traffic manager at the AUS ATCT issued a memorandum with the subject "Low Visibility Operations Refresher." The memorandum reminded tower personnel that, once the RVR for runway 18L decreases below 1,200 ft, the SMGCS plan needs to go into effect, and the ATIS needs to be updated with that information. The memorandum also stated the following:

> Remember that everything slows down during low visibility operations. Speeds on final will be slower, aircraft will take longer to exit the runway, departures will taxi slower and take longer to start [the] departure roll, etc. Also, we are required to maintain two miles (increasing to three within one mile of the departure end of the runway) between an arrival and departure. If the departure hasn't started [the] take off roll by the time the arrival reaches a two mile final, we must take action (send the arrival around and/or cancel the departure's take off clearance)…. Low visibility operations already add risk to the NAS [National Airspace System]. Make sure we are not adding any additional risk!

On February 24, 2023, the air traffic manager issued a memorandum to all AUS personnel that clarified information about the RVR sensors referenced in the low-visibility operations LOA and SMGCS plan. The memorandum stated that, "unless a specific RVR Sensor is stated (Runway 18L Touchdown RVR), then **any** [emphasis in original] RVR sensor applies." The memorandum also stated that (1) "if either of the RVRs for 18R fall below 1600 [ft], we must discontinue use of that runway" and (2) "if any RVR reading is below 1200 [ft], the airfield should be in SMGCS." Further, the memorandum stated that "**anytime the temperature is below 3 degrees (C) and/or freezing fog is reported, expect most or all airlines to conduct a 30 second run up on the runway prior to starting takeoff roll**" [emphasis in original].

On April 24, 2023, AUS completed a "Low-Visibility Operations/Surface Movement Guidance and Control System" tabletop exercise. On May 15, 2023, the AUS ATCT and the City of Austin Department of Aviation issued a revised AUS SMGCS plan to clarify procedures, and they established a new LOA that became effective on July 31, 2023.

[61] The team's other recommendations were related to facilities, equipment, and technology; process integrity; staffing; and funding.

On January 17, 2024, the FAA reported that the local controller was undergoing recertification on tower positions. The FAA subsequently reported that the controller had been recertified on the local control west and local control east positions on February 29, 2024.

On March 14, 2024, the FAA announced that it launched the approach runway verification technology at AUS and planned to launch this technology at other ATCTs to provide "controllers with visual and audible alerts if an approaching aircraft is lined up to land on the wrong airport surface, or even the wrong airport." On April 15, 2024, the FAA announced that AUS would be one of the first four airports to receive SAI, which will use ADS-B data to "display surface traffic to controllers at airports that do not have a surface surveillance tool."[62] The FAA explained that "aircraft and ADS-B–equipped vehicles [will] appear as icons on an airport map that depicts runways, taxiways, hold ramps and other areas." The FAA stated that the four airports would receive this system by July 2024 and that "scores of other airports" would receive the system by the end of 2025. On May 13, 2024, the FAA stated that the approach runway verification was installed at AUS during the second quarter of fiscal year 2024, SAI was targeted to be operational at AUS before the fourth quarter of 2024, and the installation of the runway incursion device at AUS was proposed for the first quarter of fiscal year 2025. (The runway incursion device was discussed in section 1.10.2.1.)

[62] The other three airports expected to receive SAI by July 2024 are Indianapolis International Airport, Indianapolis, Indiana; Nashville International Airport, Nashville, Tennessee; and Dallas Love Field Airport, Dallas, Texas.

2. Analysis

2.1 Introduction

This incident occurred after the local controller cleared the SWA airplane for takeoff on runway 18L and instructed the FedEx airplane to continue its approach to the same runway. The controller was unable to see the SWA airplane in the dense fog conditions that existed at the time. The FedEx first officer saw the SWA airplane at the approach end of the runway and called for a go-around, and the FedEx captain began to execute the missed approach procedure. The FedEx first officer then transmitted "Southwest abort" and "FedEx is on the go."[63] The SWA captain reported that he did not hear the "abort" transmission or a similar instruction from the controller, so the SWA airplane continued its takeoff roll. The airplanes came within 150 to 170 ft of each other at their closest point.

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

- the lack of ATCT and flight deck technology to detect potential conflicts on a taxiway or runway surface (section 2.3);
- the need to ensure, especially during low-visibility conditions, that controllers are aware when pilots, after receiving takeoff clearance, might need extra time on the runway (which occurred during the incident sequence when the SWA flight crew performed the operator's engine run-up procedure) (section 2.4);
- the AUS ATCT's lack of training on the airport's SMGCS plan and low-visibility operations (section 2.5); 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 SWA and FedEx flight crews were certificated and qualified in accordance with federal regulations. The local controller was certified and current on all nonsupervisory tower positions at AUS.

Controller sleep opportunities: The controller was off from work on February 1, 2023, worked an 8-hour day shift on February 2, and was off from work on

[63] Although it is not standard operating procedure for a pilot of an aircraft to issue an abort instruction to another aircraft, in this case the FedEx first officer stated "abort" to prevent an accident.

February 3. The day of the incident (February 4) was a scheduled overtime shift for the controller. The shift occurred during daytime hours, and the controller had been on duty for only about 1 hour when the incident occurred.

In November 2021 (about 15 months before the incident), the local controller was diagnosed with mild obstructive sleep apnea. Afterward, the controller began treatment with a CPAP machine and, according to his sleep medical care provider, achieved excellent control of his condition with treatment. During the 30 days before the incident, the controller adhered to CPAP treatment and used his CPAP machine each day, averaging more than 6 hours of use per day.

During the overnight period before the incident, the controller used his CPAP machine for less than 4 hours. However, the controller’s 72-hour history and cell phone activity showed that he had adequate sleep opportunities before the incident and that he likely slept for about 8 hours during the night before the incident shift. Further, no evidence showed any chronic sleep loss or circadian disruption, and a review of ATC recordings found no evidence (such as yawning) indicating that the controller was fatigued during the incident shift. In addition, the controller’s communications with the flight crews of previous departing airplanes on the morning of the incident contained no readback errors.

ATCT staffing: The AUS ATCT was not at its authorized facility staffing level, which required controllers to routinely work overtime shifts. However, the tower cab staffing at the time of the incident (which comprised one local controller and one operations supervisor) exceeded the ATCT’s mid-watch hour tower cab configuration, which required only one controller to be in the tower cab (with all positions combined).

Flight crew sleep opportunities: The SWA captain and first officer had adequate sleep opportunities during the days before the incident flight. The FedEx captain likely had less than 3 hours of sleep before the incident flight, and the FedEx first officer likely had about 3 hours 20 minutes of sleep.[64] Thus, the FedEx flight crewmembers were likely not well rested before the incident flight. However, given the flight crew’s actions in identifying the SWA airplane in dense fog, communicating that the SWA flight crew should abort the takeoff, calling for a go-around, and conducting a missed approach to avoid a collision with the SWA airplane on the

[64] The FedEx captain worked a flight that departed at 2223 on February 3 and arrived at 0004 on February 4. The captain could not recall when he went to sleep after the flight, and he likely had to report for the flight to AUS at the same time as the FedEx first officer (0230). The first officer went to sleep by 2130 on February 3 and awoke at 0050 on February 4 to report at 0230 for the incident flight.

runway, the FedEx captain's and first officer's lack of sleep did not affect their performance during the incident flight.[65]

Thus, the NTSB concludes that none of the following were factors in this incident: (1) pilot and controller qualifications, (2) controller fatigue, (3) ATCT staffing at the time of the incident, and (4) flight crew fatigue.

2.2 Incident Sequence

2.2.1 Weather Conditions

Low IFR conditions were occurring at AUS before and during the incident. The controller received weather briefings before the start of his shift and was aware that low-visibility conditions existed at the airport. The ASOS observation 22 minutes before the incident indicated a visibility of 1/4 mile in dense freezing fog and a vertical visibility of 200 ft agl; the observation 7 minutes after the incident indicated that the visibility had decreased to 1/8 mile.[66] The low IFR conditions made the operational environment complex.

Although the controller had some experience working in the ATCT during low-visibility weather conditions, he had not experienced such conditions during the year preceding the incident. The controller had a tower display workstation that provided him with visual cues to identify and monitor aircraft approaching the airport. However, the controller did not have sufficient visual cues to locate aircraft moving on the airport surface on the morning of the incident. The controller stated that he could not see the SWA airplane on the taxiway or runway, and the AUS ATCT had no surface detection equipment, such as ASDE-X, to aid the controller in determining the location of the airplane (as discussed further in section 2.3).

2.2.2 Controller's Expectation for Departing Airplanes

The SWA flight crew told the controller that "we're short of one eight left" and "we're ready," and the controller provided takeoff clearance and advised the

[65] Other evidence showed that the FedEx captain's and first officer's lack of sleep did not negatively impact their performance during the incident flight. For example, they were able to follow published flight deck crew procedures related to the ILS approach to runway 18L, manage the aircraft's flightpath to the runway, follow instructions from the controller, and avoid a near midair collision after the SWA airplane became airborne (the last of which is discussed in section 2.2.5).

[66] Although freezing fog was reported, ice accretion was not likely occurring at the airport due in part to the location of ASOS sensors, which were in a low-lying area that was subject to colder air than surrounding areas.

flight crew that a Boeing 767 (the FedEx airplane) was on a 3-mile final approach; the SWA flight crew acknowledged the information. (The NTSB's aircraft performance study found that the FedEx airplane was 3.9 miles from the runway 18L threshold at that time.)

The controller stated that he assumed that the SWA airplane was already at the hold-short line (a taxiway marking that indicates where an aircraft must stop unless the aircraft has already received clearance to enter the assigned runway) when the flight crew reported that the airplane was short of the runway and ready for takeoff. However, during postincident interviews, the SWA flight crewmembers stated that, at the time of their takeoff clearance request, the airplane was approaching (but was not yet at) the hold-short line. The aircraft performance study for this incident confirmed this information; the study found that, at the time of the SWA flight crew's takeoff clearance request, the SWA airplane was on taxiway B about 550 ft from the hold-short line for runway 18L.[67]

ATC recordings showed that the flight crews of airplanes that departed AUS before the SWA flight used similar (but not the same) phraseology in their takeoff clearance request. For example, one request included the phrase "we'll be ready at one eight left," and another request was phrased as "ready for takeoff one eight left." Thus, the controller would not have had a reason, based solely on phraseology, to question the SWA airplane's position at the time. However, because the controller was unable to see the SWA airplane due to the low-visibility conditions, the controller should have been more vigilant and verified the airplane's position. No evidence indicated that the controller asked the SWA flight crewmembers (or the crewmembers of any other departing airplane) to verify their location when they requested takeoff clearance.

Further, the controller stated that SWA was the airport's "most ready carrier." Given his previous experience with SWA departures while at the AUS ATCT, the controller expected that, when a SWA pilot said that an airplane was ready to depart, the airplane would already be at the hold-short line and that "you give them the traffic and they go." Two SWA departures before the SWA incident flight were 400 and 500 ft from the hold-short line at the time of their takeoff requests (that is, 150 and 50 ft closer to the hold-short line, respectively, than the SWA incident airplane). The time between their takeoff clearances and their takeoff rolls were both under 1 minute (59 and 49 seconds, respectively), which was faster than the time for the incident flight (1 minute 20 seconds).

[67] As stated earlier, at least 7 of the 10 previous departing airplanes on the morning of the incident had not reached the hold-short line for the assigned runway when the flight crews requested takeoff clearance, and four of these airplanes were within 100 ft of the SWA airplane's position (550 ft before the hold-short line) when the flight crews requested takeoff clearance.

The controller's actions on the morning of the incident were not consistent with the intent of paragraph 3-1-7 of FAA Order 7110.65Z, which required controllers to determine the position of an aircraft before issuing takeoff clearance. Paragraph 3-1-7 noted that "when ATC is unable to determine position visually or via a display system, position reports may be used." However, the controller did not instruct the SWA flight crew (or flight crews of other departing airplanes) to provide these reports, which he should have done given his inability, due to the low-visibility conditions on the morning of the incident, to see surface traffic.

The controller's assumption about the SWA airplane's position on the taxiway was likely due to expectation bias, which occurs when a person responds in a way that is consistent with what they expect rather than what is actually occurring. Expectation bias is a psychological concept associated with perception and decision-making that can allow a mistaken assessment to persist when a person manipulates perceived elements in a way that is consistent with the person's expectation (Bhattacherjee 2001). Past experiences (such as the controller's experience with SWA airplanes departing quickly after crews reported that they were holding short) or repetition (such as the similar phrasing of takeoff clearance requests on the morning of the incident) can exacerbate this bias. In addition, the controller likely expected that the SWA airplane would depart uneventfully given that all previous departures that morning were unremarkable despite the dense fog and reduced visibility that the flight crews encountered. However, it is important to note that none of the previous departures occurred while the controller was also handling an airplane that was approaching the airport.

Expectation bias is not a new phenomenon in aviation. The NTSB has investigated numerous accidents and incidents that involved errors resulting from expectation bias, particularly in night visual meteorological conditions when fewer cues were available to aid in decision-making. For example, during our investigation of the July 2017 taxiway overflight event involving Air Canada flight 759 in San Francisco, California, the NTSB found that multiple cues were available to the flight crew to distinguish the landing runway from a parallel taxiway but that other cues also existed to confirm the flight crew's expectation that the airplane was aligned with the intended landing runway. The NTSB concluded that the cues available to the flight crewmembers to indicate that the airplane was aligned with a taxiway were not sufficient to overcome their belief, as a result of expectation bias, that the taxiway was the intended landing runway (NTSB 2018a).

More recently, for the January 2023 JFK runway incursion event, the flight crew of the American Airlines airplane deviated from the taxi instructions that the ground controller issued and mistakenly crossed runway 4L, where the Delta Air Lines airplane had just begun its takeoff roll. The American Airlines flight crewmembers believed that the controller had cleared the airplane to cross the runway in front of them, and the NTSB's report stated that the crewmembers would likely not have expected that an airplane would be taking off on that runway. The NTSB concluded that the American Airlines flight crew's nondetection of the Delta airplane on runway 4L likely resulted from, among other things, expectation bias (NTSB 2024).

The controller's expectation bias led to his lack of situational awareness regarding the position of the SWA airplane. Situational awareness forms a basis for decision-making; the three levels of situation awareness are the perception of elements in the current situation, comprehension of the current situation, and the projection of future status (Endsley 1995).[68] In this case, because he thought that the SWA airplane was already at the hold-short line, the controller was not able to predict the loss of separation that would later occur between the SWA and FedEx airplanes and take action to preclude that situation.

The NTSB notes that the controller might have realized that the SWA airplane had not yet reached the hold-short line for runway 18L if the SWA flight crew had specified, in its takeoff clearance request, that the airplane was near taxiway F (while on taxiway B). The controller also stated, during a postincident interview, that he and the operations supervisor had advised flight crews of departing airplanes of the expectation that the airplanes would be at the hold-short line when the crews requested takeoff clearance. As a result, the local controller stated that he fully expected that the airplanes would be at the hold-short line when the flight crews made initial contact to request takeoff clearance. However, ATC recordings showed that the controller did not advise flight crews of the expectation that airplanes would be at the hold-short line when the crews requested takeoff clearance. In addition, he did not ask flight crews to verify their airplane's position, which would have been a prudent action given the low-visibility conditions and the lack of surface detection technology in the tower.

A mental model allows decision-makers, when faced with a complex or an uncertain situation, to determine an appropriate response strategy. The formation of an accurate mental model depends on accurate information (Klein 2008). However, in this case, the controller did not have an accurate mental model of the separation between the SWA and FedEx airplanes due to his lack of situational awareness about the SWA airplane's position on the taxiway The NTSB concludes that the controller's inaccurate mental model of the SWA airplane's position on the taxiway resulted from his (1) expectation that the SWA airplane would be at the hold-short line for runway 18L when the flight crew requested takeoff clearance and (2) failure to verify

[68] These three levels of situational awareness, which are sequential, are followed by decisions and performance of actions. The NTSB notes that, in her research, Endsley referenced the cited human performance theory as "situation awareness."

the SWA airplane's position on the taxiway at the time of the takeoff clearance request.

The air traffic manager at the AUS ATCT stated that, at the time of the incident, the ATCT had not conducted refresher training regarding low-visibility operations during the 2 years that he had been at the tower. Review of the ATCT's refresher training revealed no evidence of low-visibility training for controllers. Thus, the AUS ATCT had not adequately prepared the controller for the low-visibility conditions on the morning of the incident. As a result, the NTSB also concludes that the controller's lack of training in low-visibility conditions and his expectation that the SWA airplane would depart quickly were factors that led to his inaccurate mental model of the SWA airplane's position on the taxiway.

2.2.3 FedEx Airplane Approach to Runway

The FedEx airplane was performing a category III ILS approach to runway 18L using the autoland system because the RVR for runway 18L was below category I minimums (which are based on visual reference requirements). FedEx procedures stated that normal category III operations do not require pilot intervention unless the airplane's performance is inadequate or an approach to a touchdown cannot be safely accomplished. Thus, the use of autoland assumes that pilots would be focused on flight deck instruments because the pilots would not need to look outside the airplane to land.

Both the FedEx captain and first officer heard the SWA flight crew's takeoff clearance request ("short of one eight left" and "we're ready") and were concerned that the SWA airplane would be on the runway when they would be landing. As a result, the FedEx flight crewmembers contacted the controller to confirm that their airplane was cleared to land. The controller provided confirmation and informed the crew about a Boeing 737 (the SWA airplane) that would depart before the FedEx airplane would arrive. The FedEx flight crew acknowledged this information.

According to FAA Order 7110.65Z, the controller was required to apply a 2-mile separation between a departing aircraft on its takeoff roll and an arriving aircraft on final approach. The NTSB's aircraft performance study showed that the FedEx airplane was 2 miles from the runway 18L threshold when the SWA airplane entered the runway, which was the minimum allowable separation between the airplanes.

The controller was using his tower display workstation to determine the FedEx airplane's distance from the runway. A review of tower display workstation records found that visual cues of the FedEx airplane's trajectory (the airplane's groundspeed and distance from the approach end of the runway) were available; the controller would have used these cues along with the time on the workstation clock to determine the FedEx airplane's progress to the runway. However, after descending through 800 ft agl, the FedEx airplane's information would no longer have been displayed on the workstation (due to the limitations of the radar system that the workstation used). Because the low-visibility conditions limited the controller's view of the FedEx airplane as it approached the runway, the controller would have had to remember the FedEx airplane's position information while handling the SWA airplane, as further discussed in the next section.

2.2.4 SWA Airplane Position on Runway

By the time that the SWA airplane was lining up with the runway 18L centerline, the separation between the two airplanes had decreased and was less than the required 2 miles. About 11 seconds later, the SWA airplane stopped on the runway; several seconds afterward, the SWA flight crew began the engine run-up procedure, which the operator required when engine anti-ice was being used for takeoff and the outside air temperature was 3°C or below. (The ASOS report in effect at the time of the incident indicated that the temperature was -1°C with freezing fog). ATC recordings showed that the SWA flight crew did not notify the controller that the airplane would be temporarily stopped on the runway, but the SWA flight crew would likely not have considered providing such notification given that the controller had not instructed the crew to expedite the takeoff due to the arriving airplane, as further discussed in section 2.4.

FDR data showed that, during the run-up, engine power was advanced from 37% to 56% and that, once the airplane's groundspeed began to increase from 0 knots, engine power was advanced to 68%.[69] When the SWA flight crew completed the engine run-up procedure (19 seconds after the airplane stopped on the runway), the separation between the SWA and FedEx airplanes was about 0.7 miles.

In addition, even though the SWA incident airplane was the only departure on the morning of the incident to fully stop on the runway, the time from its takeoff clearance to its takeoff roll (1 minute 20 seconds) was only 2 seconds longer than the average time for nine of the previous departures (1 minute 18 seconds).[70]

During a postincident interview, the controller stated that, when low-visibility conditions were present, he would listen for engine sounds to determine if an aircraft

[69] Although the SWA engine run-up procedure instructed flight crews to "accomplish a static engine run-up to a minimum of 70 percent N1" and recommended a 30-second run-up, the N1 percent achieved during the run-up and the run-up duration were acceptable.

[70] The times for the nine departures ranged from 49 seconds to 1 minute 51 seconds.

had begun its takeoff roll. However, the controller reported that he did not hear such sounds coming from the SWA airplane (likely because the SWA flight crew was performing the engine run-up then and the takeoff roll had not yet begun). The controller stated that he recognized that a problem existed when he did not "hear anything" from the SWA airplane, but the controller also stated that he was hesitant to instruct the FedEx airplane to go around when it was inside 2 miles in case the SWA airplane was already rotating.

Although the controller might have had an accurate mental model of the FedEx airplane's position, he could not accurately determine the SWA airplane's position on the runway and, as a result, could not have determined that the separation between the airplanes was less than the required 2 miles. The NTSB concludes that the controller's failure to fully understand the SWA airplane's position upon entering and while on the runway resulted in insufficient separation between the SWA and FedEx airplanes.

Accurate and timely perception of visual and aural information is critical to air traffic controller decision-making (Shorrock 2007). A controller's ability to use visual and aural cues to detect and identify information and objects is essential in complex environments, such as the one on the morning of the incident. The controller could only use his sense of hearing to determine whether the SWA airplane was rolling because he could not see the airplane's location on the runway and the tower did not have surface detection equipment to aid him. However, the controller's sense of hearing did not provide him with adequate information about the status of the SWA airplane.

After confirming that the FedEx airplane was cleared to land, the controller asked the SWA flight crewmembers to confirm that their airplane had begun its takeoff roll. The SWA flight crew confirmed that the airplane was "rollin' now." The controller did not ask the crew whether the takeoff roll was just beginning or whether the airplane was already rolling down the runway; instead, the controller assumed that the SWA airplane would depart from the runway before the FedEx airplane arrived. However, the FedEx airplane was less than 0.7 miles from the runway at that time. When the FedEx airplane crossed the runway 18L threshold, the SWA airplane was 900 ft beyond the threshold, which was inconsistent with the requirements for same runway separation in FAA Order 7110.65, paragraph 3-10-3; specifically, an arriving aircraft cannot cross a landing threshold until another aircraft using the same runway has departed and crossed the runway end.

The NTSB concludes that the controller's incorrect assumption that the SWA airplane would depart before the FedEx airplane would arrive set up a hazardous situation that could have resulted in an accident. This situation could have been avoided altogether if the controller had followed established ATC procedures to ensure proper separation. It is important to note that the controller reported, during a postincident interview, that he "definitely could have held" the SWA flight and that "there was no pressure to expedite" the SWA departure. Thus, the NTSB also concludes that the controller could still have appropriately separated both airplanes if he had either (1) held the departing SWA airplane until after the arriving FedEx airplane landed or (2) if the SWA airplane had already received its takeoff clearance, canceled the clearance and instructed the FedEx airplane to go around.

2.2.5 FedEx Airplane Missed Approach and SWA Airplane Liftoff

The FedEx captain and first officer became concerned when they heard that the SWA airplane was "rollin' now" because of the FedEx airplane's proximity to the runway. When the FedEx first officer saw a light from and the silhouette of the SWA airplane through the fog, he communicated the need to go around to the captain, and the FedEx captain began to execute the missed approach procedure.[71] The first officer then told the SWA flight crew to abort the takeoff and stated "FedEx is on the go" within a 3-second period. The SWA captain stated that he did not hear the "abort" transmission from the FedEx pilot or receive a similar instruction from the controller, so the SWA airplane's takeoff continued. The NTSB concludes that the quick reaction of the FedEx first officer after seeing the SWA airplane and the quick response of the FedEx captain in performing a missed approach avoided a potential runway collision between the SWA and FedEx airplanes and led to the successful resolution of the loss of separation.

While both airplanes were airborne, the pilots noticed a traffic advisory on their airplane's TCAS. According to the FedEx flight crewmembers, their TCAS showed that the SWA airplane was about 700 ft below them; the SWA flight crewmembers stated that their TCAS showed the FedEx airplane about 600 ft above them. The SWA first officer stated that he responded to the TCAS advisory by "shallowing" the airplane's climb; this action facilitated a further increase in separation as both flight crews maneuvered their airplanes away from the other. As a result of the FedEx crew's missed approach and the SWA crew's maneuvering, the airplanes were not in danger of a midair collision, which TCAS was designed to prevent, or a near midair collision, and both flights continued to their destinations without further incident. The NTSB concludes that the SWA flight crew's actions to shallow the airplane's climb in response to an advisory from the TCAS contributed to the increased separation between the two airplanes.

[71] Because the CVR installed on the FedEx airplane was overwritten after the incident, the NTSB was unable to determine how the first officer communicated to the captain the need to go around. (The ATC transcript did not provide this information.) The recording duration of the CVR is discussed in section 2.6.

2.3 Lack of Technology to Detect Surface Movement

2.3.1 Air Traffic Control Tower Technology

Surface detection equipment, such as ASDE-X, allows air traffic controllers to track the movement of aircraft and vehicles on airport surfaces and provides controllers with visual and aural warnings when a potential conflict exists. This technology can be especially useful when low-visibility conditions occur, such as those at AUS on the morning of the incident.

As previously stated, the AUS ATCT did not have any surface detection equipment, which impeded the controller's ability to properly separate the SWA and FedEx airplanes given the lack of visual references outside the tower. The ability of air traffic controllers to determine a departing aircraft's location on a taxiway or runway surface is critical, especially when salient cues outside the tower cab are not available.

The NTSB has long recognized the benefit that surface detection equipment could provide air traffic personnel. For example, in June 1991, the NTSB recommended that the FAA expedite efforts to fund the development and implementation of an operational system to alert controllers about pending runway incursions at all terminal facilities scheduled to receive ASDE-III (Safety Recommendation A-91-29). That recommendation was superseded in July 2000 by Safety Recommendation A-00-66 because the NTSB recognized the importance of providing warnings to both air traffic controllers and flight crews.[72] Safety Recommendation A-00-66 asked the FAA to require, at all airports with scheduled passenger service, a ground movement safety system that would provide a direct warning capability to flight crews about potential runway incursions. The NTSB recognizes the benefits that such systems are expected to have (see section 2.3.2). Nevertheless, as the facts of this incident demonstrate, the NTSB also recognizes the benefits that surface detection equipment (such as ASDE-X and ASSC) provide controllers.

The FAA's most recent response to Safety Recommendation A-00-66, which was dated October 2023, focused primarily on three ATC-related technology efforts that were underway. According to the FAA, the SAI system was expected to "provide surface traffic displays to towers at airports that do not currently have a surface surveillance system…[to] improve controller situational awareness and reduce runway

[72] In its safety recommendation letter, the NTSB recognized that providing warnings only to air traffic controllers would unnecessarily increase the time to alert flight crews about a potential runway incursion. The NTSB stated that a "significant amount of time" would be required for a controller to detect an alert, identify the problem, determine the necessary action, and contact the involved flight crew. All these actions would decrease the amount of time that a flight crew would have to react.

incursions." The "Approach Runway Verification" was expected to provide "an aural and [a] visual alert" to controllers that would "aid in the prevention of wrong runway landings." The "Runway Incursion Device" was expected to provide "a visual and [an] aural alert to controllers when a runway is not available for departing or landing aircraft." In May 2024, the FAA stated that the approach runway verification was installed at AUS during the second quarter of fiscal year 2024, SAI was expected to be operational at AUS before the fourth quarter of 2024, and the installation of the runway incursion device at AUS was proposed for the first quarter of fiscal year 2025.

If the AUS ATCT had surface detection equipment to detect potential runway incursions, that technology would have allowed the local controller to track the surface movement of the SWA airplane during the low-visibility conditions that existed, which would have improved the controller's situational awareness and possibly avoided the incident. During a postincident interview, the local controller stated that access to ASDE-X information might have changed how he handled the SWA airplane on the morning of the incident. The NTSB concludes that, if surface detection equipment had been installed in the ATCT, the system would have allowed the controller to track the position of the SWA airplane while it was on the taxiway and runway, which would have provided an opportunity for the controller to detect the insufficient separation between the SWA and FedEx airplanes and take action to mitigate the situation.

The FAA is no longer installing ASDE-X and ASSC at airports certificated under 14 *CFR* Part 139 because of the costs associated with these systems. However, because of their demonstrated benefits, surface detection systems that are currently under development should be installed (once they become available) at all Part 139-certificated airports that are not equipped with ASDE-X or ASSC to improve surface safety at those airports. Therefore, the NTSB recommends that, for airports that are certificated under Part 139 and are currently not equipped with ASDE-X or ASSC, the FAA implement surface detection equipment that

- tracks the movement of arriving and departing aircraft,
- determines the proximity between those aircraft, and
- provides air traffic controllers with visual and aural cues of surface movements to aid in their decision-making processes.

In March 2024, the FAA stated that it launched the approach runway verification technology at AUS and planned to launch this technology at other ATCTs. The NTSB is encouraged that the FAA is providing certain airports, including AUS, with technology that should allow controllers to detect and prevent wrong surface landings. However, this technology would not provide the surface detection capability necessary to alert controllers about potential runway incursions.

In April 2024, the FAA announced that four airports, including AUS, would be receiving the SAI system and that "scores of other airports" would receive the system by the end of 2025. SAI is expected to improve controller situational awareness at airports that do not currently have surface detection capability by providing the location of aircraft and ADS-B–equipped vehicles on a map of the airport's runways, taxiways, and other areas. The NTSB believes that the SAI system could potentially satisfy the intent of Safety Recommendation A-24-10, which was discussed earlier in this section. However, because the system has not been deployed at any airports, the NTSB cannot accurately assess whether the system would address all the elements of Safety Recommendation A-24-10.

2.3.2 Flight Deck Technology

The flight deck of a certificated transport-category airplane is configured with various systems that supplement the information presented on flight instruments; such systems provide flight crews with visual and aural annunciations to increase a crew's situational awareness. Both the SWA and FedEx airplanes were equipped with TCAS, as required, to alert pilots about nearby in-flight (intruder) traffic and the need to take evasive action to avoid a midair collision. (As previously stated, TCAS was not designed to prevent runway incursions.) However, transport-category airplanes are not currently required to have a system that would (1) provide visual and aural cues of nearby airplanes operating on an airport surface and (2) alert flight crews when a potential surface conflict exists.

The FedEx airplane, a Boeing 767, was equipped with an autoland system, which allowed the flight crew to monitor other systems related to the airplane's approach without having to look outside the airplane to locate the runway. The FedEx first officer, as the pilot monitoring, would have focused his attention during the approach on scanning and monitoring the flight instruments, but the first officer reported that he looked outside the airplane because of concerns about the SWA airplane's location. As previously stated, the first officer saw a light and then the silhouette of the SWA airplane and called for a go-around. It was fortunate that the FedEx first officer observed the SWA airplane on the runway. The FedEx captain reported that he did not see the SWA airplane, but, as the pilot flying, he would have been focused on the flight instruments to execute the approach.

Although the controller was responsible for providing accurate and timely information to the FedEx flight crew regarding the traffic on runway 18L, he was unable to see the SWA airplane in the low-visibility conditions that existed at the time and did not instruct the SWA flight crew to provide position reports. As stated in section 2.3.1, the installation of surface detection equipment at ATCTs is one way to address this safety issue. However, the controller would need to detect the warning, identify the problem, and determine the necessary action before attempting to contact the flight crewmembers, who would need to act immediately to resolve the situation.

A flight deck system that produces visual and aural cues of traffic on a taxiway or runway would provide a direct warning to flight crews of an impending collision and eliminate the time that it would take to be notified by a controller. This technology would be especially beneficial in low-visibility conditions. Such a system could display the location of departing and arriving traffic on the airport surface as well as traffic that is approaching to land. In addition, such a system could provide aural and visual alerts to a flight crew about potential traffic conflicts that a crew might not see while visually scanning the outside environment. As a result, such a system would provide an additional layer of protection against runway incursions.[73]

The NTSB is aware that such technology is currently under development. For example, the NTSB received an April 2023 briefing from a systems manufacturer about a technology that it was developing to provide pilots with a direct warning of a potential runway incursion. According to information that the systems manufacturer provided the NTSB in January 2024, the system was expected to provide advisories and alerts based on ADS-B data from aircraft that are on a runway or short final approach. The manufacturer conducted a simulation, which showed that, with its runway incursion alerting system installed on the SWA and FedEx airplanes, the SWA airplane would have received an advisory and two caution alerts of traffic on final approach, and the FedEx airplane would have received two caution alerts of traffic on the runway.

The FAA's October 2023 response to Safety Recommendation A-00-66 (discussed in sections 1.10.2.1 and 2.3.1) did not address the need to provide flight crews with direct alerting about potential runway incursions. In its final report on the January 2023 runway incursion incident at JFK, the NTSB stated that an in-cockpit display of airport traffic with aural and visual conflict alerting would reduce the risk of runway incursions. The NTSB also noted that, after more than 23 years, the FAA has still not required, at all airports with scheduled passenger service, a ground movement safety system that provides a direct warning to flight crews (NTSB, 2024). On May 29, 2024, the NTSB classified Safety Recommendation A-00-66 Closed—Unacceptable Action/Superseded and issued the following three recommendations to the FAA:

> Collaborate with aircraft and avionics manufacturers and software designers to develop the technology for a flight deck system that would

[73] The NTSB notes that, although radar coverage can be limited close to an airport surface, ADS-B coverage can be improved with the installation of additional ADS-B ground receivers. Other systems, such as ground surveillance radar, can also be used to detect aircraft below ATC radar coverage.

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)

In addition, the NTSB classified Safety Recommendations A-24-4 through -6 Open—Unacceptable Response.

This technology has not yet been mandated despite its expected safety benefits based on simulation results. Such technology should have the same importance as existing technological interventions such as TCAS. The NTSB concludes that the implementation of a flight deck alerting system on air carrier aircraft would further improve safety at (1) airports without surface detection equipment and (2) airports with surface detection equipment if a controller were to inadequately respond to an alert in the tower. Therefore, the NTSB reiterates Safety Recommendations A-24-4, -5, and -6 because the investigation into this incident demonstrated the continuing need for the recommended actions.[74]

2.4 Engine Run-up during Low-Visibility Conditions

After the controller cleared the SWA airplane for takeoff, the SWA flight crew maneuvered the airplane onto runway 18L. Once the airplane was positioned on the runway, the flight crew stopped the airplane to conduct the operator's engine run-up procedure. The procedure is a final check to ensure that the airplane's engines are free of snow and ice before power is advanced for takeoff.

FAA Order 7110.65Z, paragraph 5-8-4, stated that an arriving aircraft can be no closer than 2 miles from the runway when a departing aircraft begins its takeoff roll. While the SWA flight crew was performing the engine run-up procedure, the separation between the SWA and FedEx airplanes (1.5 miles and closing) was less than the FAA's requirement.

When the SWA airplane stopped on the runway to perform the engine run-up, the FedEx airplane was 33 seconds from the runway threshold and 8,000 ft from the

[74] The NTSB can reiterate recommendations when another investigation shows the continued need for the recommended actions. A recommendation can be reiterated at any time, even if the recipient has not yet responded to the initial recommendation.

SWA airplane. However, by the time that the SWA airplane began its takeoff roll, the FedEx airplane was 3,400 ft from the SWA airplane, which increased the severity of the loss of separation. The controller's lack of awareness about the SWA airplane's position at the time could have been mitigated if the SWA flight crew had informed the controller about the planned engine run-up procedure. The NTSB concludes that, even though the SWA flight crewmembers were not required to inform the controller about their plan to stop the airplane once on the active runway, it would have been prudent for them to do so given that they were notified about traffic on short final approach.

As previously stated, another reason that the controller was unaware that the SWA airplane had stopped on the runway was because of his inability to see the airplane from the tower due to the dense fog. The NTSB concludes that the SWA flight crewmembers should have informed the controller of their plan to perform an engine run-up. Therefore, the NTSB recommends that the FAA require air traffic controllers to

- advise pilots, through direct communication and ATIS broadcasts, when visual contact with aircraft operating on taxiways and runways cannot be established or maintained and
- instruct pilots to provide accurate position reports to aid the controller in determining an aircraft's location in such conditions.

Paragraph 5-8-4 of FAA Order 7110.65 also noted that controllers should consider the effect that surface conditions, such as ice, snow, and other precipitation, might have on known aircraft performance characteristics and the influence that these conditions might have on a pilot's ability to begin the takeoff roll in a timely manner. However, the controller's mental model of the SWA airplane's position likely did not account for (1) the freezing fog and outside air temperature (3°C) that were reported, which led the SWA flight crew to use engine anti-ice and perform the engine run-up procedure, or (2) the ambient conditions (that is, the environmental conditions in the area immediately surrounding an aircraft). In addition, the SWA flight crewmembers did not notify the controller of their intent to stop the airplane on the active runway and perform the engine run-up procedure.

The NTSB concludes that, to avoid potential conflicts, it is critical for (1) controllers to consider, when providing takeoff clearance to an aircraft, whether ambient conditions might affect the timing of the takeoff roll and (2) pilots to concisely communicate pertinent aircraft position information during low-visibility conditions that might prevent a controller from seeing the aircraft. Therefore, the NTSB recommends that the FAA brief all air traffic controllers about the circumstances of this incident, emphasizing the effect that certain conditions might have on a pilot's ability to begin a takeoff in a timely manner, including

- low-visibility weather conditions, such as fog;
- ambient conditions, such as temperature; and
- surface conditions, such as ice, snow, and other precipitation, as noted in Order 7110.65, paragraph 5-8-4, Departure and Arrival.

Further, section 4.3.14 of the FAA's AIM stated that "the tower controller will consider that pilots of turbine-powered aircraft are ready for takeoff when they reach the runway…unless advised otherwise." However, the AIM did not specifically instruct pilots to notify the controller, after receiving clearance for takeoff, if they would need additional time on the runway before beginning the takeoff roll. In addition, section 5.5.2(a)(4) of the AIM stated that a pilot "promptly complies with an air traffic clearance upon receipt" and "advises ATC as soon as possible and obtains an amended clearance, if [a] deviation is necessary." Thus, to further aid local controllers in determining an aircraft's status (including its location on or near a runway in low-visibility conditions that might preclude a controller from seeing the airplane) and ensuring appropriate separation between aircraft, the NTSB also recommends that the FAA amend the AIM so that it instructs pilots to inform controllers, before entering an active runway with the intent to depart, when they need time on the runway for any reason before beginning the takeoff roll.

2.5 Training on the Airport's SMGCS Plan and Low-Visibility Operations

About 0549, the local controller communicated with the flight crew of the first recorded departure at AUS on the morning of the incident. The local controller provided RVR values for runway 18L of 1,000 ft (touchdown), 1,400 ft (midpoint), and 1,800 ft (rollout). Because the touchdown RVR was below 1,200 ft, the airport's SMGCS plan should have been activated then.[75] However, the operations supervisor on the morning of the incident did not activate the SMGCS plan, which would have involved (among other things) notifying airport operations (the City of Austin Department of Aviation) that the RVR values had decreased and were expected to remain at or below 1,200 ft. Airport operations personnel would then have notified operators that low-visibility operations were in effect.

The operations supervisor reported that she had not "officially" activated the SMGCS plan because "the RVR was not consistently below 1,200 [ft]." However, the supervisor did not check with the weather observer within the ATCT to determine if

[75] Starting about 0549 on the morning of the incident, the source for RVR information was the RVR values displayed in the tower (which are continuously updated). Before that time, the RVR information source was the hourly (special) observations, which were based on the low and high values of the three sensors for runway 36R. None of those RVR values were below 1,200 ft before 0549.

the RVR was expected to trend below 1,200 ft. During a postincident interview, the air traffic manager at the AUS ATCT stated his expectation that the SMGCS plan would be activated when any RVR value (touchdown, midpoint, or rollout) was below 1,200 ft. When the local controller cleared the SWA airplane for takeoff, the touchdown and rollout RVR values for runway 18L were 1,200 and 600 ft, respectively.

The operations supervisor reported that she was using progressive taxi instructions during the morning of the incident, consistent with the SMGCS plan and the requirements of FAA Order 7110.65Z, paragraph 3-7-2, which stipulated the use of progressive taxi instructions "during reduced visibility, especially when the taxi route is not visible from the tower." However, in the case of the SWA incident airplane, the airplane had already taxied from the ramp area to taxiway B (which led to the runway), so the local controller was not required to use additional progressive taxi instructions when the SWA flight crew contacted the controller to relay that the airplane was "short of one eight left" and "ready" for takeoff.

The SMGCS plan noted that the ATCT uses position reporting when taxiing aircraft are not visible from the tower. Even though the SMGCS plan had not been activated, paragraph 3-1-7 in FAA Order 7110.65Z referenced position reporting as a method for determining an airplane's position when the airplane cannot be tracked visually or via a display system. However, the local controller did not instruct the flight crews of departing airplanes to provide position reports while taxiing to or reaching the assigned runway. It is important to note that the SWA flight crew's report that the airplane was short of runway 18L was part of the crew's takeoff clearance request and was not a position report.

The NTSB concludes that, although the visibility before and at the time of the incident required the activation of the airport's SMGCS plan, the operations supervisor's failure to implement the plan was not a factor in this incident because the local controller should have been able to appropriately manage the SWA airplane's departure using other ATC procedures.

The local controller stated that he was "pretty sure" that he had received training on the facility's SMGCS plan during initial training. Training records indicated that the local controller successfully completed initial training in 2019. However, during a postincident interview, the controller was unable to recall any details about the SMGCS plan or any associated training.

The AUS ATCT did not provide, and was not required to provide, refresher training to air traffic personnel regarding the SMGCS plan. During its review of a June 2022 PowerPoint presentation that was used during initial tower qualification training at AUS, the NTSB found that two of the slides showed the departure and arrival taxi routes when the airport's SMGCS plan was in effect. Even though refresher SMGCS training was not required, the AUS ATCT could have used that training opportunity to review additional requirements of the SMGCS plan, including when the plan should be implemented and ATC responsibilities when the plan was in effect.[76]

In addition, the SMGCS plan and the associated LOA (between the City of Austin Department of Aviation and the AUS ATCT) were generally aligned with the SMGCS guidance in FAA AC 120-57B. However, the SMGCS plan and the LOA were not aligned with each other in a key area. Specifically, the SMGCS plan stated that ATC would notify airport operations when decreasing ceiling and visibility conditions indicated that an RVR of less than 1,200 ft was imminent and that the SMGCS plan would be going into effect. However, the LOA provided instructions for ATC to notify airport operations when the RVR was less than 1,200 ft but did not specifically direct ATC to activate the SMGCS plan at that time.

The NTSB concludes that it is important for a SMGCS plan and the related LOA to have aligned information given that controllers are required to comply with the provisions of all LOAs. The NTSB also concludes that controllers need to be sufficiently trained on their airport's SMGCS plan so that they are able to effectively implement it when necessary. It is possible that similar inconsistencies and a lack of training on LOAs/SMGCS plans exist at other ATCTs. Therefore, the NTSB recommends that the FAA require all airports with a SMGCS plan to ensure that their plans and the associated LOAs correspond with each other and the stakeholder duties and responsibilities described in AC 120-57. The NTSB also recommends that the FAA direct training administrators at airports with a SMGCS plan to require initial and annual refresher training for all stakeholders, including air traffic controllers and airport operations personnel, on the information in the airport's plan.

As stated in section 2.2.2, the AUS ATCT had not conducted any training related to low-visibility operations during the 2 years that the air traffic manager had been at the tower. Also, the controller had not worked a shift with low-visibility conditions for at least 1 year before the incident. As a result, the controller did not receive adequate preparation to properly handle traffic in the low-visibility conditions that existed on the morning of the incident.

Although FAA Order 3120.4R included "weather" and "tower visibility" as topics to be included in refresher training, individual ATCT facilities could decide the specific items to be trained under those topics. Thus, training on handling traffic during low-visibility operations might not occur, even though low-visibility conditions can affect every ATCT facility, including those without a SMGCS plan and those

[76] Four days after the incident, the air traffic manager issued a memorandum to remind controllers that, once the RVR for runway 18L decreases below 1,200 ft, the SMGCS plan needs to go into effect, and the ATIS needs to be updated with that information.

without surface detection capability (similar to AUS). The NTSB concludes that refresher training on low-visibility operations would benefit ATCT personnel at all operating towers in the National Airspace System because such conditions can affect operations throughout the United States. Therefore, the NTSB recommends that the FAA require training administrators at all operating ATCTs to conduct annual refresher training on low-visibility operations. Such training could include general precautions, best practices, and locally based information specific to the facility location.

2.6 Cockpit Voice Recorder Duration

Because the 2-hour CVR installed on the FedEx airplane was overwritten after the incident, the NTSB was unable to determine when the first officer saw the SWA airplane or how he communicated the need to go around to the captain. (The SWA airplane also had a 2-hour CVR installed.) In October 2018, the NTSB issued Safety Recommendations A-18-30 and -31, which recommended that new and existing airplanes, respectively, be equipped with CVRs that record 25 hours of data to ensure that investigations would not be hindered by the lack of CVR data. For this incident, a 25-hour CVR would have recorded the above-mentioned information as well as other audio information that was not captured on ATC recordings.

Other NTSB investigations have highlighted the need for 25-hour CVRs. For example, both airplanes involved in the JFK runway incursion had a 2-hour CVR installed, and both CVRs had been overwritten by the time that the NTSB learned about the incident. The final report for the JFK incident reiterated Safety Recommendations A-18-30 and -31 because of the loss of critical information of interest to the investigation, including the content and timing of crew communications, potential distractions, and crew situational awareness. In addition, postincident interviews of the American Airlines flight crew involved in the JFK incident did not occur until about 1 month after the incident. Because memories can decay or become distorted with time, CVR information was needed to corroborate the crew's recollections.

The NTSB recognizes that the FAA has taken action to address Safety Recommendation A-18-30 by publishing an NPRM that proposed that newly manufactured aircraft be equipped with CVRs capable of recording 25 hours of data. However, the NTSB 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, as discussed in Safety Recommendation A-18-31.

On May 16, 2024, the FAA Reauthorization Act of 2024 became law. The act required 25-hour CVRs for aircraft operated under 14 *CFR* Part 121, other transport-category airplanes that were type certificated with a seating capacity of

30 or more passengers, and cargo derivatives of such airplanes that are operated under other regulations. The act specified that newly manufactured aircraft were be installed with 25-hour CVRs starting 1 year after the date of the act. Also, the act specified that affected operators were to retrofit their aircraft with a 25-hour CVR no later than 6 years after the date of the act. In addition, the act required the FAA, within 3 years of the date of the act, to issue a final rule to update applicable regulations to conform to the CVR retrofit requirement for existing aircraft.

The SWA and FedEx airplanes involved in this incident would not be subject to the proposed rulemaking that the FAA announced in December 2023, but they would be subject to the 6-year retrofit requirement in the FAA Reauthorization Act of 2024. The FAA's December 2023 NPRM did not include a requirement for 25-hour CVRs for existing airplanes, and the FAA has not issued a final rule for 25-hour CVRs for newly manufactured airplanes.

On May 29, 2024, the NTSB classified Safety Recommendation A-18-31 Closed—Unacceptable Action/Superseded because the FAA did not complete the requested action by January 1, 2024. The NTSB superseded A-18-31 with A-24-9, which asked the FAA to "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." In addition, the NTSB classified Safety Recommendation A-24-9 Open—Unacceptable Response.

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 Recommendations A-18-30 and A-24-9.

3. Conclusions

3.1 Findings

1. None of the following were factors in this incident: (1) pilot and controller qualifications, (2) controller fatigue, (3) air traffic control tower staffing at the time of the incident, and (4) flight crew fatigue.

2. The controller's inaccurate mental model of the Southwest Airlines (SWA) airplane's position on the taxiway resulted from his (1) expectation that the SWA airplane would be at the hold-short line for runway 18L when the flight crew requested takeoff clearance and (2) failure to verify the SWA airplane's position on the taxiway at the time of the takeoff clearance request.

3. The controller's lack of training in low-visibility conditions and his expectation that the Southwest Airlines (SWA) airplane would depart quickly were factors that led to his inaccurate mental model of the SWA airplane's position on the taxiway.

4. The controller's failure to fully understand the Southwest Airlines (SWA) airplane's position upon entering and while on the runway resulted in insufficient separation between the SWA and Federal Express airplanes.

5. The controller's incorrect assumption that the Southwest Airlines airplane would depart before the Federal Express airplane would arrive set up a hazardous situation that could have resulted in an accident. This situation could have been avoided altogether if the controller had followed established air traffic control procedures to ensure proper separation.

6. The controller could still have appropriately separated both airplanes if he had either (1) held the departing Southwest Airlines (SWA) airplane until after the arriving Federal Express (FedEx) airplane landed or (2) if the SWA airplane had already received its takeoff clearance, canceled the clearance and instructed the FedEx airplane to go around.

7. The quick reaction of the Federal Express (FedEx) first officer after seeing the Southwest Airlines (SWA) airplane and the quick response of the FedEx captain in performing a missed approach avoided a potential runway collision between the SWA and FedEx airplanes and led to the successful resolution of the loss of separation.

8. The Southwest Airlines flight crew's actions to shallow the airplane's climb in response to an advisory from the traffic alert and collision avoidance system contributed to the increased separation between the two airplanes.

9. If surface detection equipment had been installed in the air traffic control tower, the system would have allowed the controller to track the position of the Southwest Airlines (SWA) airplane while it was on the taxiway and runway, which would have provided an opportunity for the controller to detect the insufficient separation between the SWA and Federal Express airplanes and take action to mitigate the situation.
10. The implementation of a flight deck alerting system on air carrier aircraft would further improve safety at (1) airports without surface detection equipment and (2) airports with surface detection equipment if a controller were to inadequately respond to an alert in the tower.
11. Even though the Southwest Airlines flight crewmembers were not required to inform the controller about their plan to stop the airplane once on the active runway, it would have been prudent for them to do so given that they were notified about traffic on short final approach.
12. The Southwest Airlines flight crewmembers should have informed the controller of their plan to perform an engine run-up.
13. To avoid potential conflicts, it is critical for (1) controllers to consider, when providing takeoff clearance to an aircraft, whether ambient conditions might affect the timing of the takeoff roll and (2) pilots to concisely communicate pertinent aircraft position information during low-visibility conditions that might prevent a controller from seeing the aircraft.
14. Although the visibility before and at the time of the incident required the activation of the airport's Surface Movement Guidance and Control System plan, the operations supervisor's failure to implement the plan was not a factor in this incident because the local controller should have been able to appropriately manage the Southwest Airlines airplane's departure using other air traffic control procedures.
15. It is important for a Surface Movement Guidance and Control System plan and the related letter of agreement (LOA) to have aligned information given that controllers are required to comply with the provisions of all LOAs.
16. Controllers need to be sufficiently trained on their airport's Surface Movement Guidance and Control System plan so that they are able to effectively implement it when necessary.
17. Refresher training on low-visibility operations would benefit air traffic control tower personnel at all operating towers in the National Airspace System because such conditions can affect operations throughout the United States.

18. Cockpit voice recorders (CVR) 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 National Transportation Safety Board determines that the probable cause of this incident was the local controller's incorrect assumption that the Southwest Airlines (SWA) airplane would depart from the runway before the Federal Express airplane arrived on the same runway, which resulted in a loss of separation between both airplanes. Contributing to the controller's incorrect assumption were

- his expectation bias regarding the SWA airplane's departure,
- his lack of situational awareness regarding the SWA airplane's position when the flight crew requested takeoff clearance, and
- the air traffic control tower's lack of training (before the incident) on low-visibility operations.

Contributing to the incident was the SWA flight crewmembers' failure to account for the traffic that was on short final approach and to notify the controller that they would need additional time on the runway before the takeoff roll. Also contributing to the incident was the Federal Aviation Administration's failure to require surface detection equipment at Austin-Bergstrom International Airport and direct alerting for flight crews.

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:

For airports that are certificated under Title 14 *Code of Federal Regulations* Part 139 and are currently not equipped with airport surface detection equipment, model X or airport surface surveillance capability, implement surface detection equipment that

- tracks the movement of arriving and departing aircraft,
- determines the proximity between those aircraft, and
- provides air traffic controllers with visual and aural cues of surface movements to aid in their decision-making processes. (A-24-10)

Require air traffic controllers to

- advise pilots, through direct communication and automatic terminal information system broadcasts, when visual contact with aircraft operating on taxiways and runways cannot be established or maintained and
- instruct pilots to provide accurate position reports to aid the controller in determining an aircraft's location in such conditions. (A-24-11)

Brief all air traffic controllers about the circumstances of this incident, emphasizing the effect that certain conditions might have on a pilot's ability to begin a takeoff in a timely manner, including

- low-visibility weather conditions, such as fog;
- ambient conditions, such as temperature; and
- surface conditions, such as ice, snow, and other precipitation, as noted in Order 7110.65, Air Traffic Control, paragraph 5-8-4, Departure and Arrival. (A-24-12)

Amend the *Aeronautical Information Manual* so that it instructs pilots to inform controllers, before entering an active runway with the intent to depart, when they need time on the runway for any reason before beginning the takeoff roll. (A-24-13)

Require all airports with a Surface Movement Guidance and Control System plan to ensure that their plans and the associated letters of agreement correspond with each other and the stakeholder duties and responsibilities described in Advisory Circular 120-57, Surface Movement Guidance and Control System. (A-24-14)

Direct training administrators at airports with a Surface Movement Guidance and Control System plan to require initial and annual refresher training for all stakeholders, including air traffic controllers and airport operations personnel, on the information in the airport's plan. (A-24-15)

Require training administrators at all operating air traffic control towers to conduct annual refresher training on low-visibility operations. (A-24-16)

4.2 Previously Issued Recommendations Reiterated in This Report

The National Transportation Safety Board reiterates the following safety recommendations.

To the Federal Aviation Administration:

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)

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)

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)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JENNIFER HOMENDY
Chair

MICHAEL GRAHAM
Member

THOMAS CHAPMAN
Member

ALVIN BROWN
Member

J. TODD INMAN
Member

Report Date: June 6, 2024

Appendixes

Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified about this incident on February 4, 2023. Investigators from NTSB headquarters responded to the incident on February 6. The following investigative groups were formed: air traffic control, operations, and systems. Also, 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, medical issues, and meteorology participated in the investigation. Parties to the investigation were the Federal Aviation Administration; Southwest Airlines; Federal Express Corporation; Southwest Airlines Pilots Association; Air Line Pilots Association, International; National Air Traffic Controllers Association; The Boeing Company; and Honeywell Aerospace Technologies.

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-24-10
For airports that are certificated under Title 14 *Code of Federal Regulations* Part 139 and are currently not equipped with airport surface detection equipment, model X or airport surface surveillance capability, implement surface detection equipment that

- tracks the movement of arriving and departing aircraft,
- determines the proximity between those aircraft, and
- provides air traffic controllers with visual and aural cues of surface movements to aid in their decision-making processes.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.3.1, Air Traffic Control Tower Technology. Information supporting (b)(1) can be found on page 53; (b)(2) is not applicable; and (b)(3) can be found on pages 52 and 53.

A-24-11
Require air traffic controllers to

- advise pilots, through direct communication and automatic terminal information system broadcasts, when visual contact with aircraft operating on taxiways and runways cannot be established or maintained and

- instruct pilots to provide accurate position reports to aid the controller in determining an aircraft's location in such conditions.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Engine Run-up During Low-Visibility Conditions. Information supporting (b)(1) can be found on pages 56 and 57; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-12
Brief all air traffic controllers about the circumstances of this incident, emphasizing the effect that certain conditions might have on a pilot's ability to begin a takeoff in a timely manner, including

- low-visibility weather conditions, such as fog;
- ambient conditions, such as temperature; and
- surface conditions, such as ice, snow, and other precipitation, as noted in Order 7110.65, Air Traffic Control, paragraph 5-8-4, Departure and Arrival.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Engine Run-up During Low-Visibility Conditions. Information supporting (b)(1) can be found on page 57; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-13
Amend the *Aeronautical Information Manual* so that it instructs pilots to inform controllers, before entering an active runway with the intent to depart, when they need time on the runway for any reason before beginning the takeoff roll.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.4, Engine Run-up During Low-Visibility Conditions. Information supporting (b)(1) can be found on pages 57 and 58; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-14
Require all airports with a Surface Movement Guidance and Control System plan to ensure that their plans and the associated letters of agreement correspond with each other and the stakeholder duties and responsibilities described in Advisory Circular 120-57, Surface Movement Guidance and Control System.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5, Training on the Airport's SMGCS Plan and Low-Visibility

Operations. Information supporting (b)(1) can be found on pages 59 and 60; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-15
Direct training administrators at airports with a Surface Movement Guidance and Control System plan to require initial and annual refresher training for all stakeholders, including air traffic controllers and airport operations personnel, on the information in the airport's plan.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5, Training on the Airport's SMGCS Plan and Low-Visibility Operations. Information supporting (b)(1) can be found on pages 59 and 60; (b)(2) is not applicable; and (b)(3) is not applicable.

A-24-16
Require training administrators at all operating air traffic control towers to conduct annual refresher training on low-visibility operations.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in section 2.5, Training on the Airport's SMGCS Plan and Low-Visibility Operations. Information supporting (b)(1) can be found on pages 60 and 61; (b)(2) is not applicable; and (b)(3) is not applicable.

Appendix C: FedEx Go-Around and Missed Approach Procedures

Go-Around and Missed Approach Procedure – VNAV	
Pilot Flying (PF)	**Pilot Monitoring (PM)**
Simultaneously: • Push either GA switch and confirm thrust lever advancement [1], • Rotate to go-around attitude (if AP engaged monitor for proper rotation), • Call “GO-AROUND, FLAPS 20.”	**Simultaneously:** • Position the flap lever to 20, • Verify thrust lever advancement, pitch attitude, and FMAs.[2]
	Call “THRUST SET.” [3]
(Footnote [4])	
	Verify positive rate of climb on the altimeter and call, “POSITIVERATE.”
Verify a positive rate of climb on the altimeter and call “GEAR UP, CHECK MISSED APPROACH ALTITUDE.”	Set the landing gear lever to UP. Verify that the missed approach altitude is set. Call “____________ SET”. (e.g., “5,000 SET”).
Above 400 feet radio altitude, select or call for a roll mode.	Verify or select theroll mode asdirected by the PF.
Verify that the missed approach route is tracked.	
At acceleration height (normally 1,000 feet AGL), select or call for VNAV.	Verify or select VNAV as directed by the PF
Verify that climb thrust is set.	
Engage the autopilot, if not already engaged at go-around, after a roll and pitch mode are selected.	
Call “FLAPS __________” according to the flap retraction schedule.[5]	Set the flap lever as directed.
Call “AFTER TAKEOFF CHECKLIST”.	Do the AFTER TAKEOFF checklist.
Verify that the missed approach altitude is captured.	

1 During a single engine go-around and/or when the autothrottle system is inoperative or A/T switch OFF, ensure that the thrust lever(s) are manually advanced to an appropriate thrust setting, up to and including max thrust.

2 Verify FMAs: GA/ GA/ GA (Blank/ GA/ GA if autothrottles inop).

3 The thrust reference limits displayed on the EICAS are maximum values for the GA mode but a go-around using the AFDS system will not normally achieve this amount of thrust (commanded N1 being less than the reference N1’GA’ limit). GA thrust should be sufficient to attain 2,000 fpm climb performance.

4 These procedures remain the same for a rejected landing. However, if the airplane is on the ground (and has been below five feet radio altitude for less than two seconds when the GA switch is pushed) the autopilot go-around pitch mode will engage but the autothrottle mode will remain in IDLE. Additionally, if the airplane is floating within five feet radio altitude for more than two seconds when the GA switch is pushed, the autothrottle go-around mode will engage but the autopilot pitch mode will remain in FLARE.

5 Retract flaps for the planned flaps setting.It is acceptable to remain at FLAPS 1 or FLAPS 5, as desired.

Source: FedEx.

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For more detailed background information on this report, visit the NTSB Case Analysis and Reporting Online (CAROL) website and search for NTSB accident ID DCA23FA149. Recent publications are available in their entirety on the NTSB website. Other information about available publications also may be obtained from the website or by contacting –

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