# Runway Overrun During Rejected Takeoff
# Ameristar Air Cargo, Inc., dba Ameristar Charters, flight 9363
# Boeing MD-83, N786TW
# Ypsilanti, Michigan
# March 8, 2017

**Accident Report**


NTSB/AAR-19/01
PB2019-100293

National
Transportation
Safety Board

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# Aircraft Accident Report

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National
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490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

**National Transportation Safety Board. 2019.** ***Runway Overrun During Rejected Takeoff, Ameristar Air Cargo, Inc., dba Ameristar Charters, flight 9363, Boeing MD-83, N786TW, Ypsilanti, Michigan, March 8, 2017.*** **NTSB/AAR-19/01. Washington, DC.**

**Abstract:** This report discusses the March 8, 2017, accident involving Ameristar Air Cargo, Inc., dba Ameristar Charters, flight 9363, a Boeing MD-83 airplane, which overran the departure end of runway 23L at Willow Run Airport, Ypsilanti, Michigan, after the captain executed a rejected takeoff. The 110 passengers and 6 flight crewmembers evacuated the airplane via emergency escape slides; however, one slide failed to inflate and could not be used. One passenger received a minor injury, and the airplane sustained substantial damage. Safety issues identified in this report include the lack of a means to enable flight crews of Boeing DC-9/MD-80 series and 717 model airplanes to verify before takeoff that the elevators are not jammed, the need for improved in-service inspection techniques for critical rotating parts of all engines, the need for lower ground gust criteria for elevator physical inspections and operational checks by maintenance personnel for Boeing DC 9/MD-80 series and 717 model airplanes, the potential inadequacy of ground gust limit loads for the certification of transport-category airplanes, the lack of procedures for operators of Boeing DC-9/MD-80 series and 717 model airplanes to monitor the wind that affects parked airplanes, the lack of procedures for weather observers related to sign off and backup augmentation responsibilities during a facility evacuation, and evacuation slide malfunction. As a result of this investigation, the National Transportation Safety Board makes three safety recommendations to the Federal Aviation Administration and three recommendations to The Boeing Company.

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# Abbreviations

| | |
|---|---|
| **3-D** | three-dimensional |
| **AC** | advisory circular |
| **ACU** | acquisition control unit |
| **agl** | above ground level |
| **AIRMET** | airmen's meteorological information |
| ***AFM*** | *Airplane Flight Manual* |
| ***AMM*** | *Aircraft Maintenance Manual* |
| ***AOM*** | *Aircraft Operating Manual* |
| **ASOS** | automated surface observing system |
| **ATC** | air traffic control |
| **ATCT** | air traffic control tower |
| **ATIS** | automatic terminal information service |
| **ATP** | airline transport pilot |
| **AWOS** | automated weather observing system |
| **BFU** | German Federal Bureau of Aircraft Accident Investigation |
| **CAM** | cockpit area microphone |
| **CASS** | continuing analysis and surveillance system |
| **CFD** | computational fluid dynamics |
| ***CFR*** | *Code of Federal Regulations* |
| **CG** | center of gravity |
| ***CMM*** | *Component Maintenance Manual* |
| **CVR** | cockpit voice recorder |
| **DCP** | data collection package |
| **DO** | director of operations |
| **DTW** | Detroit Metropolitan Wayne County Airport |
| **EMAS** | engineered materials arresting system |
| **EST** | eastern standard time |
| **FAA** | Federal Aviation Administration |
| ***FAM*** | *Flight Attendant Manual* |
| ***FCOM*** | *Flight Crew Operations Manual* |

| | |
|---|---|
| **FDR** | flight data recorder |
| **FOB** | flight operations bulletin |
| **FTD** | Fleet Team Digest |
| **GCP** | ground control point |
| ***GOM*** | *General Operations Manual* |
| **IFR** | instrument flight rules |
| **LAWRS** | limited aviation weather reporting station |
| **MAC** | mean aerodynamic chord |
| **METAR** | aviation routine weather report |
| **NAVAID** | navigational aid |
| **nm** | nautical miles |
| **NOAA** | National Oceanic and Atmospheric Administration |
| **NOTAM** | notice to airmen |
| **NPRM** | notice of proposed rulemaking |
| **NTSB** | National Transportation Safety Board |
| **NWS** | National Weather Service |
| **OAMP** | on aircraft maintenance planning |
| **OID** | operator interface device |
| **OIG** | Office of Inspector General |
| **OpSpecs** | operations specifications |
| **PF** | pilot flying |
| **PIC** | pilot-in-command |
| **PM** | pilot monitoring |
| **psi** | pounds per square inch |
| **RAP** | risk assessment program |
| **RPU** | remote processing unit |
| **RSA** | runway safety area |
| **RTMA** | real-time mesoscale analysis |
| **RWIS** | runway weather information system |
| **SAWS** | stand-alone weather sensor |
| **SB** | service bulletin |

| | |
|---|---|
| **SIGMET** | significant meteorological information |
| **SMS** | safety management system |
| **SOP** | standard operating procedure |
| **SPECI** | aviation selected special weather reports |
| **sUAS** | small unmanned aircraft system |
| **TAF** | terminal aerodrome forecast |
| **TED** | trailing edge down |
| **TEU** | trailing edge up |
| **VFR** | visual flight rules |
| **$V_1$** | takeoff decision speed |
| **$V_2$** | minimum takeoff safety speed |
| **$V_R$** | rotation speed |
| **YIP** | Willow Run Airport |

# Executive Summary

On March 8, 2017, about 1452 eastern standard time, Ameristar Air Cargo, Inc., dba Ameristar Charters, flight 9363, a Boeing MD-83 airplane, N786TW, overran the departure end of runway 23L at Willow Run Airport (YIP), Ypsilanti, Michigan, after the captain executed a rejected takeoff. The 110 passengers and 6 flight crewmembers evacuated the airplane via emergency escape slides; however, one slide failed to inflate and could not be used. One passenger received a minor injury, and the airplane sustained substantial damage. The airplane was operated under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 121 as an on-demand charter flight and was destined for Washington Dulles International Airport, Dulles, Virginia. Visual flight rules conditions prevailed at YIP at the time of the accident.

During the takeoff roll, the captain, who was the pilot flying, executed the rejected takeoff 12 seconds after the airplane achieved $V_1$ (takeoff decision speed) because he perceived that the airplane did not respond normally when he pulled back on the control column to command rotation. ($V_1$ is defined, in part, as the maximum speed in the takeoff by which a rejected takeoff must be initiated to ensure that a safe stop can be completed within the remaining runway.) The check airman, who was the pilot monitoring (and was providing airplane differences training to the captain), questioned the captain's decision to reject the takeoff after $V_1$ but adhered to company standard operating procedures and did not attempt to intervene.

Data from the airplane's flight data recorder (FDR) showed that the airplane's right elevator was positioned full trailing edge down (TED) when the flight crew first powered up the airplane on the day of the accident and remained there throughout the accident sequence. An airplane performance study (based, in part, on FDR data) confirmed that the airplane did not respond in pitch when the captain pulled on the control column. Based on the study's comparison with a previous takeoff, the National Transportation Safety Board (NTSB) determined that the airplane's lack of rotational response to the control column input did not become apparent to the captain in time for him to have stopped the airplane on the runway.

Before the accident flight, the airplane had been parked on the ramp at YIP for 2 days near a large hangar, and the elevators (which, by design, did not have gust locks) were exposed to high, gusting surface wind conditions. Postaccident examination showed that the right elevator's geared tab's inboard actuating crank and links had moved beyond their normal range of travel and became locked overcenter, effectively jamming the right elevator in a full-TED position and rendering the airplane incapable of rotation during takeoff. The speed of the surface wind and gusts at YIP did not exceed the certification design limit or maintenance inspection criteria for the airplane. However, the NTSB determined the airflow at the airplane's parked location was affected by the presence of the large hangar that generated localized turbulence with a vertical component that moved the elevator surfaces rapidly up and down, which resulted in impacts against the elevator mechanical stops, imposing dynamic loads sufficient to jam the right elevator.

As a result of this investigation, the NTSB identified the following safety issues:

- **Lack of a means to enable flight crews of Boeing DC-9/MD-80 series and 717 model airplanes to verify before takeoff that the elevators are not jammed**. The accident flight crew performed both the preflight inspection and the control check

during taxi in accordance with the procedures in Ameristar's *Aircraft Operating Manual* (*AOM*) for the Boeing MD-83; however, these checks did not enable them to detect the jammed elevator condition. For all Boeing DC-9/MD-80 series and 717 model airplanes (which have a similar elevator design), a full-TED elevator position (which may be visible during the preflight walkaround inspection) is not necessarily indicative of an anomaly because the elevators can freely move to that position under a nominal ground wind. Also, on these airplane models, the control column is mechanically connected to and directly controls the elevator control tabs, not the elevators. During the taxi control check for the accident airplane, the elevator control tabs responded normally to control column input, even though the right elevator was jammed.

- **Need for lower ground gust criteria for elevator physical inspections and operational checks by maintenance personnel for Boeing DC-9/MD-80 series and 717 model airplanes.** The *AOM* contained an amplified normal checklist for flight crews that included a caution that airplanes exposed to high sustained wind or gusts greater than 65 kts were susceptible to elevator damage and/or jamming and stated that, for any airplanes suspected of such exposure, inspections and checks specified in Ameristar's *Aircraft Maintenance Manual* (*AMM*) for the Boeing MD-83 were required. The *AMM* included a warning that the airplane must be parked headed into the wind if gusts were expected to exceed 60 kts and a caution that visual and physical inspections of all flight control surfaces were required if the airplane was subjected to wind exceeding 65 kts. However, none of the recorded or forecasted wind at YIP exceeded these limits during the time that the airplane was parked on the ramp (the highest reported wind gust was 55 kts and the highest forecasted gust was 48 kts).

- **Potential inadequacy of ground gust limit loads for the certification of transport category airplanes.** The airworthiness standard current at the time of the accident specified in 14 *CFR* 25.415, "Ground gust conditions," that flight control systems and surfaces of transport-category airplanes must be designed for the limit loads generated when the airplane is subjected to a 65 kt horizontal ground gust from any direction while parked and taxiing. The regulation allowed for the assumption of static loads and provided the formula from which the hinge moments must be computed for elevators. However, considering the circumstances of the accident, the NTSB is concerned that the ground gust criteria specified in the regulation may not adequately ensure that critical flight control systems are protected from hazards introduced by ground gusts that contain dynamic, vertical wind components.

- **Lack of procedures for operators of Boeing DC-9/MD-80 series and 717 model airplanes to monitor the wind that affects parked airplanes.** Although the *AOM* and *AMM* specified actions for flight crews and maintenance personnel to take when ground gusts reached certain criteria, Ameristar had no procedures to identify who was responsible for monitoring the known and forecasted wind that may affect the company's parked airplanes. Had the wind at YIP exceeded the ground gust criteria specified in the *AOM* and *AMM*, it is unclear from Ameristar's procedures if any personnel would have known and subsequently ensured that the specified parking and/or inspection actions were taken. To ensure that the elevators of Boeing DC 9/MD 80 series and 717 model airplanes are inspected by maintenance personnel when exposed to ground gusts that meet or exceed criteria specified in the *AMM*, all operators of these airplanes must maintain awareness at all times of the forecasted and known wind where the airplanes are parked. After the accident, Ameristar implemented procedures for monitoring the wind affecting its parked airplanes.

- **Lack of procedures for weather observers related to sign off and backup augmentation responsibilities during a facility evacuation.** YIP was a Limited Aviation Weather Reporting Station (LAWRS) facility, and, on the day of the accident, all personnel evacuated from the air traffic control tower due to the high wind. Further, due to a power outage, the automated surface observing system (ASOS) lost some of its sensor functions. Before evacuating the duty station, a LAWRS observer did not sign off from the ASOS operator interface device (OID), and, after evacuating, no LAWRS observer provided any backup information to supplement the weather data that was missing from the partially disabled ASOS. As a result, throughout the day of the accident, the ASOS continued to automatically disseminate aviation routine weather reports (METARs) that did not contain the AUTO modifier (because the observer did not sign off from the OID) to show that the METARs were not being augmented by a weather observer and did not contain complete weather information.[1] The investigation identified procedural gaps in Federal Aviation Administration (FAA) Order JO 7900.5D (which was current at the time of the accident) and its subsequent revision in Change 1 (effective November 29, 2017) that could be clarified to ensure dissemination of the most complete and accurate weather information possible during circumstances in which weather observers are unable to perform their prescribed duties from their normal duty stations during normal duty hours.
- **Evacuation slide malfunction.** The evacuation slide for the airplane's right front (1R) door did not inflate when a flight attendant pulled the manual inflation handle, which rendered the exit unusable. The investigation found that the cable had been installed incorrectly in the valve assembly, which prevented proper inflation. On July 14, 2017, the slide manufacturer issued a revision to the *Component Maintenance Manual* to provide more descriptive valve testing procedures intended to prevent improper cable installation.

During the overrun, the airplane was traveling about 100 kts when it exited the paved surface off the departure end of runway 23L at YIP. It then traveled about 950 ft across the grassy part of the runway safety area (RSA) before striking the airport perimeter fence and a raised, paved road before coming to a stop. The RSA off the departure end of runway 23L met the dimensional standards specified in FAA Advisory Circular 150/5300-13A, Change 1, having been upgraded between 2006 and 2009. The NTSB notes that these upgrades were responsive to previously issued NTSB safety recommendations and were part of a national program that the FAA initiated in 1999

[1] According to FAA Order JO 7900.5D, *Surface Weather Observing*, section 14.10.a., the AUTO modifier "identifies the type of report as a fully automated report with no human intervention…the absence of AUTO indicates that the report is either a manual report or an automated report with an observer 'logged on' to the system" (FAA 2014b, 102).

to improve RSAs, install engineered material arresting systems, and relocate or make frangible FAA-owned navigational aids located in an RSA.

The NTSB determines that the probable cause of this accident was the jammed condition of the airplane's right elevator, which resulted from exposure to localized, dynamic wind while the airplane was parked and rendered the airplane unable to rotate during takeoff. Contributing to the accident were (1) the effect of a large structure on the gusting surface wind at the airplane's parked location, which led to turbulent gust loads on the right elevator sufficient to jam it, even though the horizontal surface wind speed was below the certification design limit and maintenance inspection criteria for the airplane, and (2) the lack of a means to enable the flight crew to detect a jammed elevator during preflight checks for the Boeing MD-83 airplane. Contributing to the survivability of the accident was the captain's timely and appropriate decision to reject the takeoff, the check airman's disciplined adherence to standard operating procedures after the captain called for the rejected takeoff, and the dimensionally compliant runway safety area where the overrun occurred.

As a result of this investigation, the NTSB makes safety recommendations to the FAA and The Boeing Company and reclassifies two previously issued safety recommendations to the FAA.

# 1. Factual Information

## 1.1 History of Flight

On March 8, 2017, about 1452 eastern standard time (EST), Ameristar Air Cargo, Inc., dba Ameristar Charters, flight 9363, a Boeing MD-83 airplane, N786TW, overran the departure end of runway 23L at Willow Run Airport (YIP), Ypsilanti, Michigan, after the captain executed a rejected takeoff.[1] The 110 passengers and 6 flight crewmembers (two airline transport pilots [ATPs] and four flight attendants) evacuated the airplane via emergency escape slides.[2] One passenger received a minor injury, and the airplane sustained substantial damage. The airplane was operated under the provisions of Title 14 *Code of Federal Regulations* (*CFR*) Part 121 as an on-demand charter flight and was destined for Washington Dulles International Airport, Dulles, Virginia. Visual flight rules (VFR) conditions prevailed at YIP at the time of the accident.[3]

The airplane had been parked at YIP for 2 days before the accident on a ramp area east of a large (about 0.25-mile long) hangar. About 1139 on the morning of the accident, high wind from the west resulted in a power outage at the airport that affected some weather observing equipment (see section 1.4.2.2) and prompted the air traffic control tower (ATCT) personnel to evacuate the tower. According to Federal Aviation Administration (FAA) records, the ATCT issued a notification at 1217 to advise that the airport had no air traffic control (ATC) services (referred to as "ATC Zero").

The flight crew first powered up the airplane about 1236. They followed company procedures for operations at nontowered airports and used a cell phone to obtain updated weather information and ATC clearances (see section 1.11.2.4). The captain, seated in the left seat, was the pilot flying (PF), and the check airman in the right seat (who was providing differences training to the captain) was the pilot monitoring (PM).[4] The captain performed the preflight walkaround inspection of the airplane and noticed no anomalies (see section 1.11.3.2).

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[1] All times in this report are EST.

[2] The 110 passengers included 109 charter passengers and 1 Ameristar Air Cargo ground security coordinator, who assisted with the security screening and passenger boarding. The ground security coordinator was also qualified as a flight attendant but was not acting in that capacity for this flight.

[3] (a) According to 14 *CFR* 91.155, VFR conditions for takeoffs from an airport in controlled airspace (like YIP) are visibility of at least 3 miles and a ceiling of at least 1,000 ft above ground level. (b) Supporting documentation referenced in this report can be found in the public docket for this accident, accessible from the National Transportation Safety Board's (NTSB) Accident Dockets web page by searching DCA17FA076. Other NTSB documents referenced in this report, including reports and summarized safety recommendation correspondence, are accessible from the NTSB's Aviation Information Resources web page (www.ntsb.gov/air).

[4] The captain held a type rating for Boeing DC-9 airplanes but was receiving differences training in the Boeing MD-83 airplane (which was considered a Boeing DC-9 variant) in accordance with 14 *CFR* 121.418 and Ameristar's approved training program. Until such differences training was completed, the captain could not serve as pilot-in-command (PIC) of a Boeing MD-83 operated under Part 121 by Ameristar.

During their preflight planning, the flight crewmembers considered the high gusting wind when discussing the V-speed calculations. During a postaccident interview, the check airman stated that they chose to use a maximum thrust takeoff, which was their normal procedure. According to the flight crew's completed takeoff speed card recovered from the airplane, they calculated the V-speeds as follows: $V_1$ (takeoff decision speed) was 139 kts, $V_R$ (rotation speed) was 142 kts, and $V_2$ (minimum takeoff safety speed) was 150 kts.[5] He also stated during the interview that the wind was "pretty gusty," so they agreed to increase the rotation speed about 5 kts.[6] The cockpit voice recorder (CVR) transcript indicated that the check airman advised the captain to "delay rotation until at least $V_2$…wait for me to call it."[7] The captain later confirmed their plan during his briefing, affirming to the check airman that "we are going to delay our rotation because of the gusty, strong gusty winds."

The captain's briefing also considered wind in the event of an emergency; according to the CVR transcript, he told the check airman to

> really keep an eye out on what our airspeed is doing today, ahm, in the event of an engine fire or failure at or after $V_1$, we're going to continue the takeoff ….[I]f you get any kind of a [windshear] warning, it's gonna be max thrust, ah, all the way to the firewall thrust, if necessary…we'll fly out of the shear, back me up on the, ah, airspeed calls.

While performing all their predeparture procedures and checklist items, neither pilot observed any anomalies with the airplane. The check airman performed the flight control checks during taxi and felt nothing unusual when he moved the control column forward and aft (see section 1.11.3.3).

The flight crew positioned the airplane for departure from runway 23L, and, at 1451:12, the check airman called for the captain to begin the takeoff roll. At 1451:55, the check airman called "$V_1$." Six seconds later (at 1452:01), he called "rotate," followed 3 seconds later (at 1452:04) by "$V_2$." At 1452:05, the captain said, "hey, what's goin' on?" and, 3 seconds later, "abort." The check airman stated, "no, not above…" and then "…don't abort above $V_1$ like that," and the captain replied, "it wasn't flying."

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[5] $V_1$ was defined, in part, as the maximum speed in the takeoff by which a rejected takeoff must be initiated to ensure that a safe stop can be completed within the remaining runway (FAA 1994). Ameristar's *Aircraft Operating Manual* (*AOM*) for the airplane defined $V_R$ as the speed at which rotation to the climbout attitude is initiated and $V_2$ as the speed used for initial climb following an engine failure on takeoff.

[6] During interviews, the flight crew described that they did not use an airspeed reference bug to set the increased rotation speed on the airspeed indicator, but the check airman, as PM, called out "rotate" when the airplane reached the increased airspeed. (An airspeed reference bug is a movable pointer that a pilot can use to identify specific reference speeds on the airspeed indicator.)

[7] Quotes from the CVR transcript in this report may contain punctuation, capitalization, or other editorial style revisions. See Appendix B for the unrevised transcript.

At 1452:23, the CVR captured sounds consistent with the airplane's excursion from the paved surface. The airplane exited the paved surface off the departure end of runway 23L (including a 200 ft blast pad) and traveled about 950 ft across the grassy part of the runway safety area (RSA) before striking the airport perimeter fence and a raised, paved road before coming to a stop. The airplane came to rest on the fuselage belly with the tail on the road, about 1,150 ft west-southwest of the end of the runway (see figures 1 and 2).

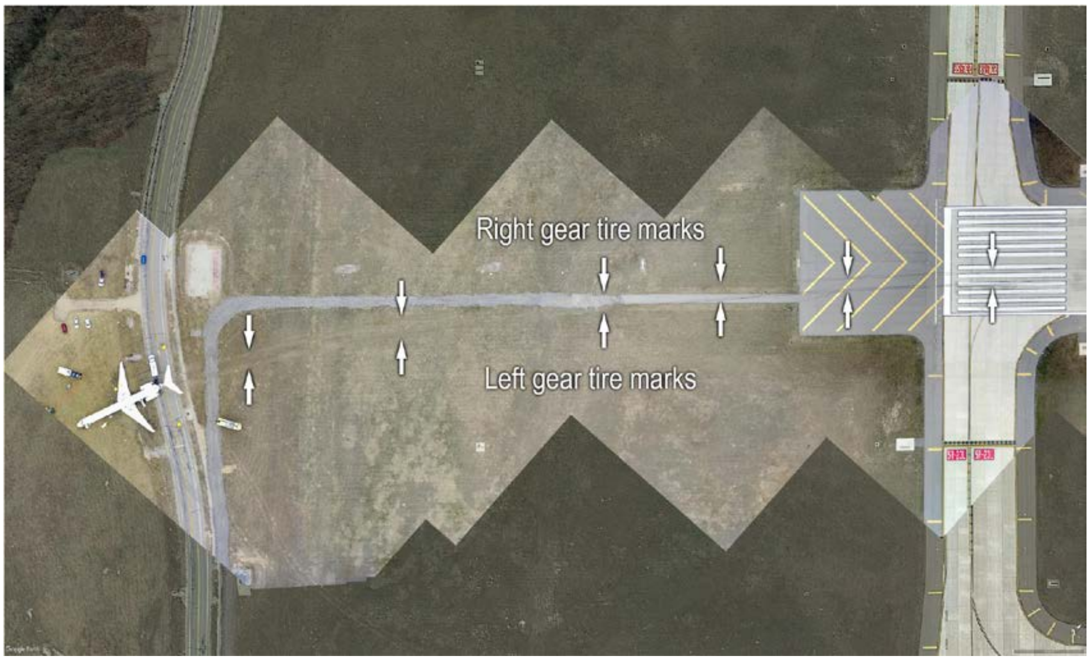



**Figure 1.** Orthomosaic image of the airplane's path from the end of runway 23L to its final location.


Source: The Boeing Company (label added by NTSB)

**Figure 2.** Rear view of the airplane wreckage.

The CVR captured that, after the airplane came to a stop, the check airman stated "evacuate, evacuate, evacuate" over the public address system at 1452:37. All 110 passengers and 6 crewmembers evacuated the airplane using four of the airplane's eight exits. Flight attendants reported that two overwing exits were not opened, and the right front (1R) door exit was unusable because the evacuation slide did not inflate. Further, the tailcone exit door initially could not open fully due to a seatbelt buckle that became wedged under it, and passengers had used other exits by the time the flight attendant cleared the buckle and opened the door (see section 1.9.1).

During a postaccident interview, the captain recalled that, when he began a normal rotation of the airplane at the "rotate" call, it did not rotate, so he applied more back pressure. (During a normal takeoff at rotation speed, pulling the control column aft results in trailing edge up [TEU] elevator movement to produce airplane-nose-up pitch; see section 1.3.2.1.) The captain said the control column was not quite to the physical limit of aft movement but was "further back than for a normal rotation." Both pilots stated in interviews that, after the captain called for the rejected takeoff, they applied maximum braking, but the airplane went off the end of the runway.

Initial examination of the airplane found that the airplane's right elevator was jammed in a trailing edge down (TED) position and could not be moved when manipulated by hand (see section 1.3.2.2).

## 1.2 Personnel Information

### 1.2.1 Captain

The captain, age 54, resided in Mequon, Wisconsin, and held an ATP certificate with type ratings for the Boeing 747, Boeing DC-9, and Saab SF-340 airplanes. He also held a flight instructor certificate. He held a first-class airman medical certificate dated January 27, 2017, with a limitation to possess glasses for near and intermediate vision. He stated in an interview that he had his glasses during the accident flight.

The captain was hired by Ameristar on January 25, 2016, and had flown the Boeing DC-9 as a first officer before upgrading to captain on February 26, 2016. He was also a proficiency check airman for the company in the Boeing DC-9 flight simulator. His most recent proficiency training was completed on February 4, 2017; his most recent proficiency check was completed on November 4, 2016, in the Boeing DC-9; and his most recent PIC line check was completed on February 2, 2017, in the Boeing DC-9.

According to company records, the captain had accumulated 15,518 hours total flight experience, which included 4,752 PIC hours and 8,495 hours in the Boeing DC-9. He had flown 68 hours, 30 hours, and 0 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. He had flown into YIP 10 times between April 17, 2016, and March 6, 2017, and his last three flights were with the check airman (January 8, 2017; January 15, 2017; and March 6, 2017).

A review of FAA records showed no previous aviation incidents or accidents involving the captain. He received a notice of disapproval in 1996 for the Saab SF-340 type rating and in 1987 for the flight instructor certificate.

### 1.2.2 Check Airman

The check airman, age 41, resided in The Colony, Texas, and held an ATP certificate with type ratings for the Boeing 737, Boeing DC-9, Dassault (Falcon) DA-20, and Learjet airplanes. He also held flight instructor and advanced (ground) instructor certificates. He held a first-class airman medical certificate dated September 8, 2016, with no limitations.

The check airman was hired by Ameristar on March 31, 2004; received his initial type rating on the Boeing DC-9 on February 13, 2007; and upgraded to the Boeing MD-80 on September 20, 201l. He was qualified for the company on the Boeing DC-9, MD-83, and 737 airplanes and was a check airman on the Boeing MD-83. He completed his most recent proficiency training on February 11, 2016; his most recent proficiency check on January 31, 2017; and his most recent PIC line check on June 9, 2016.

According to company records, the check airman had accumulated 9,660 hours total flight experience, which included 7,240 PIC hours and 2,462 hours in the Boeing DC-9 (2,047 of which were as PIC). He had flown 50 hours, 19 hours, and 0 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. He had flown 152 flights into YIP (53 times on the Boeing MD-83) between January 1, 2003, and March 6, 2017.

A review of FAA records showed no previous aviation incidents or accidents involving the check airman. He received a notice of disapproval in 1998 for the flight instructor certificate and in 1997 for the commercial single-engine airplane certificate.

## 1.3 Airplane Information

### 1.3.1 General

The Boeing MD-83 airplane was equipped with two Pratt & Whitney JT8D-219 engines and a Honeywell GTCP 281276-1 auxiliary power unit. The airplane had 41,008.6 total flight hours with 39,472 total flight cycles at the time of the accident.

#### 1.3.1.1 Maintenance

Ameristar's maintenance program for the airplane was based on the McDonnell Douglas On Aircraft Maintenance Planning (OAMP) report 761-93 and was referenced in the company's OAMP report 761-93, revision 11, dated August 1, 1993.[8] The company also had an approved continuing analysis and surveillance system (CASS). The December 2016 to March 2017 CASS report was reviewed with no issues noted with the elevator, elevator controls, hydraulic system, or elevator structures.

[8] According to the type certificate data sheet (A6WE) for the Boeing MD-83, the type certificate was previously held by McDonnell Douglas Corporation, which merged with The Boeing Company in 1997, and Douglas Aircraft Company, Inc., which merged with McDonnell Aircraft Corporation in 1967.

A review of airplane flight logs from October 2016 through March 2017 revealed no flight control discrepancies. Both right and left elevators were last lubricated on December 30, 2016.

A records review that focused on elevator and stabilizer entries found that a C-check, including all nonroutine work cards, was completed in August 2015.[9] The C-check requirements included detailed visual inspections of the horizontal stabilizer and elevator skins, internal structures, attachments, and actuation mechanisms. The inspection was completed with no nonroutine work cards generated for these components. A corrosion control inspection reported no findings of corrosion.

The previous C-check, completed in July 2013, included seven nonroutine work cards for discrepancies found on both elevators and tabs. Four of the nonroutine items involved hail dents that required reinspections. A special inspection task was created for the 500-hour inspection of the hail dents for each elevator and tab. The right elevator float tab was found to be delaminated, which required a more restrictive 300-hour repetitive inspection per the *Structural Repair Manual*. A 300-hour repetitive inspection was not found; the inspection was included in the 500-hour repetitive inspection. The airplane had flown 611.4 flight hours since the July 2013 C-check when the delamination was discovered.

The C-check completed in July 2011 included replacing and rigging the right elevator control tab in accordance with the *Aircraft Maintenance Manual* (*AMM*). There was a write-up for the right elevator damper leaking, and the records reflected that a check of the right elevator damper was accomplished in accordance with the *AMM* with no leaks noted.

**1R Door Evacuation Slide**

Records showed that the evacuation slide for the 1R door was overhauled by Shoreline Marine, Inc., dba Safetech, on July 6, 2015, in accordance with the manufacturer's *Component Maintenance Manual* (*CMM*) 25-26-48, revision 21, and *CMM* 25-65-11, revision 26. It was installed on the accident airplane on July 14, 2015, in accordance with the *AMM*.

**Recent Log Items**

On the inbound flight to YIP, the following three log items were generated and resolved before the accident flight:

> (a) Navigation number one will not receive ILS [instrument landing system] Frequency. Maintenance replaced the navigation receiver.
>
> (b) Forward [f]light [a]ttendant seat shoulder harness will not retract. Maintenance adjusted the harness.

[9] A C-check, which is a comprehensive inspection of installations with maximum access to components and systems, is accomplished every 3,500 flight hours or 24 months, whichever occurs first. It includes qualitative and quantitative checks on the components and systems for performance deterioration.

(c) Auto Throttles will not engage. After replacing the navigation receiver, maintenance performed the Auto Throttle system test and the Digital Flight Guidance System return to service test, both tested good.

#### 1.3.1.2 Weight and Balance

The company flight-follower performed initial weight and balance estimates on the accident airplane using the weight and balance software approved for company use by Operations Specification (OpSpecs) A025-3. After loading the passengers and baggage, the flight crew manually entered the weight and balance data into the company's load manifest and takeoff information form.

For the accident flight, the crew used a standard weight of 195 lbs per passenger, which included 16 lbs per passenger for carry-on baggage weight, and standard average weights for the baggage; their planning resulted in an estimate of 5,002 lbs for checked baggage and 1,760 lbs for carry-on baggage. They calculated the takeoff weight to be 145,076 lbs and rounded it up to 146,000 lbs, and the takeoff center of gravity (CG) to be 11.7% of mean aerodynamic chord (MAC).[10] The airplane's maximum certificated takeoff weight was 160,000 lbs with forward and aft CG limits of 3.7% and 22.1% MAC, respectively.

After the accident, the National Transportation Safety Board (NTSB) weighed all of the baggage. The total actual weight of the checked baggage was 6,353 lbs, and the total actual weight of the carry-on baggage was 1,462 lbs. Actual passenger weights could not be determined. Postaccident calculations using the actual baggage weights and assumed passenger weights showed a total takeoff weight of 146,427 lbs with a CG of 10.4% MAC.

### 1.3.2 Elevator Control System

#### 1.3.2.1 General Design

The airplane is a t-tail design, such that the elevators and horizontal stabilizer are attached near the top of the vertical stabilizer about 30 ft above ground level (agl). The left and right elevators are attached by hinges to the rear spar of the horizontal stabilizer, and each is equipped with control, geared, and antifloat tabs attached to the trailing edge (see figure 3). Each elevator can travel between 27° TEU and 16.5° TED between mechanical stops mounted on the horizontal

[10] The company's passenger and baggage weight program was defined in OpSpecs A099, which specified that, for large cabin aircraft (like the accident airplane), either actual weights or standard average weights could be used in aircraft weight and balance calculations for passengers and baggage. The flight was carrying a college basketball team, band members, and cheerleaders, as well as support staff and family members, including children. FAA guidance in Advisory Circular 120-27E, "Aircraft Weight and Balance Control," recommended using actual passenger weights (or established average weights) for flights carrying passengers of a nonstandard weight group (such as a sports team) when performing weight and balance calculations (FAA 2005).

stabilizer.[11] (A stop arm on each elevator contacts the mechanical stops to limit elevator travel, and a torsion bar distributes the increased loading.)

Each elevator is also equipped with a damper designed to prevent elevator flutter during flight and dampen rapid movement of the elevator during gusty wind when the airplane is on the ground. When the airplane is parked, each elevator is free to move independently within the confines of the mechanical stops if acted upon by an external force, such as wind or manipulation by maintenance personnel. The elevator system (by design) has no gust lock, and the elevators are not interconnected.

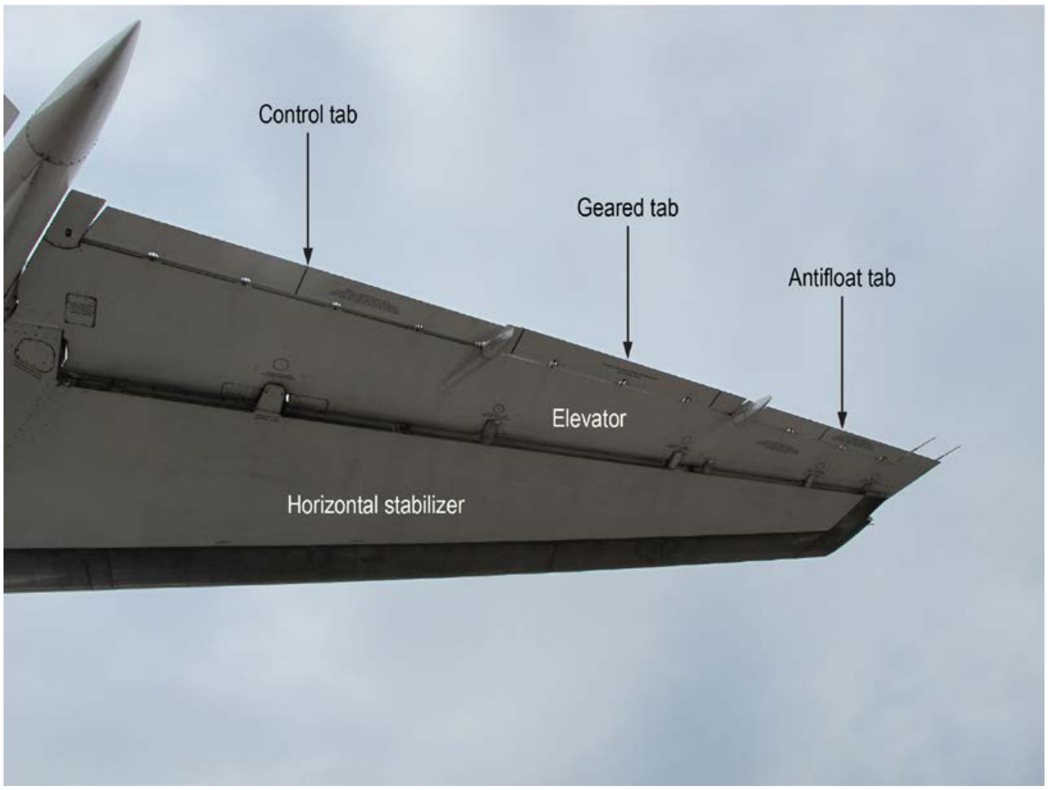



**Figure 3.** Right elevator and relative locations of control, geared, and antifloat tabs.

[11] These values +/- 0.5° are within AMM-specified limits.

Elevator control is accomplished via the trailing-edge elevator control tabs, which are mechanically connected to and directly controlled by the cockpit control column. During takeoff (at $V_R$ or higher) and during flight, when a pilot provides aft or forward control column input to command a change in airplane pitch, the elevator control tabs mechanically deflect, and the resultant aerodynamic forces on the deflected control tabs move the elevator surfaces to produce the change in airplane pitch. For example, when a pilot pulls the control column aft to command airplane nose-up pitch (such as during rotation), the control tabs respond by deflecting TED, and the resultant aerodynamic forces move the elevators TEU (see figure 4).

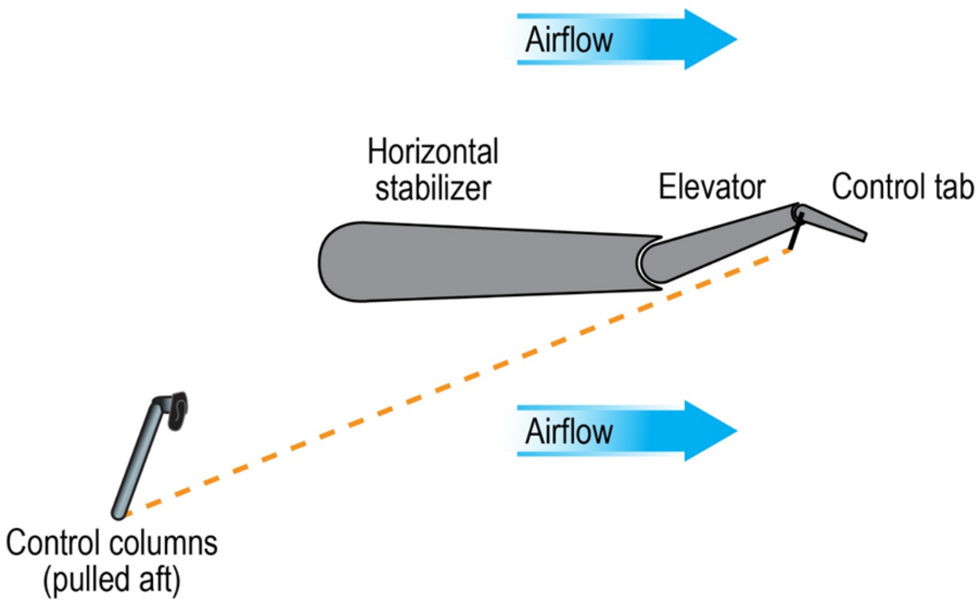
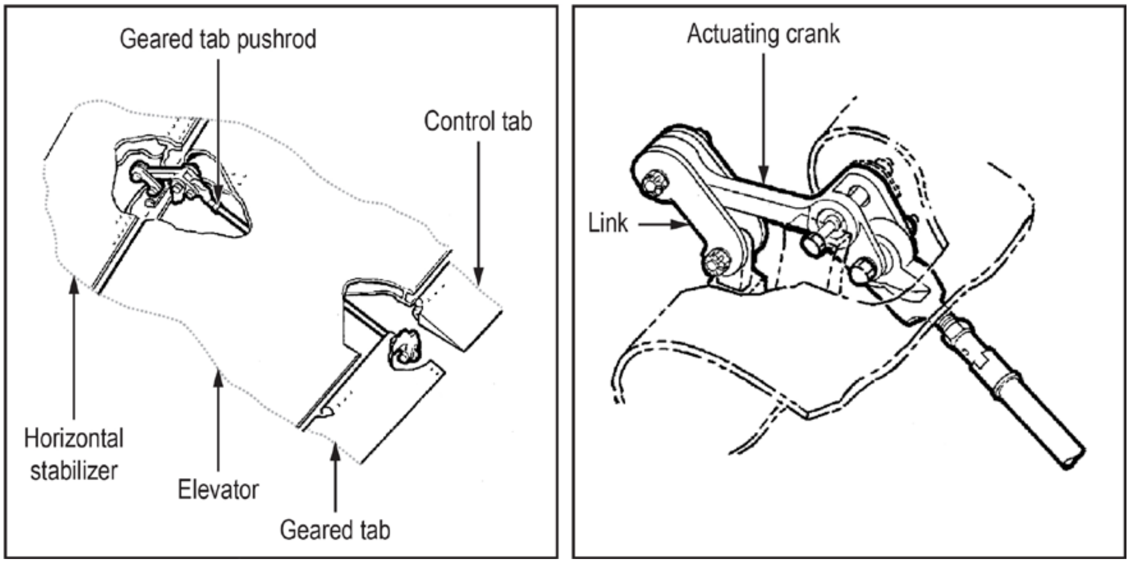



**Figure 4.** Simplified diagram showing the direct connection between the cockpit control columns and the control tab on each elevator.

Elevator geared tabs, which mechanically deflect in response to elevator movements, are attached to the horizontal stabilizer through a system of drive linkages. The geared tab drive linkage consists of a pushrod that is attached to the horizontal stabilizer spar by means of an actuating crank and links (see figure 5). The antifloat tabs are connected to the horizontal stabilizer through mechanical linkages and deflect based on stabilizer position to prevent down-float of the elevator when the horizontal stabilizer position exceeds certain criteria.




Source: The Boeing Company (some labels and revisions added by NTSB)

**Figure 5.** Drawing of installed location of geared tab linkage components (left) and closer view of the links and actuating crank (right).

Additional system features include a hydraulically operated elevator power control boost cylinder for each elevator that will activate to help drive the elevators toward TED when a large amount of airplane nose-down pitch is commanded (via control tab deflection) and the resultant elevator position cannot be achieved through aerodynamic forces alone.

### 1.3.2.2 Damage Observed on Accident Airplane

During an on-scene postaccident examination, investigators established flight control continuity for the elevator system by exercising the cockpit control columns through their full range to the control column stops in both the aircraft nose-up and aircraft nose-down directions. The left and right elevator control tabs responded with movement in the appropriate direction. Investigators noted that the control columns in some positions did not move smoothly, and there were tactile and audible indications of control cable friction under the cockpit floor. Further examination revealed airplane structural damage in an area where the cables were routed; the cables were riding on the damaged structure.

Using a lift to access the elevators, investigators found that the airplane's right elevator was jammed in a TED position and could not be moved when manipulated by hand. Examination found that the inboard actuating crank for the right elevator's geared tab was bent outboard, and its links were bent (see figure 6). Further, the actuating crank and links were found locked overcenter beyond their normal range of travel (see figure 7).

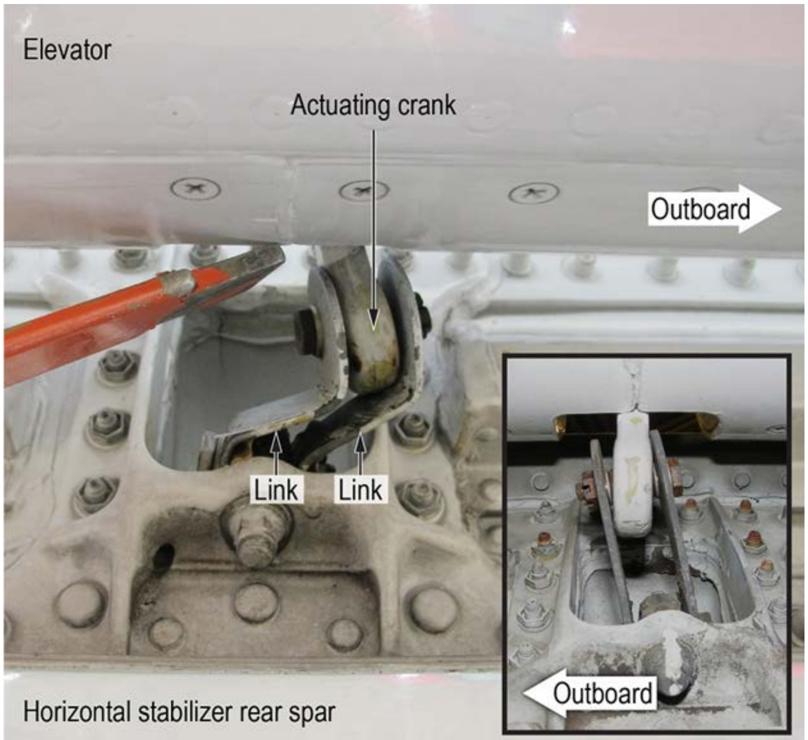



**Figure 6.** View of accident airplane's elevator geared tab links and actuating crank in an overcenter position with links bent outboard. Inset shows undamaged exemplar links and actuating crank in an overcenter position.

Note: The orange bar is not part of the airplane and was used as a pointer.

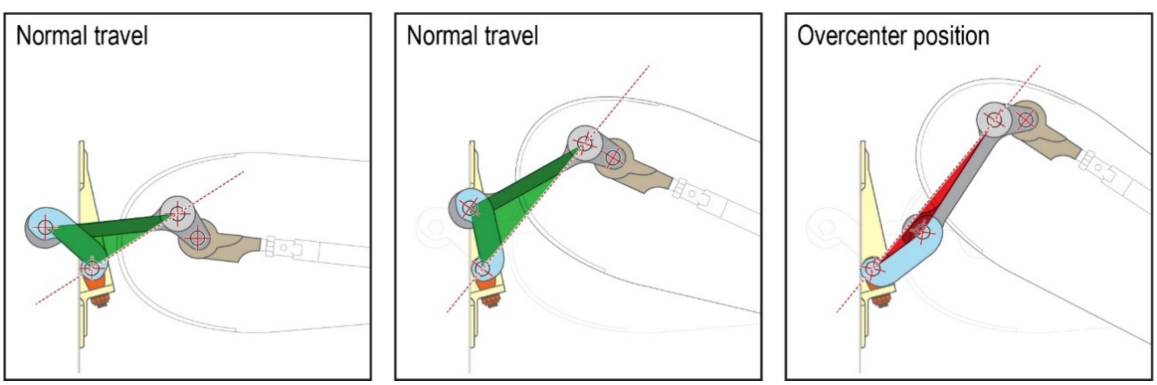



**Figure 7.** Diagram showing the relative positions of the links (blue) and actuating crank (gray) when moving within their normal range of travel (in green) and when locked overcenter after having moved beyond their normal range of travel (in red).

Examination of the left elevator found that it moved freely when manipulated by hand, and the left geared tab and linkages moved normally. When the left elevator surface was manipulated through its full range of motion (between the TED and TEU stops), the inboard actuating crank and links for the left geared tab moved within their normal travel range, and their relative positions never neared overcenter. Both elevators (including torsion bars, stop arms, and trailing-edge tabs), dampers, and boost cylinders were removed from the airplane for further examination and testing (see section 1.10.2).

#### 1.3.2.3 Elevator Design Standard for Ground Gust Loads

The airworthiness standard current at the time of the accident specified in 14 *CFR* 25.415, "Ground gust conditions," that flight control systems and surfaces of transport-category airplanes must be designed for the limit loads generated when the airplane is subjected to a 65 kt horizontal ground gust from any direction while parked and taxiing. The regulation allowed for the assumption of static loads and provided the formula from which the hinge moments must be computed for elevators.

The airworthiness regulation effective at the time the airplane was originally certificated specified a ground gust value of 88 ft per second (about 52 kts); it was revised in 1997 to increase the ground gust speed to 65 kts. Boeing stated in its submission to the investigation that the MD-80 series airplanes (which include the MD-83) were designed to withstand a 65 kt horizontal ground gust. According to Boeing, in the history of this elevator design (which exists on all Boeing DC-9/MD-80 series and 717 model airplanes), this accident was the first notification that Boeing had received of an elevator jam occurring on an airplane exposed to ground gusts lower than 65 kts. Boeing noted that the elevator design first entered service in 1965 on the then-Douglas DC-9 airplane.

## 1.4 Meteorological Information

### 1.4.1 General

The National Weather Service (NWS) surface analysis chart for 1600 identified a northeast–southwest-oriented cold front over central lower Michigan that was advancing southeast. A trough extended southwest from Ontario, Canada, into the region that included the accident location. Wind ahead of the cold front was generally from the west or west–southwest with wind magnitudes at or above 25 kts at many locations.

Regional weather radar for 1445 did not depict any echoes across the accident region, and satellite data imagery from the same time identified no clouds over the accident site at the accident time.

### 1.4.2 Airport Surface Weather

#### 1.4.2.1 Forecasts and Advisories

The most recent terminal aerodrome forecast (TAF) for YIP before the accident was issued at 1222 and was valid for a time period that included the accident. The expected conditions in the TAF for the accident time were sustained wind from 250° at 32 kts with gusts to 48 kts, visibility greater than 6 miles, and few clouds at 6,000 ft agl. An NWS area forecast issued at 1445, valid for the accident time and location, forecasted surface wind from the west at 30 kts with gusts to 45 kts.[12]

A significant meteorological information (SIGMET) advisory was issued at 1441, valid for the accident time and location. The SIGMET advised of occasional severe turbulence below 12,000 ft due, in part, to strong low-level wind. Airmen's meteorological information (AIRMET) advisories for strong surface wind were issued at 0945 and 1441, each valid for the accident time and location. Each AIRMET Tango advised that sustained surface wind greater than 30 kts was expected.[13]

#### 1.4.2.2 Official Observations

YIP was a limited aviation weather reporting station (LAWRS) facility and, as such, had FAA-certified ATC specialists who were responsible for the completeness and accuracy of the weather observations. These included the aviation routine weather reports (METARs) and aviation selected special weather reports (SPECIs) disseminated by the automated surface observing system (ASOS) located near midfield with an anemometer height of about 33 ft agl.

On the morning of the accident, the METAR issued at 1153 was the last report for which complete ASOS data with LAWRS observer augmentation were available. It contained the following information:

> Wind from 260° at 35 kts with gusts to 50 kts, visibility 10 miles or greater, sky clear below 12,000 ft agl, temperature 11°C, dew point -11°C, altimeter setting of 29.81 inches of mercury with remarks that the station had a precipitation discriminator, a peak wind from 260° of 55 kts occurred at 1139, sea level pressure was 1009.5 hectopascals, temperature 10.6°C, and dew point -10.6°C.[14]

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[12] All wind directions in this report are in reference to true north unless otherwise indicated.

[13] An AIRMET Tango is issued to describe conditions of moderate turbulence, sustained winds of 30 kts or greater, or nonconvective low-level windshear (FAA 2018a, 5-21).

[14] The 55 kt gust at 1139 (reported in the 1153 METAR) was the highest gust recorded before the power outage. A 45 kt wind from 246° at 1133 was the highest sustained wind recorded before the outage (based on a review of the raw ASOS data for each minute). According to the National Oceanic and Atmospheric Administration's (NOAA's) "ASOS User's Guide," generally, ASOS-reported gust information is computed once every 5 seconds based on the greatest 5-second average wind speed (and corresponding direction) during the past minute and is stored for 12 hours

After 1202, some ASOS equipment was no longer operational because of the power outage. After the tower was evacuated about 1217, no LAWRS observer provided augmentation or backup information for the ASOS.[15] Each of the following METARs were disseminated automatically but did not contain the AUTO modifier. (See section 1.12.3 for more information about weather observer sign-off procedures [for nonaugmented METARs] and backup responsibilities.)

- The 1253 report contained only an altimeter setting and the remarks, which included, in part, a statement that a peak wind of 46 kts from 240° occurred at 1156 and that maintenance was needed on the system.
- The 1353 and 1453 reports also contained only an altimeter setting and the remarks, which included, in part, a statement that maintenance was needed on the system.

### 1.4.2.3 Other Sources of Wind Data

The Wayne County Airport Authority owned and operated several runway weather information system (RWIS) units. An RWIS remote processing unit (RPU) located near the touchdown zone of runway 5R included an anemometer that was 9 to 10 ft agl and was unaffected by the power outage. The airport authority (and the vendor that processed the data) provided the NTSB with archived data from this RWIS RPU.[16] The average wind and gusts it reported about the time of the accident are shown in table 1.[17]

(with some specified exceptions). An ASOS-reported sustained wind is computed every 5 seconds from a running 2-minute average (NOAA 1998).

[15] According to NWS personnel, the ASOS's three pressure sensors and its acquisition control unit (ACU), which publicly disseminates automated reports of ASOS-collected data, were powered by a source unaffected by the outage and remained operational. The ASOS data collection package (DCP), which collects data from most of the ASOS sensors on the field, lost power at 1139 but ran on battery backup until 1202. (The DCP resumed normal operation about 9 hours later.) For the time period in which the ASOS ACU was operational but the DCP was not, the ACU continued to disseminate automated METARs that did not include any DCP-provided information. YIP was also equipped with an FAA-owned stand-alone weather sensor (SAWS) located near the approach end of runway 23L that included an anemometer that was 35 ft agl. During normal operations, the SAWS provides real-time data to the ATC tower. On the day of the accident, the SAWS went out of service at 1138 due to the power outage, and its data were not archived. (According to the FAA, no formal archiving of SAWS data exists across the National Airspace System.)

[16] The airport authority maintained this equipment for its own use; the data from it were not publicly disseminated.

[17] Wind and gust magnitudes (which were reported in mph) and wind direction (which was reported in reference to magnetic north) have been converted in the table to kts and true north, respectively. (According to the airport diagram effective for the date of the accident, YIP had a magnetic variation of 7.1° west.)

**Table 1.** Wind data from airport authority's anemometer.

| Time | Wind magnitude | Wind direction (true) | Gust magnitude |
|---|---|---|---|
| 1438 | 29 kts | 248° | 44 kts |
| 1443 | 31 kts | 228° | 49 kts |
| 1448 | 26 kts | 243° | 43 kts |
| 1453 | 24 kts | 248° | 37 kts |
| 1458 | 31 kts | 235° | 41 kts |
| 1503 | 24 kts | 238° | 41 kts |

Archived wind data from the RWIS RPU from earlier in the day, between 0703 and 1158, were compared with the available wind data from the ASOS. In general, the average ratio of the RWIS RPU's wind magnitude to that from the ASOS was 0.76 (the average ratio of the gust magnitude was 0.82). The average difference between the RWIS RPU's wind direction and that of the ASOS was 16°.

## 1.5 Airport Information

### 1.5.1 General

YIP was located 24 miles southwest of Detroit, Michigan, at an elevation of 716 ft. It had six runways: 5R/23L, 5L/23R, and 9/27. Runway 5R/23L was 7,543 ft long and 150 ft wide with a grooved concrete surface.[18] Runway 23L had a 0.2% upslope gradient and a 200-ft paved blast pad (for runway 5R) off the departure end. The airport was certificated under Part 139 and was in Class D airspace during ATCT operating hours.

### 1.5.2 Runway Safety Areas

The airport was equipped with RSAs at the ends of runways 5L/23R and 5R/23L that met the dimensional standards specified in FAA Advisory Circular (AC) 150/5300-13A, Change 1, "Airport Design." The accident airplane crossed the RSA beyond the end of runway 23L before it ran through the airport perimeter fence and struck a raised road.

According to the FAA Airports Division, the RSAs at YIP had been upgraded between 2006 and 2009. The NTSB notes that these upgrades were responsive to NTSB Safety Recommendation A-03-11 (see section 1.12.2) and were part of a national program that the FAA initiated in 1999.[19]

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[18] The 150-ft width was verified with measurements taken using current satellite imagery. (The 2016 Jeppesen 20-9 airport chart listed the width as 161 ft; more recent Jeppesen and FAA airport charts listed the width as 150 ft.)

[19] The FAA had issued Order 5200.8 in 1999 to bring all RSAs in the United States up to standards specified in AC 150/5300-13, whenever possible. AC 150/5300-13 was current when we issued Safety Recommendation A-03-11; the version current at the time of this report was AC 150/5300-13A, Change 1 (FAA 2014a).

The FAA stated that improving the RSAs on the ends of runways 5R/23L and 5L/23R involved land acquisition, filling in a ravine (the maximum depth of which was 30 ft in some locations), removing a taxiway, moving or making frangible approach lighting systems, removing structures and concrete markers from the RSA, and moving the perimeter fence and a road about 200 ft. The YIP RSA improvement project had cost $20 million, with a federal investment of $19 million. Figure 8 shows aerial photographs provided by the FAA of the RSA off the end of runway 23L both before and after the improvements.


Source: FAA (some labels added by NTSB)

**Figure 8.** Photographs of the RSA off the departure end of runway 23L before upgrade (left) and after (right).

As shown in the left side of figure 8, the former RSA configuration included a taxiway (which no longer exists) and a different location of the airport perimeter road.

## 1.6 Flight Recorders

The airplane was equipped with an L-3/Fairchild FA2100 model flight data recorder (FDR) that records a minimum of 25 hours of flight data in a digital format using solid-state flash memory as the recording medium. The NTSB examined the unit, found it to be in good condition, and extracted the data normally. (Select FDR data referenced throughout this report are time, acceleration, airspeed, altitude, attitude, engine, and various other parameters, including elevator position and control column position.) The FDR recording contained about 368 hours of data; data from the accident flight and the airplane's previous takeoff and landing were used to support an airplane performance study (see section 1.10.1).

The airplane was also equipped with an L-3/Fairchild FA2100-1020 model CVR that records onto solid-state memory modules a minimum of 2 hours of digital audio from four channels (typically one channel for each pilot, one channel for a cockpit observer, and one channel for the cockpit area microphone [CAM]). The NTSB examined the unit, found it to be undamaged, and extracted 124 minutes of audio information (from 1249:35 to 1453:49). For the accident flight, the CVR provided excellent-quality audio information from one channel of the flight crew audio panel and good-quality audio from the CAM.[20] The CVR group prepared a partial transcript for the recording, the timing for which was correlated with common events recorded by the FDR and converted to reflect local time. (The transcript can be found in Appendix B.)

## 1.7 Wreckage and Impact Information

As described in section 1.1, the airplane ran through the airport perimeter fence and struck a raised, paved road before coming to a stop with the tail resting on the road. The nose landing gear and both main landing gear were bent, fractured, and displaced aft; all examined fracture surfaces exhibited features consistent with overstress. The fuselage lower skin panel assemblies, including longeron and frames, exhibited severe buckling, deformation, missing sections, and severed internal structure at several locations; the damage was consistent with ground impact after the collapse of the landing gear.

## 1.8 Medical and Pathological Information

Postaccident drug and alcohol testing for the captain and the check airman indicated negative results.

## 1.9 Survival Aspects

### 1.9.1 Emergency Evacuation

All four flight attendants (identified by the company as flight attendants A, B, C, and D) were seated in their jumpseats at the time of the runway excursion. The lead flight attendant (flight attendant A) was seated with flight attendant C in a two-place jumpseat at the door exit on the front left side of the airplane (1L door), flight attendant B was seated alone in a two-place jumpseat at the tailcone exit, and flight attendant D was seated at the door exit on the rear left side of the airplane (2L door). The airplane was also equipped with a door exit on the front right side (1R door) and four overwing exits (a forward and aft exit on each wing).

The flight attendants described (in postaccident statements and interviews) that the takeoff roll was normal until they felt the airplane's brakes suddenly applied, then they felt the airplane "shake" and "jump and jerk" after it left the runway. (The CVR captured sounds consistent with the airplane departing the paved surface at 1452:23.) The lead flight attendant reported seeing the terrain outside the airplane change, and both he and flight attendant C began shouting "heads down, stay down" until the airplane came to a stop. (The CVR captured these instructions at 1452:27.) Flight attendants B and D said that they heard the pilot's "evacuation" announcement after the

[20] According to the CVR quality rating scale, generally, excellent-quality audio allows easy and accurate understanding of virtually all of the crew conversations (with possibly one or two words unintelligible), and good-quality audio enables such understanding for most of the crew conversations (with possibly several words or phrases unintelligible). For the accident flight's recording, two of the four recorded channels did not provide useful audio information. (One channel contained no audio information, and another, which lacked microphone input from the flight crew audio panel, recorded only radio/intercom information.)

airplane came to a stop, but neither the lead flight attendant nor flight attendant C recalled hearing it.

The lead flight attendant said that he assessed the conditions and opened the 1L door to initiate the evacuation. He said he had to pull twice on the slide's manual inflation handle before it inflated; once it did, he started evacuating passengers from that exit. Flight attendant D said that she assessed the 2L door, opened it, and evacuated passengers. She said that, at first, she thought the engine was still running but then realized it was the wind pushing the engine blades.

Flight attendant C said that she assessed the 1R door and opened it, but when she pulled the manual inflation handle for the slide, it did not inflate. When she pulled it a second time, the slide deployed from the slide pack and hung outside the door but did not inflate. She blocked the unusable exit and redirected passengers to use another exit.

Flight attendant B said that he assessed the tailcone exit door and opened it, but it opened only a few inches before becoming stuck by a seatbelt buckle (from an unbuckled jumpseat seatbelt) wedged under it. He said the Ameristar ground security coordinator (who was trained as a flight attendant) was near him and yelled to the passengers, "Exit blocked, go forward!" Flight attendant B pushed the door closed, cleared the seatbelt from its path, then opened the door fully. He saw that the tailcone had not jettisoned. He went to the end of the catwalk and pulled the manual jettison handle; the tailcone fell, and the slide inflated. He went back to the cabin to start the evacuation but found that everyone had already exited the airplane.

Flight attendants described that, during the evacuation, the passengers were "incredibly calm and responsive," "followed flight attendant directions," and "did not take or attempt to take luggage" or personal belongings with them. They also stated that, after exiting via the slides, the passengers remained orderly and quickly moved away from airplane.

Flight attendants walked through the airplane and checked the lavatories to ensure that all passengers had evacuated. After all four flight attendants evacuated, they gathered the passengers to conduct a head count. All 110 passengers and 6 crewmembers evacuated the airplane with one reported minor injury (a leg laceration that required sutures).

The investigation found that, of the airplane's eight exits, four were used: passengers evacuated from the 1L and 2L doors and the left and right forward overwing exits. The aft left and right overwing exits were not opened, and, as described above, no passengers used the 1R door exit (with the unusable slide) or the tailcone exit.

Investigators retained the 1R door slide and inflation assembly for further examination (see section 1.10.5). Postaccident examination of the tailcone jumpseat found that both the left and right seatbelts were unbuckled.[21] The emergency procedures section of Ameristar's *Flight Attendant Manual* (*FAM*) stated that the cabin floor (due to a damaged condition or displaced items) may have obstacles to egress.

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[21] According to the *FAM* (page 3-17 [G][4]), unoccupied jumpseats should be stowed with the seatbelts buckled. It was not determined which seat's belt initially prevented the tailcone exit door from fully opening.

### 1.9.2 Runway Safety Area

RSAs are designed to reduce injuries to persons and damage to aircraft in the event of a runway overrun, veer-off, or undershoot. As described in section 1.5.2, YIP was equipped with a dimensionally compliant RSA off the end of runway 23L that had been upgraded between 2006 and 2009. The improvements included removing a taxiway and relocating the perimeter fence and road (some of which are visible in figure 8).

According to the FAA Airports Division, the improved RSA at the end of runway 23L "provided a clear area to accommodate the [accident airplane's] excursion. The FAA believes the RSA performance in this instance demonstrates the design standard's contribution to aircraft accident survivability in the event of an excursion."

## 1.10 Tests and Research

### 1.10.1 Airplane Performance Study

The NTSB performed an airplane performance study using FDR data for the accident flight (and the previous flight and maintenance check); CVR data; postaccident calculated airplane weight and balance information (see section 1.3.1.2); a calculated 10-kt headwind component; and site mapping information that included the locations of tire marks on the runway, grass and dirt disruption beyond the end of the runway, and the airplane's final location (see figure 9).[22]


**Figure 9.** Orthomosaic image showing runway, airplane, and annotated locations of tire marks.

[22] The study used FDR-recorded longitudinal acceleration data as a basis for calculating the airplane's groundspeed and ground track, and the 10-kt headwind component was calculated using the FDR-recorded airspeed and integrated groundspeed (and was consistent with anemometer-reported wind information on the day of the accident, as described in section 1.4.2.3). The ground mark and airplane resting location information, including an orthomosaic image, was provided by the Michigan State Police, who photographed the site using a small unmanned aircraft system.

FDR data showed that, on March 6, 2017, the airplane was powered up for about 2 minutes for a maintenance check (unrelated to the elevator system) while parked at YIP. (This check occurred more than 5 hours after the flight crew had parked the airplane following the completion of its most recent flight.) Review of the data showed that, while the airplane was powered on for the check, the left elevator was about -2° TED, and the right elevator was about 13° TEU. The check occurred about 0710 (based on correlating the FDR time with local time), and wind at the time was relatively light. The airplane was not powered up again until the day of the accident.

### 1.10.1.1 Accident Flight Takeoff

FDR data showed that, from the time that the accident airplane was first powered up (about 1236) on the day of the accident, repositioned for loading (about 1242 to 1249), and then prepared and taxied for takeoff (beginning about 1435), the left elevator moved in the wind to various positions between about -16° TED and 27° TEU, but the right elevator did not move and remained about -16° TED.

As described in section 1.1, before takeoff, the flight crew determined $V_1$, $V_R$, and $V_2$ to be 139 kts, 150 kts, and 150 kts, respectively. (They calculated $V_R$ to be 142 kts but chose to increase it about 5 kts because of the strong, gusty wind conditions.) The performance study determined that, during the attempted takeoff, at 1451:56 (about 1 second after the check airman called "$V_1$"), the airplane was at an airspeed of about 138 kts, a slight input on the elevator control column was applied, the airplane's left elevator moved from -15° TED to -13° TED, and the right elevator did not move, remaining about -16° TED.[23]

Five seconds later, at 1452:01 (when the check airman called "rotate"), the airspeed was about 151 kts, and a large control column input was applied over the next 8 seconds. The left elevator moved to about 15° TEU, and the right elevator remained about -16° TED until the last 3 seconds of maximum control column input, at which time the right elevator moved to about -13° TED. The airplane did not respond in pitch and did not rotate (see figure 10).

[23] As described in section 1.3.2.1, only the elevator control tabs (not the elevators) are directly controlled by the cockpit control columns. Control column input deflects the elevator control tabs through a direct mechanical linkage, and the elevators move as a result of aerodynamic forces on the tabs to produce the desired change in airplane pitch. The FDR does not record elevator control tab position.

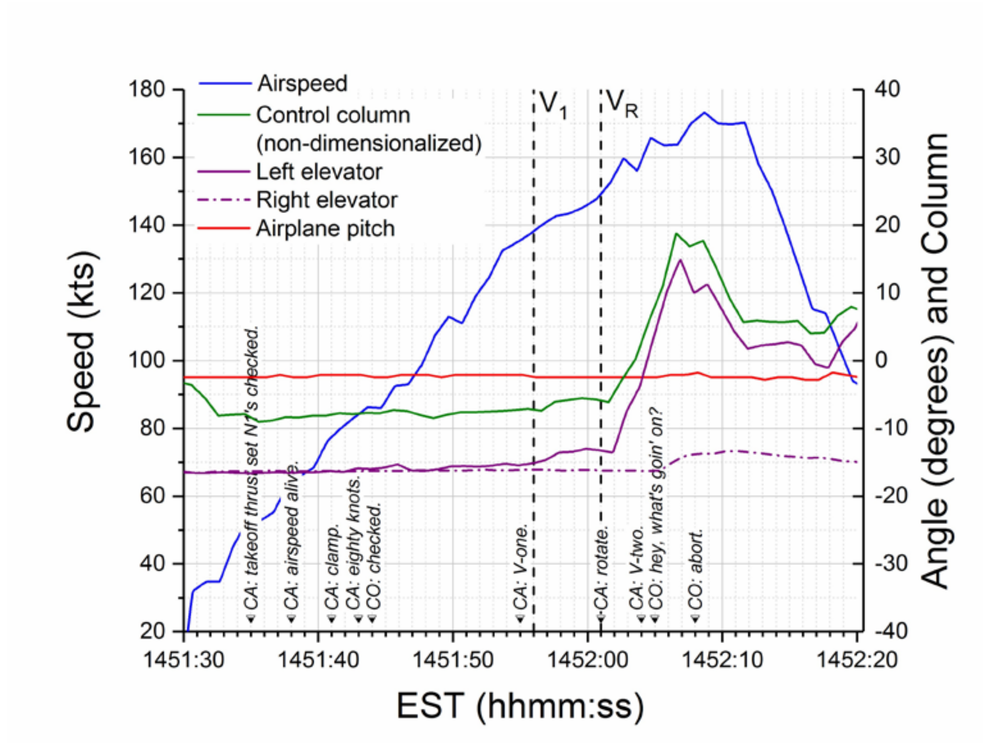


**Figure 10.** Airplane performance parameters over time.

Note: "CA" indicates comments from the check airman, while "CO" indicates comments from the captain.

The study found that the brakes were applied at 1452:08 (about the same time the captain called "abort"), and the control column was released 1 second later. The study determined that the airplane's maximum airspeed had reached 173 kts (163 kts calculated groundspeed) before it began to decelerate with the brake application and continued to decelerate with the deployment of spoilers at 1452:10 and thrust reversers between 1452:13 and 1452:15. The study determined that the airplane overran the end of the paved surface at 1452:16 and struck the raised airport perimeter road at 1452:24, at which time the accelerometer data abruptly stopped. (It resumed 11 seconds later and recorded loads consistent with the airplane at rest.)

Using integrated groundspeed data, the study determined that the airplane traveled 8,600 ft from the start of its takeoff roll to its final location; this information was used as a basis to calculate that the takeoff roll began about 80 ft from the runway 23L threshold. The study determined that, during the takeoff, the airplane had traveled 5,850 ft before the brakes were applied, which left about 1,800 ft of paved surface remaining (including the paved blast pad area). The first tire mark evidence on the runway was about 5,956 ft down the runway (about 5,876 ft from the beginning of the takeoff roll), with about 1,780 ft of paved surface remaining. The airplane's calculated groundspeed was 100 kts when it left the paved surface (about 7,650 ft from the start of the takeoff roll) and 40 kts when it struck the raised perimeter road and came to a stop (about 8,600 ft from the start).

#### 1.10.1.2 Deceleration Profile and Distance to Stop

The study used the deceleration profile of the accident flight's integrated groundspeed over distance to determine that, to successfully stop the airplane on the runway, the crew would have had to start braking once the airplane was about 5,000 ft into the takeoff roll. (The accident crew began braking about 5,800 ft into the roll.) When the accident flight was 5,000 ft into its takeoff roll, the airspeed was about 164 kts (groundspeed 151 kts). The study determined that, at that time, the left elevator was only beginning to reach a neutral position (it had not yet moved to TEU) in response to the control column input that had begun 3 seconds earlier (and the right elevator remained TED). For comparison, the study examined FDR data from the flight crew's previous takeoff in the accident airplane and found that the airplane took about 3 seconds to begin responding in pitch to the control column input.[24]

### 1.10.2 Elevator Component Examinations and Testing

Examination of the damaged actuating crank from the right elevator's geared tab revealed that the bearings were free to rotate with no signs of binding. Materials properties testing on the actuating crank and links yielded results consistent with the part requirements specified on the manufacturer's engineering drawings.

Examination of each elevator's torsion bar and stop arm revealed no evidence of damage. Hardness testing on various locations on each torsion bar yielded results consistent with the manufacturer's drawings. Magnetic particle testing (which can detect cracks down to a size of 0.010 inch) performed on the splines of the right elevator's torsion bar and stop arm revealed no indication of cracking. Sealant was observed on the left elevator's torsion bar bearing surfaces, and investigators had difficulty removing the bar from the elevator.

Examination of each elevator's damper revealed that each had a broken safety wire, but none of the bolts intended to be secured by the wires appeared to be displaced. Functional testing of both dampers was performed in accordance with the component overhaul manual procedures.

Visual inspection of both elevator boost cylinders showed no evidence of anomalies. Functional testing of both boost cylinders in accordance with the component overhaul manual procedures revealed that the right elevator's boost cylinder passed all tests except for the relief valve reseat test (it did not meet the required minimum reseat pressure of 2,050 lbs per square inch [psi], having tested to a maximum of 1,950 psi), and the left elevator's boost cylinder passed all tests.

### 1.10.3 Wind Simulation

The NTSB provided weather data from YIP and photogrammetric products developed using imagery obtained from a small unmanned aircraft system (sUAS) (see section 1.13) to Boeing for use in performing a computational fluid dynamics (CFD) model wind simulation.

[24] For the previous takeoff, the airplane departed March 5, 2017, from Lincoln, Nebraska, en route to YIP. During that takeoff, the airplane was at an airspeed of about 140 kts when the control column input was applied.

Because the airplane was parked downwind of a large hangar and other structures that could affect wind flow, the CFD study was used to determine a plausible scenario of the wind flow pattern at the airplane's parked location.

The simulation examined a period of variable wind magnitudes, directions, and gusts simulated over three-dimensional (3-D) objects developed from images captured by the sUAS. Boeing further processed 3-D obstacles to optimize them for use in the CFD simulation and inserted a 3-D model of an MD-83 to represent the position of the accident airplane's elevators at its parked location (see figure 11). The analysis used ASOS-observed wind data to initialize the simulation.[25]

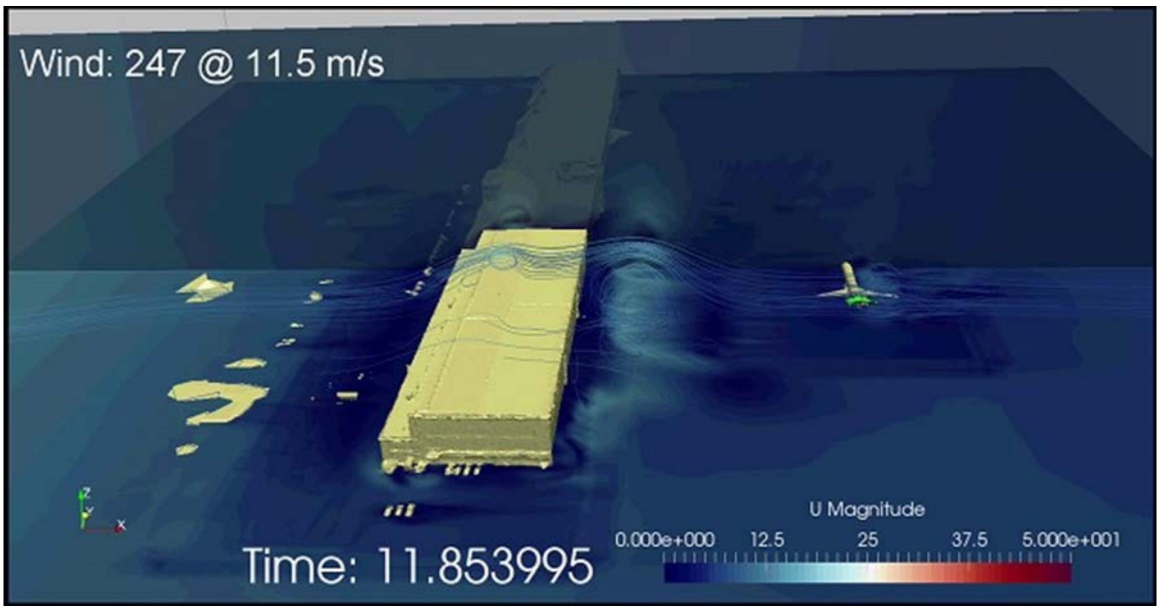


**Figure 11.** 3-D visualization of wind simulation results for a discrete time showing the locations of the hangar and airplane. Wind flow from the west (left side of image) is disrupted downwind of the hangar.

Note: The airplane's horizontal tail surfaces are highlighted in green.

The results of the wind simulation revealed that, shortly after a 55 kt gust from 261° was introduced (consistent with the maximum ASOS-observed gust), a small-scale horizontal gust of 58+ kts moved over the airplane. The gust appeared to be related to turbulence generated downwind of the hangar. The simulation also sampled and tabulated wind data at several locations on the airplane's tail for the time period that the maximum gusts were affecting the airplane. The tabular data for the simulation showed instances of upward vertical wind followed within 1 second by downward vertical wind at the airplane's tail, including the elevators. The results of the simulation enabled the NTSB to gain an understanding of the relative wind flow and possible wind

[25] A postmodel analysis verified that the prescribed wind in the simulation could be correlated to the observed wind from the ASOS. Thus, the study concluded that the use of ASOS-observed wind data to initialize the simulation was valid.

speed fluctuations in the area where the accident airplane was parked (see figures 12 and 13), which assisted in designing a representative test plan for the airplane's elevator system.

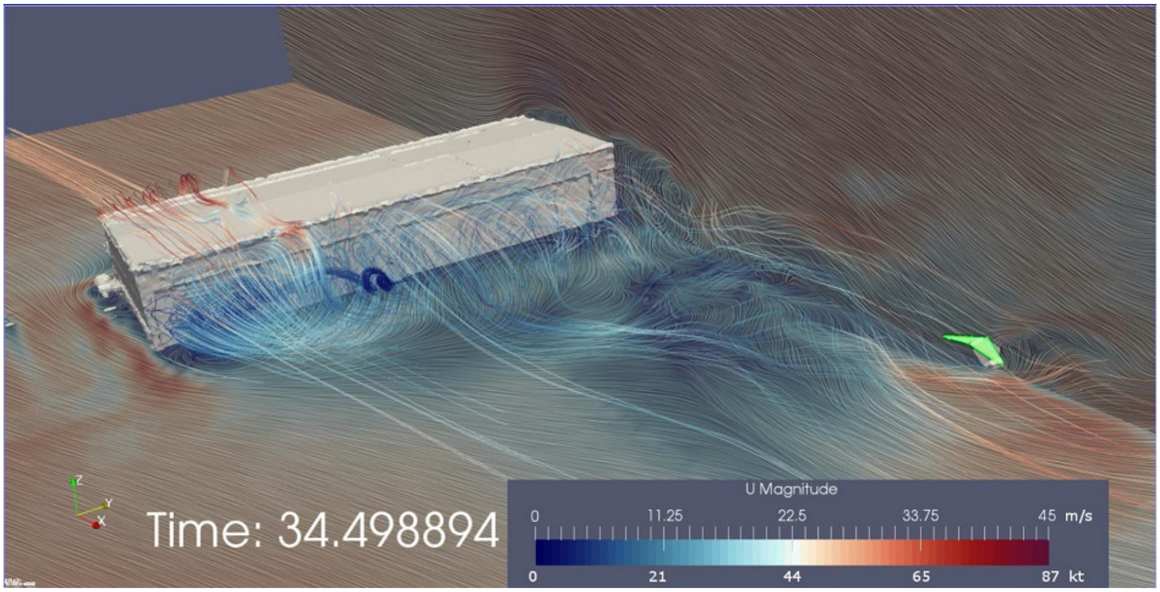


**Figure 12.** 3-D visualization of wind simulation results for a discrete time showing turbulence generated downwind of the hangar.

Note: The airplane's horizontal tail surfaces are highlighted in green (fuselage is not shown).

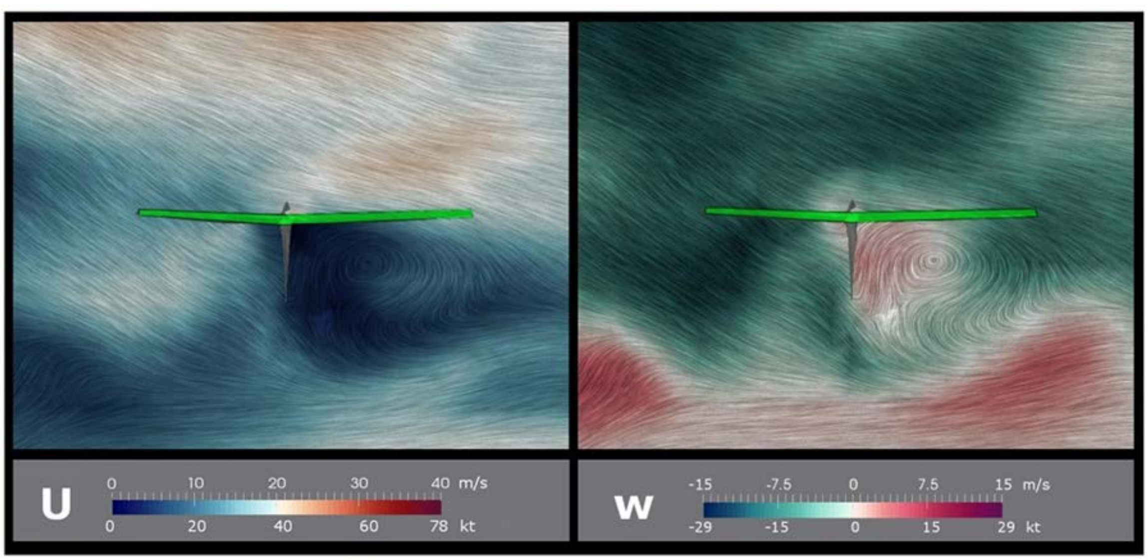


**Figure 13.** Vertical cross-section visualization of wind simulation results for a discrete time showing flow pattern and horizontal ("U") and vertical ("w") wind magnitudes near the accident airplane's elevators (view from behind looking forward).

Note: The airplane's horizontal tail surfaces are highlighted in green (fuselage is not shown).

### 1.10.4 Static and Dynamic Elevator Load Testing

Considering the CFD wind simulation results and the overcenter position of the right elevator's geared tab components, the NTSB designed several series of static and dynamic elevator load tests to determine how an exemplar elevator system would perform under various gust loads. The tests were performed at the Boeing laboratory in Huntington Beach, California, using a test rig, which included a ground-based fixture supporting an exemplar horizontal stabilizer. Components from the accident airplane served as an exemplar elevator system and included the left elevator (with its torsion bar and stop arm assembly), right elevator damper, and right boost cylinder.[26] (Accident airplane components were examined and/or tested as described in section 1.10.2 before being used on the test rig.) A hydraulic test bench supplied pressure to the boost cylinder, representative of the airplane's hydraulic system (see figure 14).

**Figure 14.** Test rig representing an exemplar horizontal stabilizer and elevator system.

[26] The elevator damper and boost cylinder are not left- or right-specific and can be mounted on either elevator.

In preparing the test plan, the NTSB used the hinge moment formula specified in 14 *CFR* 25.415 (described in section 1.3.2.3) to calculate the hinge moments needed to simulate elevator loads from ground gusts of 25, 55, 60, 65, 70, and 75 kts (the maximum recorded wind gust at YIP was 55 kts). For most tests, the calculated loads were distributed across 11 hinge points along the trailing edge of the elevator on the test rig using weights secured at each hinge point and an assumed loading profile of 60% loading on the control tab, 30% loading on the geared tab, and 10% loading on the antifloat tab. (Some tests required a different loading profile to simulate boost cylinder activation.)

For both the static and dynamic tests, a beam deflection gauge measured the deflection (rotation) of the torsion bar and stop arm assembly, calibrated such that 0° deflection represented the torsion bar position when the stop arm was in contact with the TED stop and there was no load on the elevator.

### 1.10.4.1 Results Summary

For each static load test, the elevator was positioned such that the stop arm was resting on the TED stop when the load was applied. Tests that simulated gust loads of 25, 55, and 75 kts (the only speeds tested for the static condition) both with and without boost cylinder activation revealed that the applied loads resulted in torsion bar rotation and elevator position travel beyond the nominal unloaded TED stop position of 16.5°. Each successive increase in load resulted in increased torsion bar rotation and elevator surface deflection, and the tests performed with the boost cylinder activation produced comparatively greater rotation and deflection for each load than the tests without the activation. None of the static tests resulted in the geared tab linkage becoming overcenter.

For each dynamic test, the load was applied to the elevator; the elevator was then raised to either a neutral or full-TEU position (using a forklift and lifting straps) before it was released (using a quick-release mechanism). Releasing the lifted elevator from either the neutral or full-TEU position allowed it to travel downward and dynamically contact the TED stop.

A series of dynamic tests without the boost cylinder activation and with the elevator starting in either a neutral or full-TEU position did not result in the geared tab linkage becoming overcenter for simulated gust loads of 25 and 55 kts. For the 60-kt simulated gust load, the linkage became overcenter for only the full-TEU initial elevator position test (see table 2). For the 65-, 70-, and 75-kt simulated gust loads, the linkage became overcenter for the neutral initial elevator position tests (the full-TEU initial position was not tested for these loads).[27]

[27] In addition, dynamic tests with the boost cylinder activated were not conducted for loads above 25 kts due to concerns about damaging the test rig. For the 25-kt gust load, the linkage did not become overcenter for either the neutral or full-TEU initial elevator position.

**Table 2.** Results of dynamic load tests (without boost cylinder).

| Gust speed | Elevator initial position | Maximum stop arm/ torsion bar rotation | Maximum estimated elevator surface position* | Geared tab linkage overcenter? |
|---|---|---|---|---|
| 25 kts | Neutral | 1.98° | 17.82° | No |
| | TEU | 2.91° | 18.44° | No |
| 55 kts | Neutral | 4.84° | 19.73° | No |
| | TEU | 6.20° | 20.64° | No |
| 60 kts | Neutral | 5.43° | 20.12° | No |
| | TEU | 7.16° | 21.28° | Yes |
| 65 kts | Neutral | 6.17° | 20.62° | No |
| 70 kts | Neutral | 6.65° | 20.94° | Yes |
| 75 kts | Neutral | 6.90° | 21.10° | Yes |

* Estimated elevator surface position calculated as follows: (torsion bar rotation x 0.667) + nominal elevator TED stop position of 16.5°.

### 1.10.4.2 Additional Test: Effect of Lifting Force on Locked Linkage

After the completion of the dynamic tests (described in the previous section), investigators sought to determine if adding a lifting force (to simulate airplane-nose-up air loading that would develop during the takeoff roll) would result in damage to the geared tab actuating crank and links similar to the damage observed on the accident airplane. With the geared tab inboard linkage in an overcenter position, an upward force was applied to hinge locations on the control tab. When the load cell reached about 800 lbs, the links began to fail; the load cell peaked at 975 lbs before the links completely bent outboard (see figure 15).

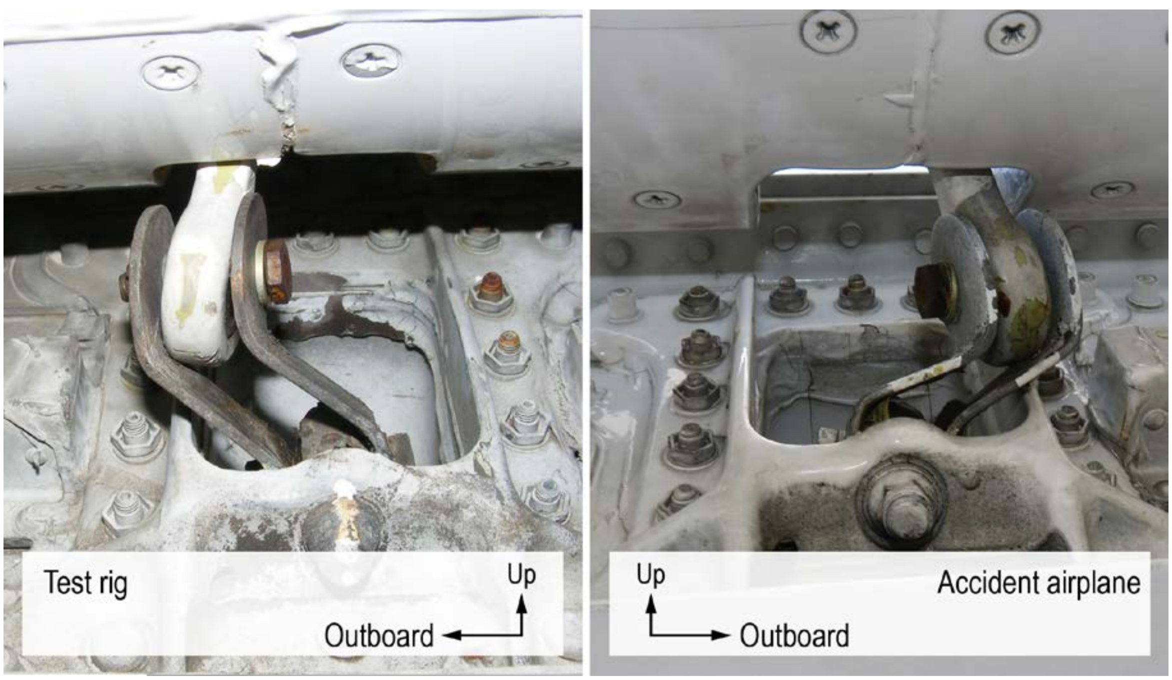


**Figure 15.** Damage to the left geared tab inboard links and actuating crank (left) after load testing versus damage observed postaccident on the accident airplane's right geared tab inboard links and actuating crank (right).

### 1.10.5 Evacuation Slide and Inflation Assembly Examination

Postaccident examination of the 1R door evacuation slide and inflation assembly (consisting of a gas reservoir and valve) was performed at Zodiac Aerospace (the parent company of the slide manufacturer, Air Cruisers) in Wall Township, New Jersey. By design, when the evacuation system is deployed, the packed slide releases below the airplane door. The manual inflation handle for the evacuation slide is directly connected to the valve release cable routed inside the slide inflation valve housing, and within the housing, the cable ball end engages into a pulley recess to mechanically operate the valve. During normal operations, manually pulling the valve release cable (via the handle) rotates the pulley to open the inflation valve. Once open, the valve releases the compressed gas from the reservoir into the slide to inflate it.

Examination of the slide and inflation assembly found that the reservoir and valve were in place in the slide packboard. The reservoir was found fully charged, and the valve was in the closed position without the manual inflation cable in place. Examination of the cable, which had come free of the housing when pulled by the flight attendant, found no evidence of anomalies.

The valve was reassembled with the valve release cable installed for testing. A test gauge was attached to the outlet fitting. Pulling the cable required 15 lbs of force to open the valve, which was consistent with the maximum force specified in the *CMM*. The valve operated smoothly, and the reservoir system pressure reading was 2,832 psi. (The *CMM* specified an expected value of 2,840 psi.) Investigators subsequently closed the valve, removed the test gauge, and attached the evacuation slide to test the system. Pulling the valve release cable resulted in successful slide inflation, with an internal slide pressure of 2.72 psi. (The *CMM* specified an expected value of 2.3 to 3.25 psi.)

Disassembly examination of the valve revealed chafe marks inside the pulley housing near the cable through hole, which is inconsistent with what would be expected during normal valve operation. Investigators found it was possible to incorrectly install the valve release cable in the pulley housing such that that ball end would catch in the area where the chafe marks were observed. Such an incorrect installation would not enable the cable ball end to engage the pulley recess to properly operate the valve.

On July 14, 2017, Zodiac Aerospace issued a revision to the *CMM* to provide more descriptive valve testing procedures intended to prevent improper cable installation, which included the following instructions:

> Verify that the valve release cable is pulled into the pulley housing as the pulley is rotated to the valve closed position…. Gently pull or tug on the valve release cable. Looking closely around the gaps in the valve cover assembly on the inflation valve, verify that there is slight movement of the pulley and the lock pin due to the movement of the valve release cable. The valve release cable should not pull free of the inflation valve assembly. If the valve release cable can withdraw from the valve assembly, either the lock pin is not fully engaged or the inflation cable was not fully inserted into the pulley during the arming procedure. Repeat [the preceding steps] to resolve unacceptable cable movement.

## 1.11 Organizational and Management Information

In accordance with 14 *CFR* 119.21(e), Ameristar Air Cargo, Inc., was authorized to conduct supplemental operations in common carriage under Part 121 and to use the business names Ameristar and Ameristar Charters. The company's principal base of operations was in Addison, Texas, and it employed 16-17 pilots and about 20 flight attendants. The company fleet consisted of two Boeing 737, four DC-9, and two MD-83 airplanes (including the accident airplane).

An organizational chart in the *General Operations Manual* (*GOM*), chapter 1, showed that all line pilots, ground instructors and check airmen reported directly to the chief pilot. The chief pilot reported directly to the director of operations (DO), who, along with the director of safety, reported to the company president. The pilots flew about 20 to 25 hours per month. By policy, pilots had an 18-day schedule in which they were on-call. The average flight segment was about 1 to 1.5 hours.

According to the *GOM*, the DO's duties included, in part, ensuring that flights were monitored with respect to departures, arrivals, and diversions; maintenance and mechanical delays; and conditions that may adversely affect the safety of flight. The DO was jointly responsible with the PIC for the initiation, continuation, diversion, and termination of a flight in compliance with regulations and OpSpecs.

According to the director of safety, voluntary reporting of safety information was accomplished through irregularity reports that were submitted to the DO and the chief pilot and were forwarded to the director of safety for review. The director of safety said he typically received about two irregularity reports per month.

### 1.11.1 Risk Assessment Program

Ameristar's risk assessment program (RAP), which was defined in the company's Safety and Emergency Response Program, was a process for data collection, reporting, and audits. The company used the collected data to identify latent unsafe conditions. According to the director of safety, the company was in the process of implementing a safety management system (SMS).[28]

According to the RAP, flight-followers were required to review each flight for hazards and risk mitigation strategies, prepare the flight release, and complete a risk assessment worksheet to provide to the pilots with their flight release paperwork. The worksheet, which was completed via a computer program, included elements with numerical values for predetermined operational risks. The worksheet scored total risk on a scale of 0 to 30; a score of 1-10 was considered low risk, 11-20 medium risk, and 21-30 high risk. According to the director of safety, any score that was 20 or greater required the DO's or the chief pilot's approval to conduct that flight, and the captain always had the right to discuss any flight with them.

[28] According to the FAA, an SMS is an organization-wide, comprehensive, and preventive approach to managing safety. It includes a safety policy, formal methods for identifying hazards and mitigating risk, and promotion of a positive safety culture. An SMS also provides assurance of the overall safety performance of an organization (FAA 2015). As of March 9, 2018, Part 121 operators must have an SMS that meets the requirements of 14 *CFR* Part 5.

The risk assessment conducted for the accident flight by the flight-follower and provided to the pilots indicated a total score of 0 (low risk). The worksheet box for "[Weather] — Thunderstorms at Departure or Destination or wind gusts above 30 [kts]" was not checked for the accident flight. According to the company *Safety and Emergency Response Manual* (Appendix B-1, page 4), the score for wind gusts above 30 kts was 4 points.

### 1.11.2`Flight Release and Weather Information for Flight Crews

#### 1.11.2.1 Accident Flight's Release

The company used a software program to develop its flight plans that would automatically populate the flight release with the most current weather. The original flight plan was generated at 1200. The flight-follower for the accident flight said that ATC did not accept the initial flight plan, and he generated a new flight release at 1213 that changed the routing of the flight. He did not update the weather information from the earlier release.

The flight release contained one METAR for YIP, which was the 1153 report that included wind from 260° at 35 kts with gusts to 50 kts and the remark that a peak wind from 260° at 55 kts occurred at 1139. The release contained a forecast for YIP that expected conditions from 1100 to include wind from 240° at 33 kts with gusts to 47 kts and conditions from 1600 to include wind from 260° at 34 kts with gusts to 48 kts.

#### 1.11.2.2 Company Procedures

According to the *GOM* (chapter 4, paragraph 4.10.1), all flights were to be filed and flown under instrument flight rules (IFR), and flight crews must obtain the ceiling and visibility values (or a specified runway visual range) from the latest weather report to determine whether a visual takeoff can be performed.

The *GOM* (paragraph 4.2.10) also specified that pilots must use the airplane radios to obtain approved weather information to include at least the ceiling, visibility, altimeter, temperature, wind direction, and wind velocity. According to the *GOM,* any of the following sources were acceptable:

> 1. [Automated weather observing system (AWOS)]-3 or above;
>
> 2. A flight service station receiving hourly weather information from departure/destination airport;
>
> 3. An operating control tower; or
>
> 4. A certified weather observer that is capable of transmitting the current weather to the pilots at least 30 minutes before estimated time of arrival or departure and must begin in time to provide pilots with an observation before beginning an approach or departure. Basic weather watch must not be discontinued until the arrival or departure is completed.

The *GOM* (paragraph 4. 2.10) also stated, in part, that pilots departing from an uncontrolled airport that has automated weather capability (like ASOS) should monitor automated broadcasts. According to the *GOM*, in the event that temperature information is missing from an automated broadcast, pilots should follow the company's procedure for obtaining a real-time mesoscale analysis (RTMA) temperature from company personnel.

#### 1.11.2.3 Related Regulations

Title 14 *CFR* 121.119, "Weather reporting facilities," stated the following:

> (a) No certificate holder conducting supplemental operations may use any weather report to control flight unless it was prepared and released by the [NWS] or a source approved by the Weather Bureau.…
>
> (b) Each certificate holder conducting supplemental operations that uses forecasts to control flight movements shall use forecasts prepared from weather reports specified in paragraph (a) of this section.

Title 14 *CFR* 121.599, "Familiarity with weather conditions," which applied to supplemental operations, stated in paragraph (b) that "[n]o [PIC] may begin a flight unless he is thoroughly familiar with reported and forecast weather conditions on the route to be flown."

Title 14 *CFR* 121.651, "Takeoff and landing weather minimums: IFR," stated the following:

> (a) Notwithstanding any clearance from ATC, no pilot may begin a takeoff in an airplane under IFR when the weather conditions reported by the [NWS], a source approved by that Service, or a source approved by the Administrator, are less than those specified in -
>
> (1) The certificate holder's [OpSpecs]; or
>
> (2) Parts 91 and 97 of this chapter, if the certificate holder's [OpSpecs] do not specify takeoff minimums for the airport.

In a response to an NTSB inquiry for a legal interpretation of 14 *CFR* 121.651 with regard to the circumstances associated with the accident day (that is, equipment outages), the FAA responded in a June 8, 2017, memorandum that stated, in part, the following:

> Although [14 *CFR*] 121.651(a) is silent on the operational capabilities of weather facilities and the recency of reported weather, reported weather conditions are a precondition for takeoff, which indicates a nearness in time. Furthermore, [P]art 121 contains other weather report and aircraft performance regulations that require reports of weather conditions that are occurring at the time of takeoff. For example, [14 *CFR*] 121.189(e) requires, in relevant part, "correction…for the ambient temperature and wind component at the time of takeoff" when determining maximum weights, minimum distances, and flight paths.

> Accordingly, to operate consistently with [14 *CFR*] 121.651(a) and other related regulations, a pilot must have a reasonable certainty that conditions existing at the time of takeoff have been accurately reflected by the weather report that is used to determine the flight will meet or exceed the required minimums and thereby ensure safe operation of the aircraft.

#### 1.11.2.4 Flight Crew's Efforts to Obtain Weather Information

During interviews, the flight crewmembers stated that, before departure, they attempted to obtain the most current weather information at YIP but that, due to the power outages at the airport, the information was incomplete. The check airman said that he used his cell phone to call the automatic terminal information service (ATIS) frequency but received a report that was "just an updated version of the previous weather with winds about 260[°] at 40 [kts]." (The CVR captured that, at 1314:39, the flight crew listened to the ATIS recording that was from 1153, and the check airman mentioned calling to "ask can we legally use this weather." The CVR captured numerous subsequent phrases from the check airman consistent with cell phone calls to obtain weather information and ATC clearances up until 1448:46.) The check airman stated that he also used his cell phone to obtain the weather observation at Detroit Metropolitan Wayne County Airport (DTW), about 8 nautical miles (nm) east of YIP, and to call the DO to obtain an RTMA temperature at YIP.

The flight crewmembers said that they used a windsock to determine the most favorable runway for takeoff. The CVR captured the flight crew discussing the windsock at 1437:07. Windsocks nearest to the accident airplane during its taxi and takeoff included a primary windsock at midfield (on the south side of runway 23L) and supplemental windsocks near approach ends of runways 23L and 27. According to the airport authority, all of the windsocks at the field were universal and complied with FAA AC 150/5345-27E, "Specification for Wind Cone Assemblies," which specified that a fabric windsock must fully extend when exposed to a wind of 15 kts (FAA 2013).

### 1.11.3 Flight Crew Procedures

#### 1.11.3.1 High-Wind Parking and Inspection Procedures

An amplified normal checklist in Ameristar's Boeing DC-9 (Boeing MD-83) *Aircraft Operating Manual* (*AOM*) (volume 1, page 1.2-2) contained the following caution:[29]

> Caution
>
> Airplanes that are exposed to high-sustained winds, or wind gusts, greater than 75 [mph] (approximately 65 [kts]) are susceptible to elevator damage and/or

[29] The *AOM* stated that "a caution is used to highlight specific information [that], if not followed, could cause damage to the equipment." It also indicated that "a warning is used to highlight specific information [that], if not followed, could cause damage to the equipment and harm to the operator and occupants."

> jamming. In accordance with the …[*AMM*], airplanes suspected to have been exposed to these conditions must have visual and physical inspections (moving surfaces by hand) of all flight controls and operational check of these [systems].[30]

Ameristar's Boeing DC-9 (Boeing MD-83) *AMM* contained the following warning and caution under "Parking: General Procedures":

> WARNING:
>
> If wind gusts are expected to exceed 69 [mph] (60 [kts]), aircraft should be headed into wind to prevent structural damage to primary control surfaces.
>
> CAUTION:
>
> If there is any possibility that [the] aircraft has been subjected to winds in excess of 75 [mph] (65 [kts]), and aircraft has not been headed into wind or wind direction changed during parking, perform visual and physical inspections (moving the surfaces by hand) of all flight controls and an operational check of these systems.

According to the DO, a pilot would be responsible for alerting maintenance personnel if the pilot knew that a parked airplane was exposed to wind that exceeded the 65 kt limit, but pilots were not expected to monitor wind when they were off duty because such an activity would be considered duty time.[31] He said that Ameristar did not have a process or procedure for monitoring wind affecting parked airplanes or a policy that placed the duty on a specific person or persons to take action when wind exceeding 65 kts affected or was forecasted to affect the parked location of a company airplane.

The director of quality control/assurance also stated that the company did not have notification procedures for wind exceeding 65 kts at locations where airplanes are parked. He said that maintenance personnel would be responsible to conduct the required inspections specified in the *AMM*, but it would take a system to monitor the airplane and airports at all times to determine who would notify maintenance personnel of an airplane's potential high-wind exposure. He said that, on the day of the accident, no one notified maintenance about high wind possibly affecting the accident airplane.

During an interview, the flight-follower for the accident flight stated that he did not monitor wind when an airplane was on the ground, and he had not known about the 65-kt wind gust

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30 A physical inspection of the elevators and tabs (which are about 30 ft above the ground) would require the use of a lift or other equipment.

31 According to the *GOM* (page 41), duty time (which differed from a flight duty period) included activities related to ground school, company errands, or activities that the company directed but were not associated with a flight. By definition, a flight duty period began when a flight crewmember was required to report for duty with the intention of conducting a flight and ended when the airplane was parked after the last flight. It included the duties performed by the flight crewmember on behalf of the company that occur before a flight segment or between flight segments without an intervening required rest period.

limitation before the accident flight. He said he did not know if it was the pilot's or mechanic's responsibility to monitor the wind when the airplane was on the ground.

A review of the *GOM* found no reference that defined a duty or responsibility for a flight crewmember to monitor a particular parked airplane for wind effects when they were not operating it (such as, during an overnight situation after a flight duty period).

#### 1.11.3.2 Elevator Preflight Inspection

**Procedures**

The *AOM* stated that the flight crew's preflight walkaround inspection of the airplane helps provide assurance of its airworthiness. The *AOM*'s normal checklist (page 1.2-8) for the preflight inspection of the elevators stated, "Elevators and tabs….Condition Good." The *AOM*'s amplified normal checklist (page 1.2-3) indicated that the flight crews should check surfaces and structures to ensure that they are undamaged and the "flight control surfaces [are] clear."

**Training**

Ameristar provided its pilots preflight inspection training and proficiency checks during initial and recurrent training in accordance with 14 *CFR* 121.441, "Proficiency checks." According to the preflight inspection proficiency requirements specified in Part 121, Appendix F, the pilot must

> (1) Conduct an actual visual inspection of the exterior and interior of the airplane, locating each item and explaining briefly the purpose for inspecting it; and
>
> (2) Demonstrate the use of the prestart check list, appropriate control system checks, starting procedures, radio and electronic equipment checks….

Ameristar was approved to use an "Advanced Pictorial Preflight" for the preflight training and proficiency checks per OpSpec A005, exemption 4416Q.[32] The pictorial, which consisted of a slide presentation, included a slide with a photograph showing a view from the ground of primarily one elevator and its tabs (see figure 16). A tabular description of the presentation referenced the proficiency check requirements and described the slide as showing the "elevators and tabs" as the "item to be checked" and indicated that the photograph depicted "condition good."

[32] According to the proficiency check requirements specified in Part 121, Appendix F, an approved pictorial that "realistically portrays the location and detail of preflight inspection items and provides for the portrayal of abnormal conditions may be substituted for the preflight inspection."


Source: Ameristar

**Figure 16.** Excerpt from Ameristar's preflight inspection pictorial training (elevator control system).

Both the captain and the check airman were trained and evaluated using the pictorial during their most recent proficiency checks and both achieved "satisfactory" results.

#### 1.11.3.3 Taxi Checklist: Elevator Control Check

The *AOM*'s normal checklist (page 1.2-5) contained a taxi checklist with challenge/response items to be completed, which included "Flight controls/Elev[ator] Aug[mentation] (B)…CHECKED." The *AOM*'s amplified normal checklist (page 1.2-31) included, in part, the following description for this item:

> Control column to the full aft position while noting that the ELEVATOR POWER ON Light is off and then pushing the control column full forward while noting that the Blue ELEVATOR POWER ON Annunciator Light illuminates indicating the elevator augmentation system is working…..

Aileron/Spoiler Operational Check: The First Officer will check elevators by noting fluctuations on both hydraulic pressure indicators…. The last check is to note that the ELEVATOR POWER ON light goes out after releasing the control column….

#### 1.11.3.4 Increased Rotation Speed for Windshear Mitigation

The *AOM* provided precautions for pilots to take to mitigate a potential encounter with windshear during takeoff. The precautions advised pilots to "Use Maximum Rated Takeoff Thrust" and "Consider Using Increased Rotation Speed," among other considerations.

#### 1.11.3.5 Rejected Takeoff

**Company Procedures and Guidance**

The *AOM* Rejected Takeoff Procedure (page 4-35) specified that

[t]he right hand of the Captain will remain on the thrust levers until $V_1$ speed is reached. In this way, the Captain can respond quickly to a decision to reject the takeoff regardless of who is performing the takeoff. The decision to continue or reject the takeoff will always be made by the [captain].

At high speeds (at or near $V_1$), consideration should be given to the effect of a high-energy reject. Experience has shown that, in many cases, rejected takeoffs at high speed have had far more negative or catastrophic results than would have been likely if the takeoffs had been continued…. In general, if the aircraft's flying performance has not been affected (such as in a tire failure), the safer course of action may be to continue the takeoff and then land under a controlled condition at a lighter weight and slower speed.

Therefore, as a consideration, a rejected takeoff above 100 [kts] should be made only for safety of flight items such as the occurrence of an engine failure or a condition where there is serious doubt that the airplane can safely fly.

If, during the takeoff, a pilot recognizes a malfunction, he should make the callout clearly and precisely. The Captain must make a decision and react accordingly. If the decision is to reject the takeoff, the following actions must be accomplished immediately:

- Disconnect Autothrottles.
- Retard the throttle levers to idle.
- Manually deploy the spoilers, simultaneously apply maximum wheel braking.
- Apply reverse thrust.
- The [first officer] should advise ATC.

- Clear the runway, if practical, and notify the tower….
- Take the necessary steps to assure the safety of passengers, crew, and the aircraft.
- Consider Emergency Evacuation.
  - Make [public address] to passengers…
    - If an evacuation of the aircraft is necessary and after the aircraft comes to a stop, complete the Evacuation Checklist and use the evacuation commands:
      - "EVACUATE, EVACUATE, EVACUATE" announce three (3) times
- Call for the After Landing Checklist….

During a postaccident interview, the check airman stated that the captain was always in command for a rejected takeoff decision and that they had briefed this ahead of time. He said that he never felt the airplane's nose come off the ground, but everything happened fast. He said that, after the captain called for the rejected takeoff, he (the check airman) started to reach toward the control column but observed that the captain had already disconnected the autothrottles and reduced the engine thrust to idle. The check airman said that he did not assume control of the airplane but assisted with applying maximum reverse thrust and wheel braking.

The *AOM* (page 5-1-6) described rejected takeoff considerations, including the following:

> ***The Go/No-Go Decision***
>
> Every takeoff has the potential for a rejected takeoff. A [rejected takeoff] close to $V_1$ must use maximum deceleration to stop on the remaining runway. The most critical condition is an engine failure close to $V_1$ at a weight near the Runway Limited Takeoff Weight.
>
> ***Factors Affecting Go/No-Go Decisions***
>
> The decision to continue or reject a takeoff rests solely with the Captain. The [rejected takeoff] decision must be made, and appropriate procedures initiated, before reaching $V_1$ so that deceleration begins at or before $V_1$. Stopping ability is directly dependent on the kinetic energy which increases as a square of the ground speed. A change in speed has a greater impact on kinetic energy than a proportional change in weight. A 10% increase in speed increases kinetic energy by approximately 21%, while a 10% increase in takeoff weight only increase[s] kinetic energy by 10%.

The same section of the *AOM* (page 5-1-7) stated, in part, the following:

***$V_1$***

$V_1$ is the end of the Go/No-Go decision process, not the beginning.

- If brakes have not been applied by $V_1$, the go decision has been made by default.
- If an engine failure is recognized and maximum braking applied no later than $V_1$, [a rejected takeoff] can be accomplished on the remaining runway.
- If an engine failure is recognized at or after $V_1$, the takeoff can be continued with a climb to 35 [ft] before reaching the end of the runway.

The *AOM* described the consequences of a late no-go decision under "Performance" (page 5-1-8) that included the following:

***Consequences of…[a] Late…No-Go Decision***

When takeoff weight is at or near the runway limited takeoff weight (due to field length, not obstacle clearance), the balanced field length approaches the available runway. In this scenario:

- [A rejected takeoff] past $V_1$ (late decision) results in the aircraft unable to stop on the remaining runway. Delaying [a rejected takeoff] 4 to 6 [kts] beyond $V_1$ (approximately 1 second) may cause the aircraft to leave the end of the runway at approximately 70 [kts] or more. …[A]nything less than maximum deceleration significantly increase[s] that speed.

**Boeing Guidance**

The Boeing *Flight Crew Operations Manual* (*FCOM*) contained guidance for rejected takeoffs under "Procedures and Techniques – Takeoff" (pages PT.20.14-PT20.16) that included, in part, the following:

The Captain has the sole responsibility for the decision to reject the takeoff. The rejected takeoff maneuver must be initiated no later than $V_1$….Rejecting the takeoff after $V_1$ is not recommended unless the Captain judges the airplane to be incapable of flight.[33]

[33] This guidance is consistent with longstanding FAA and industry guidance. In 1989, after several takeoff accidents that resulted from improper rejected-takeoff decisions and procedures, a joint FAA/industry taskforce (including airframe manufacturers, airlines, pilot groups, and regulatory agencies) studied what actions might be taken to increase takeoff safety. As a result, the taskforce developed the *Takeoff Safety Training Aid* (announced by FAA AC 120-62, "Takeoff Training Safety Aid, Announcement of Availability," and published in 1994) dedicated to reducing the number of rejected takeoff accidents (FAA 1994). Section 2 of the training aid, known as the "Pilot Guide

**Training**

Ameristar trained its Boeing MD-80 series pilots at the American Airlines Training Center in Fort Worth, Texas, using its own instructors and check airmen to conduct training and evaluations. Simulator training was conducted in an American Airlines Level C simulator.

The training program was outlined in Ameristar's Flight Crewmember Training Program that was designed to fulfill the requirements specified in Part 121, Subparts N and O, and Appendixes E, F, and H. Rejected takeoff training was included in the initial and recurrent training programs. According to the *Check Airman/Instructor Guide* (page 37), rejected takeoff training was accomplished "during a normal takeoff run after reaching a reasonable speed determined by giving due consideration to aircraft characteristics, runway length, surface conditions, wind direction and velocity, brake heat energy, and any other pertinent factors that may adversely affect safety or the airplane." According to interviews and a review of company training documents, Ameristar Air Cargo did not train MD-80 pilots on rejected takeoffs past a speed of $V_1$.

Company records showed that the captain performed a rejected takeoff during his most recent proficiency check and was graded "satisfactory." The check airman also was graded "satisfactory" on a rejected takeoff he performed during his most recent proficiency check, which an FAA aviation safety inspector observed in the simulator.

### 1.11.3.6 Emergency Evacuation

**Procedures for Pilots**

According to the *GOM* (chapter 7, page 7), "it is the responsibility of the PIC to determine the requirement for and order evacuation of the aircraft. If the PIC is incapacitated, this responsibility will follow the chain of command to other flight crewmembers."

A red-bordered emergency evacuation checklist was found on two emergency checklist cards installed in the cockpit. It included procedures for securing the airplane and commanding an evacuation using the "evacuate, evacuate, evacuate" command over the public address system.

**Procedures for Flight Attendants**

According to the *GOM* (chapter 6, page 28), flight attendants were to wait for an evacuation command from the flight deck. If a signal was not given and there was no response from the flight deck, the flight attendants were directed to initiate the evacuation, if necessary.

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to Takeoff Safety," recommended that pilots "consider $V_1$ to be a limit speed: Do not attempt [a rejected takeoff] once the airplane has passed $V_1$ unless the pilot has reason to conclude the airplane is unsafe or unable to fly. **This recommendation should prevail no matter what runway length appears to remain after $V_1$**" [emphasis in original] (FAA 2004).

The Ameristar *FAM* provided guidance under "Emergency Procedures" (page 12-3) that stated, in part, the following:

> ***Evacuation Criteria***
>
> Whether planned or unplanned, the decision to do an emergency evacuation must be made by a crewmember.[34] The following must be taken into consideration:
>
> 1. **Necessity of evacuation –** Is it in the best interests of the passengers to get out of the aircraft? Injuries often result while passengers are evacuating. If the aircraft is still intact and the emergency is under control, evacuation may not be necessary. This situation may occur in an aborted takeoff or runway excursion.
>
> 2. **Best way to evacuate –** This decision will be made by the [flight attendants] in most cases. They will command the passengers to proceed to the nearest and most accessible exit.
>
> 3. **Who will decide –** Preferably the Captain decides if an evacuation is necessary. However, the decision will rest upon the [flight attendants] should a signal from the flight deck not be received.

## 1.12 Additional Information

### 1.12.1 Previous Elevator Jam Event

According to an incident report from the German Federal Bureau of Aircraft Accident Investigation (BFU), on December 26, 1999, a Douglas DC-9-83 was involved in a rejected takeoff incident at Munich Airport, Munich, Germany (BFU 2000). The BFU reported that the inboard linkage of the left elevator's geared tab was jammed, causing the left elevator to be jammed in a TED position. The airplane had been exposed to gusty tailwinds up to 70 kts when parked before the flight. As a result of its investigation, the BFU recommended in November 2000 that (1) the *Airplane Flight Manual* (*AFM*) be revised to state that the elevator control can jam and that a special examination of the flight controls is necessary if the airplane is subjected to wind exceeding 65 kts when not parked facing into the wind, (2) the checklist should include directions for examining the elevator's hydraulics (including moving the control column) under specified criteria, and (3) the *AMM* should mention the possibility of a jammed elevator and should contain instructions for a special examination of the airplane if subjected to wind exceeding 65 kts when not parked facing into the wind.

Subsequently, on June 25, 2001, Boeing issued Flight Operations Bulletin (FOB) MD-80-01-02, "Flight Control Jam," that alerted operators about the circumstances of the incident, including the belief that the wind forced the left elevator into a TED position beyond the design

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[34] The *GOM* (chapter 6, page 27) defined a planned emergency as an emergency for which the crew has 10 minutes or more to plan.

limits, causing it to jam.[35] The FOB stated that the flight crew and maintenance personnel had been concerned about the high wind exposure and performed an "operational check" by exercising the flight controls from the cockpit and noted no anomalies. The FOB stated that "it is believed that the control tabs responded properly to the cockpit input, but that the 'feel' with one elevator jammed was not sufficiently different from the norm to alert the crew to the problem." Boeing subsequently issued revisions to the *AMM* to prescribe physical inspections of the flight controls to include moving the control surfaces by hand. (Ameristar's *AMM* contained this information.)

### 1.12.2 Previously Issued Safety Recommendations Related to Runway Safety Areas

As described in sections 1.5.2 and 1.9.2, the RSAs at YIP (a Part 139-certificated airport) were upgraded between 2006 and 2009 and, at the time of the accident, conformed to the standards prescribed in AC 150/5300-13A, Change 1. According to the FAA, the performance of the RSA at YIP, which provided a clear area to accommodate the accident airplane's overrun, demonstrated the design standard's contribution to accident survivability.

The NTSB notes that the FAA's efforts to upgrade the RSAs at YIP were responsive to Safety Recommendation A-03-11 (described later in this section), issued on May 6, 2003, that asked the FAA to require all Part 139 airports to meet the AC standards. This recommendation is part of our decades-long history of advocating for adequate RSAs based on evidence discovered during accident investigations.

We issued our first safety recommendation related to RSAs on April 20, 1977, as a result of our investigation of the November 16, 1976, accident involving a McDonnell Douglas DC-9-14 airplane that ran off the end of the runway during an aborted takeoff and caught fire after striking two ditches and nonfrangible structures in Denver, Colorado (NTSB 1977).[36] Based on our findings, we recommended that the FAA

> [a]mend [14 *CFR* 139.45] to require, after a reasonable date, that extended [RSA] criteria be applied retroactively to all certificated airports. At those airports [that] cannot meet the full criteria, the extended [RSA] should be as close to the full 1,000-foot length as possible. (Safety Recommendation A-77-16[37])

The FAA replied on July 11, 1977, that extended RSAs at all existing airports would be "impractical and infeasible." The FAA said it would instead propose an amendment to Part 139 to require extended safety areas concurrently with the construction of new airports, new runways,

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[35] The FOB, which applied to all Boeing DC-9, C9, MD-80, MD-90, and 717 airplanes, was also referenced by number DC-9-01-02, MD-90-01-02, and B-717-01-05.

[36] Nonfrangible structures do not break, yield, or distort upon impact in a manner that presents a minimum hazard to an aircraft in the event of a collision (FAA 2014a, 6, 61).

[37] When we issued the recommendation, Part 139 did not specify dimensions for RSAs. Effective February 28, 1983, AC 150/5300-12 established that an RSA should be at least 500 ft wide and should extend 1,000 ft beyond each runway end. Subsequent revisions included AC 150/5300-13, which became effective on September 29, 1989; AC 150/5300-13A, which became effective September 28, 2012; and AC 150/5300-13A, Change 1, which became effective February 26, 2014.

and major runway extensions at existing airports. To that effect, on October 23, 1985, the FAA published Notice of Proposed Rulemaking (NPRM) 85-22, “Revision of Airport Certification Rules.” In our February 5, 1986, comments about the NPRM, we said that we continued to believe that the RSA criteria should be mandatory at all certificated airports, regardless of the date of construction. On January 1, 1988, the final rule based on the NPRM became effective, and, because it did not require retroactive upgrades of RSAs, we classified Safety Recommendation A-77-16 “Closed—Unacceptable Action.”

As a result of our investigation of an April 27, 1994, accident in which a Piper PA-31-350 airplane ran off the end of the runway during landing in Stratford, Connecticut, and crashed into a blast fence, killing 8 people on board the airplane and seriously injuring another person (NTSB 1994), on January 5, 1995, we recommended that the FAA

> [i]nspect all…Part 139 certificated airports for adequate [RSAs] and nonfrangible objects, such as blast fences, and require that substandard [RSAs] be upgraded to [AC] 150/5300-13 minimum standards wherever it is feasible. (Safety Recommendation A-94-211)

On October 15, 1997, the FAA told us that its inspections revealed that 58% of the RSAs met current standards, 25% were substandard but feasibly improvable, and 17% were substandard but not feasibly improvable. The FAA stated that improving the RSAs at the feasibly improvable airports would cost $1.2 billion, and that, due to the cost and the infrequency of overruns, RSA upgrades would be required only as part of overall runway improvement projects. In our February 10, 1999, response, we expressed our concerns that the FAA’s plan could delay RSA upgrades and allow substandard RSAs to continue for many years. As a result, we classified Safety Recommendation A-94-211 “Closed—Unacceptable Action.”

Subsequently, on March 5, 2000, a Boeing 737-300 operated by Southwest Airlines overran the runway during landing and collided with a blast fence and an airport perimeter wall before coming to rest on a city street near a gas station off the airport property in Burbank, California (NTSB 2002). We noted during our investigation that the RSA for the runway was significantly smaller than that prescribed in the AC and that the FAA subsequently funded and completed the installation of an engineered material arresting system (EMAS) in January 2002.[38] The FAA had developed EMAS in the 1990s as a result of Safety Recommendation A-84-37, and, since then, the technology had been shown to be a practical, affordable, and effective system for use at the end of runways that could not, with feasible improvements, meet the minimum RSA standards.[39] As a result of our investigation, on May 6, 2003, we recommended that the FAA

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[38] An EMAS uses crushable material placed at the end of a runway to stop an aircraft that overruns the runway. The tires of the aircraft sink into the lightweight material, and the aircraft is decelerated.

[39] As a result of our 1984 safety study on airports, on April 11, 1984, we recommended that the FAA “initiate research and development activities to establish the feasibility of soft-ground aircraft arresting systems and promulgate a design standard, if the systems are found to be practical” (Safety Recommendation A-84-37) (NTSB 1984). The FAA completed the research and development and responded on February 27, 1997, that it had installed a prototype arrestor bed. As a result, we classified Safety Recommendation A-84-37 “Closed—Acceptable Action” on June 2, 1997.

> [r]equire all…Part 139 certificated airports to upgrade all [RSAs] that could, with feasible improvements, be made to meet the minimum standards established by [AC 150/5300-13]. The upgrades should be made proactively, not only as part of other runway improvement projects (Safety Recommendation A-03-11); and
>
> [r]equire all…Part 139 certificated airports to install [EMAS] in each [RSA] available for air carrier use that could not, with feasible improvements, be made to meet the minimum standards established by [AC 150/5300-13]. The systems should be installed proactively, not only as part of other runway improvement projects. (Safety Recommendation A-03-12)

The FAA responded on August 7, 2003, stating that, although it agreed with the intent of Safety Recommendation A-03-11, it did not believe that regulatory action was needed. The FAA referred to FAA Order 5200.8, *[RSA] Program*, which was issued October 1, 1999, and stated that the program's objective was for all RSAs at all Part 139 airports and federally obligated airports to conform to the AC's standards, to the extent practicable (FAA 1999).[40]

After issuing Safety Recommendations A-03-11 and -12, we continued to investigate accidents involving runway overruns. On December 8, 2005, a Boeing 737-74H operated by Southwest Airlines collided with a blast fence, an airport perimeter fence, and an occupied passenger car on an adjacent roadway after it overran the runway during landing in Chicago, Illinois (NTSB 2007). Eighteen of the airplane's 103 occupants sustained minor injuries; of the people in the car, one person (a child) was killed, another person received serious injuries, and three others received minor injuries. The RSA extended 82 ft beyond the end of the runway (the AC standard was 1,000 ft) and had no EMAS. Our investigation found that, in 2000, the FAA had determined that achieving RSA standards for the runway did not appear practicable (due, primarily, to land constraints), but it had asked the airport operator to explore all options to bring the airport's RSAs into full conformance. We found that the FAA had followed up in 2003, asking the city to assess enhancement measures for improving the RSAs, but the city concluded in May 2004 (19 months before the accident) that there was insufficient spacing for an EMAS installation. Our investigation determined that the installation of a shorter, nonstandard EMAS at the end of the accident runway could have safely stopped the airplane. (After the accident, the FAA approved [and the city began installing] nonstandard EMAS beds at the airport.)

On February 18, 2007, an Embraer ERJ-170 operated by Shuttle America, Inc., dba Delta Connection flight 6448, overran the runway during landing in Cleveland, Ohio (NTSB 2008). The airplane had crossed the 60-ft-long, 275-ft-wide RSA and struck a navigational aid (NAVAID) and the perimeter fence before coming to rest adjacent to a road. In our investigation, we found that the RSA had not been upgraded to the AC's standards. The FAA had inventoried the RSA in 2000, notified the airport authority about some short-term and long-term options to enhance the RSA (one of which included shifting the runway and installing an EMAS), and asked the airport authority to evaluate the options and make a recommendation by March 2001. We found that the

[40] The NTSB was already familiar with the order, having referenced it in our May 6, 2003, letter to the FAA. At the time, we acknowledged the order's objective but noted that it did not require RSAs to be proactively upgraded; instead, it restated the FAA's position to require RSA improvements only as part of overall runway improvement projects.

airport provided the FAA its first draft RSA report in 2004 (with subsequent drafts in 2006 and 2007) but had not recommended a solution. The FAA extended the airport's deadline for completing the RSA upgrades to September 2010. Had the RSA been upgraded with a runway shift and EMAS installation, the airplane would have come to a stop within the EMAS.

From November 2007 through November 2008, the Department of Transportation's Office of Inspector General (OIG) had conducted an audit of the FAA's RSA program and issued a report on its findings on March 3, 2009. The OIG reported that the FAA had made significant progress and was "generally effective in identifying, prioritizing, and funding needed RSA improvements with two major exceptions: NAVAIDs and data quality" (DOT OIG 2009). The OIG audit found that noncompliant NAVAIDs in some RSAs posed significant safety risks, and the FAA's ability to track and report RSA improvements was hampered by inaccurate and incomplete data. The OIG also noted that the FAA's annual report to Congress (which was based on those data) did not provide sufficient detail for decision-makers and overstated the number of RSAs meeting full standards. As a result of the audit, the FAA agreed to identify and address noncompliant NAVAIDs and take steps to improve its RSA data and annual report to Congress (DOT OIG 2009).

As a result of Safety Recommendation A-03-11 and FAA Order 5200.8, the FAA evaluated more than 1,000 runway ends at all Part 139 airports for compliance with current RSA standards. The improvements made were divided into two categories, based on the funding source for the improvements. RSA improvements involving airports progressing to meet dimensional standards were funded with grants from the Airport Improvement Program. All RSA improvements that were practicable under this program (including the RSA improvements made at YIP between 2006 and 2009) were completed by December 31, 2015, which was a congressionally mandated deadline.[41] Upgrades involving relocating or making frangible FAA-owned NAVAIDs located in the RSAs were funded from the FAA's facilities and equipment budget. As of April 6, 2017, the FAA said that, by the end of fiscal year 2016, it had improved 84% of RSAs with NAVAIDs needing relocation or to be made frangible and that it expected to complete the NAVAID program by the end of 2018. On June 8, 2017, pending completion of the NAVAID project, Safety Recommendation A-03-11 was classified "Open—Acceptable Response."

With regard to the installations of EMAS at locations where RSA dimensional conformance was not feasible, as recommended in Safety Recommendation A-03-12, on August 12, 2015, the FAA said that it had installed EMAS beds at 83 runway ends at 53 airports in the United States and that these installations had safely stopped 9 aircraft during overruns. Additional EMAS installations were scheduled to be completed at 13 runway ends at 11 airports by the end of 2015 (including the runway in Stratford, Connecticut, where a 1994 accident was the basis for Safety Recommendation A-94-211). On September 29, 2015, pending completion of the EMAS program, we classified Safety Recommendation A-03-12 "Open—Acceptable Response."

According to the FAA's July 5, 2018, EMAS fact sheet, EMAS had been installed at 113 runway ends at 68 airports in the United States, and 7 additional EMAS installations were planned for 6 more US airports (FAA 2018b). The FAA also said that, as of the date of the fact

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[41] Congress had enacted Public Law 109-115 on November 30, 2005, that required Part 139 airports to comply with RSA design standards by the end of 2015 and required the FAA to report annually to Congress on its progress.

sheet, EMAS installations had safely stopped 13 overrunning aircraft with 288 crew and passengers aboard those flights.

### 1.12.3 Procedures for Weather Observers

#### 1.12.3.1 Sign Off for Nonaugmented Reports (Automated METAR)

As described in section 1.4.2.2, YIP was a facility with LAWRS observers. During normal operations, a LAWRS observer is logged in to the ASOS operator interface device (OID) and provides augmentation of the METARs and SPECIs.

Soon after the power outage on the morning of the accident, the tower personnel evacuated, and a LAWRS observer did so without logging out of the system. As a result, the automatically disseminated METARs did not contain an AUTO modifier. According to FAA Order JO 7900.5D, *Surface Weather Observing*, section 14.10.a., the AUTO modifier "identifies the type of report as a fully automated report with no human intervention…the absence of AUTO indicates that the report is either a manual report or an automated report with an observer 'logged on' to the system" (FAA 2014b, 102).

A review of the ATCT evacuation procedures identified no guidance for observers to log out of the ASOS OID. FAA Order JO 7900.5D, section 5.3, which addressed "sign on/sign off" procedures, did not specify sign-off (log-out) procedures except for scenarios involving certain weather events that are occurring at the close of augmentation coverage (FAA 2014b, 32).

#### 1.12.3.2 Backup Responsibilities During Equipment Outage

As described in section 1.4.2.2, after 1202 on the morning of the accident, the ASOS lost some of its sensor functions due to the power outage, but its OID retained dissemination capability. As a result, the ASOS automatically disseminated METARs that contained incomplete information.

According to section 2.5.a. of FAA Order JO 7900.5D (which was current at the time of the accident),

> [c]ertified observers are responsible for the completeness and accuracy of the weather observation. If the complete automated observation is unavailable due to sensor/system malfunction…, backup information must be provided….(FAA 2014b, 6[42])

Appendix C, section C.5.b., of the order stated the following:

[42] The section indicated that a sensor/system malfunction occurs when "[o]ne or more sensors or the entire observing system is (are) not reporting data (for any reason). Provide manual backup and make appropriate maintenance notifications."

> If portions of, or the complete automated systems with SPECI capability observation is unavailable due to sensor/system malfunction…LAWRS must backup, at a minimum, the following weather elements at sites with an automated system with SPECI capability:… (1) Wind (2) Visibility to 10 miles (3) Present weather and obscurations… (4) Sky condition to 12K feet (5) Temperature/dew point (6) Altimeter setting. (FAA 2014b, 146)

FAA Order JO 7900.5D did not provide LAWRS procedures that specifically addressed whether the backup requirements applied if observers must evacuate from a duty station. Section 1.8.d. contained the following general guidance for unforeseen scenarios:

> No set of procedures and practices can cover all possibilities in weather observing. The observer must use good judgment, adhering as closely as possible to this order, to describe phenomena not adequately covered by specific instructions. (FAA 2014b, 2)

No LAWRS observer provided any backup information to supplement the missing ASOS data after evacuating the tower due to high wind about 1217.

## 1.13 Effective New Investigation Techniques

To maximize the fidelity of the CFD wind simulation described in section 1.10.3, NTSB investigators conducted a mapping mission using an sUAS to obtain the imagery necessary to produce an accurate, photogrammetric 3-D model of the hangar, other buildings, and terrain near the area where the airplane was parked.

The mapping consisted of seven missions with overlapping grids and oblique orbits between 100 and 150 ft agl. These missions were flown within the YIP Class D airspace under an amended Certificate of Authorization or Waiver from the FAA to operate at or below 250 ft agl, as coordinated with the YIP ATCT. In accordance with the authorization, a notice to airmen (NOTAM) was issued, continuous communication with ATCT personnel was maintained, and airport operations were not affected.

The missions obtained about 900 high-resolution photographs. The team also created multiple ground control points (GCPs), logged the position of each using a handheld global navigation satellite system, then processed the data using software and a nearby continuously operating reference station to increase the positional accuracy of the handheld measurements. Still imagery and GCP information was processed using photogrammetry software to produce full-resolution orthomosaic .kmz files and a 3-D model that was further processed and used in the CFD simulation (see figure 17).[43]

**Figure 17.** Screenshot of one view of the hangar 3-D model created from sUAS-captured imagery.

Using conventional techniques, 3-D modeling of the complex building and terrain environment would have required the use of blueprints, photographs, terrain data, and computer-aided design software to manually create the model. This would have involved considerable resources (time and manpower) to accurately model the basic hangar and all its small-scale obstructions that could affect wind patterns (such as duct work, chimneys, ladders, architectural details, bushes, trees, and terrain). Manually modeling the hangar and its detailed features would have taken several weeks and may not have produced the level of accuracy necessary for effective use in the CFD simulation (Bauer et al. 2018).

[43] A .kmz file is a compressed file that contains imagery and corresponding keyhole markup language files that enable the imagery and associated file information to be viewed on Google Earth.

## 1.14 Postaccident Safety Actions

### 1.14.1 Boeing's Multioperator Message and Ongoing Efforts

In its May 1, 2018, submission to the investigation, Boeing noted that it had issued a multioperator message to provide operators with details about the jammed elevator condition seen in this accident, including the overcenter position of and damage to the geared tab linkage and the wind conditions that affected the airplane while parked near the large hangar. The message emphasized the importance of inspecting airplanes that potentially have been exposed to high wind or gusts while on the ground.

In November 2018, Boeing provided an update that included copies of revised Fleet Team Digest (FTD) documents that it had distributed to operators.[44] According to the FTDs, Boeing was developing a service bulletin (SB) for modifying the elevator structure of Boeing DC-9/MD-80 series and 717 model airplanes to attach a secondary travel stop that would prevent the excessive elevator TED travel that could result in the geared tab linkage becoming locked overcenter.

Boeing also reported that it was developing a revision to the *AMM* for Boeing DC-9/MD-80 series and 717 model airplanes to add new elevator wind damage inspection procedures, which would also include a lower wind speed threshold for the inspection. The inspection would involve verifying that an elevator was positioned trailing edge neutral or above. For an elevator that appeared below neutral, performing additional control checks with a ground observer or a hands-on check of the elevator to ensure freedom of movement would be required. (These new inspection procedures would not apply to any airplanes with the secondary stop installed per the SB.)

In addition, Boeing revised the *FCOM* (and planned to revise the *AFM*) for Boeing 717 model airplanes to include a taxi procedure for the flight crew to check the system configuration synoptic (part of the advanced flight deck display in the cockpit) for indications of elevator position movements when a control column is moved full aft.

### 1.14.2 Ameristar's Wind Monitoring Procedures for Parked Airplanes

On May 22, 2018, Ameristar issued an FAA-accepted bulletin for flight-followers that prescribed company procedures for monitoring the wind that affects its parked Boeing DC-9 (MD-80 series) airplanes. The bulletin stated that flight-followers (who are flight control personnel) should use the TAF for each airplane's parked location to evaluate, for the entire TAF timeframe, whether any wind speeds were forecasted to reach or exceed 50 kts. The procedure included, in part, the following:

[44] FTD documents 717-FTD-27-18001 and DC-9-FTD-27-18001 were each revised November 28, 2018.

1. If it is determined that 50 [kts] may be reached or exceeded for the timeframe that an aircraft is on the ground, [flight control] will notify [maintenance control] of the forecast winds.

2. [Flight control] will monitor the METARs for actual winds being reported during the timeframe that they have been forecast to exceed 50 [kts].

3. If [flight control] finds that a METAR indicates winds in excess of 50 [kts] has been reached or exceeded, [maintenance control] must be notified with the affected aircraft and airport location. [Maintenance control] will determine if the High Wind/Gust Damage Inspection will be required….

4. If [maintenance control] determines that a High Wind/Gust Damage Inspection is required, [maintenance control] will notify [flight control] to place the affected aircraft in a "RED" status.

The bulletin provided required procedures for documenting daily the TAF information on the company's wind analysis form for each airplane and for saving the files into a company directory that is subject to random audits by the director of safety.

# 2. Analysis

## 2.1 Introduction

This accident occurred when the Boeing MD-83 airplane overran the departure end of runway 23L at YIP during a rejected takeoff, crossed through the RSA, and struck the airport perimeter fence and a raised road before coming to a stop. The captain, who was the PF, executed the rejected takeoff after $V_1$ when he perceived that the airplane did not respond normally when he pulled back on the control column to command rotation. All 116 persons on board evacuated the airplane via the emergency escape slides with only one reported minor injury; however, one slide failed to inflate.

FDR data showed that the airplane's right elevator was full TED when the flight crew first powered up the airplane on the day of the accident and remained there throughout the accident sequence. An airplane performance study (based, in part, on FDR data) confirmed that airplane did not respond in pitch when the captain pulled on the control column. Before the accident flight, the airplane had been parked on the ramp at YIP for 2 days near a large hangar, and the elevators (which, by design, did not have gust locks) were exposed to high, gusting surface wind conditions. Postaccident examination showed that the right elevator's geared tab's inboard actuating crank and links had moved beyond their normal range of travel and became locked overcenter, effectively jamming the right elevator in a full-TED position. Thus, the NTSB concludes that the right elevator's jammed condition rendered the airplane unable to rotate during takeoff.

The following analysis discusses the flight crew's performance, including their preflight airplane inspection and control checks, preflight weather planning, and execution of the rejected takeoff after $V_1$ (section 2.2), and evaluates the following:

- The right elevator's jammed condition, including geared tab linkage damage, effects of wind flow characteristics at the airplane's parked location near the large hangar, and static and dynamic elevator load testing (section 2.3);
- Mitigations to prevent takeoffs with an undetected jammed elevator for Boeing DC-9/MD-80 series and 717 model airplanes (section 2.4);
- RSA enhancements at YIP and nationwide (section 2.5);
- Weather observer procedures during a facility evacuation (section 2.6); and
- Evacuation slide inflation malfunction (section 2.7).

Further, the investigation examined the following issue areas and found no related factors that contributed to the accident:

- **Flight crew qualifications.** The captain and the check airman were certificated, current, and qualified in accordance with federal regulations and company requirements. The captain and the check airman held valid and current FAA airman medical certificates.

- **Flight crew alcohol or other drug use.** Postaccident alcohol and drug testing on specimens from each pilot revealed no evidence of alcohol or other drugs.
- **Airplane maintenance.** The airplane was properly equipped and maintained in accordance with federal regulations. No evidence indicated that any maintenance discrepancy contributed to the jammed elevator condition.
- **Airplane weight and balance.** Although the FAA guidance in AC 120-27E recommends using actual passenger weights (or established average weights) for flights carrying passengers of a nonstandard weight group (such as a sports team) when performing weight and balance calculations, Ameristar's OpSpecs allowed for the use of standard weights for passengers and baggage for the accident flight. Postaccident calculations performed using assumed passenger weights and actual baggage weights determined that the airplane was within weight and CG limits at takeoff.

Thus, the NTSB concludes that the investigation determined that (1) the captain and the check airman were appropriately qualified for the operation, (2) neither pilot was impaired by alcohol or other drugs, (3) the airplane was properly maintained, and (4) the airplane was within weight and CG limits at takeoff.

## 2.2 Flight Crew's Performance

### 2.2.1 Preflight Responsibilities Related to Elevators

#### 2.2.1.1 Parking and Inspection Criteria for High-Wind Exposure

Ameristar's *AOM* for the Boeing MD-83 contained an amplified normal checklist for flight crews that included a caution that airplanes exposed to high sustained wind or gusts greater than 65 kts were susceptible to elevator damage and/or jamming and stated that, for any airplanes suspected of such exposure, inspections and checks specified in the *AMM* were required. Ameristar's *AMM* for the Boeing MD-83 included a warning that the airplane must be parked headed into the wind if gusts were expected to exceed 60 kts and a caution that a visual and physical inspection of all flight control surfaces was required if the airplane was subjected to wind exceeding 65 kts. However, none of the recorded or forecasted wind at YIP exceeded these limits during the time that the airplane was parked on the ramp (the highest reported wind gust was 55 kts and the highest forecasted gust was 48 kts). Thus, the NTSB concludes that, based on the available wind data for YIP, the flight crew was not required to perform high-wind parking procedures or request flight control inspections from maintenance personnel.

#### 2.2.1.2 Preflight Inspection and Taxi Control Check

The amplified normal checklist in the *AOM* and Ameristar training specified that a pilot must visually check the general condition of the elevators and tabs before each flight segment. The captain performed the preflight inspection and noted no visible damage. Flight crews are not required to physically move the elevator surfaces (which are about 30 ft above the ground), and the geared tab linkage is not visible from the ground. Although it is possible to see when an elevator is positioned full TED (as evident in figure 2, which shows that the accident airplane's jammed elevator was in a full-TED position), a full-TED elevator position is not necessarily indicative of an anomaly because the elevators can freely move to that position under nominal ground wind.

The amplified procedures in *AOM* for the taxi checklist specified that a pilot must move the control column through the full range of travel to determine if the controls are free and normal. The check airman performed this check and noticed nothing unusual, and postaccident examination found that moving the control columns forward and aft resulted in the correct corresponding movement of the elevator control tabs. (Investigators noted some difficulty moving the cockpit control columns; however, this was likely due to impact-damaged airplane structure that was in contact with the control cables.) The control tabs are the only parts of the elevator system that are connected to the control column, and the control tabs were not damaged. Thus, the NTSB concludes that the flight crew's preflight inspection and control check during taxi, which were performed in accordance with the procedures specified in the *AOM*, could not have detected the overcenter position of the right elevator geared tab's linkage or the resultant jammed elevator condition.

### 2.2.2 Preflight Weather Evaluation and Decision to Use Increased Rotation Speed

The flight crew was required by regulations and company procedures to verify that the takeoff weather conditions met the minimum requirements. However, at the time of departure, the ASOS, ATIS, and ATCT at YIP had not been operational for 3 hours. The flight crew attempted to obtain current information from the ASOS and ATIS using the airplane's radios, but, finding it incomplete, the check airman used a cell phone to access the YIP ATIS, weather information from DTW (which was 8 nm away), and the DO to obtain the RTMA temperature. The FAA legal interpretation dated June 8, 2017, stated, in part, the following concerning these circumstances on the day of the accident:

> Although [14 *CFR*] 121.651(a) is silent on the operational capabilities of weather facilities and the recency of reported weather…, to operate consistently with [this] and other related regulations, a pilot must have a reasonable certainty that conditions existing at the time of takeoff have been accurately reflected by the weather report that is used to determine the flight will meet or exceed the required minimums and thereby ensure safe operation of the aircraft.

The NTSB notes that the weather conditions at YIP were VFR based on the most recent METAR received by the flight crew, DTW was reporting VFR conditions when the check airman called to receive the information, and the flight crew visually verified that the conditions at YIP were VFR at the time of the departure. Thus, the NTSB concludes that the flight crew's preflight weather evaluation was sufficient to establish with reasonable certainty that the conditions existing at the time of takeoff met the required minimums for departure.

Ameristar procedures allow flight crews to use an increased $V_R$ to mitigate a potential encounter with windshear during takeoff, which the flight crew had reason to expect as likely due to the high, gusting wind conditions on the day of the accident. As a result, the flight crew chose to increase the rotation speed about 5 kts. Thus, the NTSB concludes that the flight crew's decision to use an increased rotation speed was appropriate for the known weather conditions and consistent with company procedures.

### 2.2.3 Decision to Reject Takeoff after $V_1$

$V_1$ is the maximum airspeed at which a rejected takeoff can be initiated and the airplane stopped on a runway that is limited by field length. Company guidance specified that initiating a rejected takeoff even 4 to 6 kts (about 1 second) after $V_1$ may result in a runway overrun at high speed. Although the flight crew's use of the increased rotation speed to mitigate a possible windshear encounter during takeoff was appropriate, it resulted in the check airman not calling "rotate" until 5 seconds after the airplane achieved $V_1$. By the time the captain recognized that the airplane would not rotate and called to abort the takeoff, 12 seconds had elapsed since $V_1$, essentially guaranteeing that the airplane would overrun the runway.

Ameristar guidance and training specifically stated that the captain was solely responsible for the decision to continue or reject a takeoff and that the no-go decision must be made—and the appropriate procedures initiated—before the airplane reached $V_1$. The guidance stated that, in many cases, rejected takeoffs at high speed have resulted in far more negative or catastrophic outcomes than would have been likely if the takeoffs had been continued. For decades, pilot training has extensively emphasized that the no-go decision must be made before $V_1$.

However, company guidance also stated that a high-speed rejected takeoff should be made only for safety of flight items, such as a condition where there is serious doubt that the airplane can safely fly. Boeing guidance also stated that rejecting the takeoff after $V_1$ is not recommended unless the captain judges the airplane to be incapable of flight.

In the case of this attempted takeoff, it was not until after the airplane had exceeded $V_1$ that the captain discovered that the airplane would not rotate in response to his control inputs. When the check airman called "rotate," the captain pulled back on the control column, observed that the airplane did not respond in pitch, then added more back pressure until the control column came "further back than for a normal rotation," but the airplane still did not respond. The captain called for the rejected takeoff, and the flight crewmembers applied maximum braking, but the airplane went off the end of the runway. The airplane performance study showed that, assuming the same deceleration profile as that of the accident flight, the captain would have had to start braking 4 seconds sooner for the airplane to have come to a stop on the paved surface. However, at that point in the accident flight's takeoff, the captain's control column input had been applied for only 3 seconds. A review of FDR data showed that, during the airplane's previous successful takeoff, at 3 seconds after control column input, the airplane had only begun to respond in pitch. Thus, the NTSB concludes that the airplane's lack of rotational response to the control column input during the accident takeoff did not become apparent to the captain in time for him to have stopped the airplane on the runway.

Rarely could all of the safeguards in place to ensure an airplane is airworthy before departure (such as proper aircraft maintenance, preflight inspections, and control checks) fail to detect that an airplane was incapable of flight, as occurred with the jammed elevator on the accident airplane. Perhaps even more remarkable was that a flight crew would be placed in a situation in which the airplane's inability to fly would not be discoverable until after it had accelerated past $V_1$ during a takeoff roll. The captain had extensive flight experience with many takeoffs, but none of them presented a scenario like the one he faced during the accident takeoff. Although the captain was relatively new to flying the Boeing MD-83, because of his prior experience in the Boeing DC-9 (a variant with an identical elevator system and controls), he correctly assessed the state of the accident airplane and quickly called for and initiated the rejected takeoff. Thus, the NTSB concludes that, once the airplane's inability to rotate became apparent, the captain's decision to reject the takeoff was both quick and appropriate.

Crew coordination during takeoff is essential to managing one of the most critical phases of a flight. Effective crew coordination and performance depend on the flight crewmembers having a shared mental model of each task; such a mental model, in turn, is founded on effective standard operating procedures (SOPs) (FAA 2017b). Flight crew adherence to SOPs during a takeoff, including maintaining the defined roles of PF and PM, is of paramount importance to flight safety (FAA 2017b).

Although Ameristar's procedures for a rejected takeoff clearly establish that the responsibility for the go/no-go decision is exclusively that of the captain, in this flight, the PM was also a check airman providing airplane differences instruction to the captain trainee; thus, the check airman was the PIC of the flight. This increased the potential for confusion as to who was truly responsible for the go/no-go decision during an anomalous situation. Instructors typically have more experience in the airplane than the pilot receiving instruction (as was the case with this crew) and are primed to assume control should the trainee's actions pose a risk to the flight. Although the check airman instinctively reached toward the control column after the captain's "abort" call out (and stated to the captain that they should not reject a takeoff after $V_1$), the check airman did not take control of the airplane but rather observed that the captain had initiated the rejected takeoff procedures and then took action to assist the captain in executing those procedures.

The flight crew's coordinated performance around the moment that the captain rejected the takeoff showed that both pilots had a shared mental model of their responsibilities. By adhering to SOPs—rather than reacting and taking control of the airplane from the captain trainee—the check airman demonstrated disciplined restraint in a challenging situation. Had the check airman simply reacted and assumed control of the airplane after the captain decided to reject, the results could have been catastrophic if such action were to further delay the deceleration (at best) or to try to continue the takeoff in an airplane that was incapable of flight. Thus, the NTSB concludes that the check airman's disciplined adherence to company SOPs after the captain called for the rejected takeoff likely prevented further damage to the airplane and reduced the possibility of serious or fatal injuries to the crew and passengers.

## 2.3 Right Elevator Jammed Condition

### 2.3.1 Damage to Right Elevator's Geared Tab Actuating Crank and Links

As stated in section 2.1, based on FDR data (which showed when the right elevator was last in a different position), the overcenter position of the right elevator geared tab components occurred sometime during the 2 days that the airplane was parked on the ramp and exposed to high gusting wind before the accident (between 0712 on March 6 and 1236 on March 8).

Examination (and, in some cases, functional and/or materials testing) of various elevator system components (including both elevator power control boost cylinders, dampers, torsion bars, and stop arms) revealed no preexisting conditions or defects within the system that could have resulted in the locked-overcenter condition of the right geared tab linkage.[45] Although a similar jammed elevator condition occurred with a Boeing MD-83 that was involved in a rejected takeoff incident in Munich, Germany, in 1999, that airplane had been exposed to ground gusts that exceeded the certification design limits for the airplane. As stated in section 2.2.1.1, none of the recorded or forecasted wind at YIP exceeded these limits during the time that the airplane was parked on the ramp. However, the investigation sought to determine whether the presence of a large hangar upwind of the airplane's parked location may have altered the wind flow that affected the airplane.

### 2.3.2 Simulation of Wind Conditions at Airplane's Parked Location

To determine a plausible scenario of the wind flow that affected the parked airplane, Boeing (as a party to the investigation) performed a CFD wind simulation using NTSB-provided weather data for YIP and a detailed 3-D model of the large hangar that was upwind of the airplane's parked location. (The 3-D hangar model was developed using imagery obtained from the NTSB's sUAS.) The simulation used ASOS-observed wind data to examine a period of variable wind magnitudes, directions, and gusts simulated over real-life, 3-D models of the hangar and an MD-83 airplane.

The wind simulation presented a visual representation of the air flow around the parked airplane and various wind speeds at points around the airplane. During the simulation, shortly after a 55-kt gust from 261° was introduced (consistent with the maximum ASOS-observed gust), a localized horizontal gust of 58+ kts, which appeared to be related to turbulence generated downwind of the hangar, moved over the airplane. The simulation also showed that the wind affecting the airplane's elevators included an upward and downward vertical component.

A review of the tabulated wind data from the simulation showed that, during the maximum gust, a speed increase occurred near the top of the vertical stabilizer and the tip of the right elevator. Further, as the gust wave flowed across the tail as shown in the simulation, the airflow would provide a lifting motion followed by a downward push in less than 3 seconds. In higher gust conditions, this would result in a hard slam of the elevators against either the upper or lower stop, depending on the direction of motion. Thus, the NTSB concludes that, based on the results of the CFD simulation, the airflow at the airplane's parked location was affected by the presence of the large hangar that generated localized turbulence with a vertical component that moved the elevator surfaces rapidly up and down, which resulted in impacts against the elevator mechanical stops. The results of the simulation enabled the NTSB to gain an understanding of the relative wind flow and possible wind speed fluctuations in the area where the accident airplane was parked, which assisted in designing a representative test plan for the airplane's elevator system.

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[45] Some elevator system components showed unrelated anomalies: the right elevator's power control boost cylinder did not meet the relief valve reseat pressure criteria when tested, but the possible effect of this condition would apply only after a boost cylinder activation (which is highly unlikely to occur while an airplane is parked and could not cause the right geared tab linkage to become locked overcenter). Neither the sealant found on the left elevator torsion bar bearing surfaces (which could result in a smaller-than-normal rotation of the left torsion bar under some conditions) nor the left elevator damper's unknown compliance with acceptable torque values could affect any right elevator system components.

### 2.3.3 Elevator Load Testing

Considering the results of the CFD wind simulation, the NTSB designed several series of static and dynamic elevator load tests to determine what conditions, consistent with the known circumstances of the accident, could enable the inboard actuating crank and links of the right elevator's geared tab to move beyond their normal range of travel and become locked in an overcenter position (and, as a result, jam the right elevator).

In preparing the test plan, the NTSB used the hinge moment formula specified in 14 *CFR* 25.415 to calculate the hinge moments needed to simulate elevator loads from ground gusts ranging from 25 to 75 kts. (The regulation specified that flight control systems and surfaces must be designed for the limit loads generated when the airplane is subjected to a 65-kt horizontal ground gust from any direction while parked and taxiing.) These loads were distributed across the elevator hinge points during full-scale static and dynamic testing using the accident airplane's left elevator (including torsion bar and stop arm assembly) and other elevator components that were not damaged before or during the accident.

During the static tests, 25-, 55- and 75-kt simulated gust loads both with and without boost cylinder activation resulted in torsion bar rotation and elevator position travel beyond the nominal unloaded TED stop position of 16.5°. Although each successive load increase resulted in increased torsion bar rotation and elevator surface deflection, and the tests performed with the boost cylinder activation produced comparatively greater rotation and deflection for each load, none of the static tests resulted in the geared tab linkage becoming overcenter. Thus, the NTSB concludes that a static load on the elevators consistent with the airplane's certification design limit for a ground gust as specified in 14 *CFR* 25.415 would not likely result in an overcenter condition of an elevator's geared tab linkage.

A series of dynamic tests without the boost cylinder were performed by starting the loaded elevator in either a neutral or full-TEU position and then releasing it, which allowed it to accelerate due to gravitational forces and impact the stop. This testing was intended to simulate elevator motion while exposed to turbulent flow, such as the rapid fluctuations in vertical wind magnitude shown to flow over the tail in the simulation. The dynamic tests did not result in the geared tab linkage becoming overcenter for simulated gust loads of 25 and 55 kts. For the 60-kt simulated gust load, the linkage became overcenter for only the full-TEU initial elevator position test. For the 65-, 70-, and 75-kt simulated gust loads, the linkage became overcenter for the neutral initial elevator position tests (the full-TEU initial position was not tested for these loads). Estimated elevator surface positions during the overcenter cases were between about 20.9° and 21.3° TED.

These tests showed that an elevator under loading that dynamically impacts the stop is subjected to increased hinge moment (versus the static loading condition) that results in greater torsion bar deflection and, thus, increases the likelihood that the geared tab linkage could travel to an overcenter position. Based on the results of the testing conducted, gust loads between 55 and 60 kts could result in an overcenter condition of the geared tab linkage if the elevator traveled from a full-TEU position to the TED stop. Thus, the NTSB concludes that, although the reported wind at the airport did not exceed the horizontal ground gust limits specified for transport-category airplanes, the effects of the large hangar near the accident airplane's parked location resulted in a turbulent windflow with vertical components that imposed dynamic loads on the elevator system sufficient to jam the right elevator.

## 2.4 Mitigations to Prevent Future Occurrences

### 2.4.1 Review of Elevator Design Standard for Ground Gust Loads

The airworthiness standard current at the time of the accident specified in 14 *CFR* 25.415(a), "Ground gust conditions," that flight control systems and surfaces of transport-category airplanes must be designed for the limit loads generated when the airplane is subjected to a 65-kt horizontal ground gust from any direction while parked and taxiing. Paragraph (b) of the regulation allowed for the assumption of static loads when computing the hinge moments for elevators (and other control surfaces). Although the regulation in effect when the MD-80 series airplane was originally certificated specified only a 52-kt ground gust, Boeing stated that the airplane was designed to withstand a 65-kt horizontal ground gust. However, as the NTSB concluded above, the accident airplane's elevator became jammed when exposed to a horizontal wind gust that was lower than 65-kts but had been altered by the effects of the hangar to include dynamic, vertical wind components.

The NTSB notes that, in the past, the FAA has amended parts of 14 *CFR* Part 25 to consider dynamic factors for certain types of systems and circumstances. For example, in 2014 (effective for February 9, 2015), the FAA revised 14 *CFR* 25.415 to provide an additional multiplying factor to account for dynamic amplification, which it further explained in AC 25.415-1, "Ground Gust Conditions," (released concurrent with the final rule), as follows:

> There have been several incidents and accidents caused by hidden damage that had previously occurred in ground gust conditions. Although many of these events were for airplanes that had used the lower [than 65-kt] wind speeds from earlier rules, analysis indicates that the most significant contributor to the damage was the dynamic load effect. The dynamic effects were most significant for control system designs in which the gust locks were designed to engage the control system at locations far from the control surface horn. Based on these events, [the regulation was revised via Amendment 25-141] to include additional factors for use in those portions of the system and surfaces that could be affected by dynamic effects.

Although that particular regulatory amendment was prompted primarily by the FAA's review of events involving airplanes equipped with certain control systems with gust locks, given the circumstances of this accident, a similar review could ensure the adequacy of the regulation as it pertains to free-floating elevator designs like that of the accident airplane. Therefore, the NTSB recommends that the FAA determine if the ground gust limit loads contained in 14 *CFR* 25.415 adequately ensure that critical flight control systems are protected from hazards introduced by ground gusts that contain dynamic, vertical wind components.

### 2.4.2 Means to Enable Flight Crews to Detect a Jammed Elevator, Lowered Wind Criteria for Elevator Inspections

As described in section 2.2.1.1, the *AOM* cautioned flight crews that parked airplanes exposed to high, sustained wind or gusts greater than 65 kts were susceptible to elevator damage and/or jamming and that airplanes suspected of such wind exposure must receive flight control inspections and operational checks "in accordance with the [*AMM*]." The *AMM* warned that, if wind gusts were expected to exceed 60 kts, the airplane should be parked headed into the wind and cautioned that visual and physical inspections and operational checks of all flight control systems were required for wind exposure in excess of 65 kts (if there were any possibility the airplane was not parked into the wind or the wind direction changed). Thus, the NTSB concludes that, although a unique combination of the large hangar's effects on the wind at the airplane's parked location resulted in the elevator becoming jammed during ground gust conditions that were below the caution and warning criteria specified in the *AOM* and *AMM*, the circumstances of this accident highlight that Boeing's safeguards do not adequately protect flight crews and passengers from the possibility that a free-floating elevator can become jammed, and the condition can remain undetected, before takeoff.

After this accident, Boeing began exploring potential airplane modifications and new preflight inspection procedures intended to prevent takeoff attempts with a jammed elevator. These efforts included initiating the development of an SB for modifying the elevator structure of Boeing DC-9/MD-80 series and 717 model airplanes to attach a secondary travel stop that would prevent the geared tab linkage from becoming locked overcenter. Boeing also initiated the development of a revision to the *AMM* for Boeing DC-9/MD-80 series and 717 model airplanes to add new elevator wind damage inspection procedures, which would include a lower wind speed threshold for the inspection and specific actions to ensure elevator freedom of movement. Boeing also revised the *FCOM* (and planned to revise the *AFM*) for Boeing 717 model airplanes to include a taxi procedure for the flight crew to check the system configuration synoptic (part of the advanced flight deck display in the cockpit) for indications of elevator position movements when a control column is moved full aft. However, the NTSB notes that this procedure would require airflow over the tail for the elevators to move in response to control column inputs, and it would not apply to the Boeing DC-9/MD-80 series airplanes, which were not equipped with such displays.

The NTSB notes that, given the circumstances of this accident and the potentially catastrophic outcome of an undetected jammed elevator, effective mitigations are needed. Therefore, the NTSB recommends that Boeing complete the development of a modification for Boeing DC-9/MD-80 series and 717 model airplanes that will prevent the possibility of elevator jamming due to ground wind exposure. The NTSB also recommends that Boeing develop new preflight procedures or other mitigations for Boeing DC-9/MD-80 series and 717 model airplanes that will enable a flight crew to verify before takeoff that the elevators are not jammed. The NTSB further recommends that Boeing, until the actions in the preceding two recommendations are completed, revise the *AOM* and *AMM* for Boeing DC-9/MD-80 series and 717 model airplanes to lower the ground gust criteria that will require physical inspections and operational checks of the elevators by maintenance personnel.

### 2.4.3 Operator Procedures for Monitoring Wind Affecting Parked Boeing DC-9/MD-80 Series and 717 Model Airplanes

Although the *AOM* and *AMM* specified actions for flight crews and maintenance personnel to take when ground gusts reached certain criteria, Ameristar had no procedures to identify who was responsible for monitoring the known and forecasted wind that may affect the company's parked airplanes to determine if those criteria were met or exceeded. The accident airplane had been parked at YIP for 2 days; however, the company had no expectation for off-duty pilots to monitor the wind (as any such monitoring would be considered duty time), maintenance personnel received no notification of possible high-wind exposure, and the flight-follower who provided the flight release for the accident flight was unaware of the *AMM* wind limitations and had never been asked to monitor wind for the location of a parked airplane. The NTSB notes that, had the wind at YIP exceeded the ground gust criteria specified in the *AOM* and *AMM*, it is unclear from Ameristar's procedures if any personnel would have known and subsequently ensured that the specified parking and/or inspection actions were taken.

The NTSB notes that, after the accident, Ameristar implemented FAA-accepted procedures for its flight control personnel (the flight-followers) to monitor the wind that affects its parked Boeing DC-9 (MD-80 series) airplanes and to document this information on a company wind analysis form. These procedures, which were based on wind speeds that were more conservative than those prescribed in the *AOM* and *AMM*, required flight control personnel to notify maintenance control personnel any time that a TAF or METAR for an airplane's parked location referenced wind (forecast or reported, respectively) of 50 kts or more. The procedures specified that maintenance control personnel were responsible for determining if a high-wind/gust damage inspection of the airplane was required. Thus, the NTSB concludes that, to ensure that the elevators of Boeing DC-9/MD-80 series and 717 model airplanes are inspected by maintenance personnel when exposed to ground gusts that meet or exceed criteria specified in the *AMM*, operators of these airplanes must maintain awareness at all times of the forecast and known wind where the airplanes are parked. Therefore, the NTSB recommends that the FAA ensure the operators of Boeing DC-9/MD-80 series and 717 model airplanes have procedures that define who is responsible for monitoring the wind that affects parked airplanes and for notifying maintenance personnel when conditions could meet or exceed the ground gust criteria specified in the *AMM*.

## 2.5 Previously Issued Safety Recommendations Related to Runway Safety Areas

The RSAs at YIP (a Part 139-certificated airport) were upgraded between 2006 and 2009 to conform to the standards prescribed in AC 150/5300-13 (the version current at the time). The RSA improvement project at YIP, which had cost $20 million with a federal investment of $19 million, involved land acquisition, filling in a ravine, removing a taxiway, and relocating the perimeter fence and the road off the departure end of runways 23L and 23R. According to the FAA, the improved RSA at the end of runway 23L provided a clear area through which the accident airplane traveled and demonstrated the design standard's contribution to accident survivability. Had the area not been clear, additional damage or injuries could have resulted, as seen in other runway overrun accidents.

As described in section 1.12.2, the NTSB has a decades-long history (dating back to 1977) of advocating for effective RSAs, based on evidence discovered during numerous accident investigations. At the time that the RSA upgrades at YIP began, the FAA was responding to two safety recommendations we issued on May 6, 2003, that asked the FAA to

> [r]equire all…Part 139 certificated airports to upgrade all [RSAs] that could, with feasible improvements, be made to meet the minimum standards established by [AC 150/5300-13]. The upgrades should be made proactively, not only as part of other runway improvement projects (Safety Recommendation A-03-11); and
>
> [r]equire all…Part 139 certificated airports to install [EMAS] in each [RSA] available for air carrier use that could not, with feasible improvements, be made to meet the minimum standards established by [AC 150/5300-13]. The systems should be installed proactively, not only as part of other runway improvement projects. (Safety Recommendation A-03-12[46])

The FAA provided its initial response in August 2003, stating that it agreed with the intent of Safety Recommendations A-03-11 and -12; had implemented an RSA Program (FAA Order 5200.8) with the objective that all RSAs at all Part 139 airports and federally obligated airports conform to the AC's standards, to the extent practicable; and supported the installations of an EMAS or an alternative that could provide a comparable level of safety in areas where a full RSA cannot be achieved.

To accomplish these goals, the FAA initiated two subprograms: the first program addressed RSAs and EMAS, and the second addressed relocating or making frangible FAA-owned NAVAIDs located in RSAs. For the first program, the FAA surveyed runway ends at all commercial airports in the United States; identified about 1,000 runway ends with RSAs that were not in dimensional compliance with the AC; and, where practicable, funded improvements to bring the RSAs into compliance with the AC. These actions were completed by the congressionally mandated deadline of December 31, 2015. Where RSA compliance was not practicable, the FAA encouraged and funded EMAS installations. As of the end of 2017, EMAS had been installed at 113 runway ends at 68 airports in the United States and had safely stopped 13 overrunning aircraft with (collectively) 288 crew and passengers on board.

For the second program, the FAA (to date) has made needed improvements to NAVAIDs in RSAs at the 30 busiest US airports and is scheduled to complete the remaining RSA improvements (representing about 4% of the identified NAVAID issues at smaller Part 139 airports) before December 31, 2018. Thus, the NTSB concludes that the FAA's programs to improve RSAs, install EMAS, and relocate or make frangible FAA-owned NAVAIDs located in an RSA have led to increased safety for airplanes during runway overruns, such as in this accident. As a result, we are reclassifying Safety Recommendations A-03-11 and -12 "Closed—Acceptable Action" in this report.

[46] When we issued Safety Recommendations A-03-11 and -12, AC 150/5300-13 was current.

## 2.6 Weather Observer Procedures during Evacuation

As described in section 2.2.2, the flight crew took appropriate measures to obtain adequate preflight weather information, and weather conditions encountered during takeoff played no role in the accident. However, the investigation highlighted procedural gaps that could be clarified to ensure dissemination of the most complete and accurate weather information possible.

### 2.6.1 Sign-Off Procedures

On the day of the accident, a LAWRS observer did not sign off from the ASOS OID system before leaving the duty station when all ATCT personnel evacuated from the tower due to the high wind. As a result, after the LAWRS observer left, the ASOS continued to automatically disseminate METARs that did not contain the AUTO modifier to show that the reports were not being augmented by a weather observer. Neither the YIP ATCT evacuation procedures nor FAA Order JO 7900.5D (which was current at the time of the accident) specified any sign-off procedures for weather observers in the event that they must physically leave their stations during normal duty hours.

### 2.6.2 Backup Augmentation Responsibilities

On the day of the accident, equipment issues at YIP also affected complete and accurate weather reporting. Due to a power outage that affected some sensors, the ASOS stopped providing wind, visibility, and other critical information. After evacuating the tower, LAWRS observers did not provide any backup information to supplement the missing ASOS data. As a result, for a 9-hour period that began about 2 hours before the accident, the automatically disseminated METARs contained only an altimeter setting and some remarks. Although FAA Order JO 7900.5D prescribed procedures for LAWRS observers that specified that, in the event that portions of the ASOS data become unavailable, the observers were required to provide backup information for wind, visibility, sky condition, and other parameters (FAA 2014b), it did not clearly specify if these backup requirements applied when the observers could not physically be at their duty stations.

### 2.6.3 Subsequent Revisions to FAA Order JO 7900.5D

The FAA issued Change 1 to Order 7900.5D, effective November 29, 2017, that included some revisions related to both sign-off procedures and backup responsibilities for weather observers. Section 5.3 was revised to specify that, at part-time facilities with an automated system with SPECI capabilities (like YIP), "the observer must sign off…at the close of augmentation coverage and enter 'Last' in the remarks section of the METAR" (FAA 2017a). The NTSB notes, however, that this revised language refers only to the known close of an observer's duty day. Thus, it remains unclear whether the sign-off procedures would apply in a scenario when an observer is forced to abandon the reporting station during normal duty hours.

With regard to weather observers' responsibilities to provide backup information for wind, visibility, sky condition, and other parameters in the event that portions of the ASOS data become unavailable, the revised FAA order included changes to Appendix B that provided specific procedures only for FAA contract and nonfederal weather observers who are unable to perform their prescribed duties from their normal place of operation (FAA 2017a). The NTSB notes that, although the revised order stated that FAA contract observers must relocate to a suitable location that has access to an ASOS OID and continue to provide weather observations (or, if unable to do so, they must leave the system in standalone AUTO mode), it did not contain any such procedures for LAWRS personnel.

Thus, the NTSB concludes that, although facility evacuations are rare and no set of procedures and practices can cover all possibilities, clear guidance for weather observers that addresses circumstances involving restricted access to normal duty stations can help ensure that surface weather observations accurately reflect the augmentation status of the reports and are as complete as possible. Therefore, the NTSB recommends that the FAA revise Order JO 7900.5D, Change 1, to specify sign-off procedures and backup augmentation responsibilities for all types of weather-observing personnel when they are unable to perform their prescribed duties from their normal duty station during normal duty hours.

## 2.7 Evacuation Slide Malfunction

All 110 passengers and 6 crewmembers evacuated the airplane (with one reported minor injury) using four of the airplane's eight exits: the 1L and 2L doors and the left and right forward overwing exits. The aft left and right overwing exits were not opened, the tailcone exit's opening was delayed (the door was initially restricted from opening by a jumpseat seatbelt), and the 1R door exit was unusable after the evacuation slide failed to inflate. According to flight attendant C, she twice pulled the manual inflation handle for the evacuation slide at the 1R door, but it did not inflate, so she blocked the unusable exit and redirected the passengers.

Postaccident examination of the 1R door slide, valve, and inflation assembly found chafe mark evidence consistent with contact with the valve release cable ball end at that location, which suggests that the ball caught at that location when the flight attendant pulled the handle. Such catching could result from an incorrect installation of the valve release cable and would prevent the cable from rotating the valve to allow compressed gas to inflate the slide. Testing of the system with the cable installed correctly resulted in proper slide inflation. Thus, the NTSB concludes that the incorrect installation of the valve release cable in the valve assembly resulted in the failure of the 1R door evacuation slide to inflate.

On July 14, 2017, Zodiac Aerospace (the parent company of the slide manufacturer) issued a revision to the *CMM* to provide more descriptive valve testing procedures intended to prevent improper cable installation. The revisions included steps for verifying that the valve release cable is installed securely in the valve assembly and for ensuring that pulling the cable results in the correct corresponding movement of the valve pulley.

# 3. Findings

## 3.1 Conclusions

1. The investigation determined that (1) the captain and the check airman were appropriately qualified for the operation, (2) neither pilot was impaired by alcohol or other drugs, (3) the airplane was properly maintained, and (4) the airplane was within weight and center of gravity limits at takeoff.

2. Based on the available wind data for Willow Run Airport, the flight crew was not required to perform high-wind parking procedures or request flight control inspections from maintenance personnel.

3. The flight crew's preflight inspection and control check during taxi, which were performed in accordance with the procedures specified in the *Aircraft Operating Manual*, could not have detected the overcenter position of the right elevator geared tab's linkage or the resultant jammed elevator condition.

4. The flight crew's preflight weather evaluation was sufficient to establish with reasonable certainty that the conditions existing at the time of takeoff met the required minimums for departure.

5. The flight crew's decision to use an increased rotation speed was appropriate for the known weather conditions and consistent with company procedures.

6. The right elevator's jammed condition rendered the airplane unable to rotate during takeoff.

7. The airplane's lack of rotational response to the control column input during the accident takeoff did not become apparent to the captain in time for him to have stopped the airplane on the runway.

8. Once the airplane's inability to rotate became apparent, the captain's decision to reject the takeoff was both quick and appropriate.

9. The check airman's disciplined adherence to company standard operating procedures after the captain called for the rejected takeoff likely prevented further damage to the airplane and reduced the possibility of serious or fatal injuries to the crew and passengers.

10. Based on the results of the computational fluid dynamics simulation, the airflow at the airplane's parked location was affected by the presence of the large hangar that generated localized turbulence with a vertical component that moved the elevator surfaces rapidly up and down, which resulted in impacts against the elevator mechanical stops.

11. A static load on the elevators consistent with the airplane's certification design limit for a ground gust as specified in Title 14 *Code of Federal Regulations* 25.415 would not likely result in an overcenter condition of an elevator's geared tab linkage.

12. Although the reported wind at the airport did not exceed the horizontal ground gust limits specified for transport-category airplanes, the effects of the large hangar near the accident airplane's parked location resulted in a turbulent windflow with vertical components that imposed dynamic loads on the elevator system sufficient to jam the right elevator.

13. Although a unique combination of the large hangar's effects on the wind at the airplane's parked location resulted in the elevator becoming jammed during ground gust conditions that were below the caution and warning criteria specified in the *Aircraft Operating Manual* and *Aircraft Maintenance Manual*, the circumstances of this accident highlight that Boeing's safeguards do not adequately protect flight crews and passengers from the possibility that a free-floating elevator can become jammed, and the condition can remain undetected, before takeoff.

14. To ensure that the elevators of Boeing DC-9/MD-80 series and 717 model airplanes are inspected by maintenance personnel when exposed to ground gusts that meet or exceed criteria specified in the *Aircraft Maintenance Manual*, operators of these airplanes must maintain awareness at all times of the forecast and known wind where the airplanes are parked.

15. The Federal Aviation Administration's (FAA) programs to improve runway safety areas (RSA), install engineered materials arresting systems, and relocate or make frangible FAA-owned navigational aids located in an RSA have led to increased safety for airplanes during runway overruns, such as in this accident.

16. Although facility evacuations are rare, and no set of procedures and practices can cover all possibilities, clear guidance for weather observers that addresses circumstances involving restricted access to normal duty stations can help ensure that surface weather observations accurately reflect the augmentation status of the reports and are as complete as possible.

17. The incorrect installation of the valve release cable in the valve assembly resulted in the failure of the 1R door evacuation slide to inflate.

## 3.2 Probable Cause

The NTSB determines that the probable cause of this accident was the jammed condition of the airplane's right elevator, which resulted from exposure to localized, dynamic wind while the airplane was parked and rendered the airplane unable to rotate during takeoff. Contributing to the accident were (1) the effect of a large structure on the gusting surface wind at the airplane's parked location, which led to turbulent gust loads on the right elevator sufficient to jam it, even though the horizontal surface wind speed was below the certification design limit and maintenance inspection criteria for the airplane, and (2) the lack of a means to enable the flight crew to detect a jammed elevator during preflight checks for the Boeing MD-83 airplane. Contributing to the survivability of the accident was the captain's timely and appropriate decision to reject the takeoff, the check airman's disciplined adherence to standard operating procedures after the captain called for the rejected takeoff, and the dimensionally compliant runway safety area where the overrun occurred.

# 4. Safety Recommendations

## 4.1 New Recommendations

**To The Boeing Company:**

Complete the development of a modification for Boeing DC-9/MD-80 series and 717 model airplanes that will prevent the possibility of elevator jamming due to ground wind exposure. (A-19-1)

Develop new preflight procedures or other mitigations for Boeing DC-9/MD-80 series and 717 model airplanes that will enable a flight crew to verify before takeoff that the elevators are not jammed. (A-19-2)

Until the actions in Safety Recommendations A-19-1 and -2 are completed, revise the *Aircraft Operating Manual* and *Aircraft Maintenance Manual* for Boeing DC-9/MD-80 series and 717 model airplanes to lower the ground gust criteria that will require physical inspections and operational checks of the elevators by maintenance personnel. (A-19-3)

**To the Federal Aviation Administration:**

Determine if the ground gust limit loads contained in Title 14 *Code of Federal Regulations* 25.415 adequately ensure that critical flight control systems are protected from hazards introduced by ground gusts that contain dynamic, vertical wind components. (A-19-4)

Ensure the operators of Boeing DC-9/MD-80 series and 717 model airplanes have procedures that define who is responsible for monitoring the wind that affects parked airplanes and for notifying maintenance personnel when conditions could meet or exceed the ground gust criteria specified in the *Aircraft Maintenance Manual*. (A-19-5)

Revise Order JO 7900.5D, *Surface Weather Observing*, Change 1, to specify sign-off procedures and backup augmentation responsibilities for all types of weather-observing personnel when they are unable to perform their prescribed duties from their normal duty station during normal duty hours. (A-19-6)

## 4.2 Previously Issued Safety Recommendations Reclassified in This Report

**To the Federal Aviation Administration:**

Require all 14 *Code of Federal Regulations* Part 139 certificated airports to upgrade all runway safety areas that could, with feasible improvements, be made to meet the minimum standards established by Advisory Circular 150/5300-13, "Airport

Design." The upgrades should be made proactively, not only as part of other runway improvement projects. (A-03-11)

Reclassified "Closed—Acceptable Action."

Require all 14 *Code of Federal Regulations* Part 139 certificated airports to install engineered materials arresting systems in each runway safety area available for air carrier use that could not, with feasible improvements, be made to meet the minimum standards established by Advisory Circular 150/5300-13, "Airport Design." The systems should be installed proactively, not only as part of other runway improvement projects. (A-03-12)

Reclassified "Closed—Acceptable Action."

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**Adopted: February 14, 2019**

# Appendixes

## Appendix A: Investigation

The National Transportation Safety Board (NTSB) was notified of this accident on March 8, 2017, shortly after the accident occurred. Investigators from NTSB headquarters in Washington, D.C., arrived on scene the following morning.

Investigative groups were formed to evaluate operational factors; airplane systems, maintenance, and structures; survival factors; and the cockpit voice recorder. Also, specialists were assigned to evaluate the meteorological conditions, airplane performance, pilot toxicology reports, and the flight data recorder. An unmanned aircraft system team provided photogrammetric models to support the wind study simulation.

The Federal Aviation Administration, The Boeing Company, and Ameristar Air Cargo, Inc., were parties to the investigation.

# Appendix B: Cockpit Voice Recorder Transcript

The following is the transcript of the L-3/Fairchild FA2100-1020 cockpit voice recorder, serial number 000357984, installed on a Boeing MD-83, N786TW, which crashed after an aborted takeoff from Willow Run Airport, Ypsilanti, Michigan.

## LEGEND

| | |
|---|---|
| **ATIS** | Automated terminal information service broadcast |
| **CAM** | Cockpit area microphone voice or sound source |
| **FA** | Flight attendant voice or sound source |
| **GND** | Radio transmission from the Hanscom ground controller |
| **HDL** | Ground handler voice or sound source |
| **HOT** | Flight crew audio panel voice or sound source |
| **INT** | Intercom |
| **N555P** | Aircraft (Baron) in the pattern at Willow Run |
| **PA** | Public address system sound source |
| **RDO** | Radio transmission from N121JM |
| **TWR** | Radio transmission from the Hanscom airport tower controller |
| **-1** | Voice identified as the check airman |
| **-2** | Voice identified as the captain |
| **-3** | Voice identified as cabin crewmember |
| **-4** | Additional voice identified as cabin crewmember |
| **-5** | Additional voice identified as cabin crewmember |
| -? | Voice unidentified |
| ***** | Unintelligible word |
| **#** | Expletive |
| @ | Non-pertinent word |
| **( )** | Questionable insertion |
| **[ ]** | Editorial insertion |

Note 1: Times are expressed in eastern standard time (EST).

Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft.

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 12:49:35 | **Start of Recording** | | |
| 12:50:06 | **Start of Transcript** | | |
| 12:50:06<br>**CAM-2** | ah we wanna see that right side put back. | | |
| 12:50:12<br>**CAM-1** | I might go in and get the * *. | | |
| 12:50:15<br>**CAM-2** | alright. | | |
| 12:50:16<br>**CAM-2** | you walked around and did all that? | | |
| 12:50:17<br>**CAM-1** | yeah absolutely. | | |
| 12:50:35<br>**CAM** | [unintelligible background voices and conversations consistent with passenger boarding]. | | |
| 12:55:50<br>**HDL-1** | man alive. | | |
| 12:56:09<br>**HDL-1** | will be, should be pretty fun getting this thing off of the ground huh? | | |
| 12:56:12<br>**CAM-2** | yeah glad I don't have to get it back on the ground. Ahm thanks for comin' over. | | |
| 12:56:16<br>**HDL-1** | yeah no problem. better up here than out there. | | |
| 12:56:23<br>**CAM-2** | ahm just a couple forms we have to fill out for ground handlers. if you could please just write your name and then sign right there. | | |

| TIME and SOURCE | | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|---|
| 12:56:28 | HDL-1 | okay. okay. | | |
| 12:56:36 | CAM-2 | appreciate it. | | |
| 12:56:37 | HDL-1 | yeah no problem. | | |
| 12:56:43 | CAM-2 | all that form is, is ah, certifying that you received training on all the duties that you already know how to do, so. | | |
| 12:56:51 | HDL-1 | right right. | | |
| 12:56:52 | CAM-2 | okay there's that one. and then for ah loading. ah can I just get the first names for the guys that are gonna load? | | |
| 12:57:02 | HDL-1 | yeah @, @, @, and @. | | |
| 12:57:14 | CAM-2 | ahm @? | | |
| 12:57:15 | HDL-1 | yes. | | |
| 12:57:19 | CAM-2 | okay when you load the bags start with the far back | | |
| 12:57:23 | HDL-1 | * the back first. | | |
| 12:57:24 | CAM-2 | the back of the back. | | |
| 12:57:25 | HDL-1 | I'll get yeah. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 12:57:26 **CAM-2** | and as soon as that's full then go the front of the number three pit. | | |
| 12:57:29 **HDL-1** | okay. | | |
| 12:57:30 **CAM-2** | and then hopefully everything will fit there if not then you know work your way forward. | | |
| 12:57:34 **HDL-1** | okay. | | |
| 12:57:35 **CAM-2** | cause this thing is ah nose-heavy so. | | |
| 12:57:38 **CAM-2** | the more weight we can get in the back the better. | | |
| 12:57:40 **HDL-1** | okay. | | |
| 12:57:40 **CAM-2** | and then keep track of the number of bags in each - | | |
| 12:57:42 **HDL-1** | yes sir. | | |
| 12:57:43 **CAM-2** | location please. | | |
| 12:57:44 **HDL-1** | yeah can do. | | |
| 12:57:45 **CAM-2** | thank you appreciate it. | | |
| 12:57:46 **HDL-1** | yeah no problem. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 12:57:47<br>**CAM-2** | alright good luck. we're all counting on you. [laughter]. | | |
| 12:59:27<br>CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:01:11<br>**CAM-1** | alright (can) you get some, speeds for a hundred and forty six thousand? | | |
| 13:01:18<br>**CAM-2** | that is gonna be the weight? | | |
| 13:01:23<br>**CAM-2** | we have a current temp? | | |
| 13:01:24<br>**CAM-2** | just get off of ah. | | |
| 13:01:26<br>**CAM-1** | * below (nine) * *. | | |
| 13:01:30<br>**CAM-1** | let's go off of this one, nine degrees. | | |
| 13:01:32<br>**CAM-2** | okay. | | |
| 13:01:39<br>**CAM-1** | you got that, good deal. **. | | |
| 13:01:48<br>**CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:03:42<br>**CAM-2** | I want to me show you this real quick. using nine degrees so ten degrees Fahrenheit * * one forty six V-speeds right here. is that, did I do that (correct)? | | |
| 13:03:53<br>**CAM-1** | * * ten (knots)? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:03:54 **CAM-2** | I'm sorry yeah, you need to be in this column. | | |
| 13:03:58 **CAM-2** | so it's, all the way down here? | | |
| 13:04:01 **CAM-1** | yeah. So * speed yeah. right there. flaps sixteen * use flaps fifteen. | | |
| 13:04:06 **CAM-2** | fifteen okay very good. | | |
| 13:04:07 **CAM-1** | fifteen. | | |
| 13:04:11 **CAM-1** | so what I used to do then, use max thrust. | | |
| 13:04:15 **CAM-2** | yeah. | | |
| 13:04:16 **CAM-1** | flaps fifteen. | | |
| 13:04:18 **CAM-2** | and then stab that's for stab which we don't know yet. and then speeds are one thirty nine. | | |
| 13:04:23 **CAM-1** | one thirty nine. | | |
| 13:04:24 **CAM-2** | one forty two. | | |
| 13:04:25 **CAM-1** | one forty two. | | |
| 13:04:26 **CAM-2** | one fifty. | | |
| 13:04:27 **CAM-1** | * fifty. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:04:28 **CAM-2** | one sixty five. | | |
| 13:04:30 **CAM-2** | and then the other * *. | | |
| 13:04:32 **CAM-1** | ** delay rotation until at least V-two. | | |
| 13:04:36 **CAM-2** | yeah, that's. | | |
| 13:04:37 **CAM-1** | *** wait for me to call it. | | |
| 13:04:39 **CAM-2** | yup. | | |
| 13:04:46 **CAM-2** | I'd like to try to put the flightplan in the box if that's *. for practice. | | |
| 13:04:50 **CAM-1** | I'll ah read them off for you. | | |
| 13:04:55 **CAM-1** | CARLETON. | | |
| 13:04:56 **CAM-2** | * hold on. | | |
| 13:05:05 **CAM-2** | okay go ahead. | | |
| 13:05:08 **CAM-1** | next one is gonna be ah WOOST w- oscar oscar ah sie- sierra tango. | | |
| 13:05:16 **CAM-1** | next one is ah romeo india echo kilo echo. | | |
| 13:05:26 **CAM-2** | okay. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:05:27 **CAM-1** | next one is dryer delta juliet bravo. | | |
| 13:05:30 **CAM-2** | yup. | | |
| 13:05:34 **CAM-1** | next one is ah bravo oscar bravo charlie tango. | | |
| 13:05:44 **CAM-1** | next one is a BIGLE bravo india golf lima echo. | | |
| 13:05:53 **CAM-2** | 'kay. | | |
| 13:05:56 **CAM-1** | next one is BLISS bravo lima india sierra sierra. | | |
| 13:06:02 **CAM** | [unintelligible background conversations]. | | |
| 13:06:05 **CAM-1** | next one is OTMAN oscar tango mike alpha november. | | |
| 13:06:16 **CAM-1** | next one is JAMOX juliet alpha mike oscar x-ray. | | |
| 13:06:24 **CAM-2** | 'kay. | | |
| 13:06:26 **CAM-1** | next one is LAYED lima alpha yankee echo delta. | | |
| 13:06:38 **CAM-1** | do we have any stars in there? | | |
| 13:06:41 **CAM-2** | oh that's, that's it? | | |
| 13:06:45 **CAM-2** | ****. | | |
| 13:06:46 **CAM-1** | yeah. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:06:49 **CAM-1** | H-V-Q. let me see what's (wrong) with (any of that). | | |
| 13:06:57 **CAM-1** | * * * winds out of the west *. | | |
| 13:07:10 **CAM-1** | better not be # gusting to thirty knots out of the west. | | |
| 13:07:15 **CAM-2** | well then we'll use ah three zero * we have to. | | |
| 13:07:18 **CAM-1** | huh? | | |
| 13:07:19 **CAM-2** | have to use three zero then. | | |
| 13:07:25 **CAM-1** | yeah just put ah. put one nine right down for now. | | |
| 13:07:29 **CAM-2** | one nine right. | | |
| 13:07:35 **CAM-1** | (let’s go). | | |
| 13:07:36 **CAM-2** | ah you wanna review it before you execute? | | |
| 13:07:38 **CAM-1** | *. | | |
| 13:07:40 **CAM-2** | so, HUNTINGTON, GIBBS two. | | |
| 13:07:44 **CAM-1** | you gotta go to the legs page. | | |
| 13:07:45 **CAM-2** | legs. | | |
| 13:07:48 **CAM-2** | CARLETON, WOOST, RIEKE, DRYER, BOBCAT. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:07:54 **CAM-2** | BIGLE, BLISS, OTMAN, JAMOX, LAYED. | | |
| 13:07:59 **CAM-2** | and I should close this discontinuity, right? | | |
| 13:08:01 **CAM-1** | yeah. | | |
| 13:08:04 **CAM-2** | HUNTINGTON, PINFA, WOOJO, BERT, WHO. BEEZLY, GIZMO, BBONE, KILMER, AUTO, MAY, GRIFFIN, GIBBS, SUNY, J, Y-D-Y-U-whatever, M-A-T-T-C then vectors, CLAY, MOHE now we're on for the runway, so. | | |
| 13:08:30 **CAM-1** | we'll just see what - we'll check it * it didn't match the last two fixes but that might be because of the runway. | | |
| 13:08:30 **CAM-2** | * *. | | |
| 13:08:35 **CAM-2** | right, right. | | |
| 13:08:36 **CAM-1** | we'll check it *. | | |
| 13:08:37 **CAM-2** | I'll execute, and then ah. | | |
| 13:08:41 **CAM-2** | total distance. | | |
| 13:08:44 **CAM-2** | what do you have for the - I have ah five hundred and forty three, nautical miles? | | |
| 13:08:48 **CAM-1** | yeah. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:08:49 **CAM-2** | is that right? | | |
| 13:08:50 **CAM-1** | yeah that's with the I-L-S. | | |
| 13:08:52 **CAM-2** | sure, sure. | | |
| 13:09:01 **HOT-1** | it's an hour down there password will be @. | | |
| 13:09:09 **CAM-2** | current time is eighteen oh nine, thirty, seven. | | |
| 13:09:15 **CAM-1** | three thousand. | | |
| 13:09:25 **CAM-2** | * * * thirty three? | | |
| 13:09:25 **CAM-?** | ***. | | |
| 13:09:27 **CAM-?** | okay. | | |
| 13:09:29 **CAM-1** | ah, let's go ahead and do the brief ***. | | |
| 13:09:32 **CAM-2** | alright. it's gonna be a left seat takeoff. a hundred and forty six thousand pounds flaps fifteen. speeds one thirty nine, one forty tow, one fifty, one sixty five, one ninety nine, two forty eight. max thrust we are going to delay our rotation because of the gusty, strong gusty winds, do the short segment climb checklist * better immediate return, quite honestly, I think it would be prudent to go over to Metro for the longer runway - | | |
| 13:09:58 **CAM-1** | absolutely, we're not coming *. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:10:01 **CAM-2** | there are no M-E-Ls here. ah taxi operations we'll just go right here golf to two three left. no hot spots. departure NOTAMS * frequencies are out of service we'll have to get our clearance some other way. and we'll use C-TAF to announce our intentions. departure SID ahm there is none, initial course of whatever they give us to ah join the ah course into CARLETON. two thirty three the initial heading, just runway heading. altitude we know is gonna be three thousand feet, probably eighteen ninety five for a Detroit ah departure, transponder code * *. call out any abnormals that you see. really keep an eye out on what our airspeed is doing today. ahm, in the event of an engine fire or failure at or after V-1 we're going to continue the takeoff, treat it as an inflight emergency just head on over to Metro. level off height here is fifteen sixteen and is no * * procedure. and ah we'll head on over to Metro and do it visually. ah stall warning or windshear warning, we're not expecting any kind of stall today, but ah windshear for sure, keep an eye out on the ah, if you get any kind of a warning it's gonna be max thrust, ah all the way to firewall thrust if necessary, leave the aircraft configured, we'll fly out of the shear, back me up on the ah airspeed calls and the * speed calls. any questions anything to add? | | |
| 13:11:27 **CAM-1** | nope. | | |
| 13:11:29 **CAM-2** | let's do the ah before start to the line. | | |
| 13:11:35 **CAM-2** | is the mirror up to remind you of anything, for a reason? or, is that just up? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:11:41 **CAM-1** | briefing complete? | | |
| 13:11:42 **CAM-2** | completed, set. | | |
| 13:11:44 **CAM-1** | * * *. | | |
| 13:11:45 **CAM-2** | three on board. | | |
| 13:11:46 **CAM-1** | cockpit preparations. | | |
| 13:11:46 **CAM-2** | are complete. | | |
| 13:11:48 **CAM-1** | * preflight inspection? | | |
| 13:11:49 **CAM-2** | completed. | | |
| 13:11:49 **CAM-1** | * windows? | | |
| 13:11:50 **CAM-2** | closed and locked. | | |
| 13:11:51 **CAM-1** | **. | | |
| 13:11:51 **CAM-1** | * circuit breakers? | | |
| 13:11:52 **CAM-2** | are checked. | | |
| 13:11:53 **CAM-1** | checked oxygen and interphone. | | |
| 13:11:55 **CAM-2** | checked on one hundred percent. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:11:57<br>**CAM-1** | checked on one hundred percent, smoke goggles? | | |
| 13:11:58<br>**CAM-2** | are checked. | | |
| 13:11:59<br>**CAM-1** | pressurization? | | |
| 13:12:01<br>**CAM-2** | is ah auto up and set. | | |
| 13:12:02<br>**CAM-1** | air conditioning shutoff? | | |
| 13:12:04<br>**CAM-2** | is auto. | | |
| 13:12:04<br>**CAM-1** | anti-skid? | | |
| 13:12:05<br>**CAM-2** | is armed. | | |
| 13:12:06<br>**CAM-1** | (E)GPWS. | | |
| 13:12:07<br>**CAM-2** | tested. | | |
| 13:12:07<br>**CAM-1** | ***. | | |
| 13:12:10<br>**CAM-2** | all normal. normal. | | |
| 13:12:10<br>**CAM-1** | emergency lights? | | |
| 13:12:11<br>**CAM-2** | ah armed. | | |
| 13:12:14<br>**CAM-1** | seatbelt no smoking sign? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:12:15<br>**CAM-2** | on. | | |
| 13:12:16<br>**CAM-2** | * * *? | | |
| 13:12:17<br>**CAM-2** | ah checked and set. | | |
| 13:12:21<br>**CAM-2** | checked and set. | | |
| 13:12:22<br>**CAM-1** | clocks and altimeters? | | |
| 13:12:24<br>**CAM-2** | I've got ah twelve minutes past. altimeter two niner eight one. seven hundred and eighty feet checked and set. | | |
| 13:12:28<br>**CAM-1** | eighteen twelve, two niner eight one, * * set. F-M-S? | | |
| 13:12:34<br>**CAM-2** | checked and set. | | |
| 13:12:40<br>**CAM-1** | checked and set. engine oil quantity? | | |
| 13:12:42<br>**CAM-2** | is checked. | | |
| 13:12:44<br>**CAM-1** | takeoff warning? | | |
| 13:12:46<br>**CAM** | [sound of warning tone] slats [electronic voice], [sound of warning tone] brake [electronic voice], [sound of warning tone] flaps [electronic voice], [sound of warning tone] slats [electronic voice]. | | |
| 13:12:54<br>**CAM-2** | checked. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:12:56 **CAM-1** | ah rudder power? | | |
| 13:12:57 **CAM-2** | power. | | |
| 13:12:59 **CAM-1** | radar? | | |
| 13:12:59 **CAM-2** | is off. | | |
| 13:13:01 **CAM-1** | transponder? | | |
| 13:13:02 **CAM-2** | standby. | | |
| 13:13:03 **CAM-1** | radios? | | |
| 13:13:04 **CAM-2** | are set. | | |
| 13:13:04 **CAM-1** | set. | | |
| 13:13:05 **CAM-1** | rudder and aileron trim? | | |
| 13:13:07 **CAM-2** | free and zero. | | |
| 13:13:08 **CAM-1** | parking brakes. | | |
| 13:13:09 **CAM-2** | set * checked. | | |
| 13:13:11 **CAM-2** | (thank you). | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:13:35 **CAM-2** | feel sorry for the regional guys that're only going like an hour out of Metro and then coming back, you gotta fly in this # all day. | | |
| 13:13:49 **CAM-2** | at least long haul you can take off and get outta here. | | |
| 13:14:12 **CAM-2** | #. | | |
| 13:14:13 **CAM-?** | ****. | | |
| | | 13:14:39 **ATIS** | Willow Run tower information X-ray 1653z winds two six zero at three five gust five zero visibility one zero sky clear below one two thousand temperature one one dew point minus one one altimeter 29.81 remarks *** 1639z runway five right circle to land runway two seven ** landing and departing runway two seven ****. |
| 13:15:31 **CAM-1** | I'm gonna, I'm gonna call ask @ can we legally use this weather? because I'm not, I'm not gonna have the FAA come afterwards, how did you guys take off outta there? hold on one second. | | |
| 13:15:40 **CAM-2** | yeah that's fine. | | |
| 13:15:43 CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:15:45 **CAM-2** | you have the ah flight plan handy? | | |
| 13:15:48 **CAM-1** | they're gonna bring it out. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:15:51 **CAM-1** | they gotta send it to the other side * the power is out. [consistent with cell phone call]. | | |
| 13:16:11 **CAM-1** | * got a little problem. ahm Willow Run. ah. tower is closed. airport uncontrolled because they lost power. ATIS is out of service. * last weather reported. you gotta call in to * * * one six five three. ah how do we legally take off? [consistent with cell phone call]. | | |
| 13:16:44 **CAM-1** | yup. [consistent with cell phone call]. | | |
| 13:16:53 **CAM-1** | gusting to fifty two knots *. [consistent with cell phone call]. | | |
| 13:16:57 CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:17:00 **CAM-1** | ****. | | |
| 13:17:08 **CAM-1** | well @ is fine sir. [consistent with cell phone call]. | | |
| 13:17:12 **CAM-2** | tell him the risk assessment went way up. | | |
| 13:17:25 **CAM-1** | yeah I just want to have something on record if the FAA comes back and say how did you guys take off. [consistent with cell phone call]. | | |
| 13:17:51 **CAM-2** | they're comin' out. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:17:53 **CAM-1** | * can you call Ameristar and find out where our paperwork's * talk to @. [consistent with cell phone call]. | | |
| 13:17:59 CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:18:13 **CAM-1** | * fuel burn ***. [consistent with cell phone call]. | | |
| 13:18:20 **CAM-2** | breezy out there. | | |
| 13:18:34 **CAM-2** | hi @ is @ there please? thank you. thank you. [consistent with cell phone call]. | | |
| 13:18:41 **CAM-1** | yeah they reported I think eleven on the sixteen fifty three weather. [consistent with cell phone call]. | | |
| 13:18:55 **CAM-2** | hi @ it's @ ah @ asked me to call you they still, they still have not brought our paperwork out **** we'll keep watching for it part of the airport, part of the airport has lost power so, we'll keep looking for it. alright perfect okay excellent. thank you. yeah bye bye. [consistent with cell phone call]. | | |
| 13:18:58 **CAM-1** | * at what time? seventeen? okay and that was ten point *? okay. * appreciate it. [consistent with cell phone call]. | | |
| 13:19:34 **CAM-2** | he got an e-mail from somebody that it's on its way, but he's gonna call again to follow up. | | |
| 13:20:33 **CAM-1** | It's all * * start loading aft * *. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:20:37 **CAM-2** | and to keep track of the bags. he understood all that, so. | | |
| 13:20:51 **CAM-2** | that's extra envelope is for, Dulles, and then I got a fuel vendor audit out for Dulles, and then the PHM-four - | | |
| 13:20:59 **CAM-2** | did you set this thing ***? | | |
| 13:21:00 **CAM-2** | I did not, you don't have too. | | |
| 13:21:03 **CAM-1** | ah I don't know * * *. | | |
| 13:21:05 **CAM-2** | the PHM-four is still out and the HAZMAT form is still out. | | |
| 13:21:09 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:21:17 **CAM** | [sound consistent with stab trim aural annunciation]. | | |
| 13:21:31 **FA-4** | it's pretty nice for you, you don't have to screen. | | |
| 13:21:33 **CAM-?** | huh? | | |
| 13:21:34 **CAM-2** | hey @ how are you? | | |
| 13:21:35 **FA-?** | we're not making any money though. and we're not making any money for your guys, like we always do. | | |

| TIME and SOURCE | | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|---|
| 13:21:37 | **FA-4** | * we're missin' out on our twenty eight bucks. | | |
| 13:21:44 | **FA-4** | yeah you guys screen and we get the money. | | |
| 13:21:48 | **CAM-2** | oh you said screen, I though you said nice for us that we didn't have to scream. | | |
| 13:21:52 | **FA-4** | ah we'll do that during takeoff, I'm sure. | | |
| 13:21:56 | **CAM-2** | I was trying to figure out what you meant. I thought- | | |
| 13:21:58 | **CAM-?** | security. | | |
| 13:21:59 | **CAM-2** | yeah I got it. | | |
| 13:22:03 | **CAM-1** | I didn't see the shear ***. | | |
| 13:22:07 | CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:22:29 | **CAM-1** | thank you. appreciate it. for some reason they don't have any power here. | | |
| 13:22:30 | **CAM-?** | ***. | | |
| 13:22:34 | **CAM-1** | thank you appreciate it. | | |
| 13:22:35 | **CAM-2** | thanks for bringing it over. | | |
| 13:22:36 | **CAM-?** | yeah, cool. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:22:38 **CAM-?** | ***. | | |
| 13:22:39 **CAM-2** | oh yeah. | | |
| 13:22:42 **HDL-3** | even rockin' the airplane *. | | |
| 13:22:44 **CAM-2** | oh yeah. | | |
| 13:22:52 **HDL-3** | should be everything there. hopefully. | | |
| 13:22:55 **CAM-?** | ***. | | |
| 13:23:01 **HDL-3** | is that everything you needed? | | |
| 13:23:03 **CAM-1** | well I just needed two of these but we'll make it work. | | |
| 13:23:05 **HDL-3** | oh you need two? | | |
| 13:23:07 **CAM-1** | yeah no worries. | | |
| 13:23:10 **HDL-3** | can you make out without one? | | |
| 13:23:12 **CAM-1** | yeah. | | |
| 13:23:13 **HDL-3** | I can go get you another if you need it. | | |
| 13:23:15 **CAM-1** | no I'll I'll e-mail the it in instead of the, mailing it in. | | |
| 13:23:19 **HDL-3** | okay, have a safe flight gentlemen. thank you. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:23:42<br>CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:24:09<br>**CAM-1** | it's gonna be very bumpy *. | | |
| 13:24:29<br>**CAM-1** | [sound of sneeze] yeah you would think they would have backup generators. | | |
| 13:24:32<br>**CAM-2** | yeah. | | |
| 13:24:47<br>**CAM-2** | so you'll have to call flight service on your phone? I don't know of any other way to get 'em. | | |
| 13:25:28<br>CAM | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:25:39<br>**CAM-1** | thank you. | | |
| 13:25:59<br>**CAM-1** | * * * is ten two seventy six. | | |
| 13:26:05<br>**CAM-2** | *** the flight plan? | | |
| 13:26:07<br>**CAM-1** | ***? | | |
| 13:26:09<br>**CAM-2** | seven five forty three. | | |
| 13:26:15<br>**CAM-2** | ***. | | |
| 13:26:17<br>**CAM-1** | sixteen three. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:27:22<br>**CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:28:54<br>**CAM-2** | so what did @ we okay to go with that recorded weather it - it's an hour old? | | |
| 13:28:59<br>**CAM-1** | no, naw you gotta in and check on the ah ARCAM. it's it's on there in that runway analysis stuff and they have a ah I've never done it so I gotta go in myself. You, you can pull up the last temperatures that way and put a time on it. temperatures pretty much all everything you need. | | |
| 13:29:19<br>**FA-1** | could you guys call AVFLT and see if they ah loaded * * flagpole for the van, they're asking if we can clarify that * it's loaded on the bus. | | |
| 13:29:28<br>**CAM-1** | which AVFLT? | | |
| 13:29:29<br>**FA-1** | ** these people that loaded - | | |
| 13:29:32<br>**CAM-1** | the power is out. | | |
| 13:29:34<br>**FA-1** | and all the water and ah. | | |
| 13:29:37<br>**CAM-1** | I don't even have their phone number *. | | |
| 13:29:40<br>CAM | ***. | | |
| 13:29:46<br>**CAM-2** | it was in the, it was in the bus? | | |

| TIME and SOURCE | | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|---|
| 13:29:48 | **FA-1** | yeah. | | |
| 13:29:51 | **CAM-1** | why don't we ask one of the? | | |
| 13:29:52 | **FA-1** | why didn't she ask that when she was inside? | | |
| 13:29:57 | **CAM-?** | whatever. | | |
| 13:29:59 | **FA-1** | ah one of those one. | | |
| 13:30:00 | **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:30:17 | **CAM-2** | here's a number if you wanna call. area seven three four, four eight two - | | |
| 13:30:24 | **CAM-1** | hold on a second, seven three four. | | |
| 13:30:27 | **CAM-2** | four eight two. | | |
| 13:30:27 | **CAM-1** | yep. | | |
| 13:30:28 | **CAM-2** | two six two one. | | |
| 13:30:34 | **CAM-2** | * frequency ** it's not gonna work. | | |
| 13:30:48 | **CAM-1** | yeah the power is out. | | |
| 13:30:50 | **CAM-2** | yeah so nothing's gonna work. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:30:55 **CAM-2** | when the guy comes up to give us the bag count we'll get it from him. | | |
| 13:31:15 **CAM-1** | I don't think we can reach Detroit on the ground here. | | |
| 13:31:18 **CAM-2** | I don't think so. | | |
| 13:31:19 **CAM-1** | huh? | | |
| 13:31:20 **CAM-2** | we can try. | | |
| 13:31:22 **CAM-2** | it'd make life a lot easier. | | |
| 13:32:35 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:34:42 **CAM-2** | was the phone *? | | |
| 13:34:44 **CAM-1** | no its a- | | |
| 13:34:46 **CAM-2** | one of their ah guys will come up and give us the bag count and we'll ask him then. | | |
| 13:34:50 **FA-1** | that's uncle @ he's inside, right? | | |
| 13:34:52 **CAM-?** | yeah. there ya go. | | |
| 13:35:00 **CAM-?** | I forgot about him. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:35:02 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:35:37 **CAM-2** | hey @? | | |
| 13:35:54 **CAM-2** | hey @? Oh ah you're on the phone, I'm sorry. | | |
| 13:36:00 **FA-1** | they're coming inside right now @, so, yeah. | | |
| 13:36:08 **FA-1** | yeah it was with the luggage it was with the luggage. | | |
| 13:36:14 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:37:01 **HDL-2** | alright ahm for the rear bin we have, do you want the three sections or a total? | | |
| 13:37:07 **CAM-2** | ah three sections. | | |
| 13:37:07 **CAM-1** | do you guys have the players bags and everything on? | | |
| 13:37:10 **HDL-2** | ah the second bus has just left, so they'll be here in about fifteen. | | |
| 13:37:14 **CAM-1** | okay. | | |
| 13:37:15 **HDL-2** | but in the very rear section, twenty nine. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:37:18 **CAM-2** | look wait a minute there's another bus coming, so are you gonna add to that? | | |
| 13:37:20 **HDL-2** | yes. | | |
| 13:37:21 **HDL-2** | yeah, the- this is just in the back bin. | | |
| 13:37:23 **CAM-2** | okay so. | | |
| 13:37:23 **CAM-1** | * full already? | | |
| 13:37:24 **HDL-2** | the back bin's full, so twenty nine, twenty seven, and seven. | | |
| 13:37:31 **CAM-1** | seven in the mid already? | | |
| 13:37:32 **HDL-2** | yeah * yeah. | | |
| 13:37:35 **CAM-1** | we don't want anything in the forward, so make sure to fill up the -. | | |
| 13:37:39 **HDL-2** | * the mid? okay, yeah I mean, the basketball team normally isn't a terribly large amount. so, hopefully we'll be able to do that. | | |
| 13:37:46 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:37:50 **HDL-2** | so in D-two, | | |
| 13:37:53 **CAM-1** | alright. | | |

| TIME and SOURCE | | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|---|
| 13:37:55 | **CAM-1** | twenty nine. | | |
| 13:37:59 | **CAM-1** | twenty nine times thirty. | | |
| 13:38:01 | **CAM-1** | D-two is all the way back, it's ah eight seventy. | | |
| 13:38:04 | **CAM-2** | eight seven. eight seven zero. | | |
| 13:38:08 | **CAM-1** | * * *. | | |
| 13:38:12 | **CAM-1** | and a D-one, ah twenty seven bags at eight ten. | | |
| 13:38:18 | **CAM-2** | okay. | | |
| 13:38:26 | **CAM-1** | and in C-two, you need to scratch that off and - | | |
| 13:38:31 | **CAM-2** | oh because it's gonna be - | | |
| 13:38:32 | **CAM-1** | yeah. just initial it. | | |
| 13:38:42 | **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:38:57 | **CAM-1** | we got one eighty six, two hundred. | | |
| 13:39:00 | **CAM-2** | two hundred. three seventy * * and then *. | | |
| 13:39:05 | **CAM-1** | * one * is. | | |
| 13:39:07 | **CAM-2** | eight ten. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:39:07 **CAM-1** | eight ten. | | |
| 13:39:08 **CAM-2** | * (eight seventy). | | |
| 13:39:10 **CAM-1** | (eight seventy). | | |
| 13:39:12 **CAM-1** | you put fuel down already? | | |
| 13:39:14 **CAM-2** | ah, I put eighteen thousand in the wing, I did not put anything in the center yet. because I wasn't sure how much we were gonna burn down. | | |
| 13:39:23 **CAM-2** | want ah twelve thousand in the center? | | |
| 13:39:26 **CAM-1** | ah we'll show ah thirty point five total fuel. | | |
| 13:39:28 **CAM-2** | so twelve five then. | | |
| 13:39:33 **CAM-1** | ah we can show thirty one * * *. | | |
| 13:39:34 **CAM-2** | so then it'll be thirteen thousand in the center. | | |
| 13:39:38 **CAM-1** | *. | | |
| 13:39:44 **CAM-1** | *** fuel burn is, ten two seventy six, ten two seventy six. | | |
| 13:40:05 **CAM** | [sound similar to sneeze.] | | |
| 13:40:11 **CAM-2** | God bless you. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:40:39 **CAM** | ***. | | |
| 13:40:48 **CAM-2** | so @, we're gonna have both the band, and and the team on board or? | | |
| 13:40:52 **FA-1** | looks that way. [sound of laughter]. | | |
| 13:40:56 **CAM** | [non-flight related conversation]. | | |
| 13:41:26 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:41:53 **CAM-2** | what is ah departure eighteen ninety five out here? | | |
| 13:41:56 **CAM-1** | that's Detroit. | | |
| 13:41:59 **HOT** | [sound similar to static]. | | |
| 13:42:08 **HOT** | [sound similar to static]. | | |
| 13:42:13 **CAM-2** | I don't think so. | | |
| 13:42:15 **CAM-1** | * hearing *? | | |
| 13:42:18 **CAM-2** | not hearing anything? | | |
| 13:44:47 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:46:10 **CAM-1** | can we get some candy please? we just ran out. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:46:11 **FA-1** | we just ran out *. | | |
| 13:46:13 **CAM-1** | yeah right [sound of laughter] | | |
| 13:46:20 **CAM-2** | you want some trail mix. ***. | | |
| 13:47:02 **CAM-2** | did you see *** when we pulled up to the airport? did you look? | | |
| 13:47:07 **CAM-1** | yeah I looked I couldn't see it. | | |
| 13:48:01 **CAM-1** | huh look at this. | | |
| 13:48:04 **CAM-2** | what am I looking at? | | |
| 13:48:05 **CAM-1** | a roof panel that came up? | | |
| 13:48:09 **CAM-2** | still there. | | |
| 13:48:10 **CAM-1** | on the building. | | |
| 13:48:20 **CAM-2** | okay we're hearing them. | | |
| 13:48:38 **CAM-1** | that's why I called them instead of. I didn't want to tie up Detroit approach because that's the same frequency for everyone going into Metro. | | |
| 13:48:45 **CAM-2** | that's fine. they don't sound very busy right now. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 13:49:23 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 13:54:35 **HDL-2** | [non-flight related conversation]. | | |
| 13:57:25 **CAM-2** | I tried that earlier * * the other ramp * worked. | | |
| 13:57:53 **CAM-1** | maintenance said told me that you gotta have a signal going from NAV one one to the the autothrottles. it's like why would, why would that be connected? | | |
| 13:58:04 **CAM-2** | I don't know. that doesn't make sense. but if that's true. so. | | |
| 13:58:09 **CAM-1** | that's why it didn't work. | | |
| 13:58:15 **CAM-1** | they said they replaced the receiver on that thing. | | |
| 13:58:17 **CAM-2** | right. | | |
| 13:58:21 **CAM-1** | did you see that fuel ticket * *? | | |
| 13:58:24 **CAM-2** | ah they never brought one on. | | |
| 13:58:26 **CAM-1** | I had a little yellow one * * somewhere ***. | | |
| 13:58:36 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:02:54 **FA-3** | we got two police officers that going to be flying with 'em. | | |
| 14:02:58 **CAM-1** | fill out a form? | | |
| 14:02:58 **FA-3** | they don't have, they don't have their forms. I gotta get the forms. oh shoo. | | |
| 14:03:01 **CAM-2** | I'll get it. | | |
| 14:03:01 **CAM-1** | I'll get 'em. | | |
| 14:03:06 **CAM-1** | they're law enforcement officers? | | |
| 14:03:07 **FA-3** | yes. | | |
| 14:03:08 **CAM-1** | okay. | | |
| 14:03:09 **FA-3** | and they're carrying weapons on them. | | |
| 14:03:11 **CAM-1** | alright. | | |
| 14:03:14 **CAM-1** | so which one is that one? | | |
| 14:03:16 **CAM-2** | P-H-M seven and eight. | | |
| 14:03:21 **CAM-1** | I think we only need seven for * *. because I haven't seen it. all I've seen here are P-H-M fours. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:03:25 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 14:03:29 **CAM-2** | is it the other one? | | |
| 14:03:38 **CAM-1** | are they here on the airplane? | | |
| 14:03:40 **FA-3** | no they're still inside. | | |
| 14:03:45 **CAM-2** | it might be in that ah three ring binder, in the locked **. because I haven't seen it. all I've seen are P-H-M fours. | | |
| 14:03:58 **FA-3** | I'm gonna I probably have some in mine. | | |
| 14:04:01 **CAM-1** | would you bring that ah, overhead, binder? | | |
| 14:04:04 **FA-3** | *. | | |
| 14:04:05 **CAM-2** | he needs the key, right, isn't the key over here? | | |
| 14:04:09 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:04:33 **FA-2** | ladies and gentlemen welcome onboard Ameristar charter. please remember that all carry on articles must be stowed and properly secured under the seat in front of you or in an overhead compartment. please use caution when opening the overhead compartment, if you article do not fit properly or you need assistance in stowing **** can I have the attention of the passenger seated in an emergency exit row, please read the emergency * criterion on the safety information card in the seat packet in front of you review the information explaining the exit row requirements. if you are seated **** criterion or are unable to carry out the instructions feel free to let one of the flight attendants know so you can be reseated at this time. in compliance with federal regulations smoking is not permitted in this cabin. the smoking of e-cigarettes is not permitted in the aircraft. thank you for your attention. | | |
| 14:04:38 **CAM-2** | there's two ah breakers popped here. | | |
| 14:04:40 **CAM-1** | what is it? | | |
| 14:04:42 **CAM-2** | forward water system, and, they're both water related. they, they can go in, right? | | |
| 14:04:50 **CAM** | [multiple unintelligible voices]. | | |
| 14:05:37 **FA-3** | okay tell them I'm coming out. | | |
| 14:05:49 **CAM-1** | that's all you need. | | |
| 14:05:51 **FA-3** | just this one? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:05:53 **CAM-1** | that for * passengers are not *. | | |
| 14:06:00 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 14:06:56 **CAM-1** | [sound similar to phone ringtone] honey I gotta call you when I get to Washington, I'm very busy *****. [consistent with cell phone call]. | | |
| 14:09:12 **CAM** | [sound similar to telephone ringtone]. | | |
| 14:10:16 **CAM** | [unintelligible voices]. | | |
| 14:10:21 **CAM-?** | this is one of the police officers **. | | |
| 14:10:30 **FA-?** | you guys have ahm paperwork for an armed ***? | | |
| 14:10:33 **CAM-2** | I gave it to @ already. | | |
| 14:10:34 **FA-?** | oh okay I didn't know about that. | | |
| 14:10:35 **CAM-2** | yeah he's got it. | | |
| 14:10:37 **FA-?** | okay. | | |
| 14:10:38 **CAM** | [sounds consistent with passengers boarding the aircraft]. | | |
| 14:11:48 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:13:54 **INT** | [sound similar to passenger call button]. | | |
| 14:14:03 **FA-2** | @? | | |
| 14:14:05 **FA-5** | @? | | |
| 14:14:05 **FA-5** | yes? | | |
| 14:14:06 **FA-2** | can you ah bring a few sick bags up for me please? | | |
| 14:14:09 **FA-5** | say that one more time. | | |
| 14:14:10 **FA-2** | can you bring up a few sick bags for me? | | |
| 14:14:13 **FA-5** | sick bags? | | |
| 14:14:14 **FA-5** | okay. | | |
| 14:14:15 **FA-2** | thank you. | | |
| 14:15:28 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 14:19:02 **CAM-2** | your phone rang while you were gone, so you got a missed call. | | |
| 14:19:11 **CAM-1** | can't even fit bags. | | |
| 14:19:12 **CAM-2** | huh? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:19:13 **CAM-1** | it's * (forward) is packed. | | |
| 14:19:14 **CAM-2** | oh is it? | | |
| 14:19:35 **CAM-2** | so how did you do this R-C-A-M thing? | | |
| 14:19:39 **CAM-1** | * * *. | | |
| 14:19:40 **CAM-?** | *. | | |
| 14:19:41 **CAM-2** | because the power's out right so you couldn't - | | |
| 14:20:04 **CAM-1** | (we) can erase A and B too. | | |
| 14:20:08 **CAM-2** | I didn't put anything in. | | |
| 14:20:10 **CAM-1** | ah look here. | | |
| 14:20:40 **CAM-2** | well if they make it to Sunday they gotta pack for five days. four days I guess. | | |
| 14:21:06 **CAM-?** | almost there. | | |
| 14:21:10 CAM | [multiple unintelligible background voices]. | | |
| 14:22:22 **CAM-2** | do you know how * those numbers broke down? | | |
| 14:22:24 **CAM-1** | ah you're probably gonna have to move some passengers, to the back. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:22:28 **CAM-1** | how many do we have one twelve? | | |
| 14:22:29 **CAM-2** | I didn't hear a count. | | |
| 14:22:33 **CAM-1** | no count yet? | | |
| 14:22:35 **FA-1** | there's still people loading stuff. (we don't) everybody on board. | | |
| 14:22:36 **CAM-1** | * * *. | | |
| 14:22:39 **CAM-1** | what where's @ with the paperwork? | | |
| 14:22:41 **FA-1** | * (@) is outside, doing something. | | |
| 14:22:45 **CAM** | [unintelligible background voices and conversation consistent with passenger boarding]. | | |
| 14:23:27 **CAM-?** | hey @. | | |
| 14:23:31 **FA-2** | we got one, minus one, so one oh nine. | | |
| 14:23:38 **CAM-1** | one ten with you? | | |
| 14:23:40 **FA-2** | yeah one ten with me. | | |
| 14:23:41 **CAM** | [unintelligible]. | | |
| 14:23:41 **CAM-2** | * * * * paperwork. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:24:15 **CAM-1** | @. | | |
| 14:24:18 **FA-1** | what's up? | | |
| 14:24:19 **CAM-1** | I cannot have more than thirty passengers in zone one. | | |
| 14:24:21 **FA-1** | in zone one? | | |
| 14:24:25 **CAM-1** | that, that's all you gotta count. | | |
| 14:24:34 **CAM-1** | we'll just do this, ah you ready? | | |
| 14:24:35 **FA-1** | yeah. | | |
| 14:24:37 **CAM-1** | zone one twenty five at forty eight seventy five. | | |
| 14:24:44 **CAM-?** | (okay). | | |
| 14:24:45 **CAM-1** | zone two forty at seventy eight hundred. | | |
| 14:24:48 **CAM-?** | okay. | | |
| 14:24:49 **CAM-1** | zone three forty five at eighty * - | | |
| 14:24:52 **FA-1** | so we have thirty two in zone one but look eight of them are kids, like little tiny kids. | | |
| 14:24:58 **CAM-1** | (we) show there's twenty five, forty, forty five. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:25:00 **FA-1** | twenty five, forty, forty five. | | |
| 14:25:04 **CAM-2** | forty five at how much? | | |
| 14:25:05 **CAM-1** | eighty seven seventy five. | | |
| 14:25:06 **CAM-2** | k. | | |
| 14:25:10 **CAM-1** | uhmm. | | |
| 14:25:12 **CAM-2** | zero fuel weight? | | |
| 14:25:13 **CAM-1** | zero fuel weight is one one four, four seven six. | | |
| 14:25:17 **CAM** | [unintelligible]. | | |
| 14:25:24 **CAM-2** | taxi? | | |
| 14:25:25 **CAM-1** | taxi weight ah one four five, four seven six. | | |
| 14:25:32 **CAM-1** | takeoff weight one four five zero seven six. | | |
| 14:25:36 **CAM-2** | yup. | | |
| 14:25:37 **CAM-1** | landing weight one three four, eight hundred. * * forward C-G three point seven. aft twenty two point one. wet eleven point seven. | | |
| 14:25:54 **CAM-?** | *. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:25:55 **CAM-1** | stab trim is ah seven point zero. [sound similar to stabilizer trim aural movement sound]. | | |
| 14:26:07 **CAM-2** | * * * for A B and C two *. | | |
| 14:26:10 **CAM-1** | ah that's right ah. in ah section A show twenty bags at seven eighty six. | | |
| 14:26:21 **CAM-2** | okay. | | |
| 14:26:22 **CAM-1** | and in C thirty or I mean ah. | | |
| 14:26:26 **CAM-2** | B? | | |
| 14:26:27 **CAM-1** | yeah in B a twenty - let's show - yeah, thirty at eleven sixty. | | |
| 14:26:34 **CAM-1** | and C- two is gonna be ah twenty at a thousand. | | |
| 14:26:39 **CAM-2** | okay. | | |
| 14:26:43 **CAM-1** | you got everything? | | |
| 14:26:44 **CAM-2** | yes. | | |
| 14:26:45 **CAM-2** | here ya go. | | |
| 14:26:50 **CAM-2** | before start below the line. | | |
| 14:26:52 **CAM-1** | yeah I gotta * * *. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:26:53<br>**CAM-2** | alright. | | |
| 14:26:59<br>**CAM-1** | * * *. | | |
| 14:27:03<br>**HOT** | [sound similar to passenger call chime]. | | |
| 14:27:07<br>**CAM-1** | they're still loading *. | | |
| 14:27:09<br>**CAM-2** | yeah. | | |
| 14:27:41<br>**CAM** | [occasional unintelligible background voices]. | | |
| 14:28:23<br>**FA-3** | I gotta stand in here for a minute, I'm cold. | | |
| 14:28:27<br>**CAM-2** | I'm sorry? | | |
| 14:28:28<br>**FA-3** | I gotta stand in here for a second I'm freezing. | | |
| 14:28:30<br>**CAM-2** | It feels like the temperature is dropping. | | |
| 14:28:32<br>**FA-3** | I know. | | |
| 14:28:50<br>**CAM** | [occasional unintelligible background voices]. | | |
| 14:30:11<br>**CAM-1** | where ah * * where's the * sitting. | | |
| 14:30:20<br>**FA-1** | five, D? | | |
| 14:30:22<br>**CAM-1** | both of them? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:30:25 **FA-1** | * * *, I wasn't even aware of it until he came on. | | |
| 14:30:31 **CAM-2** | alright, below the line. | | |
| 14:30:32 **CAM-1** | fuel pumps and crossfeed. | | |
| 14:30:33 **CAM-?** | * * *. | | |
| 14:30:36 **CAM-2** | on and closed. | | |
| 14:30:37 **CAM-1** | fuel pumps, quantity * * *, fuel quantity? | | |
| 14:30:40 **CAM-2** | ah required is sixteen three we have thirty thousand five hundred on board. | | |
| 14:30:44 **CAM-1** | sixteen three * * * on board ah. | | |
| 14:30:44 **CAM** | [multiple unintelligible voices]. | | |
| 14:30:47 **CAM-1** | V- speeds? | | |
| 14:30:48 **CAM-2** | ah the one forty six thousand pound flaps fifteen, one thirty nine, one forty two, one fifty, one sixty five, one ninety nine, two forty eight set *. | | |
| 14:30:56 **CAM-1** | one thirty nine, one forty two, one fifty * * * * stabilizer trim *. | | |
| 14:31:01 **CAM-2** | okay envelopes out? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:31:03 **CAM-1** | ah I e-mailed it in. | | |
| 14:31:05 **CAM-2** | seven point zero. | | |
| 14:31:06 **CAM-1** | pull the - pull the chocks. | | |
| 14:31:07 **CAM-?** | pull chocks. | | |
| 14:31:08 **CAM-2** | seven point zero checked and set. | | |
| 14:31:10 **CAM-1** | seven point zero checked and set. * *? | | |
| 14:31:12 **CAM-2** | checked and set. | | |
| 14:31:14 **CAM-?** | [unintelligible]. | | |
| 14:31:21 **CAM-1** | tower's still down? | | |
| 14:31:22 **CAM-2** | ah I checked about ten minutes ago and it was, yes. keep trying. | | |
| 14:31:32 **FA-4** | ladies and gentlemen in preparation for our departure we do ask that all passengers be seated with their seatbelts fastened low and tight across their ** portable electronic devices * cell phones laptops be turned off and stowed at this time. we appreciate your cooperation thank you. | | |
| | | 14:31:41 **RDO-1** | Willow Run tower Ameristar ninety three sixty three. |
| 14:31:55 **CAM-2** | ready for start please. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:31:58 **HOT-1** | ready * start. | | |
| 14:32:01 **HOT-1** | documents. | | |
| 14:32:03 **CAM-2** | crossfeeds are open. | | |
| 14:32:04 **HOT-1** | documents. | | |
| 14:32:05 **CAM-2** | oh documents on board. | | |
| 14:32:06 **HOT-1** | cabin. | | |
| 14:32:07 **CAM-2** | ah secured. | | |
| 14:32:08 **HOT-1** | cockpit door. | | |
| 14:32:09 **CAM-2** | it'll be locked. | | |
| 14:32:10 **HOT-1** | pneumatic crossfeed. | | |
| 14:32:11 **CAM-2** | open. | | |
| 14:32:12 **HOT-1** | hydraulics. | | |
| 14:32:13 **CAM-2** | on high and checked. | | |
| 14:32:14 **HOT-1** | anti-collision lights. | | |
| 14:32:15 **CAM-2** | on. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:32:16 **HOT-1** | annunciator door lights. | | |
| 14:32:17 **CAM-2** | checked and lights out. | | |
| 14:32:19 **CAM-?** | * * * this thing. | | |
| 14:32:19 **HOT-1** | air conditioning supply switch. | | |
| 14:32:21 **CAM-2** | off. | | |
| 14:32:22 **HOT-1** | fuel pumps. | | |
| 14:32:23 **CAM-2** | uhm set. | | |
| 14:32:24 **HOT-1** | pitot windshield heat. | | |
| 14:32:25 **CAM-2** | captain on. | | |
| 14:32:26 **HOT-1** | ignition? | | |
| 14:32:27 **CAM-2** | is on. | | |
| 14:32:28 **HOT-1** | pneumatic pressure. | | |
| 14:32:28 **CAM-2** | check. | | |
| 14:32:29 **HOT-1** | alright ready for start check's complete. | | |
| 14:32:29 **CAM-2** | go ahead and start the right engine please. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:32:44 **HOT-1** | start valve open. oil pressure. | | |
| 14:33:09 **CAM-2** | forty percent. | | |
| 14:33:14 **CAM-2** | starting left engine. | | |
| 14:33:21 **CAM-1** | start valve open. | | |
| 14:33:31 **CAM-1** | Michigan. [consistent with cell phone call]. | | |
| 14:33:34 **CAM-1** | oil pressure. | | |
| 14:33:38 **CAM-1** | yes. [consistent with cell phone call]. | | |
| 14:33:57 **CAM-2** | forty percent. | | |
| 14:33:58 **HOT** | [electronic sound consistent with transfer of electrical power]. | | |
| 14:34:00 **CAM-?** | got it? | | |
| 14:34:01 **HOT-1** | ah good day sir this is Ameristar ninety three sixty three, that's Alpha Juliet India nine three six three. ah we're on the ground in Detroit Willow Run ah Yankee India Papa and tower I guess they lost power out here so we need to try to get a clearance with you going to Dulles. [consistent with cell phone call]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:34:26 **HOT-1** | it's gonna be departing runway two three left and we'll be ready in five minutes. [consistent with cell phone call]. | | |
| 14:34:32 **CAM-2** | after start. | | |
| 14:34:41 **HOT-1** | all right. appreciate it. [consistent with cell phone call]. | | |
| 14:34:46 **CAM-1** | after start. pneumatic crossfeeds? | | |
| 14:34:47 **FA-4** | at this time we do ask that you give your undivided attention to the flight attendant nearest you while important safety information is review. please observe the no smoking signs and fasten seatbelt signs when they are illuminated. federal aviation regulations require passenger compliance with lighted passenger information sign and posted placards and all crewmember instructions. please take a moment to review the passenger information card located in the seat pocket in front of you. it illustrates the location of operat- | | |
| 14:34:47 **CAM-2** | closed. | | |
| 14:34:48 **CAM-1** | transponder? | | |
| 14:34:49 **CAM-2** | * *. | | |
| 14:34:49 **CAM-2** | transponder one. | | |
| 14:34:50 **CAM-1** | hydraulics? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:34:51 **CAM-2** | on high and checked. | | |
| 14:34:52 **CAM-1** | A-P-U air switch? | | |
| 14:34:53 **CAM-2** | is off. | | |
| 14:34:53 **CAM-1** | engine anti-ice? | | |
| 14:34:54 **CAM-2** | is off. | | |
| 14:34:55 **CAM-2** | off. | | |
| 14:34:55 **CAM-1** | ignition? | | |
| 14:34:56 **CAM-2** | off. | | |
| 14:34:56 **CAM-1** | electrical system? | | |
| 14:34:57 **CAM-2** | checked. | | |
| 14:34:58 **CAM-1** | * ignition (start) switches? | | |
| 14:35:00 **CAM-2** | auto. | | |
| 14:35:00 **CAM-1** | * * *. | | |
| 14:35:01 **CAM-2** | on. | | |
| 14:35:02 **CAM-1** | annunciators. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:35:02 **CAM-2** | checked. | | |
| 14:35:03 **CAM-1** | shoulder harnesses. | | |
| 14:35:04 **CAM-2** | on left. | | |
| 14:35:05 **CAM-1** | on right. ground equipment? | | |
| 14:35:07 **CAM-2** | clear left. | | |
| 14:35:08 **CAM-1** | after start checklist complete. | | |
| 14:35:09 **CAM-2** | start taxiing out. | | |
| | | 14:35:19 **RDO-1** | Willow Run traffic Ameristar ninety three sixty three MD-eighty is taxiing from the ah east ramp out to runway ah two three left any inbound traffic and traffic in the pattern please advise Willow Run. |
| 14:35:35 **HOT-1** | easy on the tiller. | | |
| 14:35:36 **CAM-2** | *. | | |
| 14:35:37 **HOT-1** | yup. [consistent with cell phone call]. | | |
| 14:35:41 **HOT-1** | okay. [consistent with cell phone call]. | | |
| 14:35:46 **HOT-1** | yup. [consistent with cell phone call]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:35:48 **HOT-1** | eight one eight one. [consistent with cell phone call]. | | |
| 14:35:51 **HOT-1** | okay. [consistent with cell phone call]. | | |
| 14:35:52 **HOT-1** | thank you sir I appreciate it. [consistent with cell phone call]. | | |
| 14:36:03 **CAM-2** | okay I'll taxi slow on the off chance. | | |
| 14:36:06 **HOT-1** | yeah * do the taxi check first and then we'll- | | |
| 14:36:08 **CAM-2** | slats extend flaps fifteen taxi checklist. | | |
| 14:36:11 **HOT-1** | no, no, no straight ahead. | | |
| 14:36:29 **HOT-1** | taxi checklist, flaps and slats. | | |
| 14:36:31 **CAM-2** | no this goes to two seven we're gonna use two- | | |
| 14:36:33 **HOT-1** | yes we gotta take two seven to two three. | | |
| 14:36:35 **CAM-2** | okay. | | |
| 14:36:36 **CAM-2** | umh, fifteen, fifteen, fifteen, takeoff and a blue light. | | |
| 14:36:41 **HOT-1** | fifteen, fifteen, fifteen, takeoff, blue light. | | |
| 14:36:44 **HOT-1** | ah V-speeds. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:36:46 **CAM-2** | off the one forty six thousand pound card one thirty nine, one forty two, one fifty, recheck. | | |
| 14:36:51 **HOT-1** | one thirty nine, one forty two, one fifty recheck. | | |
| 14:36:55 **HOT-1** | stab trim. | | |
| 14:36:56 **CAM-2** | seven point zero, set. | | |
| 14:37:00 **HOT-1** | seven point zero units set, annunciators checked, I'll get the flight attendants here in a little bit. | | |
| 14:37:07 **HOT-1** | we'll just wait here. * you see the windsock, what's it better for? | | |
| 14:37:10 **CAM-2** | ah, I, I prefer two three *. | | |
| 14:37:14 **CAM-2** | it's variable. | | |
| 14:37:21 **CAM-2** | gonna hold short until you make the announcement. | | |
| 14:37:24 **HOT-1** | yes sir this is ah Ameristar ninety three sixty three we're on the ground here at Willow Run holding short of runway two three left ah ready to go like to get a clearance to Dulles. [consistent with cell phone call]. | | |
| 14:37:37 **HOT-1** | it's ah alpha juliet india nine three six three, it's Amerista ninety three sixty three. [consistent with cell phone call]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:37:46 **HOT-1** | thanks. [consistent with cell phone call]. | | |
| 14:37:58 **HOT-1** | I don't see anything in the system. [consistent with cell phone call]. | | |
| 14:38:06 **HOT-1** | no flightplan stored that's just great, ah, okay I guess we need to ah call the company and have them refile then. [consistent with cell phone call]. | | |
| 14:38:16 **HOT-1** | [sound similar to chuckle] * I ah. thank you bye-bye. [consistent with cell phone call]. | | |
| 14:38:23 **CAM-2** | unbelievable. | | |
| 14:38:26 **HOT-1** | it's just one thing after another. | | |
| 14:38:27 **CAM-2** | oh yeah. | | |
| 14:38:32 **HOT-1** | you know what? it's probably faster just for me to file myself, right? | | |
| 14:39:10 **HOT-1** | briefer. [consistent with cell phone call]. | | |
| 14:39:18 **HOT-1** | Michigan. [consistent with cell phone call]. | | |
| 14:39:47 **HOT-1** | yes sir ah we'd like to file an I-F-R flightplan please. [consistent with cell phone call]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:39:52 **HOT-1** | ah it's gonna be for alpha juliet India ah nine three six three that's Ameristar nine three six three, ah. no alpha juliet india nine three six three. it's an MD-eighty three slant let me see what we got * slant lima, ah, usually the company does this, so let me know what else you need. ah airspeed four five zero knots. ah it's gonna be kilo yankee india papa. Detroit Willow run. ah at nineteen ah as soon as possible nineteen forty five Z. altitude will be flight level three one zero. the route of flight will be ah direct to Carlton charlie romeo lima, jet three four to Dryer that's delta juliet bravo, J-eighty five to hotel victor quebec and then it's the Gibbz two arrival that's golf india bravo bravo zulu two into Dulles. destination Dulles kilo india alpha delta and alternate airport will be ah Baltimore kilo bravo whiskey india. time in route one hour and thirty - fifteen minutes. fifteen minutes. just tell 'em its a (flow) * *. [consistent with cell phone call]. | | |
| 14:41:33 **CAM-2** | *. | | |
| 14:41:33 **HOT-1** | I'm sorry. fuel on board is a two hours and thirty minutes. ah first initial alpha. last name ah golf romeo uniform sierra echo uniform sierra. based at alpha delta sierra. and the phone ah one eight hundred three six eight five three eight seven. five three eight seven. ah total people on board is ah hundred ah fifteen. and ah red and blue on white. yeah it's november seven eight six tango whiskey. [consistent with cell phone call]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:41:37 **CAM-2** | ladies and gentlemen from the flight deck welcome aboard flight nine three six three service to Washington Dulles airport, flight time today one hour fifteen minutes, experiencing just a short delay here on the ground. power on the airports not working * * air traffic **********. [sound similar to flight attendant bell]. | | |
| 14:42:53 **HOT-1** | that's it. [consistent with cell phone call]. | | |
| 14:43:12 **HOT-1** | that's it. [consistent with cell phone call]. | | |
| 14:43:20 **HOT-1** | naw we got, all that I appreciate the help. thank you sir. [consistent with cell phone call]. | | |
| 14:43:25 **HOT-?** | * * *. | | |
| 14:43:26 **HOT-1** | what a # cluster#. | | |
| 14:43:32 **HOT-1** | yup. | | |
| 14:43:41 **HOT-1** | @ said he had issues, filing it. | | |
| 14:44:01 **HOT-1** | yes sir ah this ah Ameristar ninety three sixty three ah on the ground here at Willow Run hopefully the ATC clearance is in the system this time. not yet? okay, sounds good appreciate that. okay, I'll call back here in a few minutes. Alright, sounds good, thank you, bye. [consistent with cell phone call]. | | |
| 14:44:37 **CAM-2** | let's run the taxi check while were waiting from the top please. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:44:40 **HOT-1** | we did that. the taxi check. | | |
| 14:44:41 **CAM-2** | I don't think we completed it. | | |
| 14:44:43 **HOT-1** | yeah. | | |
| 14:44:45 **HOT-1** | ah taxi check ah flap, flaps and slats? | | |
| 14:44:45 **CAM-2** | yeah. | | |
| 14:44:47 **CAM-2** | I have fifteen, fifteen, fifteen, takeoff and a blue light. | | |
| 14:44:51 **HOT-1** | fifteen, fifteen, fifteen, takeoff blue light. flight controls elevator on. | | |
| 14:44:55 **CAM-2** | checked. | | |
| 14:44:55 **HOT-1** | checked A-P-U. | | |
| 14:44:57 **CAM-2** | off. | | |
| 14:44:58 **HOT-1** | and ah fuel heat? | | |
| 14:45:00 **CAM-2** | should be off. | | |
| 14:45:00 **HOT-1** | off. takeoff briefing? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:45:02 **CAM-2** | ah left seat takeoff. assigned headings, probably three thousand feet. emergency return we'll just take it right over to Metro airport landing on one of the two one * *. | | |
| 14:45:16 **HOT-1** | before takeoff the line flaps and slats. | | |
| 14:45:18 **CAM-2** | are fifteen, fifteen, fifteen, takeoff and a blue light. | | |
| 14:45:21 **HOT-1** | fifteen, fifteen, fifteen, takeoff blue light. V-speeds? | | |
| 14:45:24 **CAM-2** | off the one forty six thousand pound card, one thirty nine, one forty two, one fifty recheck. | | |
| 14:45:29 **HOT-1** | one thirty nine, one forty two, one fifty, rechecked. stab trim? | | |
| 14:45:32 **CAM-2** | seven point zero set. | | |
| 14:45:35 **HOT-1** | seven point ah zero units set. annunciators checked. I'll get the flight attendants here. | | |
| 14:45:41 **CAM-2** | I told them to be seated for departure, I got the two dings so ah we're good to go. | | |
| 14:45:45 **HOT-1** | oh. | | |
| 14:46:00 **CAM-2** | wonder why more often than not we have trouble * *. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:46:15 **CAM-2** | I should also add to my briefing we're gonna delay rotation because of the gusty winds. | | |
| 14:46:20 **HOT-1** | yeah I'll just call rotate. | | |
| 14:46:21 **CAM-2** | yup. | | |
| 14:46:41 **CAM-2** | I'll get those n- those phone number from you. | | |
| 14:46:44 **HOT-1** | huh? | | |
| 14:46:44 **CAM-2** | I'll get those phone number from you * later today. I don't know if I have those numbers, for my own use in the future. | | |
| 14:47:07 **HOT-1** | yeah sir it's Ameristar ninety three sixty three again any luck? ready to copy. [consistent with cell phone call]. | | |
| 14:47:37 **HOT-1** | Ameristar ninety three sixty three cleared to Dulles via Akron five departure Akron direct ah hotel victor quebec as filed. three thousand three one oh in ten eighteen ninety five in seven two one four in the box hold for release. and yeah we're number one ready to go runway two three left. Two three left, yes sir. [consistent with cell phone call]. | | |
| 14:48:14 **HOT-1** | yeah void if not off by fifty one and ah time now forty eight and a half. that's all we need appreciate the help. [consistent with cell phone call]. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:48:24 **HOT-1** | heading three zero zero. hold that. [consistent with cell phone call]. | | |
| 14:48:26 **HOT-1** | ah departure. thank you bye. [consistent with cell phone call]. | | |
| 14:48:29 **HOT-1** | let me put that in real quick * Akron five. It's gonna be the one oh six out of thirteen four. | | |
| 14:48:33 **CAM-2** | what is it? | | |
| 14:48:36 **CAM-2** | alright. | | |
| 14:48:39 **CAM-2** | thank you. | | |
| 14:48:42 **HOT-1** | fix. V-lock. | | |
| 14:48:47 **CAM-2** | Akron five? | | |
| 14:48:49 **HOT-1** | yeah. | | |
| 14:49:25 **HOT-1** | there ya go. so heading three zero zero on departure. | | |
| 14:49:25 **CAM-2** | ready? | | |
| 14:49:27 **CAM-2** | alright. | | |
| 14:49:28 **CAM-2** | three hundred heading up to three thousand. ready? | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:49:30 **HOT-1** | yup. | | |
| 14:49:31 **CAM-2** | alright, let's announce our intentions. | | |
| 14:49:33 **HOT-1** | yup. | | |
| | | 14:49:35 **RDO-1** | Willow Run traffic ah Ameristar ninety three sixty three is taking an active runway ah two three left for departure and ah it will be a right turn out ah north west departure any inboud traffic please advise Willow Run. |
| | | 14:49:49 **N555P** | and a Willow Run Baron triple five papa is ah four to the northwest I'm entering a right downwind for runway two seven and I've got the ah Ameristar MD-80 visual. |
| | | 14:50:01 **RDO-1** | thank you sir appreciate it. |
| 14:50:02 **CAM-2** | before takeoff to the line. | | |
| 14:50:04 **HOT-1** | ah below the line. | | |
| 14:50:05 **CAM-2** | *. | | |
| 14:50:05 **HOT-1** | depart - ah departure runway two three left confirm ignition is on transponder T-A-R-A and landing lights are on runway alignment's set * * *. | | |
| 14:50:09 **CAM-2** | left confirmed. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:50:19 **INT-1** | ladies and gentlemen from the flight deck ah we've been cleared for departure flight attendants please be seated. | | |
| 14:50:42 **HOT-1** | final's clear. | | |
| 14:50:45 **CAM-2** | clear left. | | |
| 14:50:47 **HOT-1** | clear right. | | |
| | | 14:50:48 **N555P** | and Willow Run traffic Baron five five five papa's right downwind two seven. we're gonna be a full stop. |
| 14:51:06 **CAM-2** | alright, runway alignment is checked. | | |
| 14:51:08 **HOT-1** | checks. | | |
| 14:51:11 **CAM-2** | before takeoff is complete. | | |
| 14:51:12 **HOT-1** | go. | | |
| 14:51:18 **HOT-1** | looks like the wind is a little bit from the right. | | |
| 14:51:20 **CAM-2** | right. | | |
| 14:51:21 **CAM-2** | I'm gonna * some right crosswind *. | | |
| 14:51:27 **CAM-2** | autothrottles on please. set takeoff thrust. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:51:35 **HOT-1** | takeoff thrust set N1's checked. | | |
| 14:51:38 **HOT-1** | airspeed alive. | | |
| 14:51:41 **HOT-1** | clamp. | | |
| 14:51:43 **HOT-1** | eighty knots. | | |
| 14:51:44 **CAM-2** | checked. | | |
| | | 14:51:45 **N555P** | ah Willow Run Baron triple five papa right * two seven full stop. |
| 14:51:55 **HOT-1** | V-one. | | |
| 14:52:01 **HOT-1** | rotate. | | |
| 14:52:04 **HOT-1** | V-two. | | |
| 14:52:05 **CAM-2** | hey what's goin' on? | | |
| 14:52:08 **CAM-2** | abort. | | |
| 14:52:09 **HOT-1** | no. not above - #. | | |
| 14:52:15 **HOT-1** | # don't abort above V-one like that. | | |
| 14:52:19 **HOT-1** | #. | | |
| 14:52:19 **CAM-2** | it wasn't flying. | | |

| TIME and SOURCE | INTRA-AIRCRAFT COMMUNICATION CONTENT | TIME and SOURCE | AIR-GROUND COMMUNICATION CONTENT |
|---|---|---|---|
| 14:52:22 **HOT-1** | #. | | |
| 14:52:23 **CAM** | [sounds consistent with departure from the prepared surface]. | | |
| 14:52:27 **CAM** | speed brake speed brake speed brake [electronic voice]. | | |
| 14:52:27 **FA-1** | heads down, stay down, heads down, stay down, heads down, stay down. | | |
| 14:52:32 **CAM** | landing gear landing gear [multiple repetitions electronic voice]. | | |
| 14:52:37 **PA-1** | evacuate, evacuate, evacuate. | | |
| 14:52:41 **CAM-2** | it wasn't flying. it wasn't - I had it all the way back here it wasn't flying. | | |
| 14:52:46 **CAM** | [sounds consistent with emergency evacuation of the cabin]. | | |
| 14:53:12 **CAM-2** | it was not rotating I had it all the way back here. | | |
| 14:53:29 **CAM-2** | #. | | |
| 14:53:47 **HOT-1** | evacuation checklist. | | |
| 14:53:49 | **End of Recording** | | |
| 14:53:49 | **End of Transcript** | | |

# References

Bauer, Michael, William R. English, Michael Richards, and Matthew Grzych. 2018. "Use of sUAS in Developing Photogrammetric Model for Wind Simulation." Technical paper presented at the International Society of Air Safety Investigators 2018 Annual Seminar, "The Future of Aircraft Accident Investigation," Dubai, United Arab Emirates, October 30 – November 1, 2018. Accessed December 17, 2018. https://www.isasi.org/Documents/library/technical-papers/2018/Tues/Use%20of%20sUAS%20in%20Developing%20Photogrammetric%20Model%20for%20Wind%20Simulation%20-%20Bill%20English,%20Mike%20Bauer.pdf.

BFU (German Federal Bureau of Aircraft Accident Investigation). 2000. Aircraft Incident Report 5X011-0/99.

DOT OIG (Department of Transportation Safety, Office of Inspector General). 2009. "Actions Taken and Needed to Improve Federal Aviation Administration's Runway Safety Area Program." AV-2009-039. Accessed June 12, 2008. https://www.oig.dot.gov/sites/default/files/11WEB_FILE_RSA_Report_03-3-09_Issued.pdf.

FAA (Federal Aviation Administration). 1994. Advisory Circular 120-62, "Takeoff Training Safety Aid, Announcement of Availability." Accessed June 26, 2018. http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC%20120-62.pdf.

———. 1999. Order 5200.8, *Runway Safety Area Program*. Accessed June 8, 2018. http://www.faa.gov/documentLibrary/media/Order/Construction_5200_8.pdf.

———. 2004. "Section 2: Pilot Guide to Takeoff Safety" (Part of and excerpted from the *Takeoff Safety Training Aid*). Accessed June 26, 2018. https://www.faa.gov/other_visit/aviation_industry/airline_operators/training/media/takeoff_safety.pdf.

———. 2005. Advisory Circular 120-27E, "Aircraft Weight and Balance Control." Accessed May 14, 2018. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC120-27E.pdf.

———. 2013. Advisory Circular 150/5345-27E, "FAA Specification for Wind Cone Assemblies." Accessed June 20, 2018. http://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5345_27e.pdf.

———. 2014a. Advisory Circular 150/5300-13A – Change 1, "Airport Design." Accessed June 8, 2018. http://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5300-13A-chg1-interactive-201804.pdf.

———. 2014b. JO 7900.5D, *Surface Weather Observing*. Accessed June 23, 2018. https://www.faa.gov/documentLibrary/media/Order/JO_7900_5D.pdf.

———. 2015. Advisory Circular 120-92B, "Safety Management Systems for Aviation Service Providers." Accessed September 18, 2018. http://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-92B.pdf.

———. 2017a. JO 7900.5D – Change 1, *Surface Weather Observing*. Accessed June 23, 2018. https://www.faa.gov/documentLibrary/media/Order/JO_7900.5D.pdf.

———. 2017b. Advisory Circular 120-71B, "Standard Operating Procedures and Pilot Monitoring Duties for Flight Deck Crewmembers." Accessed October 10, 2018. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_120-71B.pdf.

———. 2018a. Advisory Circular 00-45H, Change 1, "Aviation Weather Services." Accessed December 14, 2018. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_00-45H_Chg_1.pdf.

———. 2018b. "Fact Sheet – Engineered Material Arresting System (EMAS)." Accessed June 29, 2018. https://www.faa.gov/news/fact_sheets/news_story.cfm?newsid=13754.

NOAA (National Oceanic and Atmospheric Administration). 1998. *Automated Surface Observing System (ASOS) User's Guide.* Accessed June 21, 2018. https://www.weather.gov/media/asos/aum-toc.pdf.

NTSB (National Transportation Safety Board). 1977. *Texas International Airlines, Inc. McDonnell Douglas DC-9-14, N9104, Stapleton International Airport, Denver, Colorado, November 16, 1976*. AAR-77/10. Washington, DC: NTSB.

———. 1984. *Safety Study: Airport Certification and Operations*. SS-04/02. Washington, DC: NTSB.

———. 1994. *Impact with Blast Fence upon Landing Rollout, Action Air Charters Flight 990, Piper PA-31-350, N990RA, Stratford, Connecticut, April 27, 1994*. AAR-94/08. Washington, DC: NTSB.

———. 2002. *Southwest Airlines Flight 1455, Boeing 737-300, N668SW, Burbank, California, March 5, 2000*. AAB-02/04. Washington, DC: NTSB.

———. 2007. *Runway Overrun and Collision, Southwest Airlines Flight 1248, Boeing 737-7H4, N471WN, Chicago Midway International Airport, Chicago, Illinois, December 8, 2005*. AAR-07/06. Washington, DC: NTSB.

———. 2008. *Runway Overrun During Landing, Shuttle America, Inc., Doing Business as Delta Connection Flight 6448, Embraer ERJ-170, N862RW, Cleveland, Ohio, February 18, 2007*. AAR-08/01. Washington, DC: NTSB.