Runway Collision involving Trans World Airlines Flight 427 and Superior Aviation Cessna 441, Bridgeton, Missouri, November 22, 1994

Micro-summary: **An MD-82 collides with a Cessna 441 on the active runway, destroying the Cessna.**

Event Date: **1994-11-22 at 2203 CST**

Investigative Body: **National Transportation Safety Board (NTSB), USA**

Investigative Body's Web Site: **http://www.ntsb.gov/**

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PB95-910405
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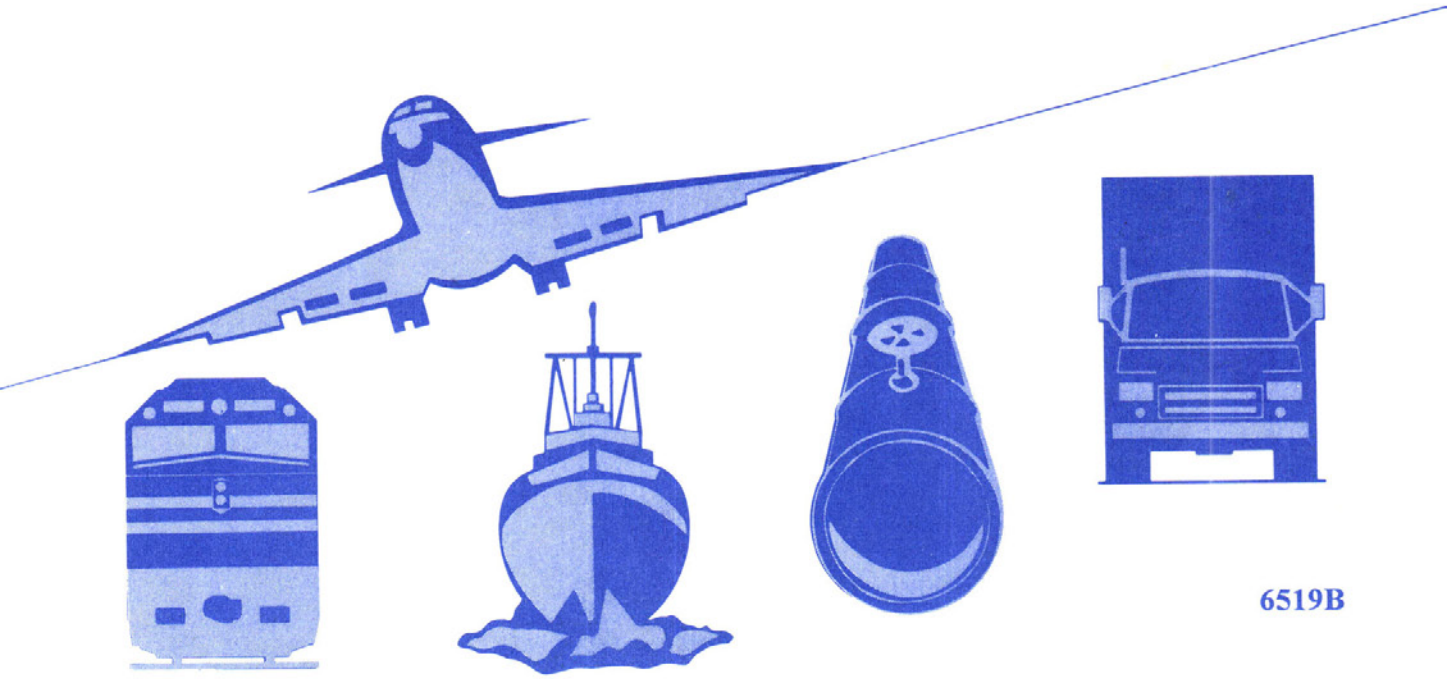
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

**RUNWAY COLLISION INVOLVING
TRANS WORLD AIRLINES FLIGHT 427
AND SUPERIOR AVIATION CESSNA 441
BRIDGETON, MISSOURI
NOVEMBER 22, 1994**



6519B

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NATIONAL TRANSPORTATION SAFETY BOARD

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AIRCRAFT ACCIDENT REPORT

RUNWAY COLLISION INVOLVING TRANS WORLD AIRLINES FLIGHT 427 AND SUPERIOR AVIATION CESSNA 441 BRIDGETON, MISSOURI NOVEMBER 22, 1994

Adopted: August 30, 1995
Notation 6519B

Abstract: This report explains the runway collision of Trans World Airlines flight 427, a McDonnell Douglas DC-9-82, and N441KM, a Cessna 441, at the intersection of runway 30R and taxiway Romeo at the Lambert-St. Louis International Airport in Bridgeton, Missouri. The safety issues discussed in the report include aircraft lighting and conspicuity; airport markings, signs, and lighting; runway 31 designation, utilization, displaced threshold; ATC and pilot phraseology (specifically, the term "back-taxi"); pilot training; runway incursion detection/prevention methods; and ASDE/AMASS development. Safety recommendations concerning some of these issues were made to the Federal Aviation Administration (FAA).

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EXECUTIVE SUMMARY

On November 22, 1994, at 2203 central standard time, Trans World Airlines flight 427, a McDonnell Douglas DC-9-82 (MD-82), N954U, collided with a Cessna 441, N441KM, at the intersection of runway 30R and taxiway Romeo, at the Lambert-St. Louis International Airport (STL) in Bridgeton, Missouri. The MD-82 was operating as a regularly scheduled passenger flight from STL to Denver, Colorado. The flight was conducted under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. There were 132 passengers, five flight attendants, and three flightcrew members aboard the airplane. The MD-82 sustained substantial damage during the collision. The Cessna 441, operated by Superior Aviation, Inc., as a 14 CFR Part 91 positioning flight, was destroyed. The commercial pilot and the passenger, who was rated as a private pilot, were the sole occupants on board the Cessna and were killed. Of the 140 persons on board the MD-82, eight passengers sustained minor injuries during the evacuation.

The National Transportation Safety Board determines that the probable cause of this accident was: the Cessna 441 pilot's mistaken belief that his assigned departure runway was runway 30R, which resulted in his undetected entrance onto runway 30R, which was being used by the MD-82 for its departure. Contributing to the accident was the lack of Automatic Terminal Information Service and other air traffic control (ATC) information regarding the occasional use of runway 31 for departure. The installation and utilization of Airport Surface Detection Equipment (ASDE-3), and particularly ASDE-3 enhanced with the Airport Movement Area Safety System (AMASS), could have prevented this accident.

Safety issues discussed in the report include aircraft lighting and conspicuity; airport markings, signs, and lighting; runway 31 designation, utilization, displaced threshold; ATC and pilot phraseology (specifically, the term "back-taxi"); pilot training; runway incursion detection/prevention methods; and ASDE/AMASS development. Safety recommendations concerning some of these issues were made to the Federal Aviation Administration (FAA). Also as a result of the investigation of this accident, the Safety Board issued safety recommendations to the FAA on February 28, 1995, concerning the runway incursion issue.

NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D. C. 20594

AIRCRAFT ACCIDENT REPORT

RUNWAY COLLISION INVOLVING TRANS WORLD AIRLINES FLIGHT 427 AND SUPERIOR AVIATION CESSNA 441 BRIDGETON, MISSOURI NOVEMBER 22, 1994

1. FACTUAL INFORMATION

1.1 History of the Flights

On November 22, 1994, at 2203 central standard time,[1] Trans World Airlines (TWA) flight 427, a McDonnell Douglas DC-9-82 (MD-82), N954U, collided with a Cessna 441, N441KM, at the intersection of runway 30R and taxiway Romeo, at the Lambert-St. Louis International Airport (STL) in Bridgeton, Missouri. The MD-82 was operating as a regularly scheduled passenger flight from STL to Denver, Colorado. The flight was conducted under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. There were 132 passengers, five flight attendants, and three flightcrew members aboard the airplane. The MD-82 sustained substantial damage during the collision. The Cessna 441, operated by Superior Aviation, Inc., as a 14 CFR Part 91 positioning flight, was destroyed. The commercial pilot and the passenger, who was rated as a private pilot, were the sole occupants on board the Cessna and were killed. Of the 140 persons on board the MD-82, eight passengers sustained minor injuries during the evacuation.

The accident occurred on the second day of a 3-day trip sequence for the MD-82 flightcrew. The captain flew the first leg of the second day, from San Jose to STL. The flightcrew had a 2-hour layover before the accident flight. The first officer performed pilot flying duties for the accident leg of the trip sequence.

The MD-82 was scheduled to depart STL for Denver at 2134, but there was a short gate delay that the flightcrew attributed to "overbooking." According to the flightcrew, the airplane was pushed back about 15 minutes late, but otherwise ground operations were routine. They received instructions to taxi to runway 30R for departure. At 2201, as the MD-82 taxied southeastbound on taxiway Papa, the first officer advised local control that they were ready for takeoff on runway 30R.

The Cessna 441 was registered to Garrett Aviation, Inc., and operated as a 14 CFR Part 135 on-demand charter aircraft by Superior Aviation, Inc., of Iron Mountain, Michigan. On

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[1]All times herein are central standard time unless otherwise noted.

the evening of the accident, the Cessna 441 had been scheduled to depart Iron Mountain between 1800 and 1830 with a charter passenger who was to be dropped off at STL. The passenger was late for the proposed departure time because she encountered snowy roads while en route to the airport. She arrived at the airport about 1900, and the flight departed shortly thereafter. The passenger stated that she had flown with the pilot frequently before the night of the accident, but indicated that she did not recognize the passenger who occupied the right seat. She reported that the flight from Iron Mountain to STL went quickly and seemed routine. She did business paperwork during the flight, and did not notice anything out of the ordinary.

Upon arrival in the St. Louis area, the pilot made a comment to the local controller about ". . . this radio . . . ." The local controller responded that the pilot's transmission was loud and clear. Several seconds later, the Cessna 441 pilot transmitted a garbled message, of which "I got you now . . . switch radios here" was discernable. The local controller then issued instructions to land on runway 30R. The Cessna 441 pilot's response was garbled.

The airplane landed on runway 30R uneventfully, and the local controller instructed the pilot to turn right at the intersection of the runway and taxiway November, and then to contact the ground controller. The Cessna 441 pilot reported clearing the runway to the local controller instead of the ground controller. The local controller then reiterated instructions to contact the ground controller.

At 2140:24, the pilot of the Cessna 441 contacted the ground controller and reported, ". . . clear goin to midwest." The ground controller stated, "November one Kilo Mike St. Louis ground taxi to Midcoast ramp." The Cessna 441 pilot replied "(unintelligible) one" and taxied to the Midcoast Aviation ramp. The airplane arrived at Midcoast Aviation to drop off the passenger about 2141. The pilot and the pilot-rated passenger helped the passenger with her bags, paid the landing fee at Midcoast, and prepared to depart for the positioning flight back to Iron Mountain. Midcoast personnel reported that the pilots appeared to be in a pleasant mood, but seemed eager to be on their way home.

At 2158, the pilot of the Cessna 441 advised ground control that he was ready to taxi. The ground controller issued taxi instructions to ". . . back-taxi[2] into position hold runway three one, let me know this frequency when you're ready for departure." The pilot acknowledged by stating "Kilo Mike."

At 2201:23, the local controller cleared the MD-82 for takeoff on runway 30R, with instructions to fly a heading of 335. The first officer confirmed the assigned heading, and the airplane taxied onto runway 30R. At 2202:29, the pilot of the Cessna 441 advised the local controller, ". . . Kilo Mike's ready to go on the right side." (See Appendix B for a complete ATC

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[2]Although not formally defined, a clearance to "back-taxi" on an active runway generally means to use that runway to taxi in a direction opposite that of departing or landing traffic to reach the takeoff position.

transcript.)

As the MD-82 began its takeoff roll, the first officer operated the flight controls, while the captain advanced and set the throttles. As the airplane accelerated on the runway, the captain made the 80-knot callout. About 2 to 3 seconds after the 80-knot call, the additional crewmember (ACM) who occupied the cockpit jumpseat yelled "There's an airplane!"

The captain and first officer reported that they saw the airplane on the runway in front of them at almost the same instant that the ACM alerted them. Both pilots applied the brakes, and the captain applied left rudder in an attempt to steer the airplane left to avoid the Cessna 441. Approximately 2 to 3 seconds after the flightcrew saw the Cessna 441, they felt an impact on the right side of their airplane. The flightcrew members reported that the impact did not adversely affect their ability to maintain directional control of the airplane. They continued to abort the takeoff, and brought the airplane to a stop on the left side of runway 30R near the intersection of taxiway November.

Ground scars and physical evidence indicated that the Cessna 441 was located almost directly on the runway centerline, and the MD-82 had veered slightly left of centerline when the collision occurred. The right wing of the MD-82 struck the tail cone and fuselage structure of the Cessna 441, separating the horizontal and vertical stabilizers from the fuselage and shearing the top of the fuselage/cockpit from the airplane. The Cessna 441 came to rest at the right side of runway 30R near taxiway Romeo, with the right engine still running. Airport Rescue and Fire Fighting (ARFF) personnel shut down the engine and secured the airplane.

According to the flightcrew members and ACM on board the MD-82, they did not observe the airplane or airplane position lights at any point during their takeoff roll. They stated that they first saw the airplane when it was illuminated by the lights from the MD-82. The pilots reported that, in accordance with normal procedure, the MD-82 had all external lighting on at the time of the accident. They reported that the runway lighting was normal for runway 30R at STL, and included runway edge, centerline, and touchdown zone lighting. (See Section 1.10, Airport Information, for the specific settings of the lighting systems.)

The accident occurred at N 38°44"9', W 90°21"6', during the hours of darkness.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Others	Total
Fatal	1*	1*	0	2
Serious	0	0	0	0
Minor	0	8**	0	8
None	8**	124**	0	132
Total	9	133	0	142

* On board Cessna 441

** On board MD-82

1.3 Damage to Airplane

The Cessna 441 was destroyed by the impact forces of the collision. The hull loss was approximately $1.2 million. The MD-82 received substantial damage to its right wing, landing gear, lower fuselage, and the right engine. The estimated cost to repair the airplane was $1.7 million.

1.4 Other Damage

There was no other damage.

1.5 Personnel Information

1.5.1 Trans World Airlines Crewmembers

The flight and cabin crews of the MD-82 were qualified in accordance with applicable Federal Aviation Administration (FAA) and company regulations and procedures. The examination of crewmember training records did not reveal anything remarkable. Further, the investigation of the background of the flightcrew did not reveal anything unusual. All crewmembers indicated that they felt well-rested on the evening of the accident.

1.5.2 Captain Information

The captain of the MD-82, age 57, held Airline Transport Pilot (ATP) Certificate No. 1521778 and was type-rated in fixed-wing (B727, B737, B747, DC-9, Learjet, and CE-500) aircraft. He also held a current FAA Class I Medical Certificate, issued in August 1994, with the limitation, "Holder shall wear corrective lenses while exercising the privileges of his airman certificate." His vision was listed as 20/100 in each eye corrected to 20/20 for distant vision, and 20/30 in each eye corrected to 20/20 for near vision. He was hired by TWA in October 1965. At the time of the accident, the captain had accumulated approximately 18,651 hours of total flight time, of which 3,178 hours were logged in the DC-9/MD-82 aircraft. He worked in the company training center from 1987 to 1993, and was involved in developing and instructing the crew resource management course. His last proficiency check was accomplished in July 1994, and his last line check was accomplished in November 1994. The captain had accrued about 34 hours of flight time in November, and over 168 hours in the 90 days before the accident.

1.5.3 First Officer Information

The first officer of the MD-82, age 38, held ATP Certificate No. 2239191. He also held a current FAA Class I Medical Certificate issued in February 1994 with no limitations or waivers. His vision was listed as 20/20 without correction for both distant and near vision. At the time of the accident, the first officer had logged approximately 10,353 hours total flight time, of which 251 hours were logged as first officer in the DC-9/MD-82 aircraft. His last proficiency check was accomplished in June 1994, and his last line check was accomplished in

July 1994. The first officer had accrued about 56 hours of flight time in November, and approximately 153 hours in the 90 days before the accident.

1.5.4 Cessna 441 Pilot

The pilot of the Cessna 441 was qualified in accordance with applicable FAA and company regulations and procedures. Investigation of his background did not reveal anything remarkable. The pilot, age 56, held Commercial Pilot Certificate No. 1596566. He possessed a current FAA Class II Medical Certificate, issued in February 1994, with the stated limitation, "Holder will wear corrective lenses while exercising the privilege of his airman certificate." His vision was listed as 20/100 in each eye corrected to 20/20 for distant vision, and 20/20 in each eye without correction for near vision. According to logbook and company records, the pilot had accumulated 7,940 hours of total flight time, including 2,060 hours in the Cessna 441. His last proficiency check was accomplished in the Cessna 441 in November 1994. The pilot had accumulated about 64 hours in the preceding month, and approximately 155 hours in the 90 days before the accident.

The Cessna 441 pilot's flight logbook records indicated that he had flown into STL once before during the preceding 7 years. The previous flight into STL had been a daytime operation and had occurred in January 1994.

The Safety Board conducted interviews with the pilot's wife, Superior Aviation personnel, and the passenger who had chartered the Cessna 441 to STL before the accident flight. These interviews revealed that the Cessna 441 pilot was known as a conscientious, safety-oriented pilot. The passenger stated that the pilot had flown many of the flights that she had chartered. She stated that the pilot habitually held the airport diagrams on his lap for reference during ground operations. She described one charter flight during which the pilot became unsure of his position on an airport; he stopped the airplane, and did not proceed until he was sure where he was.

The pilot's wife stated that the pilot usually arose between 7 and 8 a.m., and went to bed between 10 and 11 p.m. She reported the pilot also frequently took a nap in the early afternoon. The pilot's work/rest cycle for the 4 days before the accident, as described by his wife, conformed with this schedule. The pilot's wife reported that on the day of the accident, the pilot had taken a nap early in the afternoon. On the evening of the accident, the pilot was observed to be in good humor, and accomplished his duties in a normal manner. The passenger and Midcoast personnel stated that although the pilot did not seem unduly rushed to leave STL, he mentioned that it was going to snow in Iron Mountain, and they needed to be on their way.

1.5.5 Cessna 441 Pilot-rated Passenger

The private pilot-rated passenger on board the Cessna 441, age 43, was a professional accountant with a private pilot certificate, whose wife worked as a receptionist at Superior Aviation. He was riding in the right seat of the Cessna 441 for unofficial familiarization.

His presence was not required for the flight.

1.5.6 STL Air Traffic Control Specialists

The air traffic control (ATC) specialists who provided ATC services to the airplanes were qualified in accordance with current procedures. Examination of their training records revealed nothing remarkable. In addition, the investigation of these controllers' backgrounds and their activities in the 3 days before the accident did not reveal anything extraordinary.

1.5.7 STL Local Controller

The local controller, age 35, was hired by the FAA in January 1984 as an ATC specialist. She had served previously as an air traffic controller in the U.S. Air Force. Within the FAA, her initial assignment was to the St. Louis Downtown Parks Airport. In July 1990, she was transferred to STL, where she has remained employed as a controller. She achieved Full Performance Level status in May 1991. She held a current FAA Class II Medical Certificate, issued in April 1994, with no limitations or waivers noted.

1.5.8 STL Ground Controller

The ground controller, age 29, was hired by the FAA in July 1988 as an ATC specialist. He had served previously as an air traffic controller in the U.S. Air Force. Within the FAA, his initial assignment was to the Des Moines International Airport, where he achieved Full Performance Level status in October 1990. He transferred to STL in July 1993, where he achieved Full Performance Level status in April 1994. He held an FAA Class II Medical Certificate issued in June 1994 with no limitations or waivers noted.

1.6 Airplane Information

1.6.1 McDonnell Douglas MD-82

The MD-82, N954U, was certificated for transport-category flight on January 15, 1988, and was configured for two flightcrew members, with seats for five flight attendants and 132 passengers. The airplane was powered by two Pratt and Whitney JT8D turbofan engines.

Discrepancies noted in the airplane maintenance logs were either repaired or deferred to Minimum Equipment List/Cabin Discrepancy Listing (MEL/CDL). No noteworthy MEL discrepancies were found in the airplane maintenance log. No windshield deficiencies were noted during the postaccident inspection.

1.6.2 Superior Aviation Cessna 441

The Cessna 441, N441KM, was certificated for flight on February 12, 1988. The

Cessna 441 airplane, which is certificated for single-pilot operations, is a mid-range, light-twin turboprop airplane. Cessna 441s are powered by two Garrett Airesearch TPE-331 engines, which are mounted on the wings.

The airplane's maintenance log did not reveal any discrepancies. External lighting on the Cessna 441 consisted of wing-mounted retractable landing lights, a nose gear-mounted taxi light, strobe lights, red and green wing tip-mounted navigation lights, and a white tail cone-mounted navigation light. Superior Aviation procedures required that illumination of the strobe, taxi, and landing lights take place after receipt of a takeoff clearance.

1.7 Meteorological Information

The STL surface weather observation taken at 2151 indicated clear skies, with 25 miles visibility. The temperature was 33 °Fahrenheit (F), and the dew point was 22 °F. Winds were out of 270° at 8 knots, and the barometric pressure was 30.56" Hg.

A special weather observation taken after the accident, at 2242, was identical to the 2151 observation, except the temperature was recorded as 32 °F, and the remarks section stated "ACFT MISHAP." The STL hourly surface weather observation taken at 2250 indicated that skies were clear, with visibility of 25 miles. The temperature was 32 °F, dew point was 22 °F, and winds were out of 270° at 7 knots. Passengers from the MD-82, ARFF personnel, and pilots who operated in the STL area at the time of the accident reported that weather conditions and visibility were good.

1.8 Aids to Navigation

No navigational equipment outages or discrepancies were noted in the St. Louis facilities log that would have contributed to this accident.

1.9 Communications

Postaccident examination of the ATC very high frequency (VHF) transmitter and receiver equipment found that all equipment was operating within specifications.

Ground and local controllers indicated that the workload was moderate at the time of the accident. The night of the accident, the ground controller was working four positions,[3] each of which is staffed by a separate controller when the tower is operating at full complement during peak traffic. When working these positions, the controller was monitoring seven different frequencies. These combined positions with multiple frequencies created a situation in which a pilot transmitted and received on a specific frequency, depending on the service required, while

[3]The ground controller was working ground control for both the north and south sides of the airport, clearance delivery, and flight data.

the controller transmitted on all of the frequencies for which he was responsible.

Interviews with the MD-82 flightcrew members indicated that the use of combined positions/multiple frequencies occasionally resulted in difficulties. These reported problems included incomplete communications due to pilots' transmissions being "stepped on" by other pilots, increased controller workload, communication delays and confusion, and potential decreased pilot situational awareness. A review by the Safety Board of 1 1/2 hours of ATC tapes from the evening of the accident revealed several instances of simultaneous transmissions.

As the Cessna 441 was inbound to STL, there were several cases of garbled, unintelligible, or partial transmissions between the Cessna 441 and the ATC tower. At one point, the pilot of the Cessna 441 stated ". . . got you now . . . switch radios here . . . ." Several subsequent transmissions from the Cessna 441 were also distorted, but most of the Cessna's outbound transmissions to ATC were clear. Postaccident examination of the Cessna 441 communication radios revealed that they were capable of normal operation.

1.10 Airport Information

The STL airport is owned and operated by the City of St. Louis Airport Authority. The airport is located in Bridgeton, Missouri, approximately 12 miles northwest of St. Louis, and has an airport elevation of 605 feet. (See Figure 1.)

STL has five runways, three of which are parallel paved surfaces. Runways 12R/30L (11,019 feet x 200 feet) and 12L/30R (9,003 feet x 150 feet, the accident runway) are grooved concrete surfaces, with high intensity runway lights (HIRL). Parallel taxiway Foxtrot was converted to a runway (13/31) in 1988. Runway 13/31 is a 6,289 feet x 75 feet paved surface located northeast of runway 12L/30R. The first 3,989 feet of Runway 13 is asphalt, and the remaining 2,300 feet is concrete. It has medium intensity runway lights (MIRL), and is restricted to use by aircraft 12,500 pounds or less. Runway 31 is used as a "departure only" runway. However, runway markings indicate a 1,838-foot displaced threshold.

The Midcoast Aviation general aviation ramp is located northeast of runway 13/31. Taxiway Whiskey is about 150 feet long, and extends perpendicular to runway 31 between the Midcoast Aviation ramp and runway 31. Taxiway Romeo is perpendicular to the parallel runways at the approach end of runway 31. The taxiway Romeo centerline is approximately 2,500 feet from the approach end of runway 30R. Taxiway November is also perpendicular to the parallel runways, and its centerline is located approximately 4,500 feet from the approach end of runway 30R, about 2,000 feet from taxiway Romeo. (See Figure 2.)

Tower personnel reported no known difficulties with runway and taxiway lighting systems before, or at the time of, the accident. They reported that the runway 30R HIRL, centerline lighting, and the Medium Intensity Approach Lighting System with Runway Alignment Indicator Lights (MALSR) system were illuminated at the Step 3 (of five) intensity level, while the runway 31 MIRL were illuminated at the lower Step 1 (of three) intensity level. The tower

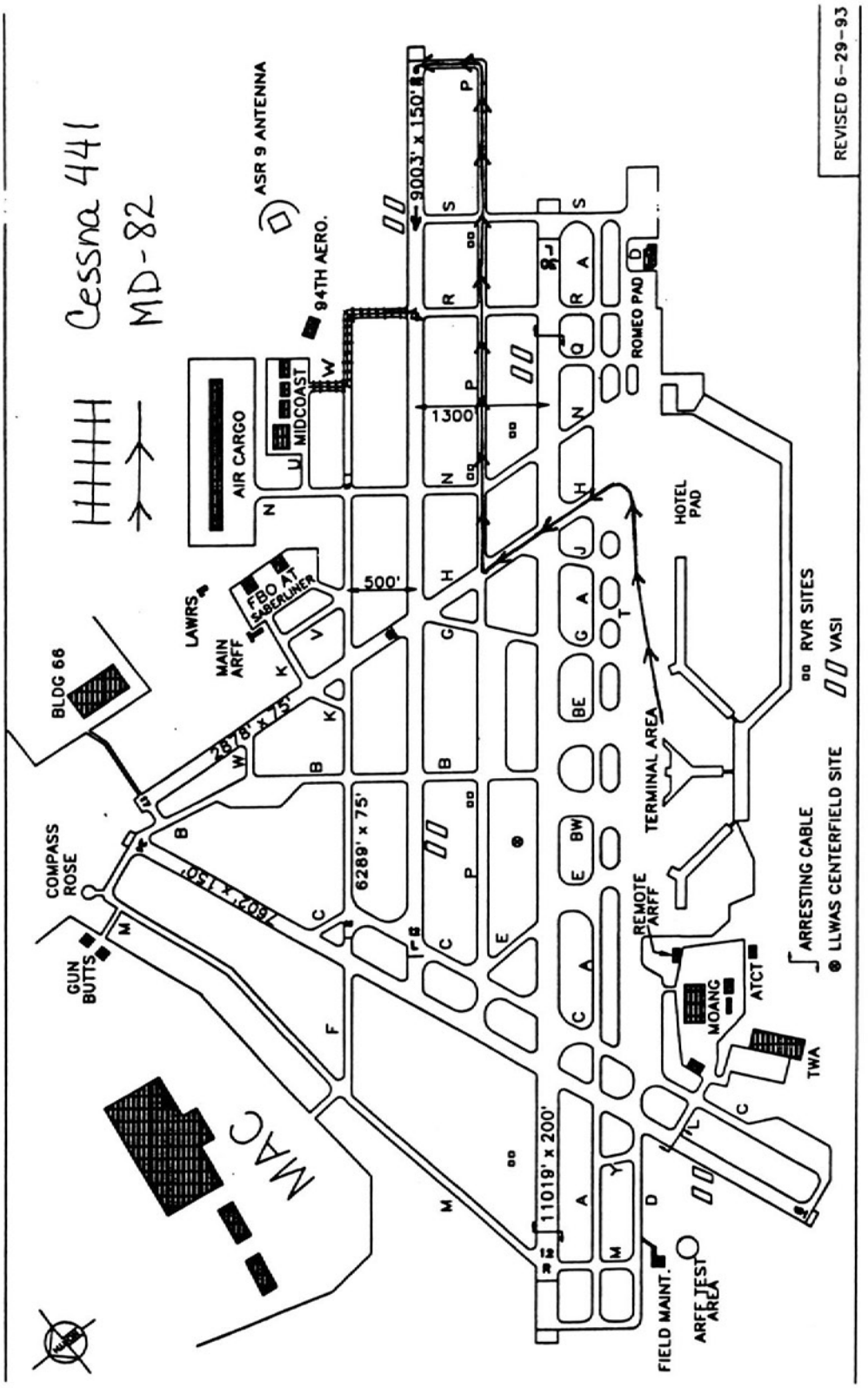

Figure 1--Lambert-St. Louis International Airport Diagram

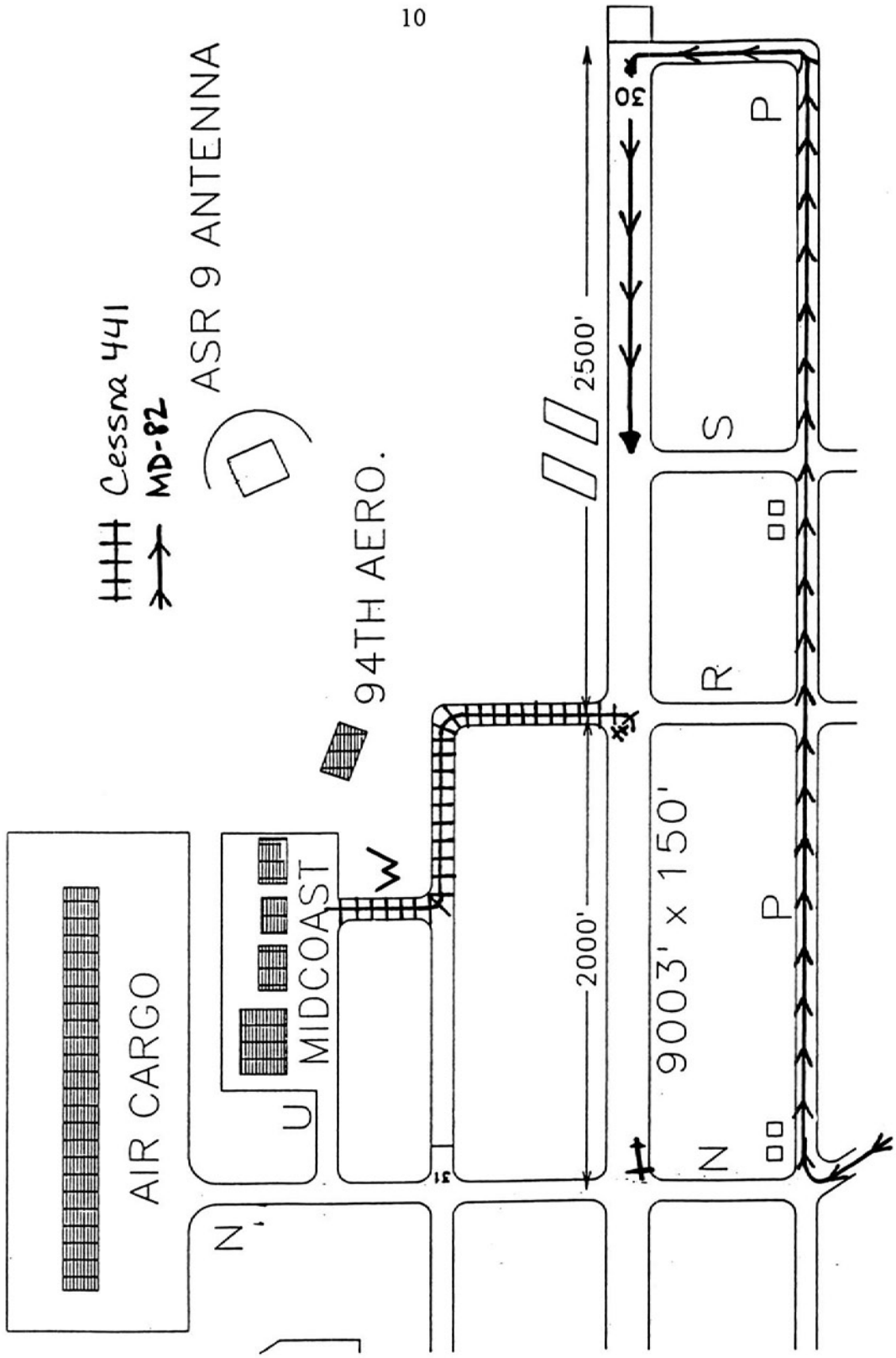

Figure 2--Lambert-St. Louis International Airport Diagram (Northeast Side)

controller stated that at these settings, the runway 30R runway lights were brighter than the runway 31 lights.

A review of airport facility maintenance and ATC tower logs found no reported difficulties with the runway/taxiway lighting systems before the accident. A search of the National Aeronautics and Space Administration's Aviation Safety Reporting System runway incursion reports revealed no pertinent reported events at STL. No significant notices to airmen were issued for the airport during the accident time period.

1.10.1 Airport Signs, Markings and Lighting

The Safety Board's examination of the airfield signs, markings, and lighting near and along the taxi route taken by the Cessna 441 revealed that they conformed to FAA standards. The Safety Board noted that upon exiting the Midcoast ramp area, there were three signs indicating runway 31 on the left side of the entrance to taxiway Whiskey. The furthest sign on the left side of the taxiway was installed in compliance with the FAA's revised (July 31, 1991) signage requirements, but was not yet in full service and was not lit. Behind this sign and slightly to its left was the in-service hold position sign. To the right of the two hold position signs was a wooden sign that read "ACTIVE RUNWAY CONTACT TOWER 121.9." (See Figure 3.)

Airport personnel told Safety Board investigators that the hold position signs for runway 13/31 were observed to be not internally illuminated during the hours following the accident: one sign had an inoperative light bulb, and one sign hadn't been hooked up to power. To simulate the signage conditions that the pilot of the Cessna 441 may have encountered the night of the accident, the Safety Board observed the signs at night, without internal illumination. Investigators noted that the three signs were clearly visible in the ambient light from the Midcoast ramp flood lights.

Investigators also noted that all taxiway markings, hold position markings, and displaced threshold markings for runway 31 were visible as they traveled from the Midcoast ramp to runway 30R, via taxiway Romeo. The yellow hold position markings on taxiways Whiskey and Romeo were highlighted in black to enhance the visibility of the markings. The runway 12L/30R hold position sign at taxiway Romeo had one inoperative light bulb on the right side of the sign. Investigators noted that the sign was clearly visible.

1.10.2 Runway 31 Information

In 1986, due to increased traffic activity and consequent delays, the STL Airport Authority temporarily established taxiway Foxtrot as runway 13/31, to be used for departures only. Despite this landing prohibition, an 1,838-foot displaced threshold was incorporated into the runway 31 marking scheme. Runway 13/31 was to be used for day, visual flight rules (VFR) operations by commuter and general aviation aircraft.

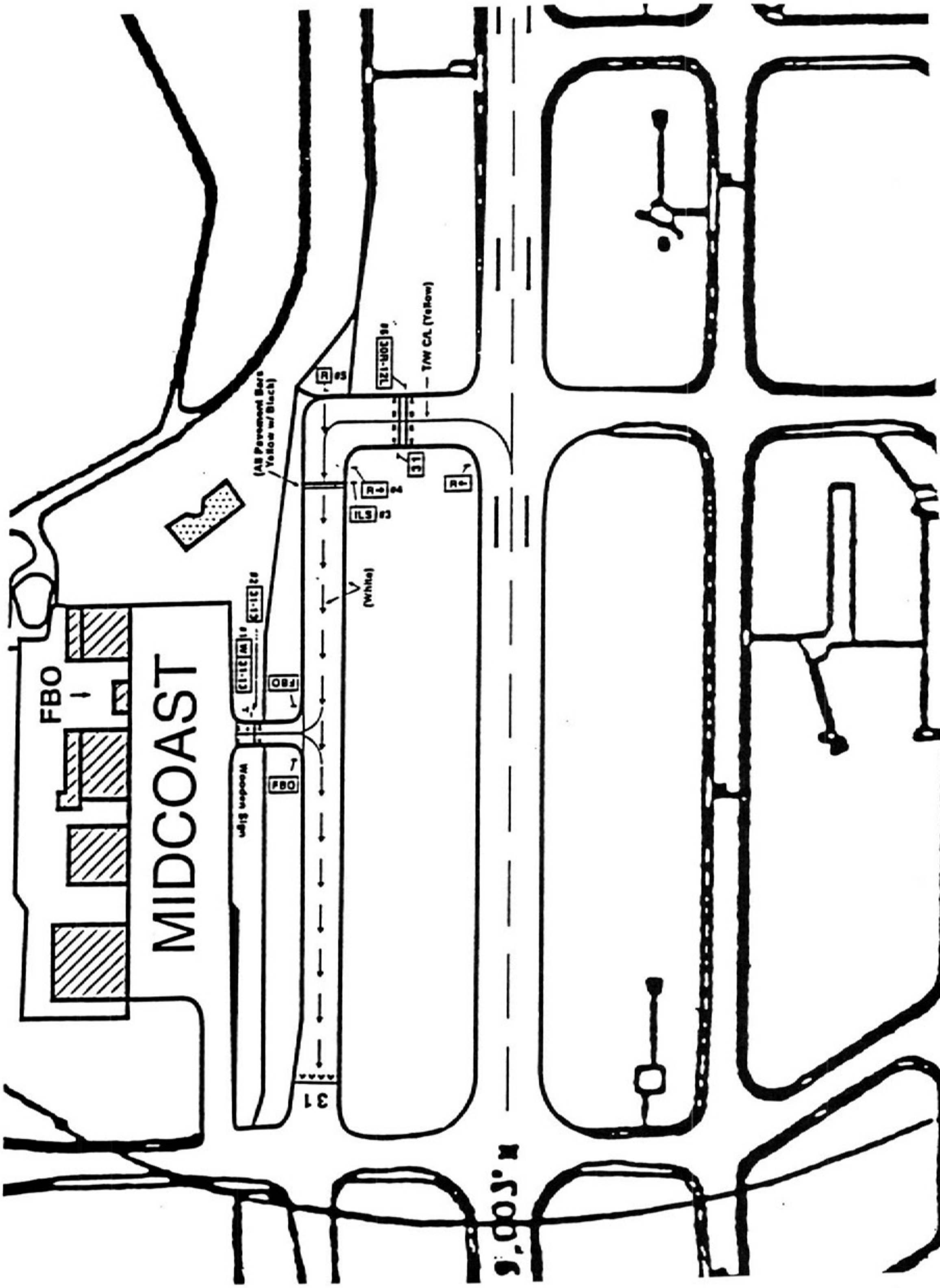

Figure 3--Airfield Signs Near and Along Midcoast Ramp and Taxiways Whiskey and Romeo

The runway 13/31 trial program was successful at reducing delays, and in 1988, the STL airport moved to make the conversion permanent. Conversion was completed in 1989, and included the signage, surface markings, and lighting required to identify it as a runway for day and night use. Pavement markings for the displaced threshold remained in place on the runway, and the landing prohibition remained.

In 1991, three incidents of air carrier aircraft mistaking runway 13 for runway 12L resulted in a plan to operate the runway 13/31 MIRL at an intensity setting lower than the runway 12L/30R HIRL. According to the tower supervisor and the local controller, the tower procedure is to turn the runway 13/31 lights to a higher intensity when a departing aircraft begins its takeoff roll and to turn the lights back down to the dimmer setting as soon as the aircraft is airborne. The local controller stated that the runway 31 lights were not turned up on the night of the accident.

According to STL ATC personnel, the majority of the time runway 13/31 is inactive, under the jurisdiction of the ground controller, and is used as a taxiway. This differs from most runways in that runways are usually under the jurisdiction of the local controller.

1.10.3 Postaccident Airport Changes

Following the accident, the STL Airport Authority installed taxi-holding position lights ("wig-wag" lights) at taxiway Whiskey to further enhance and delineate the presence of runway 13/31 for aircraft exiting the Midcoast ramp.

The STL Airport Authority also petitioned for and received approval to eliminate the 1,838-foot displaced threshold on runway 31. The STL Airport Authority anticipates that all displaced threshold runway markings will be removed and that runway 31 will be reopened full length for use by September 1, 1995.

1.10.4 ATC Tower

The ATC tower, operated by the FAA, is a tower cab facility, collocated with a Terminal Radar Approach Control (TRACON) facility. FAA statistics rank the STL ATC facility as the 14th busiest in the country. The tower structure is located on the southwest side of the runway complex and terminal buildings, about 1 1/4 miles from the site of the collision (see Figure 1).

During interviews, tower personnel stated that the Cessna 441 was visible while it was on the Midcoast ramp. They stated that when the airplane moved from the well-lighted ramp area toward runway 31, it was no longer visible. Tower personnel indicated that it was often difficult to see small airplanes operating on the north side of the airport, especially on the far end of runway 31, at night.

The facility has Airport Surface Detection Equipment (ASDE-3) radar to monitor

airplane activity on the ground (also see Section 1.18.3). The ASDE-3 was installed at STL in September 1994, and was going through its "proving period" before being commissioned. During this proving period, the equipment was occasionally used by controllers for familiarization when it was available. The ASDE-3 equipment was not available on the night of the accident because the computer hard drive had failed. Subsequent to the accident, the ASDE-3 at STL has been commissioned.

The ATC tower has 10 positions of operation that may be combined or separated as traffic conditions permit. On the night of the accident, two controllers were in the cab: the local controller (LC) and the ground controller (GC). The ground controller was assuming the duties for positions of flight data clearance delivery as well as ground control for both the north and south sides of the airport. The controller was monitoring the frequencies normally used for these different positions. The supervisory air traffic controller's scheduled shift ended at 10 p.m. He told investigators that he left the tower cab at 9:45 p.m. and went to a downstairs office to process paperwork. At the time of the accident, he was on his way home.

1.10.5 Postaccident ATC Scheduling Changes

At the time of the accident, it was standard staffing practice at STL to have two controllers on duty between 10 p.m. and midnight. ATC personnel stated that this was normally a period with little traffic, except for a "bank" of traffic between 9:45 and 10:15 p.m. Subsequent to the accident, the STL ATC tower staffing schedule was changed to retain an additional controller until 10:30 p.m. The supervisor's duty time has also been changed to have him remain in the facility until 10:30 p.m.

1.11 Flight Recorders

The Cessna 441 was not equipped with a cockpit voice recorder (CVR) or flight data recorder (FDR), nor was it required to be so equipped under current Federal Aviation Regulations.

The MD-82 was equipped with a Fairchild Model A-100 CVR, S/N 3455. Its magnetic tape provided a record of ATC and intracockpit communications. A transcript of the CVR is provided in Appendix C.

The MD-82 was also equipped with a Sundstrand Model 573 digital FDR, S/N 2432. A printout of selected parameters is provided in Appendix D.

Playback data indicated the following trends moments before the end of the recording:

1. The data were consistent with a normal takeoff roll until 2202:45. Beginning at 2202:45, there were rudder, brake, heading, and vertical and longitudinal acceleration excursions.

2. The slat disagree sensor transitioned from "agree" to "disagree" at 2202:47.

3. Peak airspeed value was 114.5 knots, recorded at 2202:50. Both thrust reversers were deployed at 2202:52.

4. The airplane decelerated to a stop at 2203:10.

1.12 Wreckage and Impact Information

All wreckage was located on runway 30R between taxiways Romeo and November. (See Figures 4 and 5.) The first item in the wreckage path was a 2-foot section of the rudder from the Cessna 441. Approximately 350 feet farther, the main portion of the Cessna 441 was located on the north edge of the runway on a heading of about 320°. Fragments of the upper cabin and empennage were scattered in the vicinity.

Approximately 1,450 feet farther, the MD-82 was located on the south edge of the runway on a heading of about 300°. Black rubber skid marks started about 75 feet east of the Romeo intersection and led down the runway to the location of the MD-82. Another set of skid marks began at the intersection and led to the location of the Cessna 441.

The physical evidence indicated that the collision occurred on runway 30R at its intersection with taxiway Romeo, approximately 2,500 feet from the approach end. Two pairs of airplane tire scuff marks were on the runway. The between-tire distances for each of the pairs corresponded to the distance between main landing gear on the MD-82 and Cessna 441. The geometry of the collision indicated that both airplanes were on the runway heading at impact.

1.12.1 Cessna 441 Wreckage Information

The airplane remained on its extended landing gear, with the two main gear tires inflated. The nose gear tire was deflated, and its strut was bent slightly aft. The left engine had pulled forward slightly from its mounts, and rested with its propeller blades and spinner on the pavement. Two of the engine's propeller blades were bent forward and exhibited severe leading edge damage and chordwise scratches. The right engine remained in its normal position on the wing, and was still running when ARFF personnel arrived at the airplane after the collision. Jagged leading edge damage was evident on all three propeller blades on the right engine, with two blades bent forward.

The upper fuselage was sheared off approximately 2 inches above the bottom of the cabin windows from the tail section to the windscreen. The outboard 7 1/2 feet of the left wing had separated. Separations at the left wing, all window frames, and cabin structure exhibited forward bending. Scrapes and indentations across the upper surface of the left wing, the left engine nacelle, and the instrument panel were angled 14 to 15° from the longitudinal axis of the airplane.

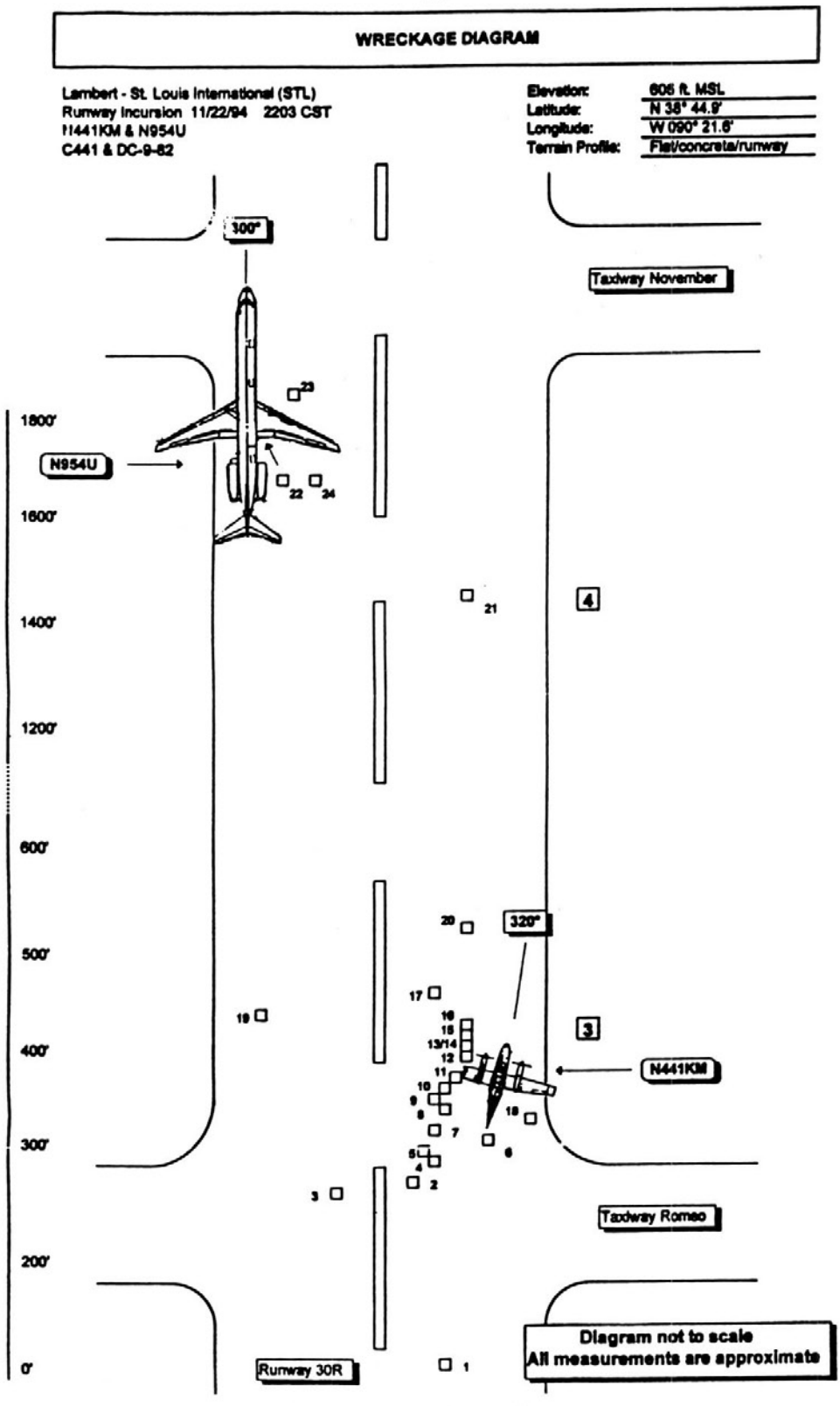

Figure 4--Wreckage Diagram

Wreckage Distribution Diagram

1. [N441KM] Top of rudder (two foot section)
2. [N441KM] Gray headrest
3. [N954U] Gear door section (twelve inch foot by eight inch section)
4. [N954U] Number two flap hinge mechanism cover (aft section)
5. [N441KM] Tail section (root faring)
6. [N441KM] Tail cone with navigation light
7. [N441KM] Right elevator (five foot outboard section)
8. [N441KM] Top cabin door section (upper half)
9. [N441KM] Left wing tip
10. [N441KM] Vertical stabilizer and rudder
11. [N441KM] Cabin oxygen outlet box
12. [N441KM] Cabin section (one foot by two foot)
13. [N441KM] Left horizontal stabilizer (two foot inboard section)
14. [N441KM] Overhead duct (twelve inch section)
15. [N441KM] Cabin vent outlet
16. [N441KM] Upper cabin section exhibiting accordion type buckling
17. [N441KM] Left elevator section (aft outboard section with weight)
18. [N441KM] Left elevator section (aft inboard section with two foot trim tab setting
19. [N441KM] Cabin door actuator
20. [N441KM] Magnetic compass
21. [N954U] Number three leading edge slat
22. [N441KM] Left horizontal stabilizer section
23. [N441KM] Left outboard wing section (fractured 7.5 feet outboard of the number one engine nacelle) found wrapped around right main gear of N954U
24. [N441KM] Wreckage from N441KM in N954U right wing leading edge
    a. Upper cabin structure
    b. Window frames
    c. Windscreen center post and frame sections
    d. Number two seat sun visor
    e. Window curtain sections
    f. Tail section inspection plate

Figure 5--Wreckage Distribution Diagram

The aft empennage was buckled and bent to the right; the entire empennage showed compression damage from the aft direction. The rudder was separated from the airplane. The vertical and horizontal stabilizers were fractured at their main attach points.

During the initial on-scene examination, the two wing-mounted retractable landing lights were found in their stowed positions. The left navigation/strobe clear cover was missing, and the anticollision/strobe light was broken. The right navigation, right anticollision/strobe, tail navigation, and nose gear taxi lights were undamaged. All external lighting cockpit switches were found in their off (down) positions, except the nose gear taxi light, which was found in the on position. ARFF personnel stated that they altered switch positions during their attempt to shut off the right engine.

Components of two headsets were in and around the airplane, and the cords were plugged into their respective receptacles. A pair of eyeglass frames were in the pilot's seat. Several loose pages of Jeppesen approach charts were located in the cockpit area, including the current STL airport diagram (Copyright 1994 Jeppesen Sanderson, Inc.), dated June 3, 1994. (See Figure 6.)

1.12.2 MD-82 Wreckage Information

The MD-82 sustained damage to the right wing leading edge devices, flaps, upper surfaces, lower surfaces, and forward spar. The wing damage area included numerous lateral slashes, surface scratches, and red, white, and blue paint smears similar to the color scheme of the Cessna 441. Scratches and smears were parallel to the longitudinal axis of the airplane. Wing damage resulted in approximately 600 gallons of fuel spilled.

The right main landing gear, the right lower fuselage, and the number two engine were also damaged. Plexiglass and metal debris from the Cessna was embedded in the MD-82. The largest piece of Cessna debris directly associated with the MD-82 was the outboard section of the left wing, which was wrapped around the right main landing gear strut.

1.13 Medical and Pathological Information

The MD-82 flightcrew submitted to toxicological tests in accordance with the FAA's drug testing regulations and company policy. There was no evidence of alcohol or other major drugs of abuse in either crewmember.

The pilot and pilot-rated passenger on board the Cessna 441 died of severe craniocerebral injuries. Blood and urine specimens obtained from the pilot-in-command and the pilot-rated passenger on board the Cessna 441 were examined by the FAA's Civil Aeromedical Institute for toxicological analysis. All specimens tested negative for alcohol or drugs.

Under the FAA drug testing program, the ATC local controller provided a urine sample for testing. No positive results were reported to the NTSB, as required by Federal

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statutes should positive results be found. The FAA did not perform drug testing on the ground controller. Both controllers declined to provide voluntary blood and urine samples for a more extensive drug screen as requested by the Safety Board.

1.14 Fire

Neither airplane was involved in a fire.

1.15 Survival Aspects

The headrests on cabin and cockpit seats on the Cessna 441 were separated or bent forward, at the same level that the upper cabin structure was sheared off. This accident was not survivable for the occupants of the Cessna. The MD-82 cockpit and cabin were not damaged, and no occupants of this airplane were injured during the collision.

1.15.1 Evacuation

As the MD-82 came to a stop on the south side of runway 30R after the collision, the captain shut down the engines, and advised ATC to, ". . . roll the emergency equipment. TWA four hundred and twenty seven hit the other airplane on the uh, runway. Roll the emergency equipment."

The flightcrew stated their evaluation of the situation revealed no fire, or imminent danger of fire, but a substantial amount of fuel was leaking from the right wing. The captain exited the left front (L1) door to further assess the situation. He noted that due to the slope of the runway, the fuel was running under the fuselage and pooling under the left side of the MD-82. He instructed the first officer to evacuate the passengers through the right front (R1) door to minimize passenger contact with the pooling fuel. The right overwing and aft exits were not used due to impact-related structural damage.

The flight attendants told Safety Board investigators that during the 2 to 3 minute delay while the flightcrew evaluated the situation, they were able to reassure and calm most passengers, which smoothed the evacuation process. They described the evacuation through the single door as orderly and calm. The average estimate of the duration of the evacuation was 7 minutes. After all passengers were evacuated, the flight attendants exited, followed by the first officer.

1.15.2 Emergency Response

Seconds after the collision, ATC notified ARFF personnel that an accident had occurred on the airport. The first of the airport's emergency vehicles arrived at the MD-82 within 2 to 3 minutes of the collision. ARFF personnel stated that when they arrived at the MD-82, they evaluated the situation and began applying fire retardant foam to both sides of the airplane and to the pooling fuel on the ground. They estimated that approximately 30 seconds after the

foam application was initiated, they saw the R1 door open, the emergency evacuation slide deploy, and the passenger evacuation begin. Several firefighters positioned themselves at the bottom of the R1 slide to catch and assist the passengers as they left the airplane. The captain and the ACM were also positioned near the bottom of the R1 slide directing passengers away from the airplane as they evacuated. About 35 minutes after the collision, buses arrived to transport the evacuated passengers back to the terminal area.

ARFF personnel located the Cessna 441 about 1 to 2 minutes after their first vehicles arrived at the MD-82. ARFF personnel reported that when they reached the second airplane, the top portion of the airplane was missing, fuel was leaking from the wreckage, and the right engine was still operating. They applied fire retardant foam to the right engine until it shut down, and applied foam to the leaking fuel. They shut off electrical power to the airplane by disconnecting the battery in the nose compartment. One firefighter boarded the Cessna 441 in an effort to assist the occupants.

Ten ARFF vehicles responded to the two airplanes. They reported that a large amount of Jet A aviation fuel was spilled on the runway and the grassy area adjacent to it as a result of the collision. They stated that a real fire hazard existed, the evacuation of the MD-82 was necessary, and the evacuation appeared orderly and timely.

1.15.3 Emergency Airport Closure

In the minutes after the ground collision, several taxiing aircraft and numerous emergency rescue vehicles were moving on the airport surface. When the evacuation began, pilots of the taxiing airplanes told the ground controller that they saw passengers wandering in the vicinity of the intersection of runway 30R and taxiway November. These pilots expressed concern that the evacuated passengers might wander into other operating aircraft. About seven minutes after the collision, Federal Express flight 1283 landed on runway 30L without incident. About seventeen minutes after the accident, the ground controller told aircraft on his frequencies that operations at the airport were suspended. The STL Airport Authority, which has jurisdiction over airport operations, did not officially close the airport after the collision.

1.16 Tests and Research

Safety Board investigators conducted tests regarding the visibility and conspicuity of the Cessna 441 from the ATC tower and from the approach end of runway 30R.

1.16.1 Night Conspicuity Tests

On November 24, 1994, a lighting and conspicuity exercise was conducted to observe the ease or difficulty in visually acquiring a general aviation airplane from the cab of the ATC tower. This exercise took place at approximately the same time in the evening as the accident, under similar weather conditions. Two observers in the ATC tower cab occupied a position near the local control position. To simulate the Cessna 441, a (slightly larger) Beech

King Air 200 was towed from the Midcoast Aviation ramp, via runway 31 and taxiway Romeo, to a takeoff position on runway 30R at its intersection with taxiway Romeo. Observations were taken at different points along the route with the airplane using different combinations of lighting. Runway lighting was set at step 1 for runway 31, and step 3 for runway 30R, as it was on the night of the accident.

During the airplane conspicuity test, observers noted that the airplane navigation lights were of little use for detection when viewed against other lights in the runway environment. When the airplane was positioned for takeoff, the single red navigation light visible from the tower blended into the other red lights in the environment. Even the taxi lights were only visible during the arc of movement as the airplane turned onto the runway. When the airplane was positioned for takeoff, the taxi light was slightly brighter, but still blended easily into other runway lights. Observers reported that the taxi light was of some value for visibility when the airplane was taxied quickly, but was of little value when the airplane taxied slowly. Only the wing-mounted high-energy anticollision/strobe lights were effective at improving airplane conspicuity.

During conspicuity tests, observers noted that the landing lights were effective for visibility in any situation or with any combination of other lights. When the landing lights were turned off, the airplane was often difficult to observe, even to observers who knew its approximate position.

1.16.2 Runway Visibility Tests

A runway visibility test was conducted to examine the line-of-sight visibility the MD-82 pilots may have had to the Cessna 441 when both airplanes were positioned for takeoff on runway 30R. To simulate the view of the MD-82 pilots, an airport rescue vehicle with an adjustable platform arm was positioned on runway 30R, with the platform set at the approximate height and runway location of the MD-82 cockpit. A test airplane, similar in size to the Cessna 441, was taxied from the Midcoast general aviation ramp, via back-taxi on runway 31 and taxiway Romeo to a takeoff position on the centerline of runway 30R at its intersection with taxiway Romeo. Visual observations were made during afternoon daylight and clear weather conditions.

The observations revealed that the test airplane (substituted for the Cessna) was visible from the time it entered the runway 31 environment up to and including the time it was in position on runway 30R. While the test airplane was in takeoff position, it was visible from the point where the tires touched the pavement to the top of the tail. There were no apparent physical obstructions to visibility. Observers noted that the airplane presented a very small target on the runway because of the small cross section when it was oriented for takeoff.

1.16.3 Recorded Radar Data

Recorded radar data from the STL radar site was reviewed by the Safety Board.

These data were used to produce a plot of the Cessna 441's ground track between 2158:14 and 2204:43. Secondary data indicated that the Cessna 441's transponder was turned off at 2143:06, and turned back on at 2156:24. The airplane taxied to the intersection of taxiway Romeo and runway 30R, where it remained for about 3 minutes before the collision. (See Appendix E.)

1.16.4 Lighting Components, Cessna 441

Selected external lighting components were retrieved from the wreckage of the Cessna 441 and examined by the Safety Board's Materials Laboratory. The filaments of the bulbs removed from the left navigation and left landing lights, and the tail light positions were stretched. Brittle fractures were apparent from fragments of filaments from the right navigation and landing light positions. Emergency response personnel reported that the nosewheel taxi light was illuminated when they arrived at the airplane.

1.16.5 Communication Radios, Cessna 441

The two communication radios on the Cessna 441 were examined at the Collins Commercial Avionics facility in Melbourne, Florida. Both radios were operative and functioned within the prescribed limits described in the manufacturer's production test procedure. Two discrepancies were noted:

1. The number one communication radio transmit light was inoperative.
2. The number two communication radio tune button was missing.

No physical evidence of preimpact discrepancy was found in the remaining components of the Cessna's communication radio installation. Impact damage precluded additional systems testing.

1.16.6 MD-82 Accelerate-Stop Data

Accelerate stop data provided by McDonnell Douglas indicate that the MD-82 could have begun its takeoff roll, accelerated to 114 knots, aborted the takeoff, and come to a complete stop within 4,600 feet. (See Appendix F.)

1.17 Organizational and Management Information

1.17.1 Superior Aviation

Superior Aviation began operations as a certificated Part 135 air taxi service on January 30, 1978. The company operation consisted primarily of "on-demand" cargo flights, feeding freight into hub airports for United Parcel Service, Federal Express, etc. These flights were bid and contracted, with scheduled route structures. The company also operated occasional on-demand air taxi passenger flights.

At the time of the accident, Superior Aviation owned 31 airplanes, ranging in size from the Beech 95 to the Swearingen (SA) 226. The company employed 38 pilots, used primarily for single-pilot operations. All of the pilots were qualified to fly as captains in one or more of the airplanes. Pilot turnover was characterized as low during the preceding 2 years.

Most of the pilots and airplanes were based at one of the company's two main bases of operation, in Iron Mountain and Lansing, Michigan. However, the company frequently shifted airplanes and pilots to other temporary duty locations to accommodate cargo contracts and schedules.

The company officers included a President/Owner; a General Manager/Director of Operations; a Director of Maintenance; and a Chief Pilot. The company's training facility and training records were located in Lansing, Michigan, while maintenance operations and documents were located in Iron Mountain. The FAA principal operations inspector (POI) reported that Superior Aviation had a good safety and training record, and reported that the company was responsive to FAA guidance.

Superior Aviation required its pilots to either file an IFR or VFR flight plan, or accomplish flight following by telephone contact with the company. The company provided its pilots with Jeppesen chart subscriptions/updates.

1.18 Additional Information

1.18.1 Automatic Terminal Information Service (ATIS)

The ATIS is a recorded message repeatedly broadcast to provide noncontrol airport and terminal area information to aircraft. FAA Order 7110.65, "Air Traffic Control," section 2-142, enumerates the required contents of the ATIS message. Paragraphs (c) and (d) state:

> c. Instrument/visual approach/s in use. Specify landing runway/s unless the runway is that to which the instrument approach is made.
>
> d. Departure runway/s (to be given only if different from landing runway/s or in the instance of a "departure only" ATIS).

Arrival and departure information for STL is contained in a single ATIS. The broadcast in effect for the Cessna 441's arrival and through the time of the accident was ATIS information "Delta." No mention was made of the occasional use of runway 31 as a departure runway in this ATIS recording. Public hearing testimony from ATC personnel revealed that they did not normally include information about the use of runway 31 on the ATIS, because runway 31 was considered a secondary runway, and it was not active the entire time. The controllers testified that they limited the information included in the ATIS recordings in an attempt to keep the ATIS "brief and concise" as requested by airport user groups (i.e., TWA, ALPA, other air carriers).

1.18.2 Air Traffic Handling/Interviews

The Cessna 441 landed on runway 30R at approximately 2140. The pilot made a right turn off the runway at taxiway November, and contacted ground control for taxi clearance. The ground controller cleared the pilot to "taxi to Midcoast ramp." The pilot taxied across taxiway Foxtrot (runway 13/31) on the way to the ramp. After dropping off the passenger, the pilot contacted ground control at 2155, requesting clearance to Iron Mountain, and at 2158 he advised ground control that he was ready to taxi. The ground controller responded, "One Kilo Mike, roger, back-taxi into position hold runway three one, let me know this frequency when you're ready for departure." The pilot of the Cessna 441 acknowledged the instructions, stating, "Kilo Mike."

Both the ground and local controllers told Safety Board investigators that, although they were unfamiliar with the airplane's call sign, the pilot of the Cessna 441 seemed to be competent, confident, and familiar with the airport. The ground controller stated that he believed the pilot of the Cessna 441 ". . . knew where he was going."

Interviews with the ATC personnel revealed that runway 13/31 is used primarily for taxi operations and secondarily as a "reliever" runway for general aviation and commuter operations. Because it is the only paved area for aircraft operations on the north side of the airport, runway 13/31 is the ground controller's responsibility until an airplane requires a takeoff clearance.

1.18.3 ASDE-3 Information

ASDE is a high resolution ground surveillance radar system that displays surface aircraft and vehicle traffic on one or more displays in the ATC tower. This system is designed to augment visual observations to enable ATC tower personnel to detect, locate, and track surface activity, to provide safe and efficient traffic flow. The FAA's 1995 Runway Incursion Action Plan (RIAP) calls for the latest generation of this equipment, ASDE-3, to be commissioned at 37 domestic airports.

STL was originally scheduled to receive ASDE-3 by October 31, 1992. Due to multiple delays, including some site-specific difficulties, installation of the ASDE-3 equipment at STL was completed in September 1994. In accordance with FAA procedures, the equipment was subjected to a proving period, during which the equipment was calibrated, functions were verified, and hardware and interface problems were resolved. The ASDE-3 equipment was not available for controller reference on the night of the accident due to a computer hard drive failure.

Since the accident, the STL ASDE-3 equipment difficulties have been resolved. The STL ASDE-3 equipment was commissioned in early 1995, and is currently operational and available for controller use 24 hours a day.

1.18.4 Airport Movement Area Safety System (AMASS) Information

AMASS is a ground-based system that augments ASDE-3 by detecting and alerting controllers to potential collisions on airport surfaces. It uses ground and airborne radar data to predict conflicts, and provides controller alerts via aural warnings and graphic display on the ASDE-3 screen. According to the FAA's RIAP, each of the 37 airports currently targeted for ASDE-3 installation will receive an AMASS. Although the production contract is still pending, the RIAP indicated that production AMASS units will become available in late 1996, and the 37 currently planned units will be commissioned by mid-1999.

1.18.5 Safety Board Actions -- Runway Incursion Issue

The Safety Board's concern about the hazard of runway incursions dates back to 1972, following an accident at the Chicago O'Hare International Airport. Since that time, the Board has issued 79 safety recommendations relating to runway incursions. These recommendations addressed issues such as procedures, training, pilot and controller communications, and airport signage.

Despite these efforts, runway incursion-related incidents and accidents continue to occur. Based on its concerns, the Safety Board included this safety issue when it adopted the "Most Wanted" Transportation Safety Improvements program in 1990. The issue continues to be a part of the "Most Wanted" list.

In 1985, the Safety Board conducted a special investigation study of runway incursion incidents. During this special study, the Safety Board investigated 25 runway incursion incidents that were summarized in the special investigation report, which was adopted in May 1986. The investigation revealed that runway incursions were typically the result of human performance issues that involved air traffic controllers and pilots of all levels of experience. The study also concluded that more uniform communication and verification of messages between pilots and controllers could serve to reduce the chance of ambiguous or erroneous commands/actions.

The Safety Board's concern about the runway incursion problem was heightened by three fatal accidents that preceded the STL accident. These accidents were the collision in Atlanta, Georgia, on January 18, 1990;[4] the collision in Romulus, Michigan, on December 3, 1990;[5] and the collision in Los Angeles, California, on February 1, 1991.[6] These accidents

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[4]Eastern Airlines flight 111 and Epps Air Service King Air A100, Atlanta Hartsfield International Airport, Atlanta, Georgia, January 18, 1990. (NTSB/AAR-91/03.)

[5]Northwest Airlines flights 299 and 1482, Detroit Metropolitan Wayne County Airport, Romulus, Michigan, December 3, 1990. (NTSB/AAR-91/05.)

highlighted the urgent need for improved preventive measures, and redundancy. The Safety Board is aware that, in addition to the more advanced ASDE-3 and AMASS airport surface traffic detection equipment, there are ongoing research and development efforts into alternative, cost-effective airport surface traffic detection systems, such as the ground induction loop.

On May 29, 1991, the Safety Board adopted the Aircraft Accident Report "Runway Collision of Eastern Airlines Boeing 727, Flight 111 and Epps Air Service Beechcraft King Air A100, Atlanta Hartsfield International Airport, Atlanta, Georgia, January 18, 1990" (NTSB/AAR-91/03). That report contained an appendix giving the history of Safety Board recommendation activity on runway incursions. The report also contained two new safety recommendations addressing the runway incursion issue, asking the FAA to:

> Expedite efforts to fund the development and implementation of an operational system analogous to the airborne conflict alert system to alert controllers to pending runway incursions at all terminal facilities that are scheduled to receive ASDE-3. (A-91-29)

> Conduct research and development efforts to provide airports that are not scheduled to receive ASDE-3 with an alternate, cost-effective system to bring controller and pilot attention to pending runway incursions in time to prevent ground collisions. (A-91-30)

Based upon the FAA's responses to these recommendations, which referred to the AMASS program, research and development activities, and the then-current schedule, the Safety Board classified these recommendations "Open--Acceptable Action" in 1994. As a result of a new recommendation being made in this report, Safety Recommendation A-91-30 is now classified "Closed--Acceptable Action/Superseded."

Since 1991, the Safety Board has issued 28 recommendations concerning the runway incursion issue. Twenty-three of those recommendations and the status of the FAA's responses are listed in Appendix G. The most recent five recommendations, Safety Recommendations A-95-30 through -34, were issued on February 28, 1995, as a result of concerns discovered during the investigation of this accident (see Appendix H for recommendation letter). The recommendations asked the FAA to:

> Require, within 45 days of receipt of the recommendation letter, that the Air Traffic Service provide a firm, finalized mission needs and operational requirements document for the AMASS. Also, no further modifications should be implemented until after the first AMASS is commissioned. (A-95-30)

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[6]USAir flight 1493 and Skywest Airlines flight 5569, Los Angeles International Airport, Los Angeles, California, February 1, 1991. (NTSB/AAR-91/08.)

Provide the Safety Board, within 60 days of receipt of the recommendation letter, with a firm schedule to commission those ASDE-3 radar systems that have been installed and adhere to that schedule. (A-95-31)

Require, for those ATC terminal facilities that commission the ASDE-3, that it be operational between sunset and sunrise. When the AMASS is commissioned, require it to be operational 24 hours a day. (A-95-32)

Issue an Administrator's Letter to Airmen that directs pilots to read back, in full, their runway assignment upon receiving taxi clearance when operating at airports that employ more than one runway. Revise the AIM [Airmen's Information Manual] to reflect this procedure. (A-95-33)

Amend FAA Order 7110.65, "Air Traffic Control," to require that air traffic controllers receive confirmation of runway assignment from pilots after issuing taxi instructions. Require that this procedure be used at those airports that employ more than one runway during operations. (A-95-34)

The FAA responded to these recommendations on April 14, 1995, and based on the FAA's response, the Safety Board classified Safety Recommendations A-95-30, -33, and -34 "Closed--Acceptable Action," and Safety Recommendations A-95-31 and -32, "Open--Acceptable Response," on August 1, 1995.

2. ANALYSIS

2.1 General

The MD-82 flight and cabin crews were certificated, trained, and qualified for their duties. No physiological factors or unusual cockpit distractions existed that would have precluded the flightcrew from seeing the Cessna 441 on the runway. However, environmental factors, such as the darkness and poor conspicuity of the Cessna 441, contributed to the flightcrew's failure to see the Cessna 441 on runway 30R.

The pilot-in-command of the Cessna 441 was certificated, trained, and qualified for the charter flight.

The local controller and ground controller were certificated, trained, and qualified for their duties. No physiological disabilities were apparent that would have detracted from their ability to perform at an acceptable level on the evening of the accident. However, the darkness, poor conspicuity of the Cessna 441, and physical distance between the ATC tower cab and the northeast portion of the STL airport contributed to the controller's failure to see the Cessna 441 on runway 30R.

STL airport markings, signs, and lighting near and along the taxi route of the Cessna 441 conformed to FAA standards.

Both airplanes were maintained in accordance with the applicable directives, and there was no evidence of any deficiency or malfunction that would have contributed to the collision.

Weather conditions were well above the criteria for VFR. In postaccident interviews, neither the flightcrew of the MD-82 nor the air traffic controllers identified environmental factors, other than darkness, as a constraint to the normal performance of their duties.

The air traffic volume in the St. Louis area during the time of the accident was moderate, and traffic complexity was routine. However, the ground controller was working seven frequencies at the time of the accident, and several instances of simultaneous transmissions occurred in the 1 1/2 hours before the accident.

The ASDE-3 airport surface detection equipment was installed at STL, but had not yet been commissioned and was not operational on the night of the accident. Although the equipment had not yet been commissioned, it would have been available to controllers except that there had been a computer hard drive failure. Had the equipment been operational, it would have displayed the Cessna 441's position at the intersection of taxiway Romeo and runway 30R for about 3 minutes before the collision.

The circumstances of this accident indicate that the pilot of the Cessna 441 unintentionally deviated from the taxi clearance he received from the ground controller and taxied onto the active runway being used by the MD-82. The Safety Board's investigation examined possible reasons why the Cessna pilot might have believed that runway 30R was his departure runway.

2.2 Cessna 441 Pilot Performance

The Safety Board believes that several personal factors may have contributed to the Cessna 441 pilot's deviation from ATC instructions. According to the pilot's wife, the accident occurred at a time of night when the pilot normally went to sleep, and he may have been tired. Company personnel reported that such late trips were unusual. Although the pilot's work-rest cycle is not consistent with chronic sleep loss, the fact that he was operating during a period in which he was normally at rest may have had some effect on his performance and level of attentiveness.

Additionally, the pilot of the Cessna 441 had commented that it was going to snow in Iron Mountain that night. Midcoast personnel stated that the pilot seemed anxious to go home, a behavior that they considered normal among pilots at that time of night. The combination of the time of day and his desire to return home before the weather deteriorated may have contributed to the mistaken actions of the Cessna 441 pilot, who was generally described in positive terms for his cautious and safe attitude.

2.2.1 Scenario: Pilot Became Lost During Airport Ground Operations

The Safety Board considered the possibility that the pilot intended to take off from runway 31, as directed, but became lost on the airport and ended up in position to take off on the wrong runway. However, the pilot did not indicate confusion in his radio responses to the taxi clearance, and radar data indicated no hesitation in his taxi route. (See Appendix E.) The passenger who chartered the Cessna 441 to STL before the accident flight reported that on a previous flight when the pilot of the Cessna 441 had become uncertain of his position at an airport, he had stopped taxiing until he determined his location. She also indicated that it was the pilot's habit to taxi with the airport diagram in front of him. The current STL airport diagram approach chart was located in the cockpit area of the Cessna 441 wreckage. Additionally, the pilot's flight logbook revealed that he had landed once before at STL. The previous flight was a daytime operation and occurred approximately 10 months before the accident.

2.2.2 Alternate Scenario: Pilot's Preconception that Runway 30R was his Departure Runway

The evidence indicates that it was unlikely that the pilot was lost, but rather that he had a preconception that he would be departing on runway 30R and thus did not register the ground controller's clearance to runway 31. Several situational cues may have reinforced the Cessna 441 pilot's preconception that runway 30R was his assigned departure runway. The Cessna 441 pilot had landed on runway 30R about 18 minutes before he received the taxi

clearance to runway 31 for his departure. The "quick turnaround" nature of the flight may have added to the Cessna pilot's belief that he would be departing on runway 30R. Also, from the time he approached STL for landing until he taxied out for takeoff, all traffic had landed and departed on runways 30R and 30L.

The ATIS that was current during the time the pilot operated in the STL area listed runways 30R and 30L as the active runways for arrivals and departures at STL. The STL controllers did not typically list runway 31 as an active runway on the ATIS, as runway 31 was only occasionally used as a departure-only runway. Also, the STL controllers did not typically treat runway 31 as if it were an active runway; for example, when the Cessna 441 pilot cleared runway 30R on his inbound flight, his taxi clearance to the Midcoast ramp did not include a clearance to cross runway 31. The Safety Board believes that if runway 31 had been referenced as a runway for occasional general aviation departures on the ATIS broadcast, the pilot may have been more attentive to the controller's taxi clearance and runway assignment.

Another situational cue that could have reinforced the Cessna 441 pilot's notion that runway 30R was his departure runway was the fact that when he began to taxi outbound from the Midcoast ramp on taxiway Whiskey (150 feet long), he almost immediately encountered runway 31, unlike the more typical airport layout in which a ramp exit leads to a parallel taxiway en route to the runway. During the on-scene investigation, several local pilots acknowledged that the proximity of runway 31 to the Midcoast ramp created a situation where pilots could inadvertently enter onto runway 31 without recognizing that they were on a runway.

The Cessna 441 pilot had an airport diagram available in the cockpit, and may have referred to it during his outbound taxi. However, it is also possible that he believed the taxi route to runway 30R was obvious and thus did not pay much attention to the diagram. Even if he had referred to the airport diagram, he may have had difficulty discerning runway 31 on it, due to dim lighting in the cockpit, and the competing tasks that included taxiing the airplane and performing checklists.

While runway 31 had markings, signage, and lighting consistent with FAA airport certification requirements, had several elements been slightly different, they might have triggered the pilot to question his notion that runway 30R was the assigned departure runway. These elements include runway width, displaced threshold, and runway markings and lighting.

Runway 31 is 75 feet wide, which is typical of taxiways at STL. In contrast, runways 30R and 30L are 150 and 200 feet wide, respectively.

At the time of the accident, a 1,838-foot displaced threshold was incorporated into the runway 31 marking/lighting scheme. The markings on the approximately 800-foot-long portion of runway 31 on which the Cessna pilot back-taxied consisted of a series of white arrows pointing toward the numbers. The runway 31 numbers were located at the end of the displaced threshold, near the intersection of runway 31 and taxiway November. The Cessna pilot's taxi route did not go past the numbers.

Along the displaced threshold, the runway lights had split red and white lenses, situated so that the white side of the lens was presented to the Cessna pilot as he back-taxied. This would have been a clue to the pilot that he was on a runway. However, the red side of the lens would have been visible to an airplane on approach for the runway, or to a pilot holding in position on runway 31 for departure. Because of the displaced threshold marking scheme, the Cessna pilot could not have seen the numbers for runway 31. Had he seen the numbers, the pilot might have been cued to question the controller as to the controller's intentions. The Safety Board acknowledges that the runway marking and lighting were in accordance with FAA requirements, and does not consider them to be factors in this accident, except to the extent that they may not have provided the pilot with sufficient cues to cause him to be more attentive to the controller's clearance.

Runways 30R and 30L have complex approach lighting systems, which are especially visible at night. At the time of the accident, the white runway edge lights of runway 31 were operating at a dimmer setting than those of runways 30R and 30L, which is standard practice at STL. The Safety Board believes that the dimmer lights on runway 31 were not sufficient to distract the pilot from his preconception that runway 30R was his intended departure runway.

Finally, as the Cessna 441 pilot proceeded from taxiway Romeo into position on runway 30R, he entered the runway at an intersection 2,500 feet from the threshold. According to the AIM, an intersection clearance can be requested by the pilot or initiated by the controller. The Cessna pilot did not request an intersection takeoff, nor did the ground controller indicate that the pilot should expect an intersection departure, and the pilot should not have entered the runway at an intersection, without specific clearance to do so. While the Cessna 441 pilot's entry onto the runway at an intersection should have been a final cue that his notion of being cleared to runway 30R was incorrect, the cue was apparently not sufficient to cause him to question his perception that he had been cleared to runway 30R.

2.2.3 Communications

Effective radio communications between the Cessna 441 pilot and ATC were critical to establishing a mutual understanding of intentions. The ground controller's multiple frequencies were congested with almost continuous communication, which resulted in several simultaneous transmissions in the 20 minutes before the accident. Additionally, there was some indication that the Cessna 441 pilot might have experienced communication radio difficulty. Specifically, the pilot complained about his communication radios during the inbound flight to STL, and several subsequent transmissions were garbled. Under these circumstances, it was especially critical for the pilot to ensure that effective communications were taking place.

The Safety Board noted that the Cessna pilot did not state the departure runway in any of his clearance readbacks. Although critical item readbacks have always been considered important in airborne operations, until recently, there was no requirement for critical item clearance readbacks for surface operations. This omission was addressed in Safety

Recommendations A-95-33 and -34, which were issued, as mentioned in Section 1.18.5 of this report, during this investigation. In response to the recommendations, the FAA stated that it anticipates changing the AIM and Advisory Circulars 61-21A, "Flight Training Handbook," and 21-23B, "Pilots Handbook of Aeronautical Knowledge," urging pilots to read back in full their runway assignment when operating at airports with more than one runway. Also, the FAA has developed a change to FAA Order 7110.65, "Air Traffic Control," to require air traffic controllers to obtain confirmation of runway assignment from pilots after issuing taxi instructions. The Safety Board believes that, had this change been in effect, this accident might not have occurred. The occasionally nonstandard radio communications between the Cessna 441 pilot and the controllers did not serve to effectively clarify intentions or expectations on either side.

There is no current FAA requirement for pilots to use standard terminology in their communications with ATC. However, the AIM provides a pilot/controller glossary that presents standard terminology. The Safety Board concludes that airport ground operations have become sufficiently complicated, that incomplete or colloquial communications are inadequate, and that more rigorous adherence to standard phraseology--by pilots as well as controllers--is essential.

2.3 MD-82 Flightcrew Performance

The Safety Board examined the ATC communications and CVR records and concludes that the actions of the MD-82 flightcrew were typical of normal airline operations and did not contribute to the accident. However, the Safety Board was interested in the extent to which the flightcrew might have been aware of the taxi operations of other airplanes.

2.3.1 Airport Traffic Awareness

The AIM and other pilot guidance material stress the need for pilots to be alert and vigilant in monitoring air traffic communications during ground operations so that they can detect situations that can lead to conflict with other aircraft or vehicles. However, at STL, as with many other airports, there are multiple ground control and local control frequencies used by different controllers to communicate with aircraft taxiing, landing, or taking off on different parts of the airport. This is necessary during busy traffic periods to distribute controller workload and reduce radio frequency congestion. At STL, there are separate ground control positions in the tower and separate radio frequencies for the north and south operations on the airport. Thus when the tower is fully staffed, air carrier pilots taxiing from the south side of the airport would normally be unable to hear tower communications with, and would thus be unaware of, aircraft taxiing from the general aviation ramp on the north side.

During periods when the traffic count permits, it is a common practice to reduce the staffing in the tower cab and assign a single controller the responsibility of multiple operations normally handled by separate controllers. This was the case on the night of the accident when a single controller was staffing both the north and south ground control positions in addition to the clearance delivery and flight data positions. When operating in this position-combined mode, the controller can assign aircraft operating from the north and south sides of the

airport the same communications frequency, or as on the night of the accident, the controller can monitor different frequencies while transmitting simultaneously on all. Thus, while the pilot of the MD-82 would have been able to hear the ground controller clear the Cessna 441 to taxi, he could not hear the Cessna pilot's acknowledgement.

It is not surprising that the MD-82 flightcrew reported that they were not aware of the Cessna 441 operation from the north side of the airport. In his testimony at the public hearing after the accident, the MD-82 captain reported, "We, as pilots, only hear part of the conversation [two-way ATC dialogue] and don't know where other aircraft are . . . .That effectively destroys our situational awareness . . . eliminates the double check on . . . safety procedures." He also testified that he believed that reduction/elimination of multiple frequencies would help pilots' situational awareness and ". . . greatly enhance safety . . . ."

While the Safety Board agrees that, when controller positions are combined, the use of a common frequency for all aircraft being worked by the controller could enhance the opportunity for pilots to be aware of potential traffic conflicts, it does not consider the use of multiple frequencies to be a factor in this accident. Had the MD-82 flightcrew been attentive to the taxi clearance issued to the Cessna 441, they would have believed that the Cessna was taxiing to runway 31 and it is not likely that they would have considered the Cessna as a potential danger to their operation. Since the Cessna pilot did not read back his runway assignment, the flightcrew of the MD-82 would not have been able to detect the possible mistake in clearance in any event.

The Safety Board concludes that the use of combined positions with multiple frequencies was not a factor in this accident. However, the Safety Board does not believe it is in the interest of safety to create a situation in which there can be simultaneous transmissions and potentially decreased pilot awareness. The Safety Board believes that, when positions are combined, ATC personnel should make every effort to use as few frequencies as possible. Those frequencies in use should be broadcast on the ATIS to enable flightcrews to communicate with the controllers.

2.3.2 Conspicuity of Cessna 441 from the Runway 30R threshold

The Safety Board conducted a test to establish the line-of-sight visibility from the MD-82 pilots to the Cessna 441 when both airplanes were positioned for takeoff on runway 30R. The purpose was to establish whether any physical obstruction to the visibility of the Cessna was caused by runway 30R gradation. Visual observations were made during afternoon daylight and clear weather conditions. Under these conditions, the Cessna was visible from the approximate vantage point of the MD-82 flightcrew, but it presented a very small target.

During the initial on-scene examination of the Cessna 441, the external lighting cockpit switches were located in their off (down) positions, except the nose gear taxi light, which was found in the on position. Additionally, during the initial examination, the two wing-mounted retractable landing lights were found in their stowed positions. However, based on ARFF

personnel reports of their activities during the emergency response, the Safety Board does not believe that these positions are necessarily an accurate depiction of switch and light positions at the time of the collision.

The Safety Board's laboratory examination of the light bulbs from the Cessna 441 indicated that filaments were stretched on the left wing tip-mounted navigation, white tail cone-mounted navigation, nose gear-mounted taxi, and the left wing-mounted landing lights. Filament stretch indicates that the filament was hot at the time of impact (an illuminated bulb). The Safety Board believes that the right wing tip-mounted navigation light and the right wing-mounted landing light filaments were not stretched because the right side of the airplane was subject to lesser impact forces. The Safety Board concludes that the Cessna 441 taxied from the Midcoast ramp with the nosewheel taxi, white tail cone-mounted navigation, and red and green wing tip-mounted navigation lights illuminated. Based on Superior Aviation company policy and common pilot practice, the Safety Board believes that the Cessna 441 wing-mounted landing lights were not illuminated until the airplane was in position on runway 30R at its intersection with taxiway Romeo.

The Cessna 441 was not equipped with a rotating red anticollision light, which on many other aircraft types is visible from behind the airplane. Wing tip-mounted anticollision/strobe lights satisfied the certification requirement for anticollision lighting. It could not be determined whether the wing tip-mounted anticollision/strobe lights were operating at the time of the collision. Based on the controllers' inability to maintain visual contact with the Cessna 441, and the common procedure among pilots to delay use of anticollision/strobe lights until takeoff clearance is received (out of consideration for the night vision of other pilots), the Safety Board considers it unlikely that the wing tip-mounted anticollision/strobe lights were operating at the time of the collision. Although the navigational lights on the Cessna met Federal standards, FAA specialists testified that the Federal standards for aircraft external lighting are primarily intended to serve in-flight conspicuity needs rather than conspicuity of aircraft on airport surfaces.

External lighting tests had been conducted during the Safety Board's investigation into the ground collision accident involving a Boeing 737 and an SA-227, in Los Angeles, California, in February, 1991.[7] These tests revealed that when the SA-227 was viewed from behind, at night, with navigation lights on, it was difficult to differentiate between an airplane in position on the runway and the lighted runway environment, especially on a runway with centerline lighting. The tests also revealed that airplane conspicuity on an active runway was increased if the airplane used anticollision/strobe lights, and was positioned offset from the runway centerline. The Safety Board issued several safety recommendations to the FAA that addressed aircraft conspicuity as a result of this investigation. Among these recommendations were:

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[7]NTSB/AAR-91/08.

Redefine the airplane certification coverage compliance standards for anticollision light installations to ensure that the anticollision light(s) of an aircraft in position on a runway are clearly visible to the pilot of another aircraft preparing to land or take off on that runway. (Class II, Priority Action) (A-91-111)

Evaluate and implement, as appropriate, suitable means for enhancing the conspicuity of aircraft on airport surfaces during night or periods of reduced visibility. Include in this effort, measures such as the displacement of an aircraft away from the runway centerline, where applicable, and the use of conspicuity enhancements, such as high-intensity strobe lighting and logo lighting by aircraft on active runways, and encourage operators of airplanes certificated prior to September 1, 1977, to upgrade their airplanes to the present higher intensity standards for anticollision light installations. (Class II, Priority Action) (A-91-112)

The current status of Safety Recommendation A-91-111 is "Open--Unacceptable Action." Although the FAA's initial response in March 1992 indicated that it had reviewed applicable design standards and found them to be adequate, almost 3 years after the recommendation was issued the FAA responded to an NTSB followup letter stating that it was continuing its effort to revise the regulations to comply with the Safety Board's recommendation, and that it was referring the matter to the Aviation Rulemaking Advisory Committee. The most recent Safety Board correspondence is dated April 27, 1995.

The current status of Safety Recommendation A-91-112 is "Closed--Unacceptable Action," also dated April 27, 1995. The FAA's response indicated that it believed that its effort to revise the regulations concerning anticollision light design standards to comply with Safety Recommendation A-91-111 would completely address the concerns raised in Safety Recommendation A-91-112. However, the Safety Board received no indication that the FAA evaluated or implemented methods to enhance the conspicuity of aircraft, or encourage operators to upgrade the lighting systems of aircraft certificated before September 1, 1977.

The Safety Board believes that the use of strobe lighting and the practice of displacing the airplane off the centerline lighting would significantly enhance the ability of other pilots and air traffic controllers to visually detect traffic conflict situations. Specifically, the Safety Board believes that, had the pilot of the Cessna 441 used anticollision/strobe lights and positioned the airplane so that it was offset from the runway centerline lighting, it would have increased the likelihood that the MD-82 flightcrew would have detected the runway incursion in time to avoid the collision.

Although Safety Recommendations A-91-111 and -112 address conspicuity issues, they do not address the evaluation of requiring pilots to use anticollision/strobe lights while in position on active runways. Therefore, the Safety Board believes that the FAA should examine the feasibility of requiring pilots to turn on anticollision/strobe lights while holding in position on active runways.

With the wing tip-mounted anticollision/strobe lights turned off, the white tail cone-mounted navigation light would have been the only light visible to the MD-82 flightcrew. The other navigational lights would have been obscured by the structure of the Cessna. The Safety Board believes that the white tail cone-mounted navigation light would have blended in with the runway centerline lighting system and that it would not be reasonable to expect that the MD-82 flightcrew could have seen the Cessna 441 in time to prevent the accident.

2.4 Role of Air Traffic Control

The Safety Board also evaluated the performance of the ATC personnel involved in this accident.

2.4.1 Issuance of Taxi Clearance

The ground controller failed to use standard phraseology in his initial taxi clearance transmission. The initial taxi clearance that the Cessna pilot received from the ground controller was, "One Kilo Mike, roger, back-taxi into position hold runway three one, let me know this frequency when you're ready for departure."

Text in the AIM that was in effect at the time of the accident, section 4-67 "TAXIING #7," tells pilots to expect ATC to first specify the runway, then issue taxi instructions, and to state any required hold short instructions. This information is also contained in FAA Order 7110.65, "Air Traffic Control," which directs controllers to issue clearances in the same manner. An example of a correct clearance would be: "Taxi to runway 31. Turn left on runway 13/31, proceed to the end, position and hold. Let me know this frequency when you're ready for departure." In effect, the pilot of the Cessna 441 received a nonstandard clearance, in which the phrase "taxi to," and the departure runway had been eliminated. Instead, the controller simply issued taxi instructions followed by more detailed instructions regarding a communications frequency. Had the taxi clearance been in accordance with prescribed phraseology, it might have altered the pilot's preconception of departing on runway 30R.

Although the initial taxi clearance included technically improper phraseology, the ground controller gave the Cessna pilot another cue that runway 31 was his assigned departure runway when he referenced runway 31 in a second transmission. When the Cessna 441 pilot advised the ground controller, ". . . we're ready to go," the ground controller replied, ". . . hold on position on runway three one and monitor the tower on one two zero point zero." The Cessna 441 pilot responded, ". . . understand position and hold, monitor the tower . . . ."

The ground controller had no indication that the pilot was not familiar with surface operations at STL. Although the pilot did not read back the departure runway when he acknowledged his taxi clearance, he gave no indication that he was uncertain about the instructions he received from the ground controller. This resulted in an illusion of effective communication, when in fact the pilot misunderstood the ground controller's intentions. Although there was no requirement at the time of this accident, the controller could have requested the

Cessna 441 pilot to read back the runway assignment. However, the controller's communication workload was heavy (as described in Section 2.4.3), and the Safety Board does not fault the controller's action in this regard. The Safety Board strongly supports the FAA's change to Order 7110.65, "Air Traffic Control," requiring that controllers obtain confirmation of runway assignment.

Additionally, the Safety Board has noted that the term "back-taxi," while commonly used, and apparently understood, by pilots and controllers, is not officially defined in either the AIM or FAA Order 7110.65, "Air Traffic Control." The Safety Board believes that the FAA should officially define the commonly used term "back-taxi" in the Pilot-Controller Glossary, and provide an explanation of the use of the term and application of the procedure in the AIM and FAA Order 7110.65, "Air Traffic Control."

2.4.2 Visual Detection/Tracking of Cessna 441

The ATC tower structure is located on the southwest side of the runway complex and terminal buildings, about 1 1/4 miles from the site of the collision. ATC tower personnel indicated that it was often difficult to see small airplanes operating on the north side of the airport, especially on the far end of runway 31, at night.

Given the known difficulty of visually acquiring general aviation airplanes at night in that area of the airport, the ground and local controllers might have heightened their vigilance when they lost visual contact with the Cessna 441. However, based on the pilot's radio communications, the controllers perceived the pilot of the Cessna 441 to be confident and familiar. Additionally, the ground controller was working the clearance delivery position at the time of the accident, which required that he intermittently have his head down to read and issue clearances. This made it less likely that the ground controller would be able to effectively visually monitor the Cessna 441.

Concerning aircraft visibility, the STL ground and local controllers reported that they did not observe any exterior lights illuminated on the Cessna 441. They stated that from the time the Cessna 441 taxied from the well-lighted Midcoast ramp, they were unable to maintain visual contact. ATC personnel acknowledged that it was not unusual to lose visual contact with general aviation airplanes operating on that part of the airport at night.

Since ATC personnel did not observe the Cessna 441 in position on runway 30R, they assumed that the airplane did not have its landing lights illuminated. However, postaccident examination of the landing light bulbs indicated that they were illuminated at impact. The Safety Board believes that the Cessna pilot may have turned the landing lights on seconds before impact in anticipation of a takeoff clearance.

The Safety Board concludes that, given the Cessna 441's lighting as it departed the Midcoast ramp, the ground and local controllers could not have reasonably been expected to visually detect the Cessna pilot's deviation from the taxi instructions. When it became apparent

to the controller that he could not follow or determine the position of the Cessna, he could have requested the pilot to turn on his landing lights and/or anticollision/strobe lights to enhance the airplane's conspicuity. However, the Safety Board acknowledges that there are no procedures requiring controllers to make such a request and thus cannot fault the controllers for not doing so. Nevertheless, if the Cessna pilot had enhanced the airplane's conspicuity by using additional lighting, especially during the 3 minutes that the airplane was in position at the intersection of taxiway Romeo and runway 30R, it would have increased the likelihood that the controllers could have detected the airplane's improper position in time to avoid the collision.

The need to enhance conspicuity for controllers as well as other pilots reinforces the Safety Board's belief that the FAA should revise the Federal Aviation Regulations to require pilots to illuminate all taxi, landing, and logo lights, or otherwise enhance the conspicuity of their aircraft when operating on an active runway (including runway crossing and position-and-hold operations). Further, the Safety Board notes that requiring pilots to turn on aircraft anticollision/strobe lights when holding in position on active runways, as discussed in Section 2.3.2, would assist air traffic controllers, as well as pilots of other aircraft in detecting runway incursions.

2.4.3 ATC Staffing and Workload

The Safety Board acknowledges that the efficient use of resources requires FAA facilities to adjust on-duty staffing levels to the traffic flow expected during different times. On the night of the accident, the ground controller was working four positions and monitoring seven radio frequencies. Although the controllers characterized the workload as moderate rather than heavy, the Safety Board believes that the higher-than-normal traffic level, as a result of the Thanksgiving Day holiday, and the continual communication on the clearance delivery and ground control frequencies, may have resulted in the controller being less attentive to the position of the Cessna than he would have been under lesser workload conditions.

The Safety Board is particularly concerned that the controller's communications workload may have been exacerbated by the difficulties of contending with blocked or garbled transmissions as two or more aircraft attempted to communicate on separate radio frequencies. Under such circumstances, the controller may have been less apt to request verbal communication confirmation from the Cessna pilot of the initial runway assignment or his subsequent position on the airport.

The Safety Board believes that, considering the workload at the time of the collision, the clearance delivery position should have been manned rather than being combined at the ground control position. The Safety Board also believes that, had the clearance delivery position been staffed, rather than combined at the ground control position, the ground controller would have had more time for other functions, such as tracking the Cessna 441.

Subsequent to the accident, the STL ATC tower staffing schedule was changed to retain an additional controller and supervisor until 10:30 p.m. The Safety Board believes that this

staffing change provides an additional level of safety.

The Safety Board is aware of several procedures and services that are being developed and used at airports throughout the country in an attempt to reduce radio frequency congestion. These procedures include standard coded taxi routes (currently in effect only at O'Hare International Airport, in Chicago, Illinois), and automated flight clearance delivery. At the time of this accident, the STL airport had the capability to deliver automated flight clearances, but the MD-82 did not have the onboard equipment to use the service. Since the accident, TWA has acquired the capability to receive automated flight clearances. Had the automated clearance delivery service been used the night of the accident, the ground controller's workload would have been significantly reduced. Thus, the Safety Board believes that the FAA should continue to develop, publish, and encourage the implementation of procedures such as automated flight clearances and standard taxi routes to reduce radio frequency congestion during ground operations.

2.5 Airport Factors - Designation of Runway 31

The Safety Board reviewed the significance of runway 13/31 being designated with a 10° offset instead of being designated as 12L/30R (with the other two parallel runways redesignated as 12C/30C and 12R/30L) as is standard for three parallel runway configurations at other airports. The Safety Board believes that had the runways been designated as 30R, 30C, and 30L, the pilot of the Cessna 441 may have discerned the significance of the taxi clearance. However, the Safety Board also acknowledges that such designation could confuse arriving pilots, who would view the two larger parallel runways as a normal right and left configuration. The Safety Board is aware that the FAA is currently studying the feasibility of redesignating these runways.

The Safety Board concludes the marking and lighting for runway 13/31 was clear, well defined, and in accordance with FAA standards, which the Safety Board believes are adequate. However, the runway 31 threshold displacement could have been a source of confusion to pilots if they were unfamiliar and/or inexperienced with displaced threshold marking and lighting. Additionally, since runway 31 was not open to landing traffic, the displacement was, in effect, superfluous. However, as mentioned previously, the STL Airport Authority petitioned for and received FAA approval to eliminate the displaced threshold on runway 31; the displaced threshold runway markings will be removed and the runway will appear full length by September 1, 1995. Runway 31 will still be restricted to departures only.

The Safety Board has noted that following the accident the airport installed taxi-holding position lights ("wig-wag" lights) at taxiway Whiskey to further enhance and delineate the presence of runway 13/31 for aircraft exiting from the Midcoast ramp. Although the Safety Board concludes that markings, signs, and lighting in that area were adequate, it also believes that this enhancement is worthwhile and provides an additional safety redundancy.

2.6 Prevention of Runway Incursions

2.6.1 Pilot Training in Ground Operations

During the Safety Board's April 19-20, 1995, public hearing on this accident, the Safety Board heard testimony from ATC personnel and air carrier pilots indicating that additional training should be undertaken to ensure that pilots are familiar with airport ground operations, including airfield markings, signs, and lighting.

A study/survey of pilots entitled, "Reports by Airline Pilots on Airport Surface Operations"[8] indicated a need for pilot training on surface operations. A solution proposed in that study recommends "That the airlines develop and implement training in cockpit procedures and communications for surface operations, emphasizing the timing and integration of all cockpit tasks and the requirement for structured verbal coordination on surface orientation, and navigation."

Currently, pilot initial and recurrent training programs are directed primarily at airborne operations. However, public hearing testimony indicated that many pilots believed the most difficult part of any trip occurred between the runway turnoff and the gate. This accident reinforced the need for pilot training on surface operations, including airfield markings, signs, and lighting. Although air carrier training was not a factor in this accident, the Safety Board believes that initial and recurrent air carrier pilot training programs should include training in airport surface movement operations and familiarization with airport markings, signs, and lighting. The Safety Board also believes that similar training on airfield surface operations, including airport markings, signs, and lighting should be provided for all general aviation pilots during initial training and biennial flight reviews.

As a result of the previously mentioned runway incursion accidents that occurred in Atlanta, Georgia; Romulus, Michigan; and Los Angeles, California;[9] the FAA generated several informational/educational handouts and flyers, which it intended to distribute to certificated pilots through a variety of methods (i.e., safety seminars, operations bulletins, etc.). The Safety Board notes that this distribution has not reached its entire intended audience. The Safety Board believes that the FAA should mass-mail all currently certificated pilots FAA publications on reducing runway incursions and airport improvement information, such as airport signage changes.

2.6.2 ASDE/AMASS

ASDE-3 was installed at STL in September 1994, and subjected to a proving

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[8]Docket No. SA-513, Exhibit No. 14B, MITRE Corporation Report on Airport Surface Operations -- May, 1994; pg xxvi, Exhibit Pg. 28.

[9]NTSB/AAR-91/03; NTSB/AAR-91/05; and NTSB/AAR-91/08, respectively.

period, during which the equipment was calibrated, functions were verified, and hardware and interface problems were resolved. During the proving period, controllers had ASDE-3 available periodically, and were encouraged to use the equipment at those times. As mentioned previously, STL controllers reported difficulty visually distinguishing general aviation airplanes operating on the northeast portion of the airport at night. An operational ASDE-3 would supplement visual scan of the airport surface. However, on the night of the accident, the ASDE-3 equipment was not available for controller use, due to the computer hard drive failure.

The Safety Board believes that had the ASDE-3 equipment been available for controller use on the night of the accident, the ground and local controllers would have had a higher probability of identifying the Cessna 441 at runway 30R. The Cessna 441's position at the intersection of taxiway Romeo and runway 30R for 3 minutes before the collision would have allowed ample time for the local controller to have identified the airplane during his routine ASDE-3 scan of the runway before issuing takeoff clearance to the MD-82.

The Safety Board is also aware of several advanced concepts in airport surface traffic detection and automation that, when perfected and combined with the correct hardware and location-specific software, could provide automated warnings to preclude accidents of a nature similar to the collision at STL. The Safety Board fully supports the early development and installation of such systems at airports where the volume and complexity of traffic flow warrant their use.

AMASS manufacturer Westinghouse-Norden Systems produced a video simulation that portrays how AMASS could have performed at STL during the accident scenario. In this simulation, the AMASS provided controllers with an aural and visual warning about 17 seconds before the collision. Adjustments of the many variables in the AMASS software, typically accomplished when the system is customized for the particular airport installation, can alter this warning time.

For AMASS to prevent or reduce the severity of a collision, the system warning must be converted into action by a minimum of two persons. The controller must recognize the warning, comprehend the situation, determine which aircraft and/or vehicles are involved, determine a preventive course of action, and relay appropriate instructions to the subject aircraft and/or vehicles. The aircraft and/or vehicle operator(s) must then comprehend those instructions, and determine and execute an appropriate response.

An operational ASDE-3 system could have compensated for the Cessna 441's poor conspicuity while operating at night on the northeast portion of the STL airport, and an operational AMASS could have provided an automated warning of the impending collision. Thus, the Safety Board believes that the installation and utilization of ASDE-3, and particularly ASDE-3 enhanced with AMASS, could have prevented this accident.

2.6.3 Other Runway Incursion Prevention Technology

Following the runway incursion accident at the Atlanta Hartsfield International Airport on January 18, 1990, the Safety Board recommended that the FAA:

> Conduct research and development efforts to provide airports that are not scheduled to receive Airport Surface Detection Equipment with an alternate, cost effective system to bring controller and pilot attention to pending runway incursion in time to prevent ground collisions.

The Safety Board remained concerned that the problem of runway incursions is not confined to the 37 major airports that are slated to receive the ASDE-3 and its associated AMASS. The Safety Board is aware that during June 1991, the FAA conducted a Broad Agency Announcement that allowed for the demonstration of alternative technologies for surface movement. These demonstration programs are outlined in the FAA's 1995 RIAP. A review of the milestones established for the development of a low-cost alternative for runway incursion prevention indicates that an evaluation of these alternatives will continue through 1996.

The Safety Board is aware of a draft FAA document entitled, "Operational Concepts for Surface Movement in the 21st Century." During an FAA-sponsored surface movement technology forum attended by Safety Board staff during March 1995, over 115 participants, comprising a cross-section of users and industry, endorsed this document with only minor changes. This comprehensive document outlines the application of future technologies and operational concepts for operating on airports within the National Airspace System. The Safety Board supports the intent of this type of advance planning and urges the FAA to embrace this document and use it as the blueprint and cornerstone for the development, implementation, and evolution of safer surface operations.

2.6.4 FAA Program Initiatives/Management

The Safety Board was encouraged by many of the FAA's actions in the aftermath of a series of runway incursion accidents during the early 1990s. These actions included new airport markings, signs, and lighting, coded taxi routes at the O'Hare International Airport, and low visibility operational initiatives at the Seattle/Tacoma International Airport. The Safety Board believes that since 1991, there has been limited action to address the runway incursion issues until the FAA's 1995 RIAP.

Public hearing testimony by MITRE Corporation personnel indicated that the FAA should consider addressing the runway incursion problem in two arenas. One suggested arena was the basic surface system in which human performance issues require corrective action on a near-term basis; the other arena was surface technology, which is more long term. It was also disclosed that MITRE's "Reports by Airline Pilots on Airport Surface Operations" study contained 40 proposed solutions for the reduction of pilot error during airport surface operations. According to the testimony, most of these solutions were not costly and were "doable"-- for

example, pilot and controller communications. The Safety Board believes that the FAA, in conjunction with industry, should now develop working groups tasked with developing mechanisms to implement these solutions.

The second part of the MITRE report is expected to be completed during September 1995. The Safety Board believes that the FAA should employ an independent source to conduct a survey, similar to that conducted by MITRE, of its terminal ATC staff to determine their concerns and views of the scope and magnitude of the runway incursion problem and their recommendations for the reduction of runway incursions.

As a longer-term measure, the Safety Board notes that the FAA has developed a working draft document entitled, "Annotated Regulatory, Procedural, and Recommended Practices for Surface Movement of Aircraft by Pilots and Ground Vehicles by Operators." This document, prepared by the FAA's Systems Architecture and Integration Division, is described as "a discussion paper and baseline document to discuss changes in roles and responsibilities on the [airport] surface." It sets forth procedures for operating aircraft and ground vehicles, emphasizes communications and interactions between the control tower and pilots of aircraft on the ground, and sets forth what might be considered "rules of the road" as a standard applicable to all pilots, both foreign and domestic. The Safety Board believes that the FAA should finalize this document to establish a blueprint for improved operations on the airport surface.

The Safety Board believes that there is a lack of accountability and stability in the FAA's long-term program management process. Statements made by principal witnesses at the public hearing indicated that since the initial development of AMASS, numerous personnel changes occurred in key offices. The Safety Board believes that the process of familiarizing new management personnel with the program may have led to unnecessary revisions in program requirements and priorities that resulted in delays in the AMASS development. The Safety Board understands that past programs have been delayed beyond initial schedule targets because the different organizations involved in establishing and accepting the criteria for equipment performance have been unable to resolve those differences quickly.

The Safety Board notes that before the public hearing on the accident, the FAA, in a formal press release, announced that AMASS would be deployed at the San Francisco International Airport in May 1996. Testimony at the public hearing indicated that a "zero bucket" [base-line] AMASS would be installed at San Francisco. The Safety Board notes that the FAA plans a validation phase for the AMASS following the planned May 1996 deployment. The Safety Board hopes that validation of the system will not result in further unnecessary delays.

The Safety Board believes that the ATC procedures for the use of AMASS should be reviewed. While acknowledging that AMASS should provide the controller an alert only after other redundancies have failed, the Safety Board does not believe that controllers should be permitted to inhibit targets that would otherwise qualify to generate an alert. In addition, the FAA should assure that the ATC procedures that relate to interface with the ASDE-3 and AMASS system are not so demanding that they will divert the controller's attention away from

his/her primary duty of separating aircraft.

The Safety Board encourages the FAA to continue the research effort in Airport Surface Traffic Automation (ASTA), which is intended to develop automation tools and more complete automation for controlling the flow of aircraft on the airport surface. In addition to reducing the frequency of runway incursions, design goals of the program should include a reduction in taxiway incursions and improvements in ATC operational efficiency. This automation, including Departure Flow Management (DFM) and Terminal Air Traffic Control Automation (TATCA), is intended to support interactions among the various aircraft on the airport surface and on the approach path.

Although the Safety Board fully supports and encourages these efforts, it nevertheless recognizes that these programs are intended for a limited number of high-density air carrier airports, and that the operational benefits will not be available until the late 1990s. The Safety Board encourages the FAA's efforts to fund, support, and implement an operational system, such as the induction loop in-ground sensor system, analogous to the airborne conflict alert system, to prevent runway incursions at all U.S.-certificated airports.

2.7 Survivability Aspects

2.7.1 Airport Closure/Emergency Operations

STL airport management, which has the authority to close the airport after an accident, did not close the airport after this collision. STL remained open, and aircraft and ground vehicle movement continued near the accident sites. Several radio transmissions from pilots of taxiing airplanes to the ground controller indicated that the pilots were concerned about the possibility of passengers from the MD-82 wandering in front of their airplanes. Seven minutes after the collision, Federal Express flight 1283 landed on runway 30L. About 17 minutes after the accident, the air traffic controllers temporarily suspended airport operations.

The Safety Board believes that, because the airport was not closed immediately following the accident, the evacuated passengers were put in danger of being injured by taxiing aircraft. While the airport authority has jurisdiction over the physical operation of the airport, air traffic controllers still have a responsibility for the safe operation of airplanes on and around the airport. Closing the airport would allow controllers and/or airport authority personnel to assess the situation and to redirect both airborne and surface traffic to areas remote from the accident site. The assessment period could have been brief, and the airport could have been reopened after safe conditions were confirmed by the airport operator.

As a result of this unsafe situation, on July 17, 1995, the Safety Board issued Safety Recommendation A-95-78 asking the FAA to:

> Provide guidance to all 14 CFR Part 139 certificated airports that in the event of an accident or significant incident, the airport be closed immediately by either the

airport operator and/or the appropriate FAA air traffic control facilities through letters of agreement with airport operators. Also, specify that the airport, or portions thereof, should not be reopened until the airport operator has ensured that: (1) aircraft operating areas are secure; (2) aircraft movement areas that are to be reopened have been properly inspected; and (3) adequate aircraft rescue and fire fighting protection is available for aircraft operations.

The FAA has not yet responded to this recommendation. (The recommendation letter containing this recommendation is in Appendix I.)

2.7.2 Evacuation of the MD-82

The MD-82 flightcrew took an estimated 2 to 3 minutes to evaluate the emergency situation before deciding on the safest method of evacuation. They indicated that the delay afforded the cabin crew some time to calm frightened passengers, and the subsequent evacuation through the single door (R1) was described as orderly. Estimates as to the duration of the evacuation varied widely, but the average was 7 minutes. The shortest estimate was 4 minutes, the longest was 15 minutes. Several passengers, especially those seated farthest aft in the airplane, complained that the evacuation took too long, because only one exit was used. The FAA certification standard requires that a full airplane must be evacuated within 90 seconds, with half of the exits blocked. The Safety Board believes that the flightcrew's evacuation decision, based on the large quantity of pooling fuel on the left side of the airplane, and the spilling fuel and impact-related physical damage on the right side of the airplane, was a safe, sound judgment. The Board also believes that the average estimate of evacuation duration was not excessively slow given absence of critical urgency.

3. CONCLUSIONS

3.1 Findings

1. The MD-82 flightcrew and the Cessna 441 pilot were properly certificated and qualified for their respective flights.

2. The air traffic control personnel were properly certificated and qualified for their duties.

3. Both airplanes were properly certificated and maintained. There is some evidence the pilot of the Cessna 441 had communication radio difficulties the evening of the accident; however, these difficulties did not contribute to the accident.

4. Airfield markings, signs, and lighting near and along the taxi route of the Cessna 441 conformed to FAA standards. Although several position signs had inoperative light bulbs, the signs were clearly visible, and therefore were not a factor in this accident. Although the runway 31 displaced threshold was properly marked and lighted, it could have misled the pilot.

5. The ARFF emergency response was timely and effective, and prevented further serious injuries. Additionally, the MD-82 evacuation was orderly and organized.

6. The pilot of the Cessna 441 acted on an apparently preconceived idea that he would use his arrival runway, runway 30R, for departure. After receiving taxi clearance to back-taxi into position and hold on runway 31, the pilot taxied into position at an intersection on runway 30R, which was the assigned departure runway for the MD-82.

7. The combination of the time of day and his desire to return home before the weather deteriorated may help explain the mistaken actions of the Cessna 441 pilot.

8. Although the controllers considered their workload moderate, the ground controller was working seven frequencies with almost constant communications.

9. The ATIS current during the time the Cessna 441 pilot operated in the STL area listed runways 30R and 30L as the active runways for arrivals and departures at STL. There was no mention of the occasional use of runway 31.

10. The controller clearly referenced runway 31 in two separate transmissions. In both cases, the pilot acknowledged the clearance, but did not read back the runway assignment. Had the controller used more precise phraseology in the issuance of the initial taxi clearance, the Cessna 441 pilot may have noted the proper departure runway.

11. Had the Cessna 441 pilot volunteered, or had the controller requested,

confirmation of the assigned runway, the pilot's error may have been detected and the accident prevented.

12. Air traffic control personnel were not able to maintain visual contact with the Cessna 441 after it taxied from the well-lighted ramp area into the runway/taxiway environment of the northeast portion of the STL airport.

13. An operational ASDE-3, particularly ASDE-3 enhanced with AMASS, could be used to supplement visual scan of the northeast portion of the STL airport surface.

14. The MD-82 flightcrew stated that they did not observe any external lights on the Cessna 441 before impact. When the Cessna 441 was in position for departure on runway 30R, the most conspicuous exterior lighting was directed forward, and, with the possible exception of wing anticollision/strobe lights, would not have been visible to the MD-82 flightcrew.

15. It is likely that the wing anticollision/strobe lights were not operating when the collision occurred.

16. Pilot training for surface movement can be improved in both air carrier and general aviation areas.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was: the Cessna 441 pilot's mistaken belief that his assigned departure runway was runway 30R, which resulted in his undetected entrance onto runway 30R, which was being used by the MD-82 for its departure.

Contributing to the accident was the lack of ATIS and other ATC information regarding the occasional use of runway 31 for departure. The utilization of an operational ASDE-3, and particularly ASDE-3 enhanced with AMASS, could have prevented this accident.

4. RECOMMENDATIONS

As a result of this investigation, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

Revise the Federal Aviation Regulations to require pilots to illuminate all taxi, landing, and logo lights, or otherwise enhance the conspicuity of their aircraft when operating on an active runway (including runway crossing and position-and-hold operations). (Class II Priority Action) (A-95-86)

Examine the feasibility of requiring pilots to use aircraft anticollision/strobe lights when holding in position on active runways. (Class II Priority Action) (A-95-87)

Define the commonly used term "back-taxi" in the Pilot-Controller Glossary, and provide an explanation of the use of the term and application of the procedure in the Airman's Information Manual and FAA Order 7110.65, "Air Traffic Control." (Class II Priority Action) (A-95-88)

Require air traffic control personnel to make every possible effort to use as few frequencies as possible when positions are combined, and to provide notice of such on the Automatic Terminal Information Service where applicable. (Class II Priority Action) (A-95-89)

Continue to develop, publish, and encourage the implementation of procedures such as automated flight clearances and standard taxi routes to reduce radio frequency congestion during ground operations. (Class II Priority Action) (A-95-90)

Mass-mail to all currently certificated pilots FAA publications on reducing runway incursions and airport improvement information, such as airport signage changes. (Class II Priority Action)(A-95-91)

Require flight instructors to stress airport surface operations, including airport markings, signs, and lighting; situational awareness; clearance readbacks; and proper phraseology during initial training and biennial flight reviews. (Class II Priority Action) (A-95-92)

Require that initial and recurrent air carrier pilot training programs include training in airport surface movement operations, and familiarization with airport markings, signs, and lighting. (Class II Priority Action) (A-95-93)

Continue research and development efforts to provide airports that are not scheduled to receive Airport Surface Detection Equipment with an alternate, cost-

effective system, such as the ground induction loop, to bring controller and pilot attention to pending runway incursions in time to prevent ground collisions. (Class II Priority Action) (A-95-94)

Require that Automatic Terminal Information Service broadcasts at Lambert-St. Louis International Airport reference runways that are being used as secondary or occasionally active runways. (Class II Priority Action) (A-95-95)

Convene a joint FAA/industry task force on human performance initiatives to produce human performance-related airport surface operation improvements that could be readily implemented, are not cost prohibitive, and would provide additional safety measures during surface operations by mitigating human error. In identifying those initiatives, consider the recommendations contained in the MITRE Corporation study, "Reports by Airline Pilots on Airport Surface Operations." (Class II Priority Action) (A-95-96)

Employ an independent source to conduct a survey of the terminal air traffic control staff, similar to the MITRE Corporation study, "Reports by Airline Pilots on Airport Surface Operations," to determine from the staff's perspective, their concerns and views of the scope and magnitude of the runway incursion problem and their recommendations toward the reduction of runway incursions with a view toward ultimate implementation of those recommendations. (Class II Priority Action) (A-95-97)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

JAMES E. HALL
Chairman

ROBERT T. FRANCIS II
Vice Chairman

JOHN A. HAMMERSCHMIDT
Member

JOHN J. GOGLIA
Member

August 30, 1995

5. APPENDIXES

APPENDIX A - INVESTIGATION INFORMATION

1. Investigation

The Safety Board was initially notified of this accident about 2250 on November 22, 1994, by the FAA. Two investigators from the NTSB's North Central Regional Office in West Chicago, Illinois, were immediately dispatched to the scene. A Washington-based team departed for the scene the following morning. The team consisted of investigative groups in the areas of Operations, Human Performance, Air Traffic Control, Airports, and Structures.

Parties to the investigation were the FAA, TWA, National Air Traffic Controllers Association (NATCA), Air Line Pilots Association (ALPA), Cessna Airplane Company, McDonnell Douglas Aerospace, and Lambert-St. Louis Airport Authority.

2. Public Hearing

A public hearing was conducted for this accident on April 19 and 20, 1995. Parties to the public hearing were the FAA, Superior Aviation, TWA, ALPA, NATCA, Lambert-St. Louis Airport Authority, and Airports Council International-North America Region.

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APPENDIX B - ATC TRANSCRIPT

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

TRANSCRIPTS

REGULAR pages 1-34
INBOUND pages 35-36
ATIS page 37

US Department of Transportation
Federal Aviation Administration

Memorandum

Subject: INFORMATION: Transcription concerning the accident involving N441KM Cessna Conquest/441 and TWA427 McDonnell-Douglas MD-80 on November 23, 1994 at 0403 UTC

Date: December 6, 1994

From: St. Louis ATCT

Reply to Attn of:

To:

This transcription covers the St. Louis ATCT Ground Meter, Outbound Ground Control, and North Local Control positions for the time period from November 23, 1994, 0317 UTC to November 23, 1994, 0411 UTC.

Agencies Making Transmissions	Abbreviations
St. Louis ATCT, Ground Meter	GM
St. Louis ATCT, Outbound Ground Control	GO
St. Louis ATCT, North Local Control	NL
St. Louis Approach Control, Low North	LN
Cessna Conquest N441KM	N441KM
Trans World Airlines 427	TWA427
Air Transport International 837	ATN837
Federal Express 1250	FDX1250
Federal Express 1283	FDX1283
Northwest Airlines 9864	NWA9864
Northwest Airlines 1048	NWA1048
Omni-Aviacao E Tecnologia 635	OAV635
Southwest Airlines 327	SWA327
Southwest Airlines 504	SWA504
Southwest Airlines 876	SWA876
Trans World Airlines 23	TWA23
Trans World Airlines 139	TWA139
Trans World Airlines 171	TWA171
Trans World Airlines 175	TWA175
Trans World Airlines 184	TWA184
Trans World Airlines 229	TWA229
Trans World Airlines 233	TWA233
Trans World Airlines 243	TWA243
Trans World Airlines 391	TWA391
Trans World Airlines 397	TWA397
Trans World Airlines 445	TWA445
Trans World Airlines 455	TWA455
Trans World Airlines 458	TWA458
Trans World Airlines 476	TWA476
Trans World Airlines 481	TWA481
Trans World Airlines 609	TWA609
Trans World Airlines 703	TWA703
Trans World Express 13	LOF13
Trans World Express 80	LOF80
Trans World Express 130	LOF130
Trans World Express 450	LOF450
Trans World Express 459	LOF459
Trans World Express 464	LOF464

Zantop International Airlines 432	ZAN432
British Aerospace Jetstream 31 N422AM	N422AM
British Aerospace Jetstream 31 N434AM	N434AM
Gates Learjet Learjet 24 N72FP	N72FP
St. Louis Lambert Emergency Vehicle 42	TRUCK42
St. Louis Lambert Emergency Vehicle 48	TRUCK48
Unknown	UNKNOWN

I hereby certify that the following is a true transcription of the recorded conversations pertaining to the subject aircraft accident involving N441KM and TWA427:

Peter B. Wilkinson
Quality Assurance Specialist
December 6, 1994

This portion of the transcription identifies communications at the GM position from 0317 UTC until 0328 UTC.

0317		
0318		
0318:56	LOF450	And good evening clearance waterski four fifty with uh ... delta to champaign
0319:06	GM	Waterski four fifty cleared to ch champaign turbo two departure decatur transition as filed maintain three thousand and squawk two one two seven
0319:15	LOF459	K two one two seven waterski four fifty good night
0319:18	GM	Waterski four fifty code correct good night
0319:22	TWA23	Clearance uh t w a twenty-three to seattle with delta
0319:25	GM	T w a twenty-three cleared to seattle ozark two departure hallsville transition as filed maintain five thousand and squawk one seven four seven

0319:32	TWA23	One seven four seven for t w a twenty-three
0319:34	GM	T w a twenty-three code correct
0319:45	SWA504	Meter southwest five o four taxi
0319:48	GM	Southwest five zero four proceed to spot november and monitor ground control on one two one point six five
0319:55	SWA504	November point six five southwest uh five o four good day
0320		
0321		
0321:28	LOF80	Clearance waterski eighty springfield illinois delta
0321:34	GM	Waterski eighty saint louis clearance delivery cleared to springfield illinois airport cards three departure capital transition as filed maintain three thousand n squawk four six seven four
0321:45	LOF80	Four six seven four waterski eighty
0321:47	GM	Waterski eighty code correct
0321:56	TWA609	Clearance t w a six zero nine delta des moines
0322:00	GM	T w a six zero nine saint louis clearance delivery cleared to des moines airport ozark two departure macon transition as filed maintain five thousand and squawk two one one six
0322:10	TWA609	Two one one six t w a six o nine

0322:13	GM	T w a six zero nine code correct
0322:23	TWA427	Clearance t w a four twenty-seven with delta to denver
0322:28	GM	T w a four twenty-seven saint louis clearance delivery cleared to denver airport ozark two departure hall huh ozark two departure hallsville transition as filed maintain five thousand squawk one seven six five
0322:41	TWA427	Ah i like that one seven six five t w a four twenty-seven thank you sir
0322:44	GM	T w a four twenty-seven code correct getting close to the end of the shift here
0322:49	TWA427	Us too huh
0322:53	TWA548	T w a five forty-eight delta to moline
0322:57	GM	T w a five forty-eight saint louis clearance delivery cleared to moline airport cards three departure neens transition as filed maintain uh five thousand and squawk one seven seven five
0323:06	TWA548	One seven seven five
0323:08	GM	T w a five forty-eight code correct
0323:10	LOF130	Clearance waterski one (unintelligible)
0323:11	N72FP	(Unintelligible) two fox papa v f r to spirit two point five we're a lear model twenty-four

0323:19	GM	Waterski one thirty to peoria is that correct
0323:22	LOF130	Affirmative
0323:24	GM	Waterski one thirty you're cleared to peoria cards three departure capital transition as filed maintain three thousand and squawk two one six three
0323:31	LOF130	Two one six three waterski one thirty
0323:34	GM	Lear jet v f r to spirit say again your call sign that was the correct code waterski one thirty
0323:39	LOF130	See ya later
0323:41	N72FP	That's lear jet seven two foxtrot papa model twenty-four
0323:49	GM	Lear jet seven two foxtrot papa cleared to depart the class b airspace maintain v f r at or below two thousand one hundred departure frequency will be one one eight point niner five squawk zero two seven four
0324:03	N72FP	Zero two seven four fox pop uh we're at sabreliner ready to taxi
0324:08	GM	Lear seven two foxtrot papa code correct current atis is delta monitor ground control now on one two one point nine
0324:15	N72FP	Fox pop good night
0324:18	GM	Good night

0324:18	TWA243	T w a two forty-three goin to tulsa we have dixie
0324:22	GM	T w a two forty-three you're cleared to the uh tulsa airport lindbergh two departure maples transition as filed maintain five thousand and squawk four seven correction four six seven five
0324:36	TWA243	Forty-six seventy-five t w a's two forty-three good night
0324:38	GM	T w a two forty-three code correct
0324:41	TWA445	Clearance t w a four four five down to dallas forth worth delta
0324:45	TWA397	T w a ... three ninety-seven delta goin to little rock
0324:52	GM	Goin t to uh tulsa or dulles say it again please little rock stand by
0324:58	TWA445	Four four five goin to dallas forth worth
0325:00	GM	Four forty-five to d f w cleared to d f w via the lindbergh two departure maples transition as filed maintain five thousand and squawk two one four one
0325:09	TWA445	Two one four one t w a four four five thank you
0325:11	GM	T w a four forty-five code correct t w a three ninety-seven was it to little rock
0325:15	TWA397	That's us

0325:16	GM	T w a three ninety-seven cleared to little rock lindbergh two departure little rock transition as filed maintain five thousand and squawk one seven two seven
0325:23	TWA397	One seven two seven t w a three ninety-seven
0325:26	GM	T w a three ninety-seven code correct
0325:28	TWA476	A four seventy-six to washington national
0325:31	GM	T w a four seventy-six cleared to d c a blues one departure louisville transition as filed maintain five thousand departure frequency one one eight point niner five squawk one seven two two
0325:41	TWA476	Seventeen twenty-two t w a four seventy-six
0325:43	GM	T w a four seventy-six code correct
0325:45	TWA391	T w a three ninety-one minneapolis delta
0325:47	GM	T w a three ninety-one cleared to minneapolis cards three departure neens transition as filed maintain five thousand and squawk one seven five five
0325:55	TWA391	Seventeen fifty-five t w a three ninety-one
0325:58	GM	T w a three ninety-one code correct
0326:00	ATN837	Clearance air transport eight thirty-seven milwaukee with delta

0326:03	GM	Air transport eight thirty-seven heavy cleared to milwaukee cards three departure capital transition direct pontiac then as filed maintain five thousand squawk one seven three four
0326:13	ATN837	Squawk one seven three four eight thirty-seven
0326:15	GM	Air transport eight thirty-seven heavy code correct call uh meter on one two seven point five five when you're ready to taxi out of the cargo ramp
0326:22	ATN837	Twenty-seven fifty-five we'll do
0326:24	TWA229	Hey john t w a two twenty-nine would like to go to albuquerque with the info
0326:27	SWA876	Southwest eight zero six push gate seventy-eight
0326:30	GM	T w a two twenty-nine wish i was goin with ya cleared to albuquerque lindbergh two departure vichy transition as filed maintain five thousand and squawk two one seven two
0326:38	TWA229	Twenty-one seventy-two yeah come along
0326:40	GM	T w a two twenty-nine code correct good night calling for uh taxi say again please
0326:45	SWA876	Southwest eight seventy-six to push seventy-eight

0326:47	GM	Southwest eight seventy-six push your discretion advise this frequency when you're ready to taxi
0326:50	SWA876	Seventy-six
0327		
0327:01	LOF464	Clearance waterski four sixty-four delta to waterloo
0327:05	GM	Waterski four sixty-four saint louis clearance delivery cleared to waterloo airport cards three departure neens transition as filed maintain three thousand squawk two one one three
0327:18	SWA327	Metering southwest three twenty-seven push at eight six
0327:19	LOF464	K two one one three waterski four sixty-four
0327:23	GM	Say again the code waterski four sixty-four you were cut out on the other frequency
0327:27	LOF464	Two one one three waterski four sixty-four
0327:30	GM	That's correct waterski four sixty-four southwest calling is it three twenty-seven
0327:34	SWA327	That's affirm three twenty-seven push *(eight) six
0327:36	GM	Push your discretion southwest three twenty-seven advise on this frequency when you're ready to taxi

0327:41	SWA327	O k cleared to push call you back for taxi three twenty-seven thanks

0328

This portion of the transcription identifies communications at the GO position from 0350 UTC until 0407 UTC.

0350

0350:05	N422AM	Saint louis ground jetstream four two two alfa mike
0350:08	GO	Jetstream two alfa mike saint·louis ground
0350:11	N422AM	Coming out a eighteen would like go sabreliner
0350:13	GO	Jetstream two alfa mike roger hold short of runway three zero left taxiway bravo
0350:18	N422AM	Three zero left at bravo two alfa mike
0350:23	TWA609	Ground metering t w a six o nine uh abeam seventy-two to taxi
0350:28	GO	T w a six zero nine saint louis ground meter roger outbound the ramp at november and taxi to runway three zero left via alfa
0350:36	TWA609	K november to the left side via alfa t w a six o nine
0350:40	GO	Jetstream two alfa mike cross runway three zero left at bravo and hold short of runway three zero right on taxiway bravo

0350:46	N422AM	Cross the left hold short of the right on bravo two alfa mike
0351		
0352		
0352:56	TWA476	Ground t w a four seventy-six taxi off fifty-two with uh dixie
0353		
0353:01	GO	T w a four seventy-six roger change your departure *(control) correction disregard that uh yeah change your departure control frequency to one one niner point one five runway three zero right hold short of runway three zero left at taxiway hotel
0353:15	TWA476	Thirty right hold short of the left hotel t w a's uh ... four seventy-six
0353:28	ZAN432	Saint louis clearance zantop four thirty-two to laredo
0353:31	GO	Zantop four thirty-two saint louis clearance delivery cleared to laredo airport via the lindbergh two departure maples transition then as filed maintain three thousand squawk one one five zero
0353:47	ZAN432	O k cleared to laredo via lambert two departure maple transition as filed maintain three and departure is uh squawk one one five zero
0353:55	OAV635	Saint louis ground omni *(six thirty-five's) clear of the right goin to sabreliner's line to park for u p s
0354:00	GO	Omni six thirty-five saint louis ground taxi to the ramp
0354:04	OAV635	Six thirty-five

0354:05	GO	Zantop four thirty-two maintain three thousand readback was correct contact me on ground control one two one point niner when you're ready taxi
0354:12	ZAN432	Roger
0354:13	TWA184	Ground t w a's one eighty-four one eighty-four with uh delta to boston
0354:18	N434AM	Saint louis ground jetstream four three four alfa mike
0354:19	TWA703	T w a seven o three to uh kansas city
0354:23	GO	T w a seven zero three clearance's on request t w a one eighty-four where'd you say you were at
0354:27	TWA184	Gate sixty-nine with uh delta to boston
0354:33	GO	T w a seven zero three and t w a one eighty-four clearance's on request jetstream calling ground say again
0354:37	N434AM	Yeah it's jetstream four three four alfa mike currently at gate eighteen like to go to sabreliner please
0354:41	GO	Jetstream four alfa mike roger
0354:53	GO	Jetstream four alfa mike join alfa hold short of runway three zero left at taxiway juliett
0354:58	N434AM	Jetstream four *(alfa) mike hold short of three zero left at juliett

0355:02	GO	T w a four seventy-six cross runway three zero left taxi runway three zero right
0355:06	TWA476	Cross thirty left go to thirty right t w a's four seventy-six
0355:09	GO	Jetstream two alfa mike expedite cross runway three zero right traffic's a mile and a half out
0355:14	N422AM	Expedite sabreliner two alfa mike
0355:20	GO	Jetstream four alfa mike go straight ahead now and cross runway three zero left and hold short runway three zero right on taxiway bravo
0355:25	N434AM	Four alfa mike copy on the bravo going across three zero left
0355:37	N441KM	(Unintelligible) i f r to iron (unintelligible)
0355:39	TWA427	T w a four twenty-seven your frequency and uh taxi
0355:42	GO	Twin cessna four four one kilo mike roger clearance on request who else called ground meter or ground control
0355:49	TWA397	Ground t w a three ninety-seven for gate seventy-two on the alley
0355:53	GO	T w a three ninety-seven saint louis ground outbound at november taxi to runway three zero left via alfa
0355:58	TWA397	Alfa to three zero left t w a three ninety-seven

0356:03	TWA427	T w a four twenty-seven taxi with ah juliett at at juliett
0356:13	TWA427	Ground t w a four twenty-seven at juliett taxi
0356:17	GO	T w a four twenty-seven saint louis ground uh roger and runway three zero right hold short runway three zero left taxiway hotel
0356:23	TWA427	Three zero right hold short of the left at hotel t w a's uh four twenty-seven
0356:27	TWA175	Clearance t w a uh one seventy-five up to cedar rapids delta
0356:28	UNKNOWN	(Unintelligible)
0356:41	UNKNOWN	(Unintelligible) *(twelve) fifty's clear of the right side
0356:46	TWA23	*(Meetering) t w a twenty-three's at uh bravo two
0356:50	GO	And uh jetstream four alfa mike traffic'll hold in position cross runway three zero right proceed to sabreliner ramp
0356:55	N434AM	Jetstream four alfa mike crossing three zero right to sabreliner thank you
0356:59	GO	And who else called ground meter
0357:00	UNKNOWN	(Unintelligible)

0357:01	TWA175	Uh t w a uh one seventy-five goin to cedar rapids with delta
0357:04	GO	All right whoever's going to cedar rapids uh clearance is on request who needs for ground meter or ground control
0357:08	TWA455	T w a four fifty-five at gate seventy-two to taxi
0357:08	TWA23	(Unintelligible) bravo two
0357:12	GO	T w a four fifty-five abeam seventy-two outbound the ramp at taxiway november taxi to runway three zero left
0357:17	TWA455	Thirty left at november t w a four fifty-five
0357:19	GO	Who else needs ground control
0357:21	TWA23	It's t t w a twenty-three at bravo two
0357:23	GO	T w a twenty-three saint louis ground runway three zero right hold short runway three zero left at taxiway hotel
0357:27	TWA23	Thirty left hold short of the right at hotel t w a's uh twenty-three
0357:31	FDX1250	*(Ex) twelve fifty clear of three zero right
0357:34	GO	T w a four twenty-seven cross runway three zero left taxi runway three zero right

0357:37	TWA427	Four twenty-seven cross the left to the right
0357:40	GO	Federal express twelve fifty saint louis ground taxi the ramp
0357:42	FDX1250	*(Ex) twelve fifty
0357:44	GO	Who else needs ground control
0357:49	GO	Who else needs ground control anybody ... o k twin cesssna four four one kilo mike you're cleared to the uh india mike tango airport via the cards three departure neens transition then as filed maintain three thousand squawk one one zero five
0358:05	N441KM	(Unintelligible) o k understand uh three thousand one one zero five uh for one kilo mike
0358:12	GO	One kilo mike readback is correct where you parked at and are you ready to taxi
0358:15	N441KM	I'm at midcoast and uh yes we are ready to taxi
0358:19	GO	One kilo mike roger back taxi into position hold runway three one let me know on this frequency when you're ready for departure
0358:23	N441KM	Kilo mike
0358:26	GO	Anybody else need clearance delivery
0358:30	TWA175	T w a one seventy-five standing by for clearance

0358:32	GO	T w a one seventy-five saint louis clearance delivery you're cleared to the cedar rapids airport via the cards three departure neens transition then as filed maintain five thousand squawk one seven five three
0358:42	TWA175	One seven five three
0358:44	GO	T w a one seventy-five code is correct
0358:46	LOF13	Waterski thirteen to *(scuff) with delta
0358:48	GO	Waterski thirteen cleared to the springfield airport via the lindbergh departure vichy transition then as filed maintain three thousand squawk four seven zero seven
0358:59	LOF13	K four seven zero seven and uh is vichy back on the air
0359:02	GO	Waterski thirteen uh no it's still out of sevice expect radar vectors over vichy
0359:07	LOF13	O k radar vectors *(ove) vichy uh ski thirteen
0359:09	TWA391	T w a three ninety-one's abeam seventy-two
0359:10	GO	T w a three ninety-one saint louis ground runway three zero right hold short of runway three zero left at taxiway hotel

0359:17	TWA391	Short of thirty left at hotel t w a three ninety-one
0359:24	NWA9864	Saint louis ground northwest ninety-eight sixty-four
0359:26	GO	Northwest ninety-eight sixty-four push off that gate let me know when you're ready to taxi
0359:30	NWA9864	Ninety-eight sixty-four will advise
0359:32	TWA481	Ground t w a uh four eighty-one spot tango taxi
0359:36	GO	T w a twenty-three cross runway three zero left taxi to runway three zero right
0359:40	TWA23	O k uh cross the left taxi the right t w a twenty-three
0359:43	GO	Who's at spot tango
0359:45	TWA481	T w a uh four eighty-one
0359:47	GO	T w a four eighty-one roger from the tango spot runway three zero right hold short of runway three zero left at taxiway juliett
0359:56	TWA481	Thirty right hold shor[illegible]r thirty left at juliett t w a four eighty-one
0400:00	TWA233	Ground t w a two thirty-three juliett

0400:02	GO	T w a two thirty-three saint louis uh ground roger i want you to give way to a company seven twenty-seven that's off the hotel spot then straight ahead taxi runway three zero left via the airline ramp and taxiway delta
0400:15	TWA233	Give way to the seven two and then uh three zero left via the airline ramp and taxiway delta t w a two thirty-three
0400:24	ZAN432	Ground zantop four thirty-two ready to go with juliett
0400:27	GO	Zantop four thirty-two saint louis uh ground uh what are you coming off the sabreliner ramp
0400:32	ZAN432	Coming out of zantop
0400:34	GO	Roger zantop four thirty-two you can pull out hold short of runway one three i'll get you moving shortly
0400:39	ZAN432	Hold short of one three zantop four thirty-two
0400:41	UNKNOWN	Ground t w a (Unintelligible) gate number two
0400:45	GO	Uh northwest for gate two your company just pushed back what i want you to do is turn left on alfa then a right turn at the bravo one spot hold behind the american gates when i get him out of there i'll get you in there

0400:54	NWA1048	Northwest ten forty-eight understand that
0400:56	TWA243	Ground i know you're busy t w a's two forty-three is number two at seventy-two
0401:01	GO	T w a two forty-three abeam seventy-two's what you said
0401:03	TWA243	Yes we're number two behind uh another d c nine
0401:06	GO	O k who's number one abeam seventy-two
0401:08	TWA445	T w a four four five
0401:09	GO	T w a four forty-five uh roger i don't have any paperwork on you uh standby...t w a four forty-five outbound the ramp at november taxi runway three zero left via alfa south uh taxiway
0401:23	TWA445	Cleared the left via alfa south t w a uh four forty-five
0401:26	GO	T w a two forty-three same for you taxi runway three zero left via alfa south taxiway follow the d c nine ahead
0401:30	TWA243	Follow the d c nine alfa south t w a's two forty-three
0401:34	GO	And uh one kilo mike you ready for departure
0401:38	N441KM	One kilo mike yeah we're ready (unintelligible)

0401:39	LOF130	Waterski one thirty is an a t r going to bravo two and we have information delta
0401:44	GO	Waterski one thirty roger proceed to bravo two monitor my frequency one two one point niner
0401:49	LOF130	O k i'm up that frequency right now
0401:50	GO	Roger that one kilo mike hold on position on runway three one and monitor the tower on one two zero point zero five
0402:00	NWA9864	Saint louis ground northwest ninety-eight *(sixty-four taxi)
0402:01	N441KM	(Unintelligible) understand position and hold monitor the tower kilo mike
0402:04	GO	Northwest nine-eight sixty-four outbound the ramp join alfa at echo taxi to the charlie pad
0402:09	NWA9864	Join alfa at echo to the charlie pad northwest nine-eight sixty-four
0402:11	GO	Northwest ten forty-eight when you see your company go out then you can taxi in to gate two
0402:16	NWA1048	Northwest ten forty-eight copies
0402:18	TWA139	Saint louis ground t w a one thirty-nine's abeam gate seventy-two with delta
0402:20	TWA81	T w a eighty-one clearance uh to wichita with delta

0402:23	GO	T w a three ninety-one cross runway three zero left
0402:25	TWA391	Cross thirty left t w a three ninety-one
0402:27	GO	T w a four eighty-one follow your company traffic to your right cross runway three zero left
0402:31	TWA481	Follow the company cleared to cross thirty left t w a four eighty-one
0402:34	GO	Waterski one thirty runway three zero right hold short of runway three zero left at taxiway bravo
0402:39	LOF130	Three zero right hold short of the left at bravo waterski one thirty
0402:43	TWA81	Saint Louis clearance t w a eighty-one we've got delta
0402:44	TWA139	T w a one thirty-nine abeam gate seventy-two delta
0402:47	GO	T w waterski one thirty cross runway three zero left there at bravo and taxi runway three zero right
0402:51	LOF130	O k cross the left taxi to the right now waterski one thirty
0402:55	GO	O k and uh calling clearance delivery stand by who needs ground meter
0402:59	TWA139	T w a one thirty-nine abeam seventy-two

0403:01	GO	T w a one thirty-nine outbound the ramp at november runway three zero right hold short of runway three zero left at taxiway november
0403:07	TWA139	Hold short of three zero uh left at november for three zero right t w a one thirty-nine
0403:12	UNKNOWN	And ground seven eleven's bravo two for taxi
0403:17	GO	Everybody stand by we've had an aircraft accident on the runway
0403:43	GO	Everybody stand by we've had an airport accident on the runway there's goin ta
0403:51		O k you say the lower beacon light's no good
0404		
0404:06	TRUCK42	Saint louis ground this is truck forty-two do you have a location on this accident
0404:10	GO	Yes it's at the uh intersection of runway three zero right and taxiway november we need you to move there now there's been an accident on the airport
0404:16	TRUCK42	Three zero right at november
0404:18	GO	Affirmative runway three zero right at taxiway november
0404:22	TRUCK42	That's clear
0404:23	GO	Yeah proceed directly to it and proceed on all the runways
0404:26	TRUCK48	Truck forty-eight clear

0404:28	GO	Truck forty-eight proceed as requested and truck forty-eight comin in from the south side cross runway three zero left
0404:33	TRUCK42	Orty-two's goin to cross at bravo
0404:40	TWA171	T w a one seventy-one's at juliett with uh delta
0404:45	GO	Ah everybody callin clearance delivery and ground control just stand by and hold your position
0405 0405:28	TWA175	(Unintelligible) t w a's one seventy-five's comin up on seventy uh *(three) and we have delta
0405:34	GO	T w a one seventy-five saint louis ground uh say again
0405:39	TWA175	We're at gate seventy-three and we have delta
0405:41	GO	T w a one seventy-five ss remain hold your position we've had an accident on the airport
0405:49	TWA175	One seventy-five roger
0406 0406:04	GO	Zantop four thirty-two what can you see from your position where you're at
0406:11	ZAN432	Eh we can't see much just uh looks like the uh t w a's uh all shut down uh have the uh air stairs open and uh rescue vehicles around em
0406:21	GO	K

0406:24	TWA229	Two twenty-nine t w a at b two
0406:26	GO	T w a ninety-eight sixty-four turn left on taxiway alfa and taxi to the charlie pad
0406:31	NWA9864	Northwest thirty-eight sixty-four we'll go to charlie pad
0406:33	GO	Northwest ten forty-eight taxi to the ramp
0406:36	NWA1048	West ten forty-eight taxi to the ramp
0406:39	TWA391	T w a three ninety-one's just going to hold here by sierra if that's alright with you
0406:43	GO	T w a three ninety-one that'll be fine
0406:45	TWA391	Figure that runway's closed now
0406:47	GO	Yes it is
0406:49	LOF130	Ground waterski one thirty we're at the intersection of papa and bravo
0406:53	GO	Waterski one thirty say again
0406:55	LOF130	We're at the intersection of papa and bravo
0406:58	GO	Waterski one thirty roger i appreciate that just uh hold your position right there (unintelligible)

0407:03	LOF130	Waterski one thirty wilco
0407:06	GO	What we're going to do is probably take everybody to the right

This portion of the transcription identifies communications at the NL position from 0356 UTC until 0411 UTC.

0356		
0356:01	NL	Waterski four fifty saint louis tower runway three zero right taxi into position and hold
0356:07	LOF450	*(Into) position and hold waterski four fifty
0356:33	NL	Fedex twelve fifty turn right ... and uh contact ground point niner ck
0356:40	FDX1250	Twelve fifty
0357		
0358		
0358:11	NL	Waterski four fifty wind two eight zero at seven runway three zero right turn right heading three five five cleared for takeoff
0358:18	LOF450	Three fifty-five cleared to go waterski four fifty
0358:23	NL	We're gonna do an o swap
0358:24	LN	O k fine
0358:25	NL	G n
0358:26	LN	R l

0358:34	NL	T w a four seventy-six saint louis tower runway three zero right taxi into position and hold
0358:37	TWA476	Position hold thirty right t w a four seventy-six
0359		
0359:01	NL	T w a four seventy-six the prop ahead'll be in a right turn northbound wind two eight zero at eight runway three zero right turn right heading three three five cleared for takeoff
0359:09	TWA476	Right three three five thirty right cleared for takeoff t w a four seventy-six
0359:15	NL	Waterski four fifty three five five on the heading contact departure good night
0359:19	LOF450	Three fifty-five we'll see ya waterski four fifty
0359:22	NL	T w a three ninety-seven saint louis tower runway thre zero left taxi into position and hold
0359:26	TWA397	Position and hold t w a three ninety-seven
0359:54	NL	Northwest ten forty-eight turn left when able and contact ground point nine as you clear the runway good night
0359:58	NWA1048	Northwest ten forty-eight
0400		
0400:25	NL	T w a four seventy-six three thirty-five on the heading contact departure good night

0400:29	TWA476	T w a four seventy-six good night
0400:32	NL	T w a three ninety-seven winds two seven zero at seven runway three zero left fly runway heading cleared for takeoff
0400:37	TWA397	Runway heading cleared to go t w a three ninety-seven
0400:39	NL	T w a four forty-five saint louis tower runway three zero left taxi into position and hold
0400:46	TWA455	Uh four fifty-five we're not quite ready yet
0400:48	NL	Uh i don't have any uh paperwork on a four fifty-five where you goin sir
0400:52	TWA455	Omaha the code is uh two one four four
0400:55	NL	O k i've got a four forty-five i don't have a four fifty-five stand by
0401 0401:04	NL	O k four fifty-five you're uh number one at three zero left is that correct
0401:08	TWA455	T w a four fifty-five that's correct
0401:10	NL	Roger change your departure frequency it'll be one one niner point one five and let me know when you're ready to go
0401:15	TWA455	K stand by one
0401:22	TWA427	And t w a four twenty-seven's ready
0402:24	NL	T w a four twenty-seven winds two seven zero at seven runway three zero right turn right heading three three five cleared for takeoff

0401:30	TWA427	Three thirty five and cleared to go t w a four two seven
0401:32	NL	T w a three ninety-seven runway heading contact departure good night
0401:36	TWA397	Three ninety-seven good night
0401:41	TWA427	Confirm uh three twenty-five for t w a's four twenty-seven
0401:47	NL	T w a twenty-seven three three five
0401:50	TWA427	Three three five thanks
0402		
0402:29	N441KM	And kilo mike's ready to go on the right side
0402:30	NL	Roger i can't roll you simultaneously with the uh traffic departing the right just continue holding in position i'll have something for you in just a second
0402:37	N441KM	Kilo mike
0402:38	TWA455	T w a four fifty-five's ready on thirty left
0402:40	NL	T w a four fifty-five runway three zero left taxi into position and hold
0402:43	TWA455	*(Position) hold three zero left t w a four fifty-five

0402:48	NL	Twin cessna four four one kilo mike winds two eight zero at eight the traffic uh uh use caution for the m d eighty that's uh departing thirty right for possible wake turbulence turn right heading uh three five five ... continue holding in position
0403:01	TWA427	T w a four hundred and twenty-seven hit the other airplane on the uh runway roll the emergency equipment
0403:15	TWA427	Do you hear me do you hear me·
0403:17	NL	Yes i do we're rolling the equipment
0403:19	TWA427	Roll the equipment ... check uh t w a four twenty-seven see if you have uh see if t w a four twenty-seven has any fire
0403:41	TWA233	And tower t w a two thirty-three is uh with you for the uh three zero left
0403:52	NL	T w a four fifty-five uh continue holding in position i'm going to have you for something for you in just a second
0403:58	TWA455	Four fifty-five roger
0404 0404:06	TWA427	Tower t w a four twenty-seven
0404:08	NL	T w a four twenty-seven the equipment's rolling right now
0404:10	TWA427	You see any fire or smoke around da aircraft

0404:14	NL	No sir i don't ... he was supposed to be on runway three one i did not see the aircraft on that runway
0404:20	TWA427	(Unintelligible) all that later i just want to make sure everything's safe here
0404:21	NL	Roger
0405		
0405:02	NL	T w a four fifty-five we've had an accident on the run on the airport i need you to go down to the next intersection ahead turn right turn right on papa taxiway and back taxi on papa taxiway back to runway three zero left
0405:16	TWA455	Wilco t w a four fifty
0405:18	TWA427	T w a's uh four twenty-seven is evacuating off the left side of the aircraft
0405:23	NL	T w a four twenty-seven understand you are evacuating at this time
0405:55	FDX1283	Tower fedex twelve eighty-three is rolling out on the final for the visual three zero left
0406:00	NL	Fedex twelve eighty-three saint louis tower runway three zero left cleared to land wind two six zero at seven
0406:05	FDX1283	Cleared to land three zero left fedex twelve eighty-three
0407		
0408		
0408:04	TWA391	Tower t t w a three ninety-one's uh with ya holding short of sierra

0408:08	NL	T w a three ninety-one uh understand you're holding short of sierra make a right turn there uh you'll plan runway three zero left uh as we uh start getting things started again plan runway three zero left uh and stay on this frequency
0408:22	TWA391	Hold short of thirty left on sierra t w a three ninety-one
0408:24	NL	Are you number one
0408:27	TWA391	Yeah we're number one on the north side
0408:29	NL	Roger
0408:32	TWA391	Give us a warning we got two engines shut down
0408:35	NL	Wilco
0408:39	TWA233	Tower t w a two thirty-three
0408:41	NL	T w a two thirty-three tower
0408:43	TWA233	Uh yes ma'am we're sitting here uh number one for three zero left ih is it going to be a while with the accident uh i mean can we shut one down er what
0408:51	NL	No sir runway three zero left is still uh an open runway we will ha we will start departures in just a just a couple of seconds
0408:59	TWA233	Ve very well thanks

0409		
0409:02	NL	And two thirty-three understand you're at the number one position on runway three zero left
0409:05	TWA233	Uh we're the number one position facing north uh for three zero left
0409:09	NL	O k four fifty-five who are you behind
0409:11	TWA455	We're behind uh the seven twenty-seven at sierra
0409:16	NL	T w a four fifty-five roger
0409:24	NL	Express four uh twelve eighty-three turn right and contact ground point niner
0409:28	FDX1283	Fedex twelve eighty-three wilco
0409:34	NL	T w a three ninety-one are are you on the uh o k three ninety-one are which aircraft are you behind the a t r forty-two
0409:42	TWA391	No we're number one seven twenty-seven for thirty left on sierra
0409:45	NL	You are the number one aircraft for thirty left on sierra
0409:49	TWA391	Affirmative
0409:50	NL	O k four eighty-one you're the number two aircraft for runway three zero left

JAN-31-1995 10:29 FAA/AAI 202 267 5843 P.04

US Department of Transportation
Federal Aviation Administration

JAN 19 1995

Subject: INFORMATION: Transcription concerning the accident involving N441KM Cessna Conquest/441 on November 23, 1994 at 0403 UTC

Date: January 17, 1995

From: St. Louis ATCT

Reply to Attn of:

To: This transcription covers the St. Louis North Local Control and Inbound Ground Control positions for the time period from November 23, 1994, 0335 UTC to November 23, 1994, 0341 UTC.

Agencies Making Transmissions	Abbreviations
St. Louis ATCT, North Local Control	NL
St. Louis ATCT, Inbound Ground Control	GI
Cessna Conquest N441KM	N441KM

I hereby certify that the following is a true transcription of the recorded conversations pertaining to the subject aircraft accident involving N441KM:

Lela J. Moore
Quality Assurance Specialist
January 17, 1995

This portion of the transcription identifies communications at the NL position from 0335 UTC until 0340 UTC.

0335		
0335:09	N441KM	An good evening tower conquest
0335:16	NL	Zthat conquest one kilo mike
0335:25	NL	Conquest one kilo mike saint louis groun tower
0335:44	NL	Conquest four four one kilo mike saint louis tower
0335:46	N441KM	this radio
0335:47	NL	Conquest four four one kilo mike your loud and clear how me

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Page 2 of 2

0335:50	N441KM	*(Well) I got you now (unintelligible) switch radios here
0335:52	NL	One kilo mike you are cleared to land runway three zero right you are following traffic three and a half miles ahead winds two seven zero at niner
0335:59	N441KM	(Unintelligible) kilo mike I got the traffic and the airport
0336		
0337		
0338		
0339		
0340		
0340:16	NL	Conquest uh one kilo mike turn right at the next intersection taxiway november contact ground control one two one point niner good night
0340:24	N441KM	Kilo mike gu night
0340:37	N441KM	Ground four four one kilo mike is uh clearing
0340:41	NL	One kilo mike contact ground control point niner good day

This portion of the transcription identifies communications at the GI position from 0340 UTC until 0341 UTC.

0340		
0340:55	N441KM	One kilo mike is clear and goin to midwest
0341		
0341:01	GI	November one kilo mike saint louis ground taxi to midcoast ramp
0341:04	N441KM	(Unintelligible) one

End of Transcript

* This portion of the rerecording is not entirely clear, but this represents the best interpretation possible under the circumstances.

U.S Department of Transportation
Federal Aviation Administration

Memorandum

INFORMATION: Transcription concerning the accident involving N441KM Cessna Conquest/441 and TWA427 McDonnell-Douglas MD-80 on November 23, 1994 at 0403 UTC

Date February 28, 1995

Reply to Attn of:

St. Louis ATCT

This transcription covers the St. Louis ATCT Automatic Terminal Information Service broadcasts for the time period from November 23, 1994, 0355 UTC to November 23, 1994, 0402 UTC.

Agencies Making Transmissions	Abbreviations
St. Louis ATCT, Automatic Terminal Information Service	ATIS

I hereby certify that the following is a true transcription of the recorded Automatic Terminal Information Service broadcast pertaining to the subject aircraft accident involving N441KM and TWA427:

Peter B. Wilkinson
Quality Assurance Specialist
February 28, 1995

0355
0355:02 ATIS *Saint louis lambert airport information delta zero two five zero zulu weather two five thousand thin scattered visibility two five temperature three four dew point two two wind two eight zero at eight altimeter three zero five six simultaneous visual approaches utilizing runway three zero right i l s localizer runway three zero left l d a d m e localizer notice to airmen vichy v o r out of service taxiway alfa south is now known as taxiway delta taxiway delta closed from taxiway charlie to the airline ramp advise on initial contact you have delta

End of Transcript

*(This broadcast is repeated nine times in full and once partially by 0402 UTC.)

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APPENDIX C - CVR TRANSCRIPT

NATIONAL TRANSPORTATION SAFETY BOARD
Engineering & Computer Services Division
Washington, D.C. 20594

SPECIALIST'S FACTUAL REPORT OF INVESTIGATION
Cockpit Voice Recorder

by

Albert G. Reitan
Transportation Safety Specialist

Warning

The reader of this report is cautioned that the transcription of a CVR tape is not a precise science but is the best product possible from an NTSB group investigative effort. The transcript, or parts thereof, if taken out of context, could be misleading. The attached CVR transcript should be viewed as an accident investigation tool to be used in conjunction with other evidence gathered during the investigation. Conclusions or interpretations should not be made using the transcript as the sole source of information.

NATIONAL TRANSPORTATION SAFETY BOARD
Engineering & Computer Services Division
Washington, D.C. 20594

SPECIALIST'S FACTUAL REPORT OF INVESTIGATION
Cockpit Voice Recorder
CHI 95 MA 044 A/B

January 10, 1995

A. ACCIDENT

Location:	St. Louis International Airport, Missouri
Date:	November 22, 1994
Time:	2202 Central Standard Time (CST)
Aircraft:	MD-82, N954U

B. GROUP

Chairman: Albert G. Reitan
Transportation Safety Specialist (CVR)
National Transportation Safety Board

Member: Martin H. Potter
Aviation Safety Inspector
Federal Aviation Administration

Member: Capt. Joe Chronic
Flight Manager DC9/MD80 Training
Trans World Airlines, Inc.

Member: Capt. Ernie Hadfield
ALPA/TWA
Trans World Airlines, Inc

Member: David Ryan
Air Safety Investigator
Cessna Aircraft Company

Member: Greg Colclasure
Air Safety Investigator
National Air Traffic Controllers Association

C. SUMMARY

A Fairchild model A-100 cockpit voice recorder (CVR), s/n 3455, was brought to the audio laboratory of the National Transportation Safety Board on November 23, 1994. The Cockpit Voice Recorder committee convened on November 27, 1994. A transcript was prepared of the last 9:50 minutes the 30:55 minute recording. (attached)

D. DETAILS OF INVESTIGATION

The exterior of the CVR showed no evidence of structural damage. The interior of the recorder and the tape sustained no apparent heat or impact damage. A Dukane underwater locator beacon (ULB) was installed and when tested in the laboratory, was found to operate satisfactorily.

The recording consisted of three channels of good quality audio information. One channel contained the cockpit area microphone audio information. The other two channels contained the Captain and First Officer, audio panel information. The timing on the tape was established using the known time of an air traffic control transmission recorded on a cassette tape provided by the FAA.

The transcript started at 2155:10 CST and continued uninterrupted until 2204:58 CST when electrical power was removed from the unit. When the recording started, the flight had just departed the loading gate and received taxi instructions. The recording continued as the crew continued taxiing to the departure runway and started the takeoff roll. The recording ended after the aircraft impacted another aircraft and the crew ordered an evacuation.

As part of the Safety Board's accident investigation process, the cockpit flight crew was invited to review the CVR group's transcript and suggest corrections or additions. The Captain, First Officer, and the jump seat occupant

(a TWA Captain) reviewed the CVR recording and transcript on January 4, 1994 and suggested the following changes.

Page 9
2200:31 {26:28}
Change **CAM-3** to **CAM-4**

Page 13
2202:38 {28:35}
Change to; one ninety four [voice vibrating possibly caused by aircraft nosewheel traveling over rough runway]

Page 14
2203:13 {29:10}
change **CAM-?** to **CAM-4**

Page 17
2204:31 {30:28}
change **CAM-2** to **CAM-3**

Page 17
2204:35 {30:32}
change **CAM-?** to **CAM-3**

Page 17
2204:39 {30:36}
change to; I'm shuttin' the right engine down.

Albert G. Reitan
Albert G. Reitan
Transportation Safety Specialist (CVR)

Attachment:

Transcript of a Fairchild A-100 cockpit voice recorder (CVR), s/n 3455, installed on a McDonnell Douglas MD-82, N954U, which was involved in a ground collision with another aircraft while departing St. Louis International Airport, on November 22, 1994.

LEGEND

RDO	Radio transmission from accident aircraft
CAM	Cockpit area microphone voice or sound source
INT	Transmissions over aircraft interphone system
RCT	Radio transmission from TWA ramp control
GND	Radio transmission from St. Louis tower
TWR	Transmission received from St. Louis ground control
PA	Transmission made over aircraft Public Address system
TW450	Radio transmission from TWA flight four fifty
TW455	Radio transmission from TWA flight four fifty five
TW183	Radio transmission from TWA flight one eighty three
TW397	Radio transmission from TWA flight three ninety seven
JSAM	Radio transmission from aircraft number JSAM
AC-?	Radio transmission from unknown aircraft
TW23	Radio transmission from TWA flight four twenty three
FE1250	Radio transmission from Federal Express flight twelve fifty
TW476	Radio transmission from TWA flight four seventy six
441KM	Radio transmission from aircraft number four four one Kilo Mike
JSAM	Radio transmission from aircraft number WS four fifty
-1	Voice identified as Pilot-in-Command (PIC)
-2	Voice identified as Co-Pilot
-3	Voice identified as ACM captain sitting in observer seat
-4	Voice identified as female Flight Attendant
-5	Voice identified as aircraft mechanical voice

-?	Voice unidentified
*	Unintelligible word
@	Non pertinent word
#	Expletive
%	Break in continuity
( )	Questionable insertion
[ ]	Editorial insertion
...	Pause

Note: Times are expressed in central standardt time (CST).
Times shown in brackets { } are computer reference times measured from the beginning of the recording.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
START of TRANSCRIPT			
		2155:10 **RDO-2**	{21:07} four twenty seven's ready to taxi.
		2155:12 **RCT**	{21:09} yes sir, they want you to go right to ground, one twenty one nine, right there. we'll see you later.
		2155:16 **RDO-2**	{21:13} see you later.
		2155:34 **RDO-2**	{21:31} ground, TWA four twenty seven.
		2155:39 **RDO-2**	{21:36} ground, TWA four twenty seven your frequency. and uh, taxi.
		2155:43 **GND**	{21:40} twin Cessna four four one Kilo Mike roger, clearance on request. who else called ground meter or ground control?
2155:47 **CAM-1**	{21:44} here we are at Juliet •		
		2155:50 **TW397**	{21:47} ground, TWA three ninety seven's abeam seventy two on the alley.
		2155:54 **GND**	{21:51} TWA three ninety seven St. Louis ground outbound at November, taxi to three zero left via Alpha.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		2155:59 **TW397**	{21:56} Alpha to three zero left, TWA, three ninety seven.
		2156:04 **RDO-2**	{22:01} TWA four twenty seven taxi with uh, Juliet, at at Juliet.
		2156:14 **RDO-2**	{22:11} ground, TWA four twenty seven at Juliet, taxi.
		2156:17 **GND**	{22:14} TWA four twenty seven St. Louis ground uh, roger, and runway three zero right hold short of three zero left taxiway hotel.
		2156:24 **RDO-2**	{22:21} three zero right, hold short of the left at Hotel. TWA's uh, four twenty seven.
2156:28 **CAM-1**	{22:25} hold short at H.		
		2156:29 **TW455**	{22:26} TWA's four fifty five abeam seventy two.
		2156:41 **TW450**	{22:38} ground, *** four fifty clear of the right side.
		2156:46 **TW183**	{22:43} metering, TWA's one eighty three's at uh, Bravo two.
		2156:50 **GND**	{22:47} and uh, Jetstream four Alpha Mike, traffic will hold in position. cross runway three zero right proceed the Saberliner ramp.
2156:55 **CAM**	{22:52} [sound of horn similar to stabilizer trim-in-motion warning]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		2156:57 **JS3AM**	{22:54} Jetstream four Alpha Mike, cross three zero right to Sabreliner. thank you.
2156:58 **CAM-2**	{22:55} full loaded boat.		
		2156:59 **GND**	{22:56} and who else called ground meter?
		2157:00 **TW455**	{22:57} four fifty five abeam seventy two.
		2157:03 **GND**	{23:00} alright, whoever's going to Cedar Rapids uh, clearance is on request. who needs for ground meter or ground control?
		2157:08 **TW455**	{23:05} TWA four fifty five at gate seventy two to taxi.
		2157:11 **AC-?**	{23:08} ... Bravo two.
		2157:12 **GND**	{23:09} TWA four fifty five abeam seventy two outbound the ramp at taxiway November, taxi to runway three zero left.
		2157:17 **TW455**	{23:14} thirty left at November, TWA four fifty five.
		2157:19 **GND**	{23:16} who else needs ground control?
		2157:20 **TW23**	{23:17} T, TWA twenty three at Bravo two.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		2157:23 **GND**	{23:20} TWA twenty three, St. Louis ground. runway three zero right, hold short runway three zero left at taxiway Hotel.
		2157:28 **TW23**	{23:25} thirty left, hold short of the right at Hotel, TWA's uh, twenty three.
		2157:31 **FE1250**	{23:28} Fed Ex twelve fifty clear of three zero right.
		2157:34 **GND**	{23:31} TWA four twenty seven cross runway three zero left. taxi runway three zero right.
		2157:37 **TW427**	{23:34} four twenty seven, cross the left to the right.
		2157:39 **GND**	{23:36} Federal Express twelve fifty, St. Louis ground, taxi to the ramp.
2157:40 **CAM-1**	{23:37} cross this thing.		
		2157:41 **FE1250**	{23:38} Fed Ex twelve fifty.
		2157:43 **GND**	{23:40} who else needs ground control?
2157:44 **CAM-2**	{23:41} he's far enough out looks like, it shouldn't be a problem.		
		2157:49 **GND**	{23:46} who else needs ground control, anybody?

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		2157:51 **GND**	{23:48} OK, twin Cessna four four one Kilo Mike you're cleared to the uh, India Mike Tango airport via the Cards three departure, Neens transition, then as filed. maintain three thousand. squawk one one zero five.
2158:06 **CAM-1**	{24:03} whenever you get organized, read that taxi check list please.		
2158:10 **CAM-2**	{24:07} alright, taxi check list.		
		2158:13 **GND**	{24:10} one Kilo Mike, readback is correct. where you parked at and are you ready to taxi?
		2158:18 **GND**	{24:15} one Kilo Mike roger, back taxi into position and hold runway three one. let me know on this freq ...
2158:27 **CAM-2**	{24:24} taxi check list says flaps and runway.		
2158:30 **CAM-1**	{24:27} eleven and takeoff thirty right.		
2158:31 **CAM-2**	{24:28} eleven and takeoff thirty right.		
		2158:33 **TWR**	{24:30} TWA four seventy six • • • three zero right taxi into position and hold.
		2158:37 **TW476**	{24:34} position and hold thirty right, TWA four, seventy six.
2158:37 **CAM-2**	{24:34} take off data TRI and airspeed bugs?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2158:39 **CAM-1**	{24:36} one fifty three big EPRs, set • cross checked.		
2158:41 **CAM-2**	{24:38} stabilizer trim?		
2158:42 **CAM-1**	{24:39} set.		
2158:44 **CAM-2**	{24:41} flight controls?		
2158:45 **CAM-1**	{24:42} checked.		
2158:46 **CAM-2**	{24:43} fuel system?		
2158:47 **CAM-1**	{24:44} that's checked.		
2158:48 **CAM-2**	{24:45} fuel heat?		
2158:49 **CAM-1**	{24:46} off.		
2158:51 **CAM-2**	{24:48} seat belt and shoulder harness?		
2158:52 **CAM-1**	{24:49} checked.		
2158:54 **CAM-2**	{24:51} taxi check list complete.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		2159:00 **TWR**	{24:57} TWA four seventy six, prop ahead 'll be in a right turn northbound. wind two eight zero at eight, runway three zero right, turn right heading three three five, cleared for takeoff.
		2159:09 **TW476**	{25:06} right three three five, thirty right. cleared for takeoff, TWA four, seventy six.
2159:10 **CAM-1**	{25:07} OK Randy, you can go ahead and start.		
2159:11 **CAM-?**	{25:08} all the better, huh?		
2159:12 **CAM-?**	{25:09} huh?		
		2159:15 **TWR**	{25:12} Water Ski four fifty, three five five on the heading. contact departure, good night.
		2159:19 **WS450**	{25:16} three fifty five, we'll see ya. Water Ski four fifty.
		2159:21 **TWR**	{25:18} TWA three ninety seven (St. Louis tower) runway three zero left, taxi into position and hold.
2159:42 **CAM**	{25:39} [sound of chime similar to aircraft generator power transfer]		
2159:52 **CAM-?**	{25:49} * check list.		
2159:53 **CAM-2**	{25:50} electrical power?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		2159:54 **TWR**	{25:51} Northwest, ten forty eight, turn left when able and contact ground point nine as you clear the runway. good night.
2159:55 **CAM-1**	{25:52} checked.		
2159:58 **CAM-2**	{25:55} APU?		
2159:59 **CAM-1**	{25:56} checked.		
2200:01 **CAM-2**	{25:58} fuel system?		
2200:02 **CAM-1**	{25:59} that's checked.		
2200:03 **CAM-2**	{26:00} fuel heat?		
2200:04 **CAM-1**	{26:01} off.		
2200:05 **CAM-2**	{26:02} engine anti-ice?		
2200:06 **CAM-1**	{26:03} off.		
2200:06 **CAM-2**	{26:03} air conditioning?		
2200:07 **CAM-1**	{26:04} auto.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2200:08 **CAM-2**	{26:05} hydraulic systems?		
2200:09 **CAM-1**	{26:06} checked and on.		
2200:12 **CAM-2**	{26:09} delayed engine start check list complete.		
2200:16 **CAM-4**	{26:13} ladies and gentlemen we're ** departure. (cabin attendants) take their seats for takeoff.		
		2200:24 **TWR**	{26:21} TWA four seventy six, three thirty five on the heading. contact departure, good night.
		2200:29 **TW476**	{26:26} 'A four seventy six, good night.
		2200:31 **TWR**	{26:28} TWA three ninety seven, wind's two seven zero at seven. runway three zero left, fly runway heading. cleared for takeoff.
2200:31 **CAM-4**	{26:28} *** I'm having trouble with these doors ****. that's why I never work up here. ****		
		2200:33 **TWR**	{26:30} TWA four forty five (St. Louis tower) runway three zero left. taxi into position and hold.
2200:44 **CAM-2**	{26:41} (was that) us?		
2200:45 **CAM-1**	{26:42} naw, she said the wrong number.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
		2200:48 **TWR**	{26:45} uh, I don't have any uh, paperwork on a four fifty five. where you going sir?
		2200:54 **TWR**	{26:51} OK, I've got a four forty five. I don't have a four fifty five, stand by.
		2201:04 **TWR**	{27:01} OK, four fifty five, you're uh, number one at three zero left, is that correct?
		2201:09 **TWR**	{27:06} roger, change your departure frequency it'll be one one niner point one five and, let me know when you're ready to go.
2201:18 **CAM-1**	{27:15} we're ready (aren't we)?		
		2201:21 **RDO-2**	{27:18} and TWA four twenty seven's ready.
		2201:23 **TWR**	{27:20} TWA four twenty seven, wind's two seven zero at seven. runway three zero right, turn right heading three three five. cleared for takeoff.
		2201:29 **RDO-2**	{27:26} three thirty five and cleared to go. TWA four two seven.
		2201:32 **TWR**	{27:29} TWA three ninety seven, runway heading. contact departure. good night.
2201:35 **CAM-2**	{27:32} *** five.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2201:36 **CAM-1**	{27:33} three twenty five, right?		
2201:37 **CAM-2**	{27:34} she said three thirty five?		
2201:39 **CAM-1**	{27:36} I don't know. ask her.		
		2201:40 **RDO-2**	{27:37} confirm uh, three twenty five for TWA's four twenty seven.
		2201:46 **TWR**	{27:43} TWA twenty seven. three three five.
		2201:49 **RDO-2**	{27:46} three three five, thanks.
2201:51 **CAM-1**	{27:48} three three five. cleared for takeoff.		
2201:53 **CAM-2**	{27:50} cleared for takeoff.		
2201:54 **CAM-1**	{27:51} before takeoff checklist.		
2201:55 **CAM-2**	{27:52} before takeoff checklist says. ice, icing considerations.		
2201:58 **CAM-1**	{27:55} checked.		
2202:03 **CAM-?**	{28:00} **		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2202:20 **CAM-2**	{28:17} pneumatic crossfeed?		
2202:22 **CAM-1**	{28:19} cleared for takeoff, three thirty five, five.		
2202:25 **CAM-2**	{28:22} correct.		
2202:27 **CAM**	{28:24} [sound of increasing frequency similar to aircraft accelerating on runway]		
		2202:28 **441KM**	{28:25} and Kilo Mike's ready to go on the right side.
		2202:30 **TWR**	{28:27} roger, I can't roll you simultaneously with the uh, traffic departing the right. just continue holding in position. I'll have something for you in just a second.
		2202:37 **441KM**	{28:34} Kilo Mike.
2202:38 **CAM-1**	{28:35} one * four. [voice vibrating possibly caused by aircraft nose-wheel traveling over rough runway]		
		2202:40 **TWR**	{28:37} TWA four fifty five runway three zero left, taxi into position and hold.
2202:40 **CAM-1**	{28:37} eighty knots.		
2202:44 **CAM-3**	{28:41} there's an airplane.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2202:06 **CAM-2**	{28:03} (it's not) working real good but I think it's on.		
2202:08 **CAM**	{28:05} [unidentified ratcheting sound]		
2202:09 **CAM-2**	{28:06} cabin alert?		
2202:09 **CAM-1**	{28:06} checked.		
2202:10 **CAM-2**	{28:07} ignition?		
2202:10 **CAM-1**	{28:07} on.		
2202:12 **CAM-2**	{28:09} and, anti-skid?		
2202:14 **CAM-1**	{28:11} armed.		
2202:15 **CAM-2**	{28:12} and, brake temperature?		
2202:16 **CAM-1**	{28:13} checked.		
2202:17 **CAM-2**	{28:14} transponder.		
2202:18 **CAM-1**	{28:15} on.		
2202:20 **CAM-1**	{28:17} closed.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2202:45 **CAM-?**	{28:42} #.		
2202:47 **CAM**	{28:44} [sound of impact]		
		2202:47 **TWR**	{28:44} twin Cessna four four one Kilo Mike wind's two eight zero at eight. the traffic uh, use caution for the MD-80 that's uh, departing thirty right for possible wake turbulence. turn right heading uh, three five fi...
2202:47 **CAM**	{28:44} [sound of two beeps similar to takeoff warning horn]		
2202:48 **CAM-5**	{28:45} slats.		
2202:49 **CAM**	{28:46} [sound of two beeps similar to takeoff warning horn]		
2202:50 **CAM-5**	{28:47} slats.		
2202:53 **CAM**	{28:50} [roaring sound similar to engine reverse thrust lasting six seconds]		
		2202:59 **RDO-1**	{28:56} roll the emergency equipment. TWA, four hundred and twenty seven hit the other airplane on the uh, runway. roll the emergency equipment.
2203:13 **CAM-?**	{29:10} head down.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2203:56 **CAM-?**	{29:53} * takeoff.		
2203:57 **CAM-1**	{29:54} we were cleared for takeoff.		
2203:59 **CAM-3**	{29:56} I was not listening, I didn't have ** you guys confirmed it and, I just saw the guy, I.		
		2204:06 **RDO-1**	{30:03} tower, TWA four twenty seven.
		2204:08 **TWR**	{30:05} TWA four twenty seven, the equipment's rolling right now.
		2204:10 **RDO-1**	{30:07} do you see any, fire or smoke around the aircraft?
		2204:13 **TWR**	{30:10} no sir, I don't.
		2204:14 **RDO-1**	{30:11} OK.
		2204:16 **TWR**	{30:13} he was supposed to be on runway three one. I did not see the aircraft o....
		2204:19 **RDO-1**	{30:16} OK, we'll handle that later. I just want to make sure everything's safe here.
		2204:22 **TWR**	{30:19} roger.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
2204:23 **CAM-1**	{30:20} OK, go back and see if there's any damage back there.		
2204:26 **CAM-3**	{30:23} - let me grab my hat.		
2204:31 **CAM-2**	{30:28} hit somebody with that right wing I guess.		
2204:33 **CAM-1**	{30:30} yeah. I want to see what, see what's happening out the right wing.		
2204:35 **CAM-?**	{30:32} OK.		
2204:38 **CAM-4**	{30:35} ladies and gentlemen • everyone seated please, everyone seated, please take your seats. everyone please stay in your seats. we will inform you as soon as possible.		
2204:39 **CAM-1**	{30:36} I'm shuttin' the right engine *.		
2204:40 **CAM-?**	{30:37} OK.		
2204:42 **CAM**	{30:39} [sound of chime similar to aircraft generator power transfer]		
2204:51 **CAM-3**	{30:48} • gasoline rolling under the airplane.		
2204:52 **CAM-?**	{30:49} fuel going all over the left.		
2204:53 **CAM-3**	{30:50} we better get off this thing.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
2204:55	{30:52}		
PA-1	easy victor, easy victor, evacuate the left side.		
2204:58	{30:55}		
PA-4	easy victor, easy victor.		
2205:00	{30:57}		
END of RECORDING			
END of TRANSCRIPT			

APPENDIX D - FDR DATA PRINTOUT

NATIONAL TRANSPORTATION SAFETY BOARD

OFFICE OF RESEARCH AND ENGINEERING
Vehicle Performance Division

Washington D.C.

April 10, 1995

FLIGHT DATA RECORDER FACTUAL REPORT OF INVESTIGATION

CHI-95-MA-044

A. ACCIDENT

Location : Lambert Field, St. Louis, MO.
Date : November 22, 1994
Aircraft : Trans World Airlines, Flight 427, MD-82, N954U
Cessna 441 N441KM

B. GROUP

Dennis R. Grossi, Group Chairman, N.T.S.B.
Luke Stahlberg, Project Engineer, TWA
Keakini E. Kaulia, Staff Engineer, Airline Pilots Association

C. SUMMARY

On November 22, 1994, about 2203 central standard time (cst), a McDonnell Douglas MD-82, N954U, operated as Trans World Airways (TWA) Flight 427, was on takeoff roll on Runway 30R at Lambert Field, St. Louis, MO., when it collided with a Cessna 441, N441KM. The Cessna, operated by Superior Aviation as a Part 91 positioning flight, was situated on Runway 30R at the taxiway Romeo intersection. The commercial pilot and the private pilot rated passenger on board the Cessna were fatally injured. The two flight crewmembers, a deadheading TWA captain, five flight attendants, and 124 of the 132 passengers on board the MD-82 reported no injuries. The eight remaining MD-82 passengers reported minor injuries.

The digital flight data recorder (DFDR), a Sundstrand Model 573 (s/n 2432), was removed from the aircraft following the accident. The recorder was sent to the Safety Board's laboratory in Washington, D.C. for readout and evaluation.

The following is a chronology of events as recorded by the fight data recorder. All time references will be local time as established by the cockpit voice recorder:

- At 2201:23, air traffic control (ATC) cleared TWA Flight 427 for takeoff on runway 30R. At this time Flight 427 was taxing on a heading of 120° (the reciprocal of the runway heading 300°).

- At 2201:45, the heading values began to decrease, indicating the start of a left turn that continued until reaching 300°, the runway heading. The EPR values increased as the heading value reached 345°, at 2202:16, and increased sharply 6 seconds later as the heading reached 309°. Runway heading (±1°) was achieved at 2202:26, as the airspeed became active, recording a value of 31.75 knots.

- At 2202:37, the EPR values for both engines stabilized at approximately 2 as the airspeed reached 75 knots.

- The data are consistent with a normal takeoff roll until 2202:45, when the rudder moves to the left 22° in one second as the airspeed increases to 109 knots. This rudder value was held for nearly a second until it changed to 23° right rudder in the following second as the airspeed reaches 111.5 knots, and the Rt. Brake Pedal Position reaches 17° at 2202:47. The longitudinal and lateral acceleration values recorded during this period are consistent with the rudder excursions. A heading change of approximately 7 degrees to the left was coincident with the right rudder input. The slat disagree parameter also switched from "agree" to "disagree" at 2202:47.

  (Note: The Cockpit Voice Recorder recorded the sound of impact at 2202:47)

- The peak airspeed value (114.5 knots) was recorded at 2202:50, 3 seconds after the slat disagree sensor transitioned from "agree" to disagree. The start of thrust reverser transition from stowed to deployed occurred at 2202:51, and both thrust reversers were deployed at 2202:52.

- The EPR values for both engines reached their peak values (reverse) of 1.79 (Lt.) and 2.16 (Rt.) 3 seconds after both thrust reversers were deployed.

- The remaining heading values are consistent with the airplane being maneuvered first to the right and then to the left until reaching a heading of 293° as the airplane decelerated to a stop at 2203:10.

- The last DFDR data for flight 427 were recorded at 2204:29.

D. DETAILS OF INVESTIGATION

1. Description of Data

This model DFDR is designed to accept digital data input information from a remote Flight Data Acquisition Unit (FDAU), and store the data in a crash survivable recording device. The DFDR utilizes coaxial tape reels that hold 820 feet of Vicalloy metal tape, ½ mil thick and ¼ inch wide. The 4 track tape moves at 0.43 inches per second while recording on one track at a time in a predetermined bidirectional sequence. The oldest data are erased before recording new data. End-of-tape sensors at both ends of the tape provide the signal to reverse the drive motor direction and switch the record electronics to the next track. Recording time for one end-to-end pass of the tape is 6.25 hours, thus the recorder will continuously record and retain the last 25 hours of selected flight data.

The FDAU provides a means of gathering, conditioning, and conversion of flight data parameters to digital data. The FDAU provides a serial binary digital data stream to the DFDR at a rate of 768 bit/1.024 seconds. A binary, or logical one, is represented by a voltage transition between clock transitions.

The FDAU input signals are time division multiplexed, with parameter identification established by means of position or time slot addresses in the serial data stream output. This output is continuously repeating every second. The first word contains a unique 12 bit synchronization (sync) word followed by 63 12 bit data words. The data stream is "in sync" when the sync word appears at 64-word intervals.

If the data stream is interrupted, either at the FDAU or the DFDR the sync word will not appear at the proper interval, and the time reference will be lost until the pattern can be reestablished. A loss of data synchronization, or sync loss, can result from either a mechanical or electrical interruption of the data. A mechanical interruption can be caused by foreign matter coming between the tape recording medium and the heads during the record or playback process. Mechanical interruptions can also be caused by DFDR vibration which can introduce wow and flutter to the tape transport, and distort the recorded signal. An interruption of electrical power to the DFDR or FDAU will also interrupt the serial data stream and cause a loss of sync.

2. Examination of Recorder

The flight recorder was examined and found undamaged.

3. Readout and Evaluation

a. Readout

The tape recording medium was removed from the DFDR and mounted on the Safety Board's raw tape transport (RTT). The data of interest were then located and transcribed. No modification of the Safety Board's hardware or software was necessary to recover the data.

b. Evaluation

An examination of the recovered data indicated that the recorder operated normally.

4. DFDR and Cockpit Voice Recorder (CVR) Time Correlation

The correlation of the DFDR and CVR recordings was established by comparing the timing of the VHF radio transmission made by Flight 427. The DFDR records when the airplane's VHF radio transmitters are keyed and released by setting a single bit (1 "keyed" or 0 "Off"). Therefore, the DFDR check the status of the radio transmissions for only 1/768 of a second once every second. As a result, it is possible for the microphone keying status to be off by as much as .9987 seconds or, if keyed less than a second, to not be recorded. The CVR, however, records when the microphone is open but only if there is a sound to record. Therefore, it is expected that a comparison of the DFDR and CVR radio transmission time histories will generally coincide to within ± a second.

The elapsed time between the last 18 transmissions as recorded by the DFDR and CVR were compared. This comparison revealed that the DFDR did not record 2 transmissions (microphone keying), and that all 14 time intervals between transmissions differed by less than 2 seconds. The two transmissions not recorded by the DFDR were short in duration (less than a seconds), and therefore could have occurred between data samples. In addition, 11 of the 14 time intervals correlated to the second.

Therefore, the DFDR/CVR time correlation was established over an elapsed time of 8 minutes and 40 seconds, and provided a match to within one second. DFDR times can be converted to CVR (local times) by the following equation:

DFDR time in seconds + 78,298 seconds = local time in seconds.

5. Data Printout

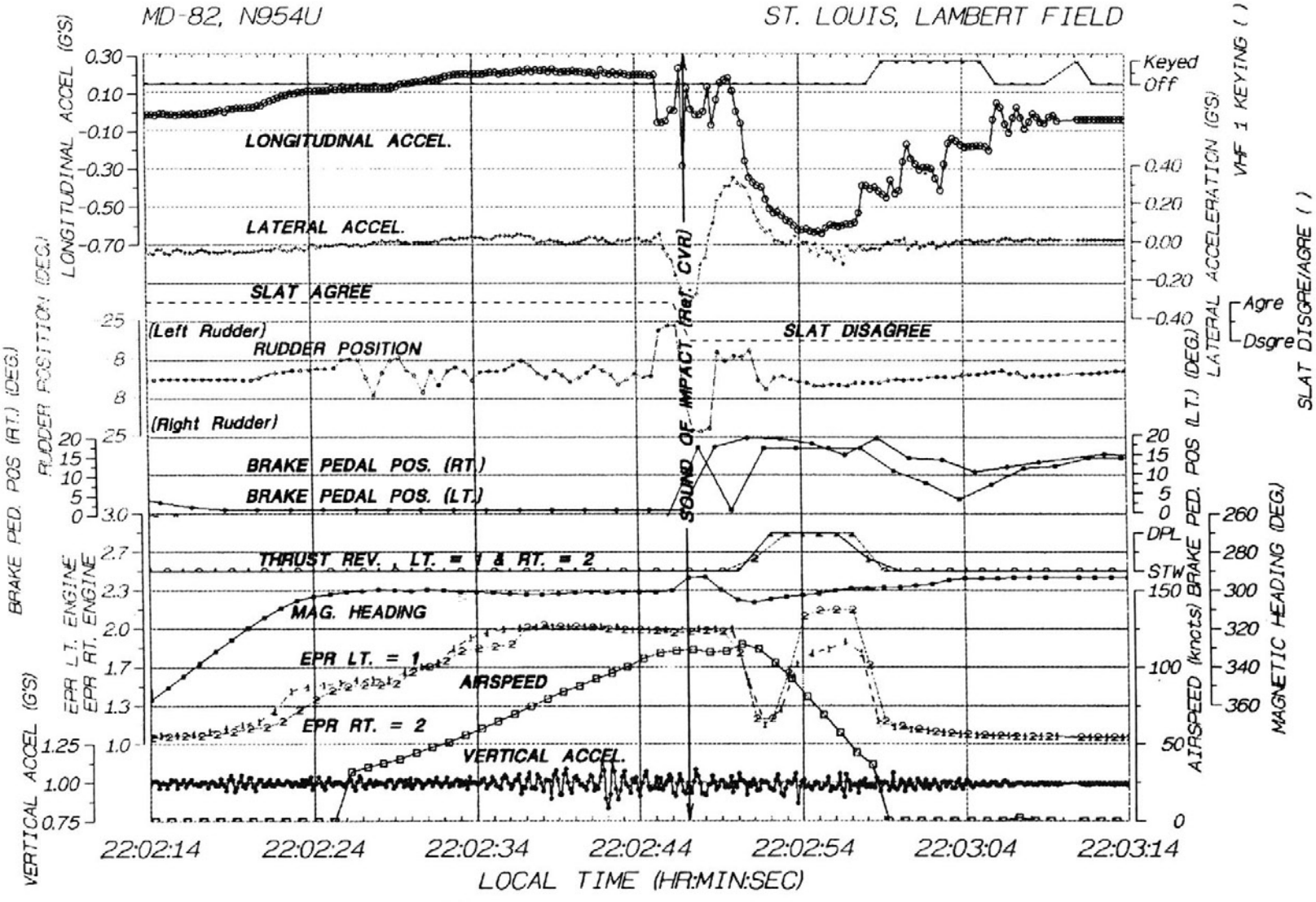
A printout of selected parameters is attached. The data covers 3 minutes which includes the turn onto the runway, the takeoff abort, and ends shortly after the aircraft comes to rest.

6. Data Plot

A plot of selected parameters covering a 60 second period commencing at 2202:14, is attached. This time period covers a portion of the turn on to the runway heading and ends as the airplane decelerated to a stop.

Dennis R. Grossi
Flight Data Recorder Specialist

TWA FLIGHT 427



Accident Date: November 22, 1994
Revised: August 17, 1995

Flight Recorders / Computers - NTSB

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APPENDIX E - RADAR STUDY
NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Washington, D.C.

March 23, 1995

SPECIALIST'S REPORT OF INVESTIGATION
RECORDED RADAR STUDY
CHI95MA044

A. ACCIDENT

Location : Bridgeton, MO
Date : November 22, 1994
Time : 2203 CST (Central Standard Time)
Aircraft : Trans World Airlines, Flight 427, McDonnell Douglas MD-82, N954U
Cessna 441, N441KM

B. GROUP

N/A

C. SUMMARY

On November 22, 1994, about 2203 central standard time, a McDonnell Douglas MD-82, N954U, operated as Trans World Airlines (TWA) Flight 427, was on the takeoff roll on Runway 30R at Lambert St. Louis International Airport when it collided with a Cessna 441, N441KM. The Cessna, operated by Superior Aviation as a Part 91 position flight, was situated on Runway 30R at the taxiway Romeo intersection. The commercial pilot and the private pilot rated passenger on board the Cessna were fatally injured. The two flight crew members, a deadheading TWA Captain, five flight attendants, and 124 of the 132 passengers on board the MD-82 reported no injuries. The eight remaining MD-82 passengers reported minor injuries.

A computer tape containing pertinent accident data was obtained from the Federal Aviation Administration's (FAA's) St. Louis Facility. Secondary data (time, range, azimuth and altitude) from the St. Louis radar site were extracted from the tape for both TWA427 and N441KM. Primary data (reflection of radar signal which indicate a two dimensional position in space - range/azimuth) from the St. Louis radar site were extracted from the tape.

Secondary data between 0358:14[1] and 0404:43 for N441KM and TWA427 and the corresponding Coordinated Universal Time (UTC) are graphically depicted along with runway 31, runway 30R, runway 30L and the St. Louis radar site in Attachment III-1. Attachment III-2 shows, in greater detail, N441KM's ground track between 0358:14 and 0402:43. Secondary and primary data between 0401:14 and 0404:43 and the corresponding UTC are graphically depicted along with runway 31, runway 30R, runway 30L and the St. Louis radar site in Attachment III-3.

Secondary data indicated N441KM turned the transponder off at 0343:06 and turned it on 13 minutes and 18 seconds later (0356:24). At 0358:19, N441KM taxied to runway 30R and stayed on runway 30R for approximately 3 minutes (0359:42 to 0402:42). The only TWA427 secondary data occurred at 0404:42 and was located approximately 0.36 nautical miles at a bearing of 299 degrees true from the last N441KM secondary data.

D. DETAILS OF STUDY

1. RECORDED RADAR DATA

A computer tape containing pertinent recorded radar data was obtained from the FAA's St. Louis Facility. St. Louis' Automated Radar Terminal Systems (ARTS) III utilizes an Airport Surveillance Radar 9 (ASR9). ARTS is the radar used to track aircraft within the operation area of airports. The St. Louis radar site independently recorded secondary data (time, range, azimuth and altitude) and primary data (reflection of radar signal which indicate a two dimensional position in space - range/azimuth) at approximately 4.6 second intervals. The assigned beacon code for TWA427 was 1765. The assigned beacon codes for N441KM were 3050 and 1105. The secondary data associated with the beacon code 1150 occurred between the last 3050 beacon code and the first 1105 beacon code and, therefore, assumed to represent N441KM. The computer tape was read out in the National Transportation Safety Board laboratory and secondary and primary data were extracted from the tape utilizing an ARTS III Radar Data Decoding Program.

Attachments I-1 to I-12 contain pertinent recorded radar data (from the St. Louis radar site) extracted from the computer tape. The data should be assessed using the following generally accepted accuracy limits:

ALTITUDE..... +/- 50 feet
RANGE..... +/- 380 feet
AZIMUTH..... +/- 1 ACP[2] (4096 ACP's = 360 degrees).

---

[1] All times are Coordinated Universal Time (UTC) according to the FAA tape.
[2] ACP is the FAA Acronym for Azimuth Change Pulse.

The altitude and range accuracy limits are usually constant assuming the aircraft transponder was calibrated properly. The azimuth accuracy limit is usually constant at +/- 1 ACP; however, the actual azimuth distance limit increases with range since the arc length of 1 ACP increases linearly with range. Range and azimuth data may exceed the normal limits for single data points.

The secondary and primary data from the St. Louis radar site were entered into a computer file named btallr0.ra and primr0.ra, respectively. The secondary and primary data in files btallr0.ra and primr0.ra were processed by the Radar ViewPoint(tm) computer program XCDRURF to convert the range/azimuth position data to latitude/longitude data (where the magnetic variation for the St. Louis radar site was 1 degrees east and the location for the St. Louis radar site was 38 degrees 44 minutes 38.18 seconds north and 90 degrees 20 minutes 28.41 seconds west). Files btallr0.urf and primr0.urf contain latitude/longitude position data for the secondary and primary data, respectively.

2. Site Position Data

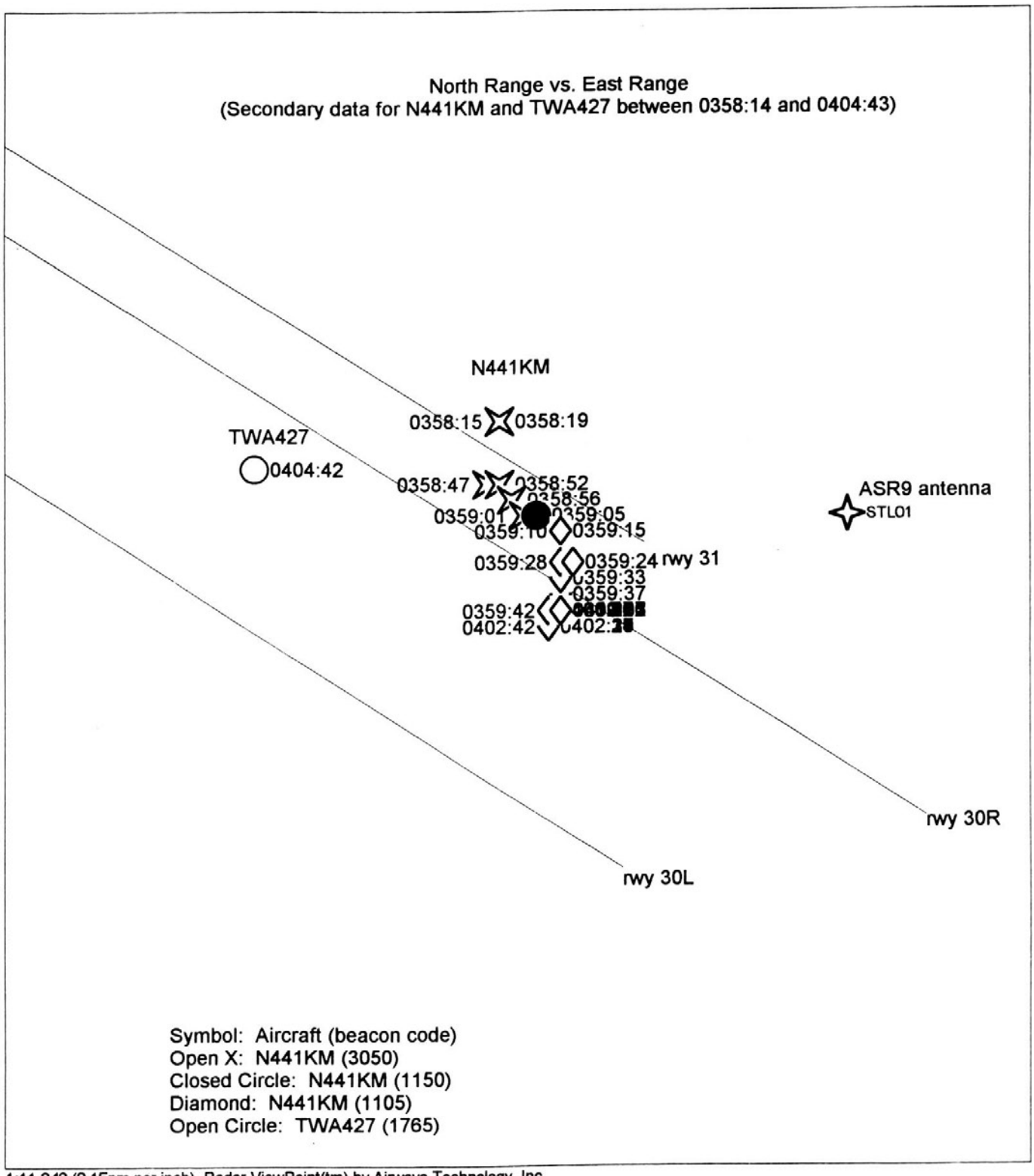
Position data in latitude/longitude format were obtained for runway 31, runway 30R, runway 30L and the St. Louis radar site. All data were obtained from the FAA. File sites.lat contains the site position data. Attachment II-1 to II-13 contain all pertinent data files.

3. Plotted Data

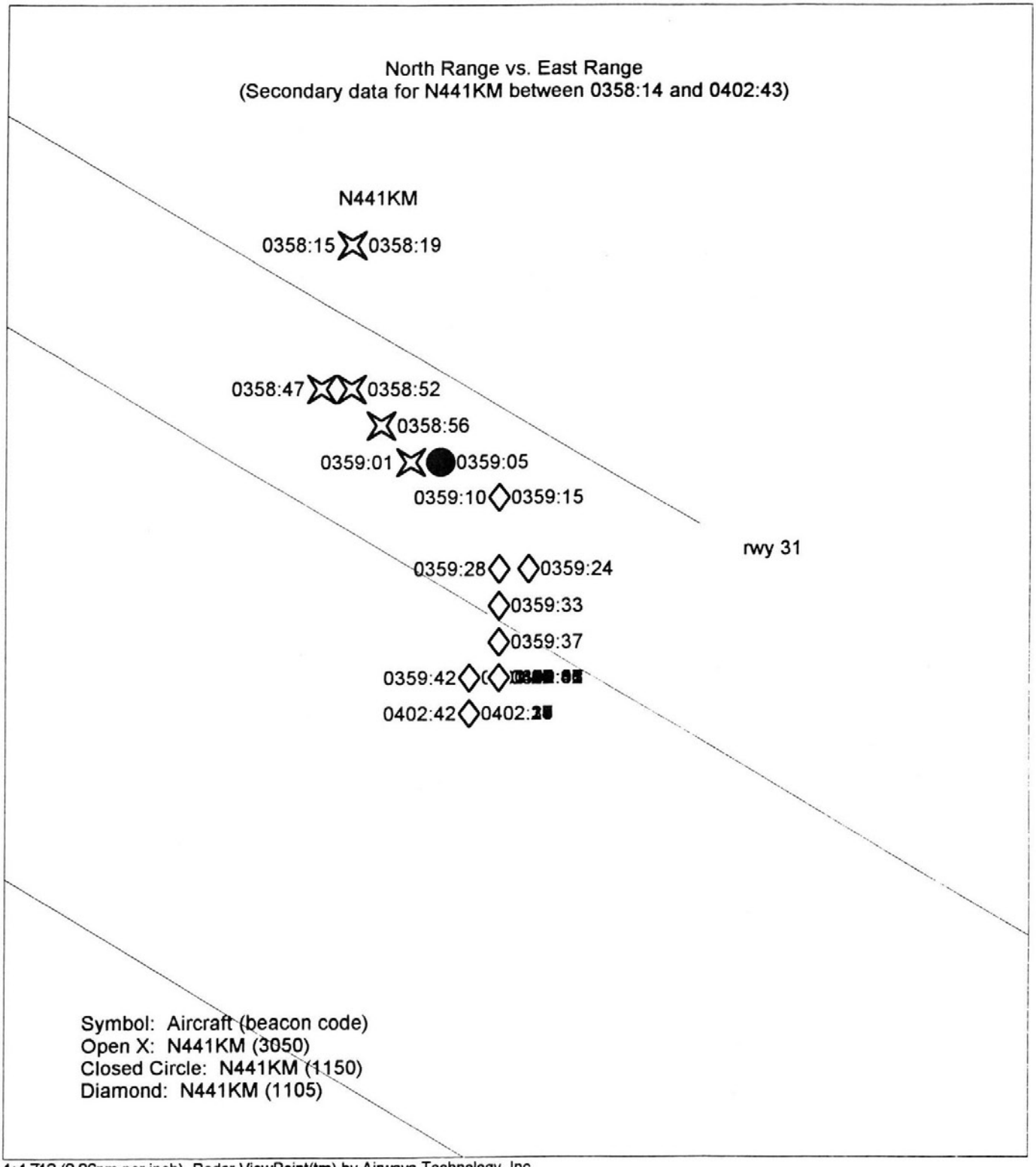
Attachments III-1 to III-3 contain various plots of the data discussed in this report.

Cassandra L. Johnson

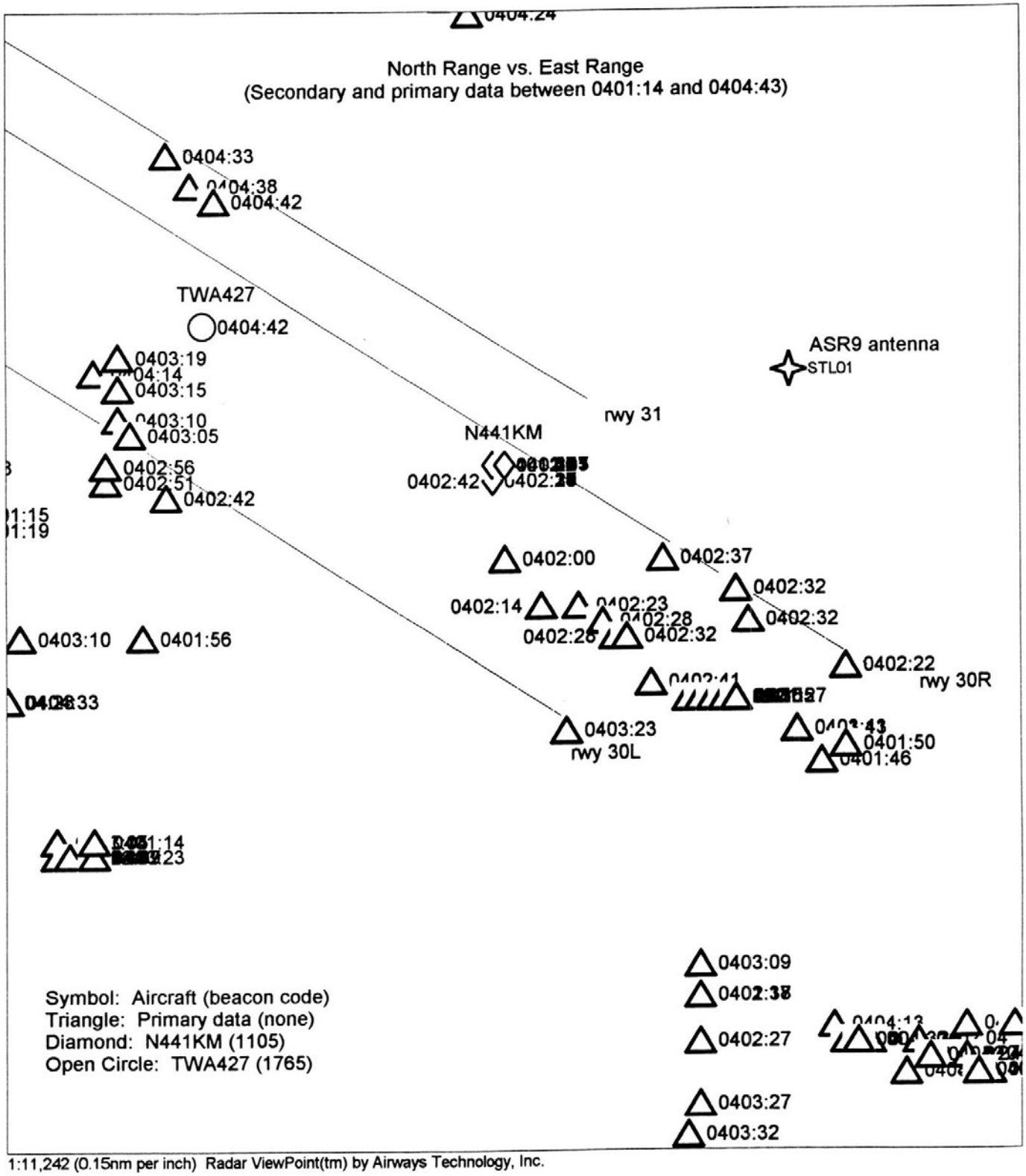
Cassandra Johnson
Mechanical Engineer



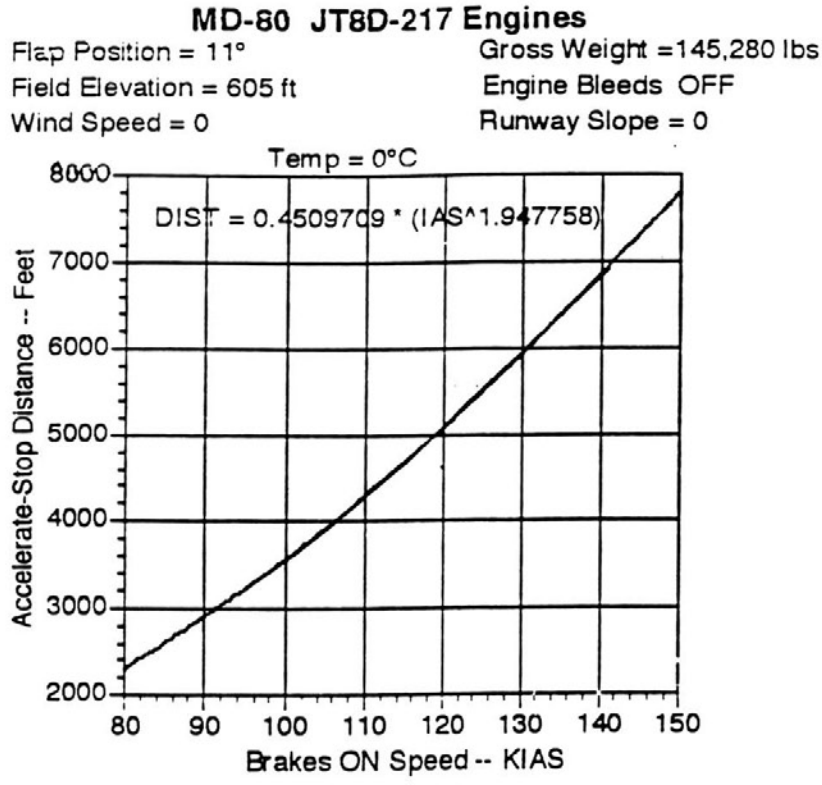
1:11,242 (0.15nm per inch) Radar ViewPoint(tm) by Airways Technology, Inc.

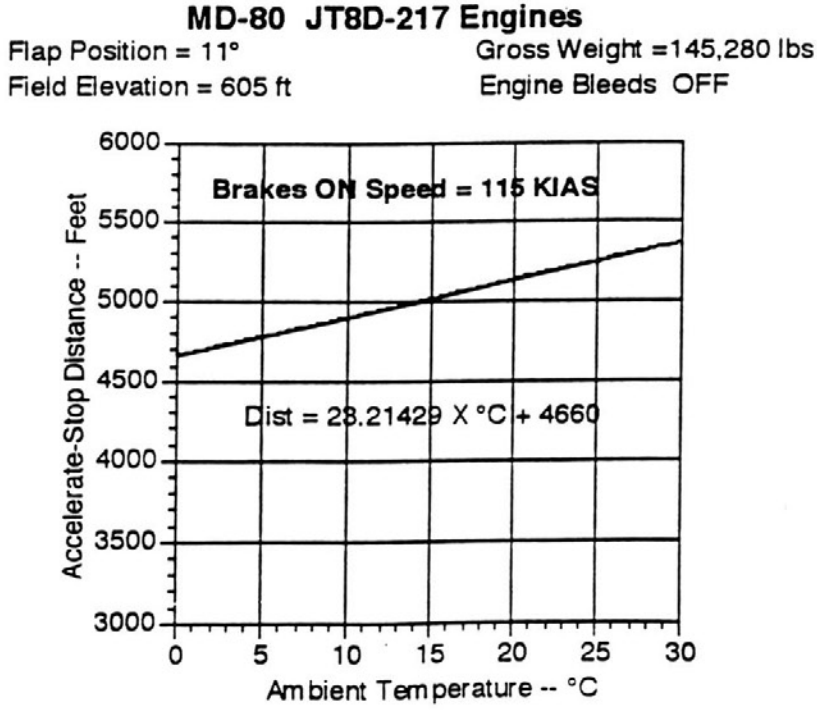


1:4,713 (0.06nm per inch) Radar ViewPoint(tm) by Airways Technology, Inc.


North Range vs. East Range
(Secondary and primary data between 0401:14 and 0404:43)
0404:33
0404:42
TWA427
0404:42
ASR9 antenna
STL01
0403:19
0403:15
0403:10
0403:05
rwy 31
N441KM
0402:56
0402:51
0402:42
0402:42
0402:00
0402:37
0402:32
0402:14
0402:23
0402:28
0402:32
0402:32
0403:10
0401:56
0402:22
rwy 30R
0403:23
rwy 30L
0401:50
0401:46
0403:09
0402:27
0403:27
0403:32
Symbol: Aircraft (beacon code)
Triangle: Primary data (none)
Diamond: N441KM (1105)
Open Circle: TWA427 (1765)
1:11,242 (0.15nm per inch) Radar ViewPoint(tm) by Airways Technology, Inc.

APPENDIX F - MD-82 ACCELERATED STOP DATA





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APPENDIX G

Runway Incursion/Ground Collision Safety Recommendations

Since 1973, the National Transportation Safety Board has issued 64 safety recommendations regarding the problem of runway incursions/ground collisions of aircraft. Of these, 49 have been classified Closed--Acceptable (or Acceptable Alternate) Action; and nine Closed--Unacceptable Action. Five are being held as Open--Acceptable Response and one as Open--Unacceptable Response.

Those classified Closed--Unacceptable Action are the following:

A-73-25 Establish and publish taxi routes for arriving and departing aircraft to be used in restricted visibility.

A-73-26 Require pilots to obtain controllers approval before crossing a lighted runway during periods of restricted visibility.

A-73-55 Require read back of taxi clearances when operating in restricted visibility.

A-78-52 Require intersection signs at displaced threshold or taxiways that enter runways at points other than the end of runway.

A-79-42 Perform a directed safety study on the runway incursion problem and fix it.

A-84-101 Develop and require uniform signs at certificated airports with functional classifications, i.e., size, shape, color to depict different meanings.

A-86-39 Include near collisions near surface of airports in near-midair reports.

A-86-45 Provide a local control coordinator position at O'Hare.

A-91-112 Evaluate and implement, as appropriate, suitable means for enhancing the conspicuity of aircraft on airport surfaces during night or periods of reduced visibility. Include in this effort measures, such as the displacement of an aircraft away from the runway centerline, where applicable, and the use of conspicuity enhancements, such as high-intensity strobe lighting and logo lighting by aircraft on active runways, and encourage operators of airplanes certificated prior to September 1, 1977, to upgrade their airplanes to the present higher intensity standards for anti-collision light installations.

The single Open--Unacceptable Response safety recommendation is the following:

A-91-111 Redefine the airplane certification coverage compliance standards for anti-collision lights installations to ensure that the anti-collision light(s) of an aircraft in position on a runway are clearly visible to the pilot of another aircraft preparing to land or take off on that runway.

The five safety recommendations being held in the Open--Acceptable Response status are the following:

A-91-29 Expedite efforts to fund the development and implementation of an operational system analogous to the Airborne Conflict alert system to alert controllers to pending runway incursions at all terminal facilities that are scheduled to receive Airport Surface Detection Equipment (ASDE III).

A-91-30 Conduct research and development efforts to provide airports that are not scheduled to receive Airport Surface Detection Equipment with an alternate, cost-effective system to bring controller and pilot attention to pending runway incursions in time to prevent ground collisions.

A-91-56 Require that CFR 139 certificated airports use reflectorized paint for airport surface markings.

A-95-31 Within 60 days of receipt of this letter, provide to the Safety Board a firm schedule to commission those Airport Surface Detection Equipment - three radar systems that have been installed & adhere to that schedule.

A-95-32 For those traffic control terminal facilities that commission the Airport Surface Detection Equipment - 3, require that it be operational between sunset & sunrise. When the Airport Movement Area Safety

All 64 of the safety recommendations are cited on the following pages listing current

status assignments and the accidents/incidents from which the safety recommendations were derived.

On May 17, 1973, as the result of a ground collision accident at O'Hare International Airport in Chicago, Illinois, on December 20, 1972, the Safety Board issued six safety recommendations to the FAA. These safety recommendations are listed below with current status assignments:

A-73-21 Closed--Acceptable Action
August 16, 1974

Standardize configuration, alignment techniques, and equipment modifications at the three existing ASDE Brite facilities in an effort to improve the performance of that equipment.

A-73-22 Closed--Acceptable Action
August 16, 1974

Do not proceed with the scheduled installation of Brite displays at other ASDE-equipped facilities which now use the direct view radar display until satisfactory operation of Brite equipment is achieved at the three facilities where it is now

A-73-23 Closed--Acceptable Action
August 16, 1974

Contingent upon favorable results of the evaluation of the new model ASDE Brite display currently being conducted by the Transportation Systems Center, install that equipment first at the three locations where Brite equipment is now used.

A-73-24 Closed--Acceptable Action
December 3, 1975

Establish standard procedures for the use of ASDE radar, and publish such procedures in appropriate air traffic handbooks.

A-73-25 Closed--Unacceptable Action
August 16, 1974

Establish and publish taxi routes for arriving and departing aircraft to be used during periods of restricted visibility on the order of 1/2 mile.

A-73-26 Closed--Unacceptable Action
August 16, 1974

Require pilots to obtain the controllers' approval before crossing a lighted runway during periods of restricted visibility on the order of 1/2 mile.

On August 10, 1973, the Safety Board issued two runway incursion-related safety recommendations as a result of ongoing investigations of three accidents. These accidents were:

United Air Lines Boeing 737 -- Chicago Midway Airport, December 8, 1972;

North Central Airlines DC-9 -- Chicago O'Hare Airport, December 20, 1972; and

Eastern Airlines Lockheed L-1011 -- Miami, Florida, December 29, 1972.

The safety recommendations issued at that time are listed below with the current status assignments.

A-73-54 Closed--Acceptable Action
August 14, 1974

Require flight crews to report their aircraft position on the airport when establishing radio communications with controllers, and require the controllers to read back the reported aircraft position when it cannot be verified either visually or by means of radar.

A-73-55 Closed--Unacceptable Action
November 16, 1973

Require flight crews to read back taxi clearances when operating in visibilities of less than one-half mile.

On August 8, 1978, as a result of a June 3, 1977, accident at the Tucson International Airport, Tucson, Arizona, the Safety Board issued the following safety recommendation to the FAA. The current status assignment is shown.

A-78-52 Closed--Unacceptable Action
April 10, 1979

Require that all operators of certificated airports where runway designs feature a displaced threshold and taxiways enter the runway at points other than the runway's end install an easily visible intersection sign which displays a displaced threshold notation.

On June 8, 1979, as a result of the investigation of three separate ground collisions, or near-collisions, the Safety Board issued Safety Recommendations A-79-42 and -43 to the FAA. The accidents involved were:

North Central Airlines, DC-9 near-collision with a Cessna Citation at LaGuardia Airport, Flushing, New York on June 21, 1978;

Delta Airlines, Boeing 727 near-collision with a Flying Tiger Lines Boeing 747 at Chicago O'Hare Airport on February 15, 1979; and

Federal Express Falcon Fan Jet collision with a Beechcraft Model 18 at Memphis International Airport, Memphis, Tennessee on February 24, 1979.

The safety recommendations issued are listed below with the current status assignment:

A-79-42 Closed--Unacceptable Action/Superseded
(by A-86-30 through -44) May 13, 1986

Conduct a directed safety study, on a priority basis, to examine the runway incursion problem and to formulate recommended remedial action to reduce the likelihood of such hazardous conflicts.

A-79-43 Closed--Unacceptable Action
May 22, 1984

Alert all controller/pilot personnel that runway incursion mishaps represent a serious safety problem which requires their immediate attention. Special emphasis should be placed on the need for both groups to maintain greater visual surveillance in those taxi operations involving any runway crossing.

On April 16, 1984, as a result of a special study of several accidents involving ground control at airports during times when the runways were contaminated, the Safety Board issued Safety Recommendation A-84-23. This safety recommendation was addressed to the FAA and reads as follows:

A-84-23 Closed--Acceptable Alternate Action
March 20, 1990

Revise FAA Order 5280.5, Ground Vehicles, to include specific criteria for determining the adequacy of ground vehicle control, such as the number of ground vehicle accidents each year, disciplinary actions taken in accident cases, the number of repeat offenders, and an annual accident rate.

On August 23, 1984, as a result of the investigation of a head-on collision between a Korean Air Lines cargo flight and a South Central Air commuter flight at Anchorage International Airport on December 23, 1983, the Safety Board issued five safety recommendations to the FAA related to ground control of aircraft. These five safety recommendations are listed below with their current status assignments.

A-84-98 Closed--Acceptable Action
March 29, 1990

Require that airports certificated for air carrier operations install signs at all runway and taxiway entrances, exits, and intersections that indicate the identity of the runway or taxiway.

A-84-99 Closed--Acceptable Action
July 12, 1989

Require that the graphics on taxiway/runway identification signs be standardized and of sufficient size to enable them to be legible to aircraft crewmembers in all meteorological conditions in which air carrier operations are authorized.

A-84-100 Closed--Acceptable Action
April 20, 1990

Require that airport operators inspect and maintain the light illuminating airport taxiway/runway identification signs as part of the daily airport inspection requirements.

A-84-101 Closed--Unacceptable Action
August 11, 1986

Require at all airports certificated for air carrier operations that uniform signs be installed which are classified by function (e.g., runway entrance, runway exit, taxiway intersection) with each function having a unique shape, color, and/or size

A-84-102 Closed--Unacceptable Action
September 12, 1985

Require that air carriers incorporate in training o their crewmembers procedures and responsibilities during ground operations in restricted visibility conditions, to enable them to operate safely in such conditions.

On February 22, 1985, as a result of the Safety Board's investigation of the December 19, 1983, collision between a Japan Airlines Boeing 747 and a pickup truck traversing a runway at Anchorage International Airport, Anchorage, Alaska, the Safety Board issued 3 safety recommendations to the FAA regarding ground control of vehicles. These three safety recommendations are listed below with their

current status assignments:

A-85-15 Closed--Acceptable Action
November 4, 1987

Develop a mechanical/aural/visual (or combination thereof) alert device and require its use by local and ground controllers to coordinate their activities when a vehicle has been cleared to operate on the active duty runway for an extended period such as in snow removal operations.

A-85-16 Closed--Acceptable Action
July 25, 1988

Periodically emphasize in the training of air traffic control personnel providing airport advisory services the proper application of runway usage procedures stressing positive coordination between control positions.

A-85-17 Closed--Acceptable Action
July 25, 1988

Periodically emphasize in the training of air traffic controller personnel the requirements contained in the air traffic control handbook 7110.65D, March 1984, for restricted vehicle and aircraft operations in the ILS critical areas when the ILS is being used for approach/landing guidance and the reported ceiling, visibility or

On April 19, 1985, as a result of the investigation of an ATC operational error at Minneapolis-St. Paul International Airport on March 3, 1985, the Safety Board issued two safety recommendations to the FAA. These safety recommendations are listed below with the current status assignments:

A-85-32 Closed--Acceptable Action
January 24, 1986

Issue a General Notice (GENOT) directing the management of all terminal air traffic control facilities to immediately brief all traffic controllers on the importance of complete and accurate coordination between local and ground controllers before taxiing airplanes on or across an active runway.

A-85-33 Closed--Acceptable Action
February 17, 1987

Develop and implement, on a priority basis, specific procedures and standards, and specify responsibilities to be used during direct face-to-face and/or interphone coordination between local ground controllers regarding requests and approvals to clear airplanes to taxi across an active runway.

On May 13, 1986, the Safety Board issued 14 safety recommendations as a result of a Special Investigation Report, "Runway Incursions at Controlled Airports in the United States." These safety recommendations are listed below with the current status assignments:

A-86-30 Closed--Acceptable Action
November 1, 1991

Revise the current tower training curriculum at the ATC Academy to include more emphasis on practical standardized hands-on tower training using dynamic laboratory and simulation facilities.

A-86-31 Closed--Acceptable Action
June 30, 1994

Establish a program for improved supervision of tower controller performance in which scanning, coordination, and use of proper phraseology is emphasized and which includes retraining of controllers who are deficient.

A-86-32 Closed--Acceptable Action
June 30, 1994

Establish an Ad Hoc task force, including controller and human performance expertise, to develop effective memory aids that would reduce incidents of air traffic controllers forgetting traffic, and to incorporate a description of these memory aids and how they should be used in the ATC Academy controller training syllabus and in the tower facility training program.

A-86-33 Closed--Acceptable Action
August 16, 1993

Require controllers to obtain a readback for all hold, takeoff, or crossing clearances and for clearances onto an active runway.

A-86-34 Closed--Acceptable Action
October 14, 1987

Emphasize in operational bulletins, the Airman's Information Manual, general aviation seminars, and pilot training programs, the importance of reading back taxi, hold-short, runway crossing, and takeoff clearances in proper phraseology; the importance of reporting when unable to promptly cross, take off from, or clear a runway when so cleared; and the need to scan properly before entering or crossing a

A-86-35 Closed--Acceptable Action
October 14, 1987

Emphasize in operational bulletins, the Airman's Information Manual, general aviation seminars, and pilot training programs, that a good operating practice for pilots of single-pilot airplanes is to monitor only assigned air traffic control communication frequencies after a clearance onto an active runway for departure, until flight from the airport traffic area is completed, or after receipt of clearance for landing, until the landing and taxi across all active runways is completed.

A-86-36 Closed--Acceptable Action
January 13, 1987

Revise controller phraseology for use when issuing takeoff and landing clearances to include the runway number (for example: American 75, Runway 36, Cleared for takeoff).

A-86-37 Closed--Acceptable Action
January 13, 1987

Issue a general notice directing the management of all terminal air traffic control facilities to brief all controllers on the dangers of attempting to expedite traffic departing or crossing runways in order to accommodate arrival and departure traffic.

A-86-38 Closed--Acceptable Alternate Action
May 8, 1989

Issue an advisory circular delineating both the pilot and controller roles and responsibilities in the prevention of runway incursion incidents.

A-86-39 Closed--Unacceptable Action
August 3, 1987

Revise the near-midair collision reporting and investigating program to clarify the intent that near-collisions on or near the airport surface constitute an occurrence which must be investigated as a near-midair collision.

A-86-40 Closed--Acceptable Action
September 22, 1992

Revise and enforce the requirements to report and to investigate operational errors, pilot deviations, and near-midair collisions that involve aircraft on the ground as well as in the air, and develop a combined data base for comprehensive procedural and human performance causal analyses of runway incursion incidents.

A-86-41 Closed--Acceptable Action
June 23, 1987

Issue an Air Carrier Operations Bulletin to require air carrier inspectors to review air carrier training and operations manuals and pilot training programs to ensure that they contain specific standardized information and guidance to pilots concerning their role in the prevention of runway incursions.

A-86-42 Closed--Acceptable Action
May 18, 1987

Disseminate copies of the Safety Board's Special Investigation Report on runway incursions at controlled airports in the United States to all terminal control facilities and to the ATC academy for use in their training programs.

A-86-43 Closed--Acceptable Action
January 15, 1992

In cooperation with terminal air traffic managers, airport managers, airline representative, and pilot groups, determine the most effective signs, markings, and procedures, from an operational and human performance perspective, to prevent pilot-induced runway incursions and issue an advisory circular to disseminate the information to airport managers and pilot organizations.

On May 27, 1986, as a result of the investigation of a May 17, 1986, air traffic control operational error at the Chicago O'Hare International Airport, the Safety Board issued three safety recommendations to the FAA. These safety recommendations are listed below with their current status assignments.

A-86-44 Closed--Acceptable Action
July 30, 1986

Issue a General Notice (GENOT) to all terminal facilities to require that every controller is briefed on the importance of issuing traffic information to airplanes that have been cleared into position to hold on a runway before takeoff as required by the controller's handbook 7110.65D, 3-103.

A-86-45 Closed--Unacceptable Action
August 3, 1987

Establish on a trial basis, for the north and for the south control operations in the Chicago O'Hare International Airport control tower, local control coordinator positions to monitor and supervise, directly, the local control positions; staff these positions whenever intersecting runways are in concurrent operation.

A-86-46 Closed--Acceptable Action
July 10, 1989

Evaluate the need for a local control coordinator position at all major airports that use intersecting runways in concurrent operations and establish the position where the need is evident.

On March 16, 1988, as a result of its investigation of another ATC operational error at th Chicago O'Hare International Airport (October 29, 1987) the Safety Board issued two safet recommendations to the FAA. These safety recommendations are listed below with the current statu assignments:

A-88-47 Closed--Acceptable Action
July 14, 1989

Establish, for the north and for the south control operations in the Chicago O'Hare International Airport control tower, local control coordinator positions to monitor and supervise, directly, the local control positions; staff these positions whenever intersecting runways are in concurrent operation.

A-88-48 Closed--Acceptable Action
May 18, 1989

Expand the current Chicago O'Hare tower notice, Order N7110.652, Circling Procedures for Runways 9R/4R, dated November 6, 1987, to provide for application to any arriving aircraft whose flightpath will traverse the departure path of another aircraft.

On July 17, 1989, as a result of the investigation of a January 10, 1989, accident at the Houston Hobby airport, the Safety Board issued Safety Recommendation A-89-74 to the FAA. The receommendation and its status are described below:

A-89-74 Closed--Acceptable Action
December 11, 1990

Assure that the Normal Procedures section of the operations manuals of all air carriers operating under Title 14 Code of Federal Regulations Parts 121 and 135 requires flightcrews to cross-check the heading indicator to the runway heading when the airplane is aligned with the runway for takeoff.

On June 12, 1991, as a result of the investigation of a January 1, 1990, accident at the William B. Hartsfield International Airport, Atlanta, Georgia, the Safety Board issued two safety recommendations related to runway incursions to the FAA. These recommendations are described below.

A-91-29 Open--Acceptable Response

Expedite efforts to fund the development and implementation of an operational system analogous to the Airborne Conflict alert system to alert controllers to pending runway incursions at all terminal facilities that are scheduled to receive Airport Surface Detection Equipment (ASDE III).

A-91-30 Open--Acceptable Response

Conduct research and development efforts to provide airports that are not scheduled to receive Airport Surface Detection Equipment with an alternate, cost-effective system to bring controller and pilot attention to pending runway incursions in time to prevent ground collisions.

On July 23, 1991, as a result of the investigation of the December 3, 1990, ground collision between a Boeing 727 and a DC-9 at the Detroit Metropolitan/Wayne County Airport, Detroit, Michigan, the Safety Board issued seven safety recommendations to the FAA addressing the runway incursion problem. These recommendations and their status are described below:

A-91-54 Closed--Acceptable Action
March 15, 1993

Improve standards for airport marking and lighting during low-visibility conditions, such as standards for more conspicuous marking and lighting; evaluation of uni-directional taxi lines for use on acute angle taxiways; and requirements for stop bars or position-hold lights at all taxiways that intersect active runways.

A-91-55 Closed--Acceptable Action
August 31, 1994

Identify, at all 14 CFR 139 certificated airports, complex intersections where a potential for pilot confusion exists. Where needed, require additional lighting and signs.

A-91-56 Open--Acceptable Response
Require that CFR 139 certificated airports use reflectorized paint for airport surface markings.

A-91-57 Closed--Acceptable Alternate Action
February 16, 1995

Require that CFR 139 certificated airports install semi-flush runway edge lights in accordance with Advisory Circular 150/5340-24.

A-91-61 Closed--Unacceptable Action
June 7, 1995

Require that air traffic control tower managers re-emphasize the concept and use of progressive taxi/progressive ground movement instructions during low-visibility ground operations in local operations position standards handbooks.

A-91-62 Closed--Acceptable Action
May 15, 1992

Require that air traffic control tower managers emphasize to local controllers the need for position determination of airplane departures in IFR conditions when direct observations of departing airplanes are not possible.

A-91-66 Closed--Acceptable Action
August 30, 1994

Require that the subject of low-visibility taxi problems become a recurring subject in all airline operations manuals and pilot training forums.

On December 3, 1991, as a result of the investigation of the February 1, 1991, accident involving the collision of a landing B-737 with a Fairchild Metroliner waiting for takeoff clearance at the Los Angeles International Airport, Los Angeles, California, the Safety Board issued eight safety recommendations to the FAA addressing the problem of runway incursion accidents. These recommendations are described below.

A-91-104 Closed--Acceptable Action
February 10, 1994

Modify air traffic control procedures at the Los Angeles International Airport to: (a) segregate arrivals and departures to specific runways; (b) provide redundancies as intended in the National Operation Position Standards in the control tower.

A-91-105 Closed--Acceptable Action
April 8, 1993

Undertake a zero-risk based evaluation of air traffic control procedures at the Los Angeles International Airport, evaluate whether changes are required, and implement necessary changes. The evaluation should consider at least the following issues: (A) runway intersection takeoffs; (B) position-and-hold clearances; (C) displaced runway thresholds; (D) hazards associated with runway crossing traffic; (E) local assist controller; (F) Airport Surface Detection Equipment

A-91-110 Closed--Acceptable Action
February 10, 1994

Conduct a one-time examination of the airport lighting at all U.S. tower-controlled airports to eliminate or reduce restrictions to visibility from the control tower to the runways and other traffic movement areas.

A-91-111 Open--Unacceptable Response

Redefine the airplane certification coverage compliance standards for anti-collision lights installations to ensure that the anti-collision light(s) of an aircraft in position on a runway are clearly visible to the pilot of another aircraft preparing to land or take off on that runway.

A-91-112 Closed--Unacceptable Action
April 12, 1995

Evaluate and implement, as appropriate, suitable means for enhancing the conspicuity of aircraft on airport surfaces during night or periods of reduced visibility. Include in this effort measures, such as the displacement of an aircraft away from the runway centerline, where applicable, and the use of conspicuity enhancements, such as high-intensity strobe lighting and logo lighting by aircraft on active runways, and encourage operators of airplanes certificated prior to September 1, 1977, to upgrade their airplanes to the present higher intensity standards for anti-collision light installations.

A-91-113 Closed--Acceptable Action
August 10, 1993

Direct the general aviation community and the airlines to take steps to ensure that pilot training programs, including cockpit resource management training and flight operations procedures, place sufficient emphasis on the need for pilots to maintain vigilance in monitoring air traffic control radio communication frequencies for potential traffic conflicts with their aircraft, especially when on an active runway and/or when conducting a final approach to a landing.

A-91-114 Closed--Acceptable Action
April 8, 1993

Incorporate into the Airman's Information Manual language that will alert pilots to the need for vigilance in monitoring air traffic frequencies for traffic conflict situations which may affect the safety of their flight.

A-91-115 Closed--Acceptable Action
April 16, 1993

Develop for inclusion in the Airman's Information Manual and the Air Traffic Control Handbook, (7110.65F) specific phraseology to be used by pilots when requesting an intersection departure and specific phraseology to be used by controllers when issuing a position-and-hold clearance for an intersection departure.

On February 28, 1995, as a result of the investigation of the November 22, 1994, accident involving the collision of a McDonnell Douglas MD-82 and a Cessna 441 at the St. Louis/Lambert International Airport, Bridgeton, Missouri, the Safety Board issued five safety recommendations to the FAA addressing the problem of runway incursion accidents. These recommendations and their status are described below:

A-95-30 Closed--Acceptable Action
August 1, 1995

Within 45 days of receipt of this letter, require that the air traffic service provide a firm, finalized mission needs & operational requirements documents for Airport Movement Area Safety System. No further modifications should be implemented until after the first Airport Movement Area Safety System is commissioned.

A-95-31 Open--Acceptable Response

Within 60 days of receipt of this letter, provide to the Safety Board a firm schedule to commission those Airport Surface Detection Equipment -- III radar systems that have been installed & adhere to that schedule.

A-95-32 Open--Acceptable Response

For those traffic control terminal facilities that commission the Airport Surface Detection Equipment -- III, require that it be operational between sunset & sunrise. When the Airport Movement Area Safety System is commissioned, require that it be operational 24 hours a day.

A-91-33 Closed--Acceptable Action
August 1, 1995

Issue an Administrator's letter to airmen that directs pilots to read back, in full, their runway assignment upon receiving taxi instructions & before receiving their takeoff clearance when operating at airports that employ more than one runway. Also revise the Airman's Information Manual to reflect this procedure.

A-95-34 Closed--Acceptable Action
August 1, 1995

Amend FAA Order 7110.65, Air Traffic Control, to require that air traffic controllers receive confirmation of runway assignment from pilots after issuing taxi instructions. Require that this procedure be used at those airports which employ more than one runway during operations.

APPENDIX H - FEBRUARY 28, 1995, RECOMMENDATIONS

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 28, 1995

In reply refer to: A-95-30 through -34

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

Approximately 2202 central standard time on November 22, 1994, a collision occurred at the intersection of taxiway romeo and runway 30R at the St. Louis/Lambert International Airport, St. Louis, Missouri. The St. Louis weather conditions were reported to be clear, with visibility at 25 miles. The accident involved a Cessna 441, N441KM, and a McDonnell Douglas MD-80, Trans World Airlines flight 427 (TWA427). TWA427 was operating as a scheduled domestic passenger service flight from St. Louis to Denver, Colorado, under the provisions of Title 14 Code of Federal Regulations (CFR) Part 121. N441KM was operating under the provisions of 14 CFR Part 91, under an instrument flight rules clearance to Iron Mountain, Michigan. Both airplanes were in radio communication with the tower local controller at the time of the accident. As a result of the collision, N441KM was destroyed and TWA427 received substantial damage. The pilot and passenger aboard N441KM were fatally injured, and there were eight injuries on TWA427.

The Safety Board's investigation of the accident is continuing. Information obtained to date indicates that N441KM landed on runway 30R at St. Louis and taxied to the ramp at the north side of the airport. After unloading a passenger, the pilot requested and was issued a clearance to Iron Mountain. The ground controller then instructed its pilot to backtaxi on runway 31, which is parallel to runway 30R. The ground controller also instructed the pilot to hold in position on runway 31 and to advise the controller when he was ready for takeoff. A little more than 3 minutes later, the ground controller inquired if the pilot was ready for takeoff. After receiving an affirmative response, the ground controller instructed the pilot to monitor the tower local control frequency.

While the pilot of N441KM was on the ground control frequency, the flightcrew of TWA427 had received their takeoff clearance on runway 30R. About 38 seconds after they acknowledged their takeoff clearance, the pilot of N441KM advised the local controller, "and kilo mike's ready to go on the right side." The local controller advised the pilot that she could not clear him simultaneously, "with the uh traffic departing on the right just continue holding in

position . . . ." About 11 seconds after the pilot of N441KM acknowledged this transmission, the airplane was struck by TWA427 which was on takeoff roll on runway 30R.

The Safety Board is focusing on many areas during its investigation and has not concluded that any specific communication was causal to the accident. Notwithstanding, the Safety Board believes that the Federal Aviation Administration (FAA) should take action to make certain that air traffic controllers and pilots clearly understand the intentions and expectations of one another. Also, the Safety Board believes that had previous actions taken by the FAA to reduce the risk of runway collisions received adequate support, this accident could have been prevented. While FAA statistics indicate that the number of runway incursions has decreased yearly since 1991, the Safety Board believes that this accident illustrates that there is no margin for error for either pilots or controllers and that unresolved errors can lead to catastrophic results.

The Safety Board's concern about the hazards of runway incursions dates back to 1972 following an accident at the Chicago O'Hare International Airport. Since that time, the investigation of other such accidents or incidents has prompted the Safety Board to issue 61 safety recommendations focused on the prevention of runway incursions. At present, this issue is included as a part of the Safety Board's "Most Wanted" Safety Recommendation Program.

Following a runway collision at the Atlanta Hartsfield International Airport that occurred on January 18, 1990, involving an Eastern Airlines Boeing 727 and a King Air A100,[1] the Safety Board recognized FAA efforts to explore and test several advanced concepts in automated airport surface traffic detection. One of those efforts, the Airport Movement Area Safety System (AMASS) was, at that time, undergoing proof-of-concept testing at the Pittsburgh International Airport. The AMASS system uses data available from the Airport Surface Detection Equipment (ASDE-3) and Automated Radar Terminal System (ARTS) to identify potential incursions and alerts the controller so that timely corrective action can be taken.

In testimony before congressional committees on March 6, 1990,[2] the FAA stated that it had entered into a contract with Norden Systems, a designer and manufacturer of electronic equipment for the Department of Defense (DOD) and the FAA, for development of AMASS. In testimony, the FAA and Norden acknowledged that while AMASS was conceptual and would require refinements, it would be able to function as a "backstop" to detect, and provide alerts in, at least 29 scenarios during which a runway incursion was most likely to occur (over 90 percent of possible incursion scenarios). FAA testimony noted that because the project had congressional interest, it would be "fast-tracked" and not totally confined to the cumbersome and time-

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[1]Aircraft Accident Report--Runway Collision of Eastern Airlines Boeing 727, Flight 111 and Epps Air Service Beechcraft King Air A100, Atlanta Hartsfield International Airport, Atlanta, Georgia, January 18, 1990 (NTSB/AAR-91/03).

[2]Statement of FAA's Executive Director for System Development before the House Committee on Science, Space, and Technology, subcommittee on Transportation, Aviation and Materials, concerning runway incursions.

consuming acquisition hurdles of most projects, and as a result, it was anticipated that the project would be operational by 1992.

Following a preliminary design review during July 1991, work began on a pre-production prototype. This required input from staff from the FAA's Air Traffic Requirements Office, which provides operational requirements for new equipment. During October 1992, a "Demonstration/Validation" of the safety logic required for detecting the 29 situations during which a runway incursion could occur was provided to the air traffic requirements team. At that time, the system was capable of tracking 128 targets, but could be expanded to track 256 targets. During December 1992, live traffic testing began at the San Francisco International Airport. Concurrent with the decision for live traffic testing, the FAA's AMASS technical officer received a letter dated December 7, 1992, from the FAA's Director of Air Traffic Requirements. The letter outlined 30 modifications to AMASS hardware and software, 15 of which required substantial and additional funding, and would expand the time frame for the completion of the project. This letter also stated that additional requirement modifications would be forthcoming. Because a date for validation during April 1993 had been established, some changes that could be done quickly were accomplished. Ironically, most of the modifications were not associated with issues of increasing safety, but rather had to do with human [controller] interface. Some requirement changes went against the basic objective of the AMASS program; for example, one requirement called for the program to be able to inhibit specific targets from generating any type of alert, even though the target would normally qualify in an intrusion scenario. While it was envisioned initially that AMASS would be a virtual hands-off system for controllers, these, and other later modifications have created an AMASS system that may now be labor intensive, and could compromise its potential safety benefits.

During a December 1993 meeting which involved senior FAA staff associated with the AMASS project, the AMASS technical officer informed attendees that, of the new requirements submitted, eight could be accomplished with existing research and development (R&D) funds. The new requirements were accomplished and demonstrated at the Boston Logan International Airport, which had since received its ASDE-3 radar system. It was also noted that, of the eight new requirements, only one was safety related, and only one was applicable to those operations conducted at the Boston airport.

During February 1994, the AMASS project then transitioned from R&D funding to facilities and equipment (F&E) funding, which permitted the initiation of the formal specification review and formal acquisition process. This process dictated that the Air Traffic Requirements program manager submit a revalidated mission needs statement and operational requirements document, which enabled the AMASS program manager to set up the AMASS program for production. The mission needs and operational requirements document has not been received, and as a result, the AMASS program remains stalled.

Over $20 million has been spent so far on the AMASS project. At present, no AMASS systems are operational in the National Airspace System (NAS) at those airports envisioned to have the program before 1996. The Safety Board is concerned that progress of this important

project has been effectively paralyzed as a result of a succession of changes in operational specifications imposed from within the FAA's Air Traffic Service. Despite the involvement of staff from the Air Traffic Requirements office in every stage of the development and acquisition process, there appears to have been reluctance to establish firm and realistic requirements that would have kept the project on schedule. While the Safety Board recognizes that the input from the Air Traffic Requirements office is prudent and necessary, it would appear that factions within it are attempting to require that AMASS become something it was never intended to be. The Safety Board also believes that had this program continued, unencumbered by repeated requirement changes, AMASS would have been available for operational consideration during 1993. The Safety Board notes that AMASS hardware production continues, in anticipation of eventual installation.

The Safety Board believes that the AMASS project should move ahead immediately. Safety Board staff has observed the AMASS system in operation and is satisfied that it works. Of more concern is that the accident at St. Louis may have been prevented had AMASS been in use at that airport. On November 29, 1993, the FAA's National Runway Incursion Manager and members of his staff provided a briefing to Safety Board staff concerning the status of major FAA runway incursion initiatives. During this briefing, the FAA advised that while some problems had been encountered and some "slippage" had occurred, for the most part, all projects were on track and on target. The Safety Board is deeply concerned to learn that this has not been the case. The Safety Board also believes that the Air Traffic Service should provide a firm, finalized operational requirements document to the AMASS technical officer within 45 days from receipt of this letter. No further modifications should be implemented until after the first AMASS system is certified by the FAA as being ready for operation (commissioned).

The ASDE-3 and AMASS are interconnected. AMASS is not capable of being a stand-alone system. During the investigation of the accident at St. Louis, Safety Board investigators learned that the hard drive on the ASDE-3 system had failed, but because it had not been commissioned it did not receive priority for logistical support to implement timely repair.

During September 1989, the ASDE-3 was installed at the Pittsburgh International Airport, Pittsburgh, Pennsylvania, to become the first system in the NAS. Since that time, 23 sites, including St. Louis, have received the ASDE-3. The Safety Board is aware that the ASDE-3 has experienced some problems since it was first introduced. One of the earlier problems, which has since been resolved, was delamination of the antenna. Another problem was site specific where it was learned that the pedestal on which the antenna is mounted was improperly installed. Another problem that has been encountered, primarily at the Atlanta Hartsfield International Airport, has been a phenomenon called "multi-path," which is the generation of false targets from intense reflectivity from buildings or other natural obstructions on the surface of the airport. When augmented with AMASS, the generation of false targets could trigger false alerts in specific areas of the airport. However, this problem has been mitigated through the use of icons superimposed over the radar target of known aircraft. Almost all problems have either been corrected or resolved in some manner, although it is acknowledged that the system is not perfect.

At the time of this accident, the Safety Board learned that of those sites that have the ASDE-3, only one airport, the Seattle/Tacoma International Airport, in Seattle, Washington, had a commissioned system. This airport was selected by the FAA to be the premier facility for low visibility operations. Since this accident, Safety Board staff has learned that six other airports with the ASDE-3 system have been commissioned.

For the controller workforce, probably the most contentious issue surrounding the ASDE-3 system has been the design of the zoom feature on the ASDE-3 display, in which the target of the airplane may appear as several targets when magnified. It is analogous to looking at printed letters with the naked eye, in which the letters will appear to be a solid line, but when magnified, the print is broken into pixels (dots). This is not a design flaw, but rather a natural feature of high resolution radar such as the ASDE-3. While this impasse is not delaying the installation of ASDE-3 at those airports slated to get the system, the controversy over this issue has possibly served as the impetus for not commissioning those systems. However, it must be recognized that for those facilities that currently have the system in place, those controllers must operate with a substandard ground-based radar system or without the benefit of any surface detection system because commissioning has not occurred.

The Safety Board believes that unless there are compelling reasons not to commission those currently installed ASDE-3 radars, the FAA should do so immediately. Safety Board investigators note that the weather conditions that prevailed at St. Louis would not have, under current procedures, required that the ASDE-3 be operational; however, had it been, it is conceivable that the local controller would have been able to confirm the position of N441KM when advised, "ready to go on the right side." As stated earlier, had the ASDE-3 been augmented with AMASS processing, an alert would have been generated. The Safety Board believes that the FAA should require that the ASDE-3 be operational between sunset and sunrise, regardless of weather, and once AMASS processing is commissioned, it should operate 24 hours a day.

With regard to the St. Louis accident, the Safety Board notes that, after receiving his clearance to taxi, the pilot of N441KM did not read back his runway assignment during any subsequent transmissions, nor was he required to. When the pilot of N441KM advised the local controller that he was, "ready to go on the right side," it seems that this transmission should have prompted the local controller concern, since her next transmission also referred to, "on the right." This was the first indication to the local controller that the pilot of N441KM was in position on the wrong runway; however, at that moment, it is doubtful that there was time to clear runway 30R. Her failure to perceive the significance of his initial transmission may have been a result of her being advised by the ground controller that the pilot of N441KM had been instructed to expect to take off on runway 31 and her resultant expectation that the pilot was in position on the adjacent, parallel runway. In addition, the pilot, after being advised by the local controller, "I can't roll you simultaneously with the uh traffic departing on the right," did not realize that he had taxied into position on the wrong runway.

The intersection at which the pilot of N441KM entered runway 30R is about 2,000 feet from the departure end of runway 30R, where the flightcrew of TWA427 was initiating their takeoff roll. The communication from the pilot of N441KM to the local controller that he was, "ready to go on the right," may have been perceived by the flightcrew of TWA427 as a routine communication in that another pilot was advising the tower that he was ready to depart, in sequence, on runway 30R.

At present, voice communication is the primary interface between the controller and pilots, and common human performance failures make it one of the most vulnerable to error. Under the circumstances of this accident, it cannot be determined what the pilot of N441KM heard or understood. As a result of its 1986 study of airport runway incursions,[3] the Safety Board issued Safety Recommendation A-86-33, which asked the FAA to "require controllers to obtain a read back for all hold, takeoff, or crossing clearances and for clearances onto an active runway." The FAA reluctantly agreed to amend the ATC Handbook to require that controllers receive a readback of all runway hold short clearances. The FAA's primary concern was that this change would create additional frequency congestion during peak traffic periods. In 1993, the FAA informed the Board that during low visibility conditions, controllers would be required to obtain a readback from pilots to confirm an airplane's movement to cross or take off from an active runway. Based on this action, the Board classified Safety Recommendation A-86-33 "Closed--Acceptable Action." The Safety Board maintains that this change is responsible, in part, for the decrease in runway incursion incidents. However, this most recent accident demonstrates that additional measures are required.

At many airports in the United States, multiple runway configurations are used for arriving and departing aircraft. The Safety Board believes that for those airports that employ multiple runway configurations, to alleviate any misunderstandings or miscommunications, pilots should confirm their runway assignment when initially issued, by stating fully the runway assignment and any other instruction that requires the pilot to taxi on, near, or to a runway. Following any subsequent frequency changes, this procedure should again be employed until the flight is airborne. The Safety Board believes that the benefit of receiving an explicit confirmation of runway assignment from the pilot before receiving takeoff clearance will provide an extra measure of safety in that this procedure will allow the controller to eliminate those errors where a pilot has misunderstood his runway assignment and will enhance situational awareness on the part of other flightcrews that are landing or are to take off on that specific runway.

The FAA has two primary tools through which pilots can quickly be provided with fundamental flight information and air traffic control procedures. These are the Airman's Information Manual (AIM) and an Administrator's Letter to Airmen. Because clear and concise communications are the backbone to safety during ground operations, the Safety Board believes that the FAA should issue an Administrator's Letter to Airmen and should amend the AIM to

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[3]National Transportation Safety Board, Runway Incursions at Controlled Airports in the United States, NTSB/SIR-86/01.

encourage pilots to read back their runway assignment during ground operations until receiving their clearance for takeoff. The rationale for this procedure should be provided, in conjunction with specific examples of appropriate phraseology.

For air traffic controllers, FAA Order 7110.65, "Air Traffic Control," should be amended to require that controllers receive full acknowledgement of runway assignment and any clearance associated with the runway assignment when multiple runway configurations are employed. Under current procedures, the possibility that miscommunication may occur is greater because there is no requirement for the pilot to fully acknowledge such clearances. The Safety Board believes that during busy traffic periods, it is imperative that the controller receive confirmation that his instructions have been clearly understood. In addition, by having specific confirmation of the runway assignment and the pilot's actions stated on the radio frequency, the information becomes available to other flightcrews to enhance their situational awareness in a manner not otherwise available under current procedures.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Within 45 days of receipt of this letter, require that the Air Traffic Service provide a firm, finalized mission needs and operational requirements document for the Airport Movement Area Safety System. No further modifications should be implemented until after the first Airport Movement Area Safety System is commissioned. (Class II, Priority Action)(A-95-30)

Within 60 days of receipt of this letter, provide to the Safety Board a firm schedule to commission those Airport Surface Detection Equipment-3 radar systems that have been installed and adhere to that schedule. (Class II, Priority Action)(A-95-31)

For those air traffic control terminal facilities that commission the Airport Surface Detection Equipment-3, require that it be operational between sunset and sunrise. When the Airport Movement Area Safety System is commissioned, require that it be operational 24 hours a day. (Class II, Priority Action)(A-95-32)

Issue an Administrator's Letter to Airmen that directs pilots to read back, in full, their runway assignment upon receiving taxi instructions and before receiving their takeoff clearance when operating at airports that employ more than one runway. Also, revise the Airman's Information Manual to reflect this procedure. (Class II, Priority Action)(A-95-33)

Amend FAA Order 7110.65, "Air Traffic Control," to require that air traffic controllers receive confirmation of runway assignment from pilots after issuing

taxi instructions. Require that this procedure be used at those airports which employ more than one runway during operations. (Class II, Priority Action)(A-95-34)

Chairman HALL, Vice Chairman FRANCIS, and Member HAMMERSCHMIDT concurred in these recommendations.

By: Jim Hall
Chairman

APPENDIX I - AIRPORT CLOSURE RECOMMENDATION

National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: July 17, 1995

In reply refer to: A-95-77 and -78

Honorable David R. Hinson
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On July 2, 1994, about 1843 eastern daylight time, a Douglas DC-9-31, N954VJ, operated by USAir, Inc., as flight 1016, collided with trees and a private residence near the Charlotte/Douglas International Airport (CLT), Charlotte, North Carolina, shortly after the flightcrew executed a missed approach from the instrument landing system approach to runway 18R. The captain, first officer, one flight attendant, and one passenger received minor injuries. Two flight attendants and 14 passengers sustained serious injuries. The remaining 37 passengers received fatal injuries. The airplane was destroyed by impact forces and a postcrash fire. Instrument meteorological conditions prevailed at the time of the accident, and an instrument flight rules (IFR) flight plan had been filed. Flight 1016 was being conducted under 14 Code of Federal Regulations (CFR) Part 121 as a regularly scheduled passenger flight from Columbia, South Carolina, to Charlotte.[1]

The National Transportation Safety Board has determined that the probable causes of the accident were: 1) the flightcrew's decision to continue an approach into severe convective activity that was conducive to a microburst; 2) the flightcrew's failure to recognize a windshear situation in a timely manner; 3) the flightcrew's failure to establish and maintain the proper airplane attitude and thrust setting necessary to escape the windshear; and 4) the lack of real-time adverse weather and windshear hazard information dissemination from air traffic control

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[1]For more detailed information, read Aircraft Accident Report – "Flight Into Terrain During Missed Approach, USAir Flight 1016, DC-9-31, N954VJ, Charlotte/Douglas International Airport, Charlotte, North Carolina, July 2, 1994" (NTSB/AAR-95/03)

(ATC), all of which led to an encounter with and failure to escape from a microburst induced windshear that was produced by a rapidly developing thunderstorm located at the approach end of runway 18R.

Contributing to the accident were: 1) the lack of ATC procedures that would have required the controller to display and issue airport surveillance radar (ASR-9) weather information to the pilots of flight 1016; 2) the Charlotte tower supervisor's failure to properly advise and ensure that all controllers were aware of and reporting the reduction in visibility and the runway visual range value information, and the low level windshear alerts that had occurred in multiple quadrants; 3) the inadequate remedial actions by USAir to ensure adherence to standard operating procedures; and 4) the inadequate software logic in the airplane's windshear warning system that did not provide an alert upon entry into the windshear.

About 1845, the CLT ATC tower activated the "crash phone" linked to the airport fire station (Station 17) and indicated that "we lost a plane on radar - 5 - 5 SOB [Souls on Board]." Eight fire fighters responded with three aircraft rescue and fire fighting (ARFF) trucks (Blaze 1, 2, and 7), and one quick response and command truck (Blaze 5) from the fire station located near the base of the ATC tower. Several fire fighters stated that at the time the equipment was dispatched "it was raining very hard."

The initial notification to the fire station by the ATC tower did not identify any particular location of the downed aircraft because of the restricted visibility; thus, the fire equipment traversed the airport, via taxiway A, searching for evidence of an accident. At 1846:09, the ATC ground controller notified the crew in Blaze 5 "we have a large area of smoke visible from the tower, now it appears to be approximately a quarter mile north of the old hangar that CCAir is using...."

Simultaneous to the ground controller's transmission, the crew of Blaze 5 heard a transmission from the City alarm room indicating that there was a "possible plane crash in the vicinity of Wallace Neel and Old Dowd." The ATC ground controller contacted the crew of Blaze 5 and stated that there were "five zero souls, plus five crew on board." The fire equipment vehicles crossed the airport, and two of the vehicles exited the airport property through a security gate (gate 36) operated by a magnetic key card. The two remaining vehicles were delayed because of difficulties opening gate 36; in fact, they "crashed" through the gate and proceeded to the accident site.

About 4 minutes after the Charlotte ARFF units arrived on scene, the Charlotte Fire Department units arrived at the accident site. The fire fighting efforts proceeded for approximately 5 minutes, using water and aqueous film-forming foam as the extinguishing agents.

The Safety Board is concerned that the response of the ARFF units was delayed because of difficulties experienced in opening airport security gate 36. The Airport Authority later determined that the gate had been functioning properly but had failed to open because the ARFF personnel had passed their magnetic cards through the card readers too quickly.

While the solution to this problem would be for emergency response personnel to pass the gate cards through the card reader more slowly, the ARFF Incident Commander testified at the Safety Board's public hearing that when the gate did open, it did so very slowly. The Safety Board believes that passing a gate card through a card reader too quickly by emergency response personnel, who would normally be anxious and hurried while responding to a disaster, is understandable. However, response time is critical in fighting fires, especially aircraft fires. The time lost in repeatedly trying to open a gate, and then waiting for the gate to retract to the open position, could jeopardize lives.

The Safety Board acknowledges that fences and restricted gate access are required for security at airports; however, devices used to provide this security should not interfere with an expeditious response by emergency personnel. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should require that all airports certificated under 14 CFR Part 139 identify gates that ARFF personnel and their equipment might need to access while responding to emergencies. Further, the FAA should require the necessary changes to ensure that ARFF personnel and their equipment can pass through these gates without hesitation or delay. Additionally, the gates that are identified and the procedures required to access them should be included in the Airport Emergency Plan.

The Safety Board is also concerned that CLT remained open and that air carrier operations continued for about 30 minutes after ARFF personnel and equipment were involved in fire fighting and rescue activities at the accident site. Although ARFF units were in close proximity to the airport and could have responded immediately to another emergency, the Safety Board found that all the available ARFF units and personnel were involved in the fire fighting and extrication efforts of USAir flight 1016. As a result, fire extinguishing materials were significantly diminished. The Safety Board believes that if another aircraft

emergency had occurred at the airport, it would have been extremely difficult for ARFF units to respond in a timely and effective manner.

About 2203, on November 22, 1994, Trans World Airlines flight 427, providing scheduled 14 CFR Part 121 service between St. Louis, Missouri, and Denver, Colorado, collided with a Cessna 441, N441KM, at the intersection of runway 30R and taxiway R, at the Lambert-St. Louis International Airport, Bridgeton, Missouri. Flight 427, a McDonnell Douglas DC-9-82, N954U, sustained substantial damage during the collision. The 2 flight crewmembers, an additional crewmember in the cockpit jumpseat, 5 flight attendants, and 124 of the 132 passengers on board evacuated the airplane without injury. The Cessna 441, operated by Superior Aviation Inc., was destroyed, and the commercial pilot and the passenger, who was a rated private pilot, received fatal injuries. The accident occurred during the hours of darkness, and visual meteorological conditions prevailed. Both flights were operating on IFR flight plans. The Cessna was holding in position awaiting takeoff clearance for an intended 14 CFR Part 91 positioning flight to Iron Mountain, Michigan.

Although the accident is still under investigation, the Safety Board found that Lambert-St. Louis International Airport remained open after the accident, and that aircraft movement continued near the accident site. Several radio transmissions to the ATC ground controller from pilots of taxiing airplanes revealed that they were concerned about the possibility of passengers from the accident flight wandering into the paths of taxiing airplanes. After receiving these transmissions, the ground controller stopped aircraft movement in the area. Shortly thereafter, all ground movement on the airport was halted.

The Safety Board believes that because the airport was not closed immediately following the accident, the potential for injury to the evacuated passengers by taxiing airplanes was high. Closing the airport would have allowed controllers to assess the situation and to redirect both airborne and taxiing traffic to areas of the airport that were remote from the accident site. The assessment period could have been brief, and the airport could have been reopened after safe conditions were confirmed by the airport operator.

Therefore, the Safety Board believes that the FAA should provide guidance to all airports certificated under 14 CFR Part 139 that in the event of an accident or significant incident, the airport be closed immediately by either the airport operator and/or the appropriate FAA air traffic facilities through letters of agreement with airport operators. In addition, airports, or portions thereof, should not be reopened until the airport

operator has ensured that: (1) aircraft operating areas are secure; (2) aircraft movement areas that are to be reopened have been properly inspected; and (3) adequate ARFF protection is available for aircraft operations.

Therefore, as a result of its investigation of these accidents, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Require that all 14 CFR 139 certificated airports identify gates that aircraft rescue and fire fighting personnel and their equipment might need to access while responding to emergencies, and make the necessary changes to ensure that emergency personnel and their equipment can pass through these gates without hesitation or delay. Additionally, the gates that are identified and the procedures required to access them should be included in the Airport Emergency Plan. (Class II, Priority Action) (A-95-77)
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> Provide guidance to all 14 CFR 139 certificated airports that in the event of an accident or significant incident, the airport be closed immediately by either the airport operator and/or the appropriate FAA air traffic facilities through letters of agreement with airport operators. Also, specify that the airport, or portions thereof, should not be reopened until the airport operator has ensured that: (1) aircraft operating areas are secure; (2) aircraft movement areas that are to be reopened have been properly inspected; and (3) adequate aircraft rescue and fire fighting protection is available for aircraft operations. (Class II, Priority Action) (A-95-78)

Chairman HALL, Vice Chairman FRANCIS, and Member HAMMERSCHMIDT concurred in these recommendations.

By: Jim Hall
Chairman

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