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Pilot of Cessna 441 Incorrectly Taxis onto Active Runway and Aircraft Is Struck by McDonnell Douglas MD-82 on Takeoff Roll

On the night of the accident, the ground controller in the U.S. Federal Aviation Administration air traffic control tower was working four positions and monitoring seven frequencies, the official U.S. report said.

FSF Editorial Staff

The pilot of the Cessna 441 twin-engine turboprop was taxiing for takeoff at night at the Lambert-St. Louis International Airport (STL), near St. Louis, Missouri, U.S. He had been instructed by air traffic control (ATC) to back-taxi on Runway 31 and to advise the tower when ready for takeoff. Instead, the pilot taxied onto Runway 30R, and told ATC that he was ready for takeoff. At the same time, a McDonnell Douglas DC-9-82 (MD-82) with 132 passengers was on its takeoff roll on the same runway. [The MD-82 is one of several models in the MD-80 family, derived from the DC-9 Super 80, a "stretched" version of the DC-9.]

As the MD-82 accelerated through 80 knots, the flight crew observed the Cessna on the runway, and maneuvered the MD-82 to the left to avoid a collision. The MD-82's right wing struck the turboprop, shearing the top of the turboprop's fuselage/cockpit. The pilot of the Cessna and the one passenger on board were killed. Eight passengers on the MD-82 received minor injuries in the Nov. 22, 1994, accident.

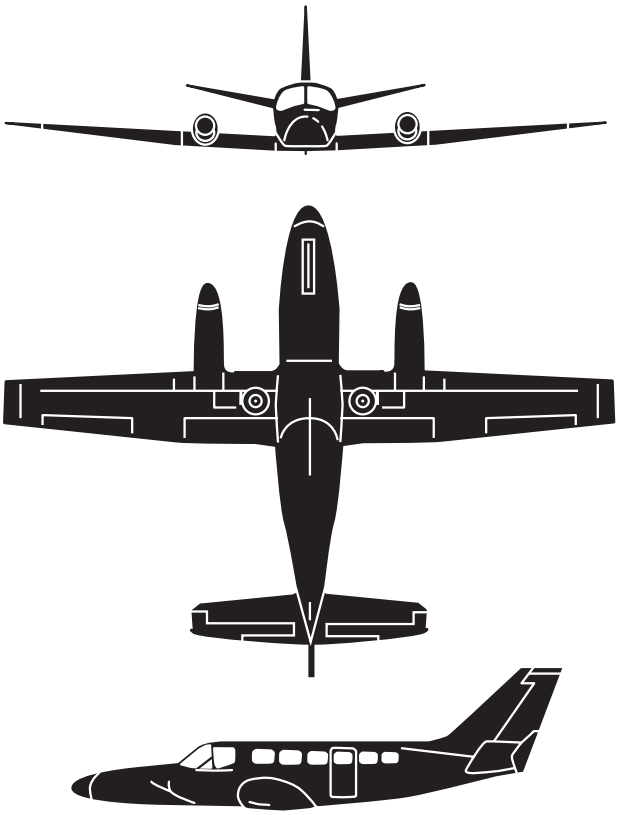
The U.S. National Transportation Safety Board (NTSB) concluded in its final accident report that the probable cause of this accident was "the Cessna 441 pilot's mistaken belief that his assigned departure runway was Runway 30R, which resulted in his undetected entrance onto Runway 30R, which was being used by the MD-82 for its departure."

The report also said: "Contributing to the accident was the lack of Automatic Terminal Information Service [ATIS, a continuous broadcast of recorded essential but routine information] and other 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 surface system (AMASS), could have prevented this accident."

[ASDE-3 is a high-resolution ground surveillance radar system that displays surface aircraft and vehicle traffic on one or more displays in the ATC tower. The system augments visual observations to enable ATC tower personnel to detect, locate and track airport surface activity. AMASS is another ground-based system that augments ASDE-3 by detecting, and alerting controllers to, potential collisions. It uses ground and airborne radar data to predict conflicts and alert controllers through aural warnings and a graphic display on the ASDE-3 screen.]

The Cessna 441 was registered to Garrett Aviation Inc., and operated by Superior Aviation Inc., of Iron Mountain, Michigan, as an air taxi service under U.S. Federal Aviation Regulations (FARs) Part 135, the report said. At about 1900 hours central standard time, the Cessna departed Iron Mountain for STL with the pilot, one revenue passenger and a nonrevenue private-pilot passenger who occupied the right seat.

On arrival in the St. Louis area, the Cessna pilot made a comment to the STL U.S. Federal Aviation Administration (FAA) tower controller about " ... this radio ...," the report



Cessna 441

The twin-turboprop Cessna 441 was first flown in 1975. It has a maximum cruising speed at 24,000 feet (7,315 meters) of 293 knots (543 kilometers per hour; 337 mph) and a service ceiling of 35,000 feet (10,670 meters). The 441's range at maximum takeoff weight with 3,183 pounds (1,444 kilograms) of fuel, maximum cruising power (with allowances for engine start, takeoff, climb, descent and 45 minutes reserves) is 2,063 nautical miles (3,820 kilometers; 2,374 miles) at 33,000 feet (10,060 meters).

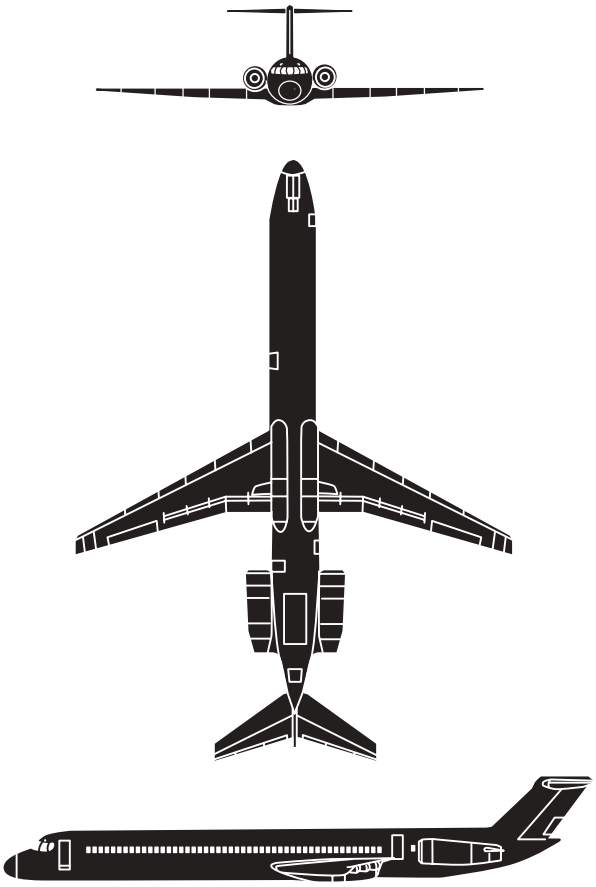
Source: *Jane's All the World's Aircraft*

said. Although the controller responded that the pilot's transmission was loud and clear, the Cessna pilot transmitted a garbled message several seconds later, of which "I got you now ... switch radios here" was discernible. The controller instructed the Cessna to land on Runway 30R, and the Cessna pilot's response was also garbled, the report said.

The Cessna landed uneventfully, and was instructed to clear the runway, and to contact ground control. "The Cessna 441 pilot reported clearing the runway to the local controller instead of the ground controller," the report said. "The local controller then reiterated instructions to contact the ground controller."

The pilot then contacted ground control and was cleared to taxi to the fixed base operator's (FBO's) ramp. At 2141, the Cessna arrived at the FBO ramp, and the revenue passenger deplaned. FBO personnel "reported that the pilots seemed to be in a good mood, but seemed eager to be on their way home," the report said.

At 2158, the Cessna pilot contacted ground control for taxi instructions. "The ground controller issued taxi instructions to ' ... back-taxi into position hold Runway 31, let me know this frequency when you're ready for departure,'" the report



McDonnell Douglas MD-82

The McDonnell Douglas MD-80 series, previously known as the Super 80, was developed from the DC-9 to meet the needs of short-to-medium range routes requiring increased passenger capacity. First flown on Jan. 8, 1981, the MD-82 was certificated in July 1981 at a maximum takeoff weight of 66,680 kilograms (147,000 pounds) and entered commercial service the same year. Fitted with two Pratt & Whitney JT8D-217 turbofan engines, the MD-82 was designed to operate at "hot and high" airports. "At an airport such as Denver, Colorado, U.S., which is 5,000 feet (1,525 meters) above sea level, the MD-82 is able to take off with 155 passengers and their baggage, and have a nonstop range of approximately 1,300 nautical miles (2,409 kilometers; 1,497 miles)," according to *Jane's All the World's Aircraft.* The MD-80 series has a normal cruising speed of 0.76 Mach.

Source: *Jane's All the World's Aircraft*

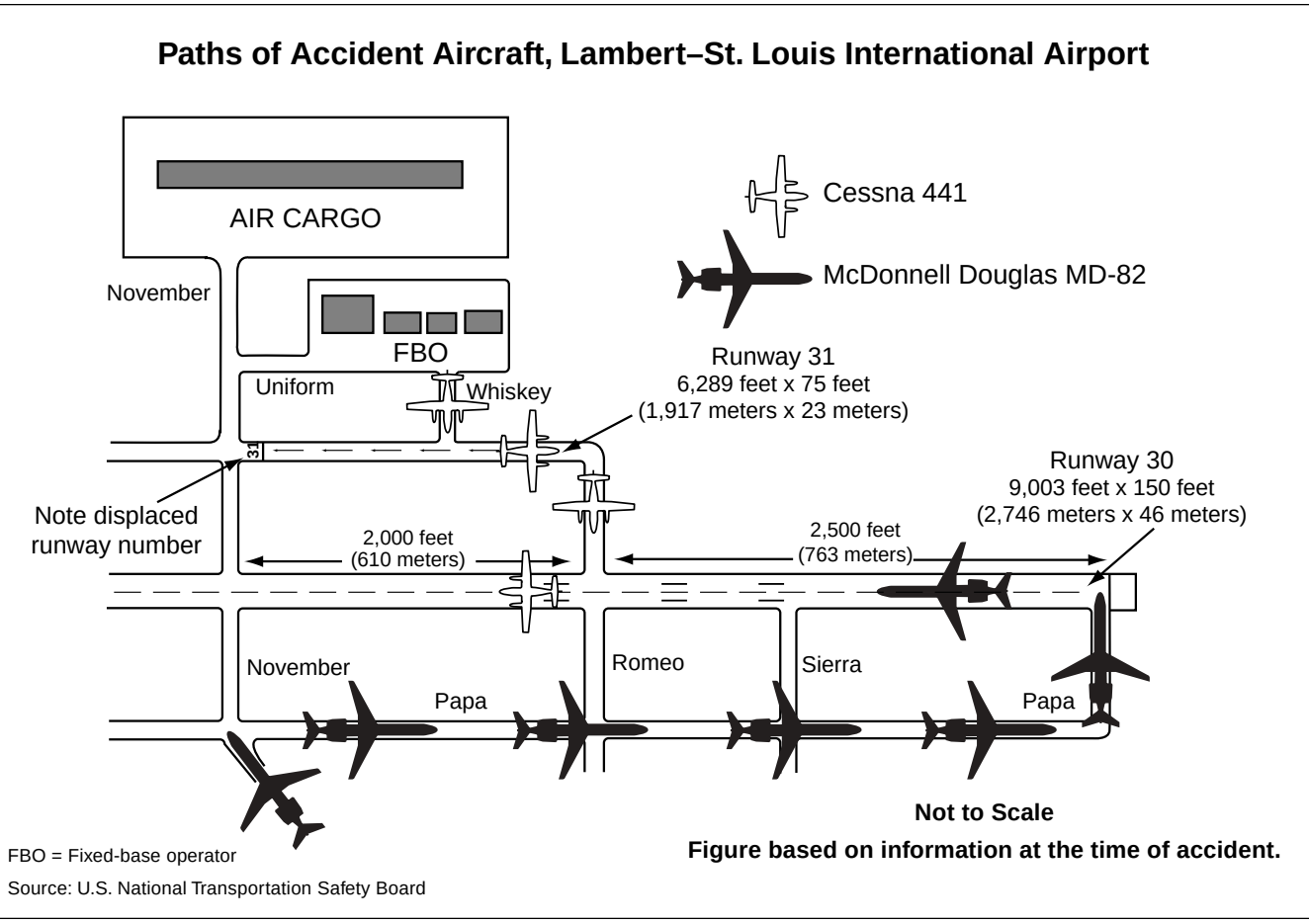


Figure 1

said. The pilot did not read back the instructions, but instead acknowledged with the last two letters of his aircraft identification.

At 2201:23, the crew of a Trans World Airlines (TWA) MD-82 that was holding short of Runway 30R was cleared for takeoff by STL tower, the report said. The first officer of the MD-82 acknowledged the takeoff clearance, and the flight taxied onto Runway 30R. At 2202:29, the Cessna pilot told STL tower that he was " ... ready to go on the right side," the report said. The tower replied, "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," the report said. The Cessna pilot had taxied onto Runway 30R from an intersecting taxiway that was 2,500 feet (762 meters) from the runway threshold (Figure 1).

The MD-82 began its takeoff roll from the threshold of Runway 30R. "The first officer operated the flight controls, while the captain advanced and set the throttles," the report said. "As the airplane accelerated on the runway, the captain made the 80-knot call-out. About two to three seconds after the 80-knot call, the additional crew member (ACM) who occupied the cockpit jumpseat yelled, 'There's an airplane!'" the report said.

At almost the same instant, the captain and the first officer saw the Cessna on the runway, the report said. "Both pilots applied the brakes, and the captain applied left rudder in an attempt to steer the airplane left to avoid the Cessna 441," the report said. "Approximately two to three seconds after the flight crew saw the Cessna 441, they felt an impact on the right side of the airplane. The flight crew 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 ... ."

The captain shut down the engines, and told STL tower to " ... roll the emergency equipment. TWA four hundred and twenty seven hit the other airplane on the, uh, runway. Roll the emergency equipment," the report said.

The MD-82 flight crew later reported that there was no fire or danger of fire at this point, but there was a large quantity of fuel leaking from the right wing, the report said. "The captain exited the left front (L1) door to further assess the situation," the report said. Fuel was running under the fuselage and pooling under the left side of the aircraft. The captain "instructed the first officer to evacuate passengers through the right front (R1) door to minimize passenger contact with the

pooling fuel," the report said. "The right overwing and aft exits were not used due to impact-related structural damage."

The cabin attendants reported that the evacuation through the single door, with the emergency slide deployed, was orderly and calm, the report said. Fire fighters, the captain and the ACM positioned themselves at the end of the slide and assisted passengers as they left the airplane. The evacuated passengers were transported by bus back to the terminal, about 35 minutes after the collision.

Estimates of the duration of the evacuation varied from four minutes to 15 minutes, with seven minutes the average estimate. All estimated times exceeded the FAA certification standard, which requires a 90-second evacuation with half the exits blocked. Nevertheless, the NTSB concluded that "the flight crew's decision [to use only the single R1 door], based on the large quantity of pooling fuel on the left side of the airplane, was a safe, sound judgment." The NTSB also believed that "the average estimate of evacuation duration was not excessively slow, given absence of critical emergency."

But the report said that the airport management's decision not to close the airport immediately after the accident put evacuated passengers at risk from taxiing aircraft. [Air traffic controllers did temporarily suspend operations about 17 minutes after the accident.] "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," the report said. "Seven minutes after the collision, Federal Express Flight 1283 landed on Runway 30L."

When investigators reviewed the damage on the MD-82, they found that the aircraft had "sustained damage to the right-wing leading-edge devices, flaps, upper surfaces, lower surfaces and forward spar," the report said. "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 [U.S.] gallons [2,271 liters] of fuel spilled."

The report continued: "The right main landing gear, the right lower fuselage and the no. 2 engine were also damaged. Plexiglas and metal debris from the Cessna [were] embedded in the MD-82. The largest piece of Cessna debris directly associated with the MD-82 was the on-board section of the [Cessna's] left wing, which was wrapped around the right main landing gear strut."

The MD-82's cockpit and cabin were not damaged, and no occupants of this airplane were injured during the collision, the report said. The airport surface weather observation taken at 2151 showed clear skies with 25 miles (40 kilometers) visibility. The temperature was 33 degrees F (one degree C) and the dew point was 22 degrees F (minus six degrees C). Winds were 270 degrees at eight knots. Barometric pressure was 30.56 inches of mercury.

Examination of the Cessna wreckage indicated that it was almost directly on the runway centerline when the collision occurred, approximately 2,500 feet (763 meters) from the approach end, the report said. The wreckage path (Figure 2, page 5) began with a two-foot (0.6-meter) section of the

Table 1
Wreckage Distribution*

1.	[N441KM]	Top of rudder (two-foot [0.6-meter] section)
2.	[N441KM]	Gray headrest
3.	[N954U]	Gear-door section (12-inch by eight-inch 30-centimeter by 20-centimeter] section)
4.	[N954U]	No. 2 flap hinge-mechanism cover (aft section)
5.	[N441KM]	Tail section (root fairing)
6.	[N441KM]	Tail cone with navigation light
7.	[N441KM]	Right elevator (five-foot [1.5-meter] 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 feet [0.3 meter by 0.6 meter])
13.	[N441KM]	Left horizontal stabilizer (two foot inboard section)
14.	[N441KM]	Overhead duct (12-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]	No. 3 leading-edge slat
22.	[N441KM]	Left horizontal stabilizer section
23.	[N441KM]	Left outboard wing section (fractured 7.5 feet [2.3 meters] outboard of the No. 1 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. No. 2 seat sun visor
		e. Window-curtain sections
		f. Tail-section inspection plate

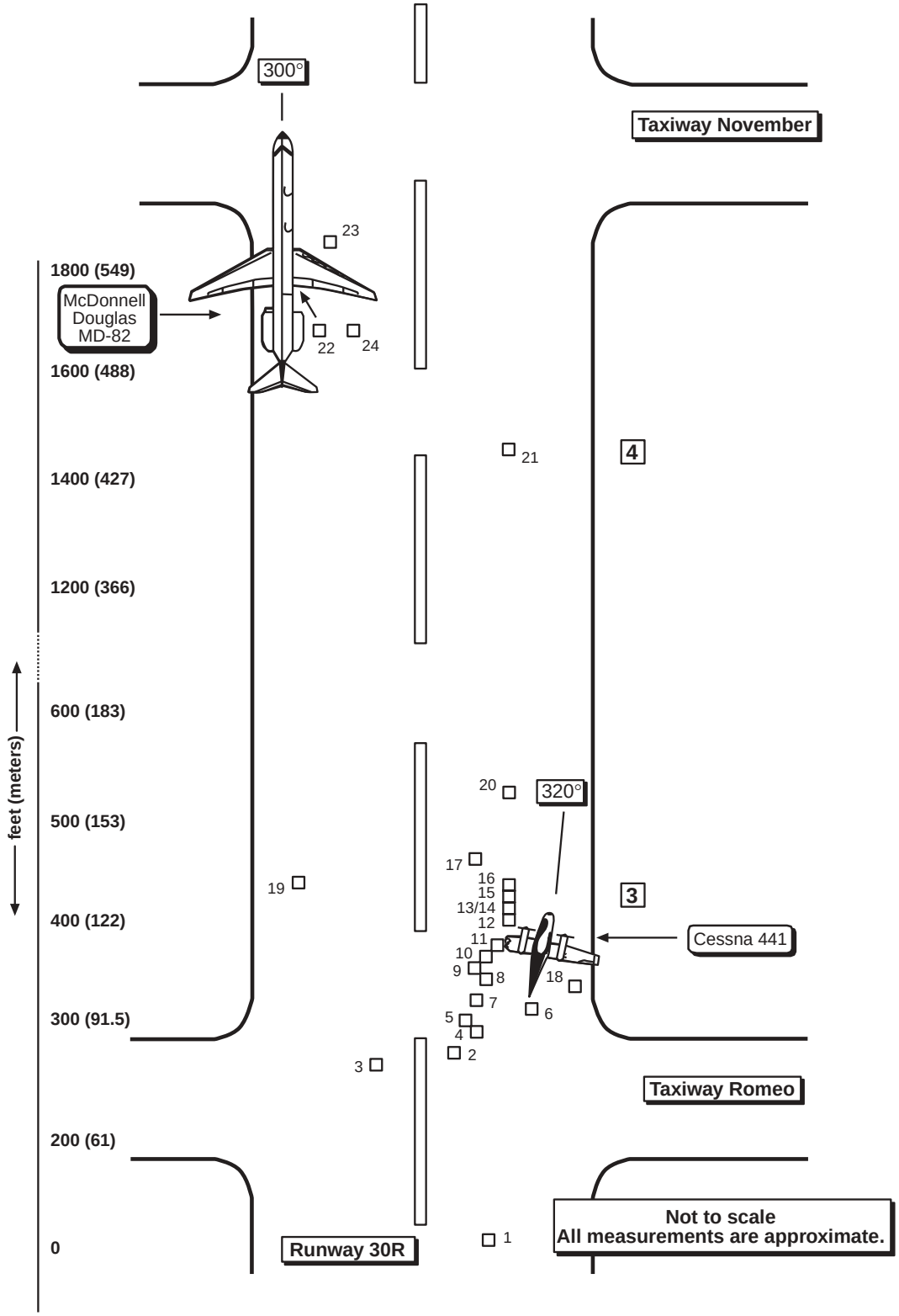
* Shown on Figure 2

N441KM = Registration number, Cessna 441

N954U = Registration number, MD-82

Source: U.S. National Transportation Safety Board

Location of Wreckage* Following Accident, Lambert–St. Louis International Airport



*For key to numbers, see Table 1 (page 4).

Source: U.S. National Transportation Safety Board

Figure 2

Cessna's rudder. The main portion of the Cessna was located on the north edge of the runway, approximately 350 feet (107 meters) farther, the report said.

The report described the wreckage of the Cessna: "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 [airport rescue and fire fighting] personnel arrived at the airplane after the collision. [Fire fighters applied fire-retardant foam to the right engine until it shut down, applied foam to the leaking fuel and shut off electrical power to the Cessna by disconnecting the battery in the nose compartment.] Jagged leading-edge damage was evident on all three propeller blades on the right engine, with two blades bent forward."

The report continued: "The upper fuselage was sheared off approximately two inches [five centimeters] above the bottom of the cabin windows from the tail section to the windscreen. The outboard 7.5 feet [2.3 meters] of the left wing had separated. Separations at the left wing, all window frames and cabin structure exhibited forward bending. ... 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."

The cabin and cockpit seats on the Cessna 441 were examined, and the headrests were "separated or bent forward, at the same level that the upper cabin structure was sheared off," the report said. "The accident was not survivable for the occupants of the Cessna."

In reviewing the injuries, the report said: "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 tested negative for alcohol or drugs."

The MD-82 crew submitted to toxicological tests, and no evidence of alcohol or drugs was found, the report said.

The background and qualifications of the flight crew of both aircraft were reviewed. The Cessna 441 pilot, 56, held a U.S. commercial pilot certificate. He had 7,940 hours of total flight time, with 2,060 hours in the Cessna 441. He had flown about 64 hours in the preceding month, and approximately 155 hours in the 90 days before the accident. The pilot held a current FAA second-class medical certificate with the limitation to wear corrective lenses while exercising the privileges of his airman certificate, the report said.

A review of the pilot's logbooks indicated that he had last flown into STL during a daytime operation, 10 months before the accident flight, the report said.

Investigators interviewed the pilot's wife, Superior Aviation employees and the passenger who chartered the Cessna 441 to STL. "The interviews revealed that the Cessna 441 pilot was known as a conscientious, safety-oriented pilot," the report said. The passenger said that when she was on other flights flown by the accident pilot, he "habitually held the airport diagrams on his lap for reference during ground operations," the report said. "She (the passenger) 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 told investigators that, on the day of the accident flight, 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 report said. "The passenger and [the FBO] 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."

The captain of the MD-82, 57, holds a U.S. airline transport pilot (ATP) certificate, and is type-rated in the Boeing 727, B-737, B-747, DC-9, Learjet and Cessna CE-500. At the time of the accident, the captain had approximately 18,651 hours of total flight time, of which 3,178 hours were in the DC-9/MD-82, the report said. He had flown approximately 34 hours in November, and had flown 168 hours in the 90 days before the accident. The captain had also been involved in the development of and instruction in the crew resource management course for TWA, the report said.

The captain held a current FAA first-class medical certificate, with the limitation to wear corrective lenses while exercising the privileges of his airman certificate, the report said.

The first officer of the MD-82, 38, holds a U.S. ATP certificate. At the time of the accident, he had approximately 10,535 hours of total flight time, of which 251 hours were logged as first officer in the DC-9/MD-82 aircraft, the report said. He had flown about 56 hours in November, and approximately 153 hours in the 90 days preceding the accident. The first officer held a current FAA first-class medical certificate with no limitations, the report said.

The maintenance records for both the MD-82 and the Cessna 441 were reviewed, and no discrepancies were found, the report said.

The external lighting on the Cessna was reviewed, and 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," the report said. Standard operating procedures for the company operating the Cessna "required [that] the illumination of the strobe, taxi and landing lights take place after receipt of a takeoff clearance," the report said.

When the wreckage of the Cessna was initially examined, "the two wing-mounted retractable landing lights were found in their stowed positions," the report said. "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."

Investigators retrieved some of the external lighting components from the Cessna, which were examined by the NTSB's Materials Laboratory. The report said 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 [illuminated] at the time of impact ... . The [NTSB] concludes that the Cessna 441 taxied from the Midcoast ramp with the nose wheel taxi, white tail cone–mounted navigation, and red and green wing tip–mounted navigation lights illuminated."

The report noted: "The Cessna 441 was not equipped with a rotating red anticollision light, which on many other aircraft types is visible from behind the airplane. ... It could not be determined whether the wing tip–mounted anticollision/strobe lights were operating at the time of the collision."

"Observers noted that the airplane navigation lights were of little use for detection when viewed against other lights in the runway environment."

Two days after the accident, investigators conducted an exercise to determine the conspicuity of the Cessna from the control tower on the night of the accident. "This exercise took place at approximately the same time in the evening as the accident, under similar weather conditions," the report said. (The STL surface weather observation on the night of the accident indicated clear skies, with 25 miles [40 kilometers] visibility.)

During the exercise, two observers in STL tower stood near the local control position, the report said. "To simulate the Cessna 441, a (slightly larger) Beech King Air 200 was towed from the [FBO], via Runway 31 and taxiway Romeo [which connects Runway 31 with Runway 30R], 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."

The report described 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 [light was] 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."

The report noted: "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."

Investigators also conducted a runway visibility test to examine the line-of-sight visibility from the MD-82 when both airplanes were positioned for takeoff on Runway 30R, and to "establish whether any physical obstruction to the visibility of the Cessna was caused by runway 30R gradation." Simulating what the MD-82 pilots could have seen on the night of the accident, "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," the report said. "A test airplane, similar in size to the Cessna 441, was taxied from the FBO 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 results of these tests "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," the report said. "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 [caused by runway gradation] 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."

Investigators interviewed STL tower personnel about their ability to observe the Cessna 441 on the night of the accident. (STL tower is located on the southwest side of the airport,

about 1.25 miles [two kilometers] from where the collision occurred.) Tower personnel told investigators "that when the airplane moved from the well-lighted ramp area toward Runway 31, it was no longer visible," the report said. "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."

Two months before the accident, ASDE-3 radar had been installed to monitor aircraft activity on the ground, the report said. The ASDE-3 equipment had not been officially commissioned but was occasionally used by controllers for familiarization when it was available. On the night of the accident, the equipment was not available because the computer hard drive had failed. "Subsequent to the accident, the ASDE-3 at STL has been commissioned," the report said.

If the ASDE-3 equipment had been available on the night of the accident, "the Cessna 441's position at the intersection of taxiway Romeo and Runway 30R for three 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 report said.

The NTSB also noted that the FAA is developing AMASS to augment ASDE-3 equipment. In a video simulation during the investigation, it was discovered that the use of AMASS could have provided controllers with a visible and audible warning about 17 seconds before the collision, the report said. "The installation and utilization of ASDE-3, and particularly ASDE-3 enhanced with AMASS, could have prevented this accident," the report concluded.

Personnel staffing of the STL tower on the night of the accident was reviewed. The tower has "10 positions of operation that may be combined or separated as air traffic conditions permit," the report said. "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 working ground control for both the north and south sides of the airport, clearance delivery and flight data. When working these positions, the controller was monitoring seven different frequencies."

Interviews with the MD-82 flight crew members indicated that "the use of combined positions/multiple frequencies occasionally resulted in difficulties," the report said. "These reported problems included incomplete communications due to pilots' transmissions being 'stepped on' by other pilots [i.e., simultaneous transmissions on the same frequency that prevented communication], increased controller workload, communications delays and confusion, and potential decreased pilot situational awareness. A review by the [NTSB] of 1.5 hours of ATC tapes from the evening of the accident revealed several instances of simultaneous transmissions."

The NTSB concluded 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, [but] it does not consider the use of multiple frequencies to be a factor in this accident," the report said.

STL tower controllers characterized their workload as moderate on the night of the accident. The report concluded: "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 [NTSB] 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."

After the accident, the staffing schedule in the STL tower was changed to retain an additional controller and supervisor until 2230 hours, the report said. "The [NTSB] believes that this staffing change provides an additional level of safety," the report said.

Interviews with the MD-82 flight crew members indicated that "the use of combined positions/multiple frequencies occasionally resulted in difficulties," the report said.

The quality of the radio transmissions from the Cessna 441 was examined. "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," the report said. "Several subsequent transmissions from the Cessna 441 were also distorted, but most of the Cessna's outbound transmissions to ATC were clear."

The communications radios from the Cessna were examined during the investigation, and found to be capable of normal operation, the report said.

When it reviewed the Cessna pilot's communications with ATC during taxi, "the [NTSB] noted that the Cessna pilot did not state the departure runway in any of his clearance readbacks," the report said. "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."

As a result of recommendations from the NTSB, the FAA stated it would change the *Aeronautical Information Manual (AIM)* and other FAA pilot-training publications to urge pilots to read back in full their runway assignment instructions when operating at airports with more than one runway, the report said. The FAA has also developed a change in FAA Order 7110.65J, *Air Traffic*

Control, the air traffic controller's handbook, "to require air traffic controllers to obtain confirmation of runway assignment from pilots after issuing taxi instructions," the report said. "The [NTSB] believes that, had this change been in effect, this accident might not have occurred."

In a letter to the FAA dated Feb. 28, 1995, the NTSB discussed the FAA controller's role in the accident. "When the pilot of [the Cessna 441] 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,'" the letter said. "This was the first indication to the local controller that the pilot of [the Cessna] 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 [the Cessna] 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."

Investigators also found that the ground controller failed to use standard phraseology in his initial taxi instructions to the Cessna, the report said. "Text in the *AIM* that was in effect at the time of the accident ... tells pilots to expect ATC to first specify the runway, then issue taxi instructions and to state any required hold-short instructions," the report said. "This information is also contained in FAA Order 7110.65[J], *Air Traffic Control*, which directs controllers to issue clearances in the same manner."

The Cessna pilot never indicated to the ground controller that he was not familiar with surface operations at STL, the report said. "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," the report said. "This resulted in an illusion of effective communication, when in fact the pilot misunderstood the ground controller's intentions."

The NTSB offered several theories to explain why the pilot of the Cessna 441 taxied to the wrong runway. Personal factors were reviewed. "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," the report said. "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."

When he was at the FBO in STL, the Cessna pilot commented that it was going to snow in Iron Mountain that night. "[The FBO] personnel stated that the pilot seemed anxious to go home, a behavior that they considered normal among pilots at that time of night," the report said. "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 of his cautious and safe attitude."

The report added: "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," the report said. "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. The current STL airport diagram approach chart was located in the cockpit area of the Cessna 441 wreckage."

The report concluded: "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."

Another element that could have influenced the pilot was that the ATIS listed Runways 30R and 30L as the active runways, the report said. Runway 31 was only occasionally used as a departure-only runway, and usually was not listed on the ATIS as the active runway. "The [NTSB] 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," the report said.

The report noted another possibility that could have reinforced the pilot's belief that Runway 30R was the departure runway. "When he [the pilot] began to taxi outbound from the [FBO] ramp on Taxiway Whiskey (150 feet [46 meters] 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," the report said. "During the on-scene investigation, several local pilots acknowledged that the proximity of Runway 31 to the [FBO] ramp created a situation where pilots could inadvertently enter onto Runway 31 without recognizing that they were on the runway."

Another element that could have added to the confusion was that Runway 31 is 75 feet (23 meters) wide, the same width as most taxiways at STL. On the other hand, Runways 30R and 30L are 150 feet (46 meters) and 200 feet (61 meters) wide, respectively, the report said.

At the time of the accident, the Runway 31 threshold was displaced by 1,838 feet (561 meters). "The markings on the approximately 800-foot-long [244-meter-long] portion of Runway 31 on which the Cessna pilot back-taxied consisted of a series of white arrows pointing toward the numbers," the report said. "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 ... . Had he seen the numbers, the pilot might have been cued to question the controller as to the controller's intentions."

The report noted: "The [NTSB] 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."

After the accident, taxi-holding position lights were installed at taxiway Whiskey "to further enhance and delineate the presence of Runway 13/31 for aircraft exiting the [FBO] ramp," the report said. The STL Airport Authority received approval to remove the displaced threshold on Runway 31.

The NTSB noted one final cue that should have prompted the Cessna pilot to question his actions. When the pilot taxied onto Runway 30R, he did so from an intersecting taxiway, 2,500 feet from the runway threshold. "According to the *AIM*, an intersection clearance can be requested by the pilot or initiated by the controller," the report said. "The Cessna 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."

As a result of its investigation, the NTSB developed the following major findings:

- "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;
- "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;
- "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;
- "Although the controllers considered their workload moderate, the ground controller was working seven frequencies with almost constant communications;
- "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;
- "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 [might] have noted the proper departure runway;
- "Had the Cessna 441 pilot volunteered, or had the controller requested, confirmation of the assigned runway, the pilot's error [might] have been detected and the accident prevented;
- "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;
- "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;
- "It is likely that the wing anticollision/strobe lights were not operating when the collision occurred; [and,]
- "Pilot training for surface movement can be improved in both air carrier and general aviation areas."

As a result of its findings, the NTSB issued the following recommendations to the FAA:

- "Revise the [FARs] 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);
- "Examine the feasibility of requiring pilots to use aircraft anticollision/strobe lights when holding in position on active runways;
- "Define the commonly used term 'back-taxi' in the Pilot/Controller Glossary [of the *AIM*], 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*;
- "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 [ATIS] where applicable;

- "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;
- "Mass-mail to all currently certificated pilots FAA publications on reducing runway incursions and airport improvement information, such as airport signage changes;
- "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;
- "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;
- "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;
- "Require [ATIS] broadcasts at Lambert-St. Louis International Airport reference runways that are being used as secondary or occasionally active runways;
- "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*[1]; [and,]
- "Employ an independent source to conduct a survey of the terminal air traffic control staff, similar to the MITRE Corporation study ... to determine from the [terminal ATC] 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."

The report also noted that the NTSB's concern about runway incursions had been expressed in 79 safety recommendations, dating to 1972. In 1985, the NTSB conducted a special investigation study of runway incursion incidents. The report from that investigation,[2] adopted in May 1986, found that runway incursions were a human-factors issue involving controllers and pilots at all levels of experience. The study concluded that more uniformity of terminology and better verification of messages between pilots and controllers could reduce the chance of dangerously ambiguous commands or erroneous actions.

The NTSB placed reduction of runway incursions on the "Most Wanted" Transportation Safety Improvements list when the program was adopted in 1990, and the issue continues to appear on the "Most Wanted" list.♦

Editorial note: This article was adapted from *Runway Collision Involving Trans World Airlines Flight 427 and Superior Aviation Cessna 441, Bridgeton, Missouri, November 22, 1994.* Report no. NTSB/AAR-95/05, prepared by the U.S. National Transportation Safety Board. The 157-page report includes appendices and illustrations.

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Additional Reading from FSF Publications

"FAA Report Surveys U.S. Airline Pilots to Discover Factors that Promote Runway Incursions." (Pilots cited poorly timed and expressed taxi instructions, inadequate signage, difficult-to-follow charts and radio frequency congestion, among other problems.) *Airport Operations* Volume 21 (July–August 1995).

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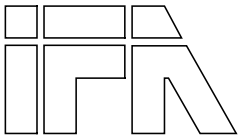

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