Overrun at Midway

The crew applied reverse thrust too late.

BY MARK LACAGNINA

The Southwest Airlines captain said that the weather on the night of Dec. 8, 2005, was the worst he had experienced. Visibility was near the minimum required for the approach, and braking action was being reported as both fair and poor on the runway at Chicago Midway International Airport. However, calculations derived from the on-board performance computer indicated that the Boeing 737-700 could be brought to a stop on the slippery runway.

The landing-distance calculations were based on crucial assumptions, including prompt application of reverse thrust after touchdown — which the flight crew did not know and failed to do, said the U.S. National Transportation Safety Board (NTSB).

Reverse thrust was applied late during the landing roll, and the 737 overran the runway, rolled through a blast fence and an airport perimeter fence, and struck an automobile before coming to a stop on a road. One automobile occupant was killed, one was seriously injured, and three received minor injuries. Of the 103 airplane occupants, 18 received minor injuries; the pilots, two of the three cabin crewmembers and 81 passengers were not injured. The 737 was substantially damaged.

In its final report on the accident, NTSB said that the flight crew failed to promptly apply reverse thrust because they were distracted by the autobrake system, which they were using for the first time.

"Contributing to the accident were Southwest Airlines' failure to provide its pilots with clear and consistent guidance and training regarding company policies and procedures related to arrival landing-distance calculations; programming and design of its on-board performance computer, which did not present inherent assumptions in the program critical to pilot decision making; plan to implement new autobrake procedures without a familiarization period; and failure to include a margin of safety in the arrival assessment to account for operational uncertainties," the report said. "Also contributing to the accident was the pilots' failure to divert to another airport given reports that included poor braking action and a tailwind component greater than 5 knots."

The report also said that the absence of an engineered materials arresting system (EMAS) in the nonstandard runway safety area (RSA) beyond the end of the runway contributed to the severity of the accident.

Delayed Departure

The 737, being operated as Flight 1248, departed from Baltimore two hours late because of a snowstorm in the Chicago area. It was the first flight of the first day of a scheduled three-day trip for the crew.

The captain, 59, was a U.S. Air Force pilot for 26 years before being hired as a first officer by Southwest in August 1995. He upgraded to captain in July 2000. He had about 15,000 flight hours, including 4,500 flight hours as a 737 captain.

The first officer, 34, was a Saab 340 pilot for Mesaba Airlines for six years before being hired by Southwest in February 2003. He had a 737 type rating and about 8,500 flight hours,

including 2,000 flight hours as a 737 first officer.

The pilots had completed a self-study training module distributed by the airline to familiarize crews with its forthcoming policy and procedures for the use of autobrakes. However, the implementation date had been changed several times, pending completion of autobrake system installation in all 441 of the 737s in the Southwest fleet. On the day of the accident, the airline issued a bulletin that delayed implementation until Dec. 12, 2005.

The crew of Flight 1248 told investigators that they had not noticed the changed implementation date while reviewing the bulletin and believed that the autobrake system policy and procedures already had been implemented. "A previous autobrake-related read-before-flight letter indicated that the autobrake policy would be in effect as soon as materials were available in the cockpit," the report said. "On the day of the accident, 'flow' cards and checklists with information regarding autobrake procedures had been placed in SWA [Southwest Airlines] airplanes."

Neither pilot had used autobrakes in an airplane or in a flight simulator. While discussing the procedures during the flight to Chicago, the captain expressed concern. "I don't know if I'm comfortable using the autobrakes in this situation," he said. Later, during the approach briefing, he said, "As far as the autobrakes go, I think I will use manual braking." The captain suggested that they postpone using the autobrakes for the first time until the next leg of the flight but then asked the first officer, "You want to try them into Midway?"

The first officer said that a friend who was experienced in the use of autobrakes had told him that the system is very effective. "I know they work better than we do [with manual braking]," the

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first officer told the captain. "At least that's what my buddy told me. … It is going to get maximum braking out of the aircraft."

"Well, keep talking," the captain said. "I guess we could do it. Let's see what the conditions are up there. We'll do it."

Mixed Reports

A winter weather advisory with a heavy snow warning had been issued for the Chicago area. Snow began falling early in the afternoon and accumulated to 10 in (25 cm) before stopping late at night.

Visibility at Midway was 1/2 mi (800 m) in moderate snow and freezing fog. Runway visual range (RVR) for the landing runway, 31C, was reported as 4,500 to 5,000 ft (1,400 to 1,500 m). Minimum RVR required for the instrument landing system (ILS) approach to Runway 31C was 3,000 ft (1,000 m). Ceilings were broken 400 ft above ground level (AGL) and overcast at 1,400 ft AGL. Surface winds were from 090 degrees at 11 kt, and braking action was reported as "fair" on the first half of the runway and "poor" on the second half. Runway 31C is 6,522 ft (1,988 m) long, but, due to a displaced threshold, available landing distance is 5,826 ft (1,776 m); the runway is 150 ft (46 m) wide.

An engineered materials arresting system was installed at the end of Runway 31C after the accident (see photo, p. 32).

The airplane was nearing Midway at 1833 local time when air traffic control (ATC) issued holding instructions because the landing runway was being cleared of snow and treated with deicing fluid. The crew had used the on-board performance computer several times during the flight. While holding at 10,000 ft, the first officer again entered updated weather and runway conditions in the computer.

"The first officer entered multiple scenarios into the [computer], entering fair and poor pilot braking action reports separately because the [computer program] was not designed to accept mixed braking action report inputs," the report said. "Based on the first officer's inputs, the [computer] estimated that the airplane would stop about 560 feet [171 m] before the departure end of the runway with fair braking action and about 40 feet [12 m] before the departure end of the runway with poor braking action."

Although the computer calculations showed that the crew would be landing with an 8-kt tailwind component, the landing-distance calculations for poor braking action assumed a tailwind component of only 5 kt, because this was the limit established by Southwest. "SWA policies and flight operations manuals indicate that the company does not authorize landings on runways with more than a 5-knot tailwind component with poor braking action," the report said. If the landing-distance calculations for poor braking action had been based on the actual 8-kt tailwind, they would have shown that the airplane would stop about 260 ft (79 m) *beyond* the end of the runway.

Unknown Assumptions

The report noted that on-board performance computers and other types of electronic computing devices reduce pilot workload but, unlike tabular performance charts, do not show the assumptions on which the calculations are based and, thus, can foster decision-making errors.

In addition to the 5-kt tailwind component assumed for a landing with poor braking conditions, the crew did not know that the landing-distance calculations for the 737-700 assumed use of reverse thrust. The on-board performance computers for the airline's 737-300s and -500s did not assume use of reverse thrust. "Because of this, the accident pilots believed that their intended use of reverse thrust during the landing roll would provide them with several hundred feet more stopping margin than the [computer] estimated," the report said.

The crew discussed the landing-distance calculations for Midway and the more-favorable weather conditions at their alternate airports — Kansas City and St. Louis, Missouri. "Although the pilots' calculations resulted in positive stopping margins for both fair and poor braking conditions and company policy indicated that landing was authorized with any positive stopping margin, the crew was concerned about the small positive stopping margin with poor braking action," the report said. They decided to divert the flight to an alternate if the tailwind component increased above 10 kt or if braking action was reported as poor for the full length of Midway's Runway 31C.

The crew did not follow a company procedure that required pilots to use the "most critical term" provided in a mixed braking action report. "Because 'poor' braking conditions were reported for a portion of the runway and SWA guidance indicates a maximum 5-knot tailwind to land if such conditions are reported, the pilots should not have landed at Midway," the report said.

Fifteen Seconds Late

The crew was cleared by ATC to leave the holding pattern at 1854 and followed radar vectors to the ILS final approach course. After clearing the crew to conduct the approach at 1904, the controller said, "Braking action reported fair except at the end, it's poor."

The crew said that the airplane was clear of clouds after descending through 1,400 ft and that RVR was about 5,000 ft. The 737 touched down about 1,250 ft (381 m) beyond the runway threshold. "Flight data recorder (FDR) data indicated that the airplane was aligned on the runway centerline as it touched down at an airspeed of about 124 knots [and a groundspeed of about 131 kt]," the report said. "The speed brakes deployed and brake pressure increased within about 1 second. Both pilots described the touchdown as 'firm.'

"The captain stated that he tried to deploy the thrust reversers immediately after touchdown but had difficulty moving the thrust reverser levers to the reverse thrust position. He further stated that he felt the antiskid system cycle after the airplane touched down but then felt it stop cycling and that the airplane

Boeing 737-400

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Produced from 1988 to 2000, the 737-400 is 10 ft (3 m) longer than the 737-300, has strengthened landing gear and can accommodate 146 to 168 passengers. Powered by CFM56-3B2 or -3C turbofan engines, maximum operating speed is 0.82 Mach, and maximum range is 2,808 nm (5,200 km). Maximum standard weights are 138,500 lb (62,824 kg) for takeoff and 121,000 lb (54,886 kg) for landing.

The accident airplane, after repairs, is shown in the photo above.

Source: *Jane's All the World's Aircraft* seemed to accelerate. He said that he subsequently applied the wheel brakes manually but made no further effort to activate the thrust reversers. He told investigators that he believed that the use of the autobrake system distracted his attention from the thrust reversers after his initial attempt to deploy them."

The first officer also sensed a decrease in deceleration and manually applied the wheel brakes. "He stated that he then looked at the throttle console and saw that the thrust reverser levers were still in the stowed position," the report said. "The first officer moved the captain's hand away from the thrust reverser levers and, about 15 seconds after touchdown, initiated deployment of the thrust reversers to the maximum reverse setting."

Groundspeed was 53 kt when the 737 overran the runway at 1914. The nosegear collapsed, and the airplane came to a stop about 500 ft (152 m) beyond the end of the runway. Aircraft rescue and fire fighting personnel arrived two minutes later and assisted in the evacuation of the passengers through the left forward cabin door and through the right rear cabin door.

"Damage to the airplane was largely limited to the forward lower fuselage, engine cowlings and components, forward portions of the wings and other wing components, with limited damage farther aft," the report said. Examination of the airplane disclosed no preimpact anomalies.

Simulation Results

Four Southwest 737s and a United Airlines Airbus A320 had been landed without incident on Runway 31C during the 25 minutes preceding the accident. The 737 landings were conducted without autobrakes but with application of reverse thrust early in the landing roll. "Three out of the four flight crews commanded maximum reverse thrust," the report said.

Simulations conducted during the investigation indicated that if the crew of Flight 1248 had promptly applied maximum reverse thrust and maintained it until stopping, the airplane could have been stopped with 271 ft (83 m) of runway remaining. Interviews of the 10 previous flight crews who operated the accident airplane revealed no difficulty in deploying the thrust reversers. Interviews of other Southwest pilots revealed that several had "difficulties deploying the thrust reversers when they tried to move the reverse thrust levers past the interlock position too rapidly," the report said. "Those pilots reported that the levers moved readily when they tried to deploy the thrust reversers again after the interlocks released."

Guidance on the use of reverse thrust differed. Although Southwest and Boeing both recommended that reverse thrust be applied as soon as possible after touchdown, the airline said that pilots should begin reducing reverse thrust after decelerating to 80 kt, while Boeing said the reduction should begin at 60 kt. After the accident, Southwest revised its procedure to be consistent with Boeing's guidance.

Investigators found that while participating in the development of the airline's autobrake program, check airmen and their first officers also had become distracted and delayed application of reverse thrust during their first few landings. After the accident, Southwest revised its training procedures to require that "pilots complete at least

Engineered Arresting Systems Corp.

EMAS installation at Midway.

four familiarization landings — two as the flying pilot and two as the monitoring pilot — on dry runways with ample stopping margins before using the autobrake system on a routine basis," the report said.

Padding the Margin

Landing performance calculations for U.S. air carrier operations typically are conducted before flight by dispatchers and before arrival by the pilots. The preflight calculations are based, in part, on landing performance demonstrated by the airplane manufacturer during certification flight tests.

"Dispatch landing distance calculations are intended to ensure that dispatched airplanes will be able to land safely at the intended destination airport or a planned alternate and are based on estimated landing weights and forecast conditions," the report said. "According to [U.S. Federal Aviation Regulations], the dry and wet/slippery landing performance data used for dispatch calculations are obtained by multiplying the numbers demonstrated during certification landings on a level, smooth, dry, hard-surfaced runway by factors of 1.67 and 1.92, respectively."

Arrival calculations are based on updated information on airplane landing weight, weather, runway conditions and other factors. "Airplane landing performance data for conditions other than bare and dry are typically calculated rather than demonstrated via a flight test," the report said, noting that no "safety margin" typically is added to arrival landing-distance calculations.

There are no regulatory requirements or standards for arrival calculations. In August 2006, the U.S. Federal Aviation Administration (FAA) issued a safety alert for operators, SAFO 06012, "urgently recommending" that all jet airplane operators develop procedures for arrival calculations. The alert further recommended that "once the actual landing distance is determined, an additional safety margin of at least 15 percent should be added to that distance."

The SAFO noted, however, that arrival calculations are not recommended before every landing. "In many cases, the before-takeoff criteria, with their large safety margins, will be adequate to ensure that there is sufficient landing distance with at least a 15 percent safety margin at the time of arrival," it said. "Only when the conditions at the destination airport deteriorate when en route [would an arrival calculation] normally be needed."

Hemmed In

The RSA beyond the end of Runway 31C — and several other RSAs at Midway — do not meet FAA standards. The Runway 31C RSA extends 82 ft (25 m) beyond the runway end; the FAA standard is 1,000 ft (305 m).

The airport operator, the Chicago Department of Aviation (DOA), told the FAA in 2004 that no practical alternatives existed for extending the Runway 31C RSA to meet the standard. It said that shortening the runway to extend the RSA would reduce the operational capacity of the airport and that acquiring land beyond the existing RSA would have a major impact on public roadways, businesses and residences.

The Chicago DOA also said that an alternative to enhance the RSA, installation of a standard 600-ft (183-m) EMAS arrestor bed, also would require shortening the runway. The FAA did not ask the airport operator to consider installation of a shorter, nonstandard EMAS bed.

Simulations conducted by an EMAS manufacturer "indicated that a nonstandard EMAS installation would have stopped the accident airplane before it departed airport property," the report said. "After the accident, the FAA approved the installation of nonstandard EMAS beds at [Midway]."

Better Data Needed

The report said that the accident showed the need for an "airplane-based" method of quantifying runway surface condition and transmitting the information for use by pilots of other airplanes in landing performance calculations. As a result, NTSB called on the FAA to explore the feasibility of "outfitting transport category airplanes with equipment and procedures required to routinely calculate, record and convey the airplane braking ability required and/or available to slow or stop an airplane during the landing roll."

Among other recommendations based on the accident investigation were that the FAA should require operators of commercial and fractional ownership aircraft to conduct arrival landing performance calculations incorporating a 15 percent safety margin before every landing and ensure that on-board electronic computing devices clearly display the critical assumptions on which calculations are based. ●

This article is based on NTSB Accident Report NTSB/AAR-07/06: "Runway Overrun and Collision; Southwest Airlines Flight 1248; Boeing 737-7H4, N471WN; Chicago Midway International Airport; Chicago, Illinois; December 8, 2005."

Further Reading From FSF Publications

Johnsen, Oddvard. "Improving Braking Action Reports." *ASW*, 8/07, p. 36.

Rosenkrans, Wayne. "Knowing the Distance." *ASW*, 2/07, p. 22.

Rosenker, Mark V. "Margins of Safety." *ASW*, 12/06, p. 11.

Rosenkrans, Wayne. "Rethinking Overrun Protection." *ASW*, 8/06, p. 13.