NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety

Washington, D.C. 20594

April 20, 2006

Group Chairmans' Factual Report

Operational Factors

DCA06MA009

A. ACCIDENT

Operator: Southwest Airlines, Inc.
Location: Chicago Midway International Airport (MDW), Chicago, Illinois
Date: December 08, 2005
Time: 1914 central standard time[1]
Airplane: B737-7H4, N471WN

B. OPERATIONAL FACTORS GROUP

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[1] All times are central standard time based on a 24-hour clock, unless otherwise noted. Actual time of accident is approximate.

C. Summary

On December 8, 2005, at 1914 Central Standard Time, Southwest Airlines flight 1248, a Boeing B-737-7H4 registered as N471WN, over ran runway 31C at Chicago Midway International Airport (MDW) in Chicago, Illinois, during the landing rollout. The airplane departed the end of the runway, rolled through a blast fence, a perimeter fence, and onto the roadway. The airplane came to a stop after impacting one automobile. Instrument meteorological conditions (IMC) prevailed at the time. The airplane was substantially damaged. The flight was conducted under 14 CFR Part 121 of the Federal Aviation Regulations (FARs) and had departed from the Baltimore / Washington International Thurgood Marshal Airport (BWI), Baltimore, Maryland.

D. Details of the Investigation

The Operations / Human Performance Group convened at the Hilton Garden Hotel, Chicago, Illinois, on December 9, 2005, to begin the field phase of the accident investigation. The following interviews and activities were conducted:

- 12/10/05: Interviewed the captain and first officer from the accident flight.
- 12/11/05: Interviewed two first officers who had previously flown with the accident captain, two captains who had previously flown with the accident first officer and a company captain who was deadheading in the passenger section of the accident airplane.
- 12/12/05: Interviewed one SWA line checkairman, and one SWA simulator instructor.
- 12/13/05: Interviewed a captain who landed at MDW prior to the accident flight, one first officer who had previously flown with the accident captain, and one captain who landed at MDW prior to the accident flight.
- 12/14/05: Interviewed a SWA flight crew that diverted to their alternate the night of the accident.

Obtained reference manuals, records, and other pertinent documents from Southwest Airlines and the Federal Aviation Administration (FAA).

The Operations / Human Performance Group concluded the initial field phase of the accident investigation on December 15, 2005.

The Operations / Human Performance Group reconvened on January 23, 2006, at SWA Headquarters in Dallas, Texas, to continue the field phase of the investigation. The following interviews and activities were conducted:

- 1/23/06: Interviewed two SWA checkairmen.

- 1/24/06: Interviewed the manager of flight instruction, director of flight operations safety, a simulator instructor, and the manager of crew resource management (CRM).

- 1/25/06: Interviewed a flight training ground instructor, a SWA line checkairman, and the FAA principal operations inspector (POI) for SWA.

- 1/26/06: Interviewed the manager of flight standards, a simulator instructor, the FAA assistant POI (APOI) and the FAA aircrew program manager (APM) assigned to the SWA certificate.

- 1/26/06: A SWA B737-700 simulator (#579) was used to make the following approaches:

    - The simulator was programmed with the following accident parameters: MDW airport, runway 31C, landing weight 119,700 pounds, wind 090/11, runway visual range (RVR) 4,500 feet, ceiling 400 feet, temperature -5°C, altimeter 30.07, autobrake MAX (armed, but disconnected after touchdown).

    - **Approach 1**: Full manual braking and reverse thrust at touchdown, *WET-FAIR*[2] runway conditions, and touchdown at 1,500 feet.
      Result: Able to come to a complete stop about 700 feet from end of runway. The on board performance computer (OPC) on the accident airplane calculated 560 feet of runway remaining after stop for this approach and these parameters.
    - **Approach 2**: Full manual braking and reverse thrust at touchdown, *WET-POOR* runway conditions, and touchdown at 1,500 feet.
      Result: Able to come to a complete stop about 100 feet from end of runway. The OPC on the accident airplane calculated 50 feet of runway remaining after stop for this approach and these parameters.
    - **Approach 3**: Full manual braking and reverse thrust delayed 15 seconds after touchdown, *WET-FAIR* conditions, and touchdown at 1,800 feet. **Result**: Able to stop about 100 feet from end of runway.
    - **Approach 4**: Full manual braking and reverse thrust delayed 15 seconds after touchdown, *WET-POOR* conditions, and touchdown at 1,800 feet. **Result**: Airplane ran off the end of the runway.

During the simulator period, the following observations and comments by company checkairmen were made:

[2] The simulator was not equipped with a selection for *WET-FAIR* and *WET-POOR* conditions. However, the simulator operator was able to select other variables such as, patchy ice and snow, to approximate those two conditions.

- Reverse N1 in the simulator indicated 79%, which is consistent with full reverse thrust expected under the field conditions programmed into the simulator.
- The simulator could not duplicate anti-skid cycling after touchdown.
- Heads-up-display (HUD) cues observed.
- Reverse thrust levers in 737-700 were no more difficult to initially raise than the -300 or -500.
- If the throttles were forward of the idle detent by about ¼ inch, the reverse thrust levers could not be pulled up.
- The auto speed brake system deployment was on the main landing gear strut compression and wheel spin up. There was a spoiler auto-stow detent in the throttle quadrant past which you could not use reverse thrust or auto speed brakes. That detent appeared to be close to 1½ inches forward of the idle detent.
- There had been no problems with pilots initially lifting the reverse thrust levers during simulator training. Sometimes, however, pilots tried to yank the levers quickly past the interlock position prior to the normal interlock release, resulting in a perceived delayed in deployment. However, after pausing there for the normal 1-3 seconds, pilots were able to deploy the thrust reversers normally.
- Pilots were taught to keep forearm on throttle knobs to keep throttles at idle and they were taught to smoothly come to the interlock, wait / hesitate, and then pull the levers into reverse.
- Thrust reversers jammed, inoperative, or failures at touchdown were not taught during simulator training.

The Operations / Human Performance Group concluded the second field phase of the accident investigation on January 27, 2006.

The Operations / Human Performance Group reconvened on February 9, 2006, at NTSB Headquarters, Washington, DC, to continue the field phase of the investigation. The following interviews and activities were conducted:

- 2/9/06: Re-interviewed the accident captain and accident first officer. Interviewed the former SWA POI.

The Operations / Human Performance Group concluded the third field phase of the accident investigation on February 9, 2006.

D. History of Flight

The accident flight (flight 1248) occurred on December 8, 2005. It was the first day of a three-day trip and the first leg was scheduled from BWI to MDW. When the captain arrived at BWI, he went to Southwest's operations office and picked up the weather package for the flight. Both pilots reviewed the weather package and associated flight paperwork prior to departure from BWI. The captain recalled that the weather conditions at MDW prior to departure were light snow and low visibility.

The flight departed about two hours late due to the weather in the Chicago area. The aircraft pushed back at 1749 eastern standard time and took off at 1758. The flight plan called for a 1 hour 40 minute flight to MDW. The captain was the pilot flying (PF) and the first officer (FO) was the pilot not flying (PNF). The flight crew had never previously flown with each other. However, both pilots had flown into MDW on prior occasions.

During the enroute portion of the flight, the accident crew stated that they received numerous weather updates regarding the conditions at MDW. Additionally, they stated that this would be their first opportunity to use the new procedures for the use of autobrakes[3] during landing. They said those procedures were reviewed and discussed. They determined that the runway conditions at MDW required an autobrake setting of MAX. The captain stated that he was initially apprehensive about using the autobrakes, but felt better after he and the FO had a thorough discussion regarding the new procedures.

Additionally while enroute, the FO stated that he entered various weather and runway conditions in the on board performance computer (OPC)[4] to determine runway stopping margins[5].

The flight crew determined that MDW was in a north operation and the approach in use was the instrument landing system (ILS) to runway 31C. The reported wind on the MDW automatic terminal information service (ATIS) around that time was from 090 degrees at 11 knots and the runway visual range (RVR)[6] was about 5,000 feet. The FO stated that those winds remained approximately the same each time the ATIS was updated. According to company limitations, the maximum tailwind component for landing was 10 knots. However, if the RVR decreased to 4,000 feet or if the runway-braking action report[7] was *POOR*, the maximum tailwind component would be reduced to 5 knots. The FO stated that it was normal to land at MDW with a tailwind.

The captain said his approach briefing was standard. It consisted of both pilots looking at the approach plate, radio frequencies, height above touchdown (HAT) at the final approach fix, decision height (DH), minimum safe altitude, runway lighting, distance measuring equipment (DME), taxiway turn-offs, missed approach procedures, notices to airmen (NOTAMs), and use of the autobrakes. There was no mention during

[3] See Section M of this report for additional details.
[4] A laptop computer carried on every airplane to assist the pilot in making take off and landing performance calculations.
[5] The runway distance remaining from the front of the nose wheel to the end of the runway pavement after the airplane comes to a stop.
[6] The horizontal distance a pilot can see down the runway from the approach end by observing runway lights or runway markings.
[7] Reports generated by pilots who have used the runways. Conditions are reported as *GOOD*, *FAIR*, *POOR*, or *NIL* and give an idea of how controllable an airplane will be during taxi, takeoff, and landing.

the briefing of any specific landing or reverse thrust techniques that would be necessary because of the runway conditions.

Flight 1248 was issued a holding clearance upon arrival in the MDW terminal area because of the low visibility and snowplow operations at the airport. While circling in the holding pattern, the crew continued to update their weather information and braking action reports. The captain said that the air traffic control (ATC) approach controller was relaying braking action reports from the control tower. He said that the worst braking action report that they heard was *FAIR*[8] for the first half of the runway and *POOR* for the second half. The FO said that he continued to enter "what if" scenarios into the OPC using those braking action reports and variable wind and weather conditions.

Note: The OPC could only accept one braking action description (*GOOD, FAIR, or POOR*) at a time.

With winds of 090 at 11, the OPC calculated a tailwind component of 8 knots. The OPC further calculated that the airplane would stop 560 feet from the end of the runway when a *FAIR* runway braking action was entered. The airplane would stop approximately 30 feet from the end of the runway when a *POOR* runway braking action was entered. The crew decided that if either the tailwind component increased to 10 knots or the runway braking action was reported as *POOR* for the "entire length of the runway", they would divert to their alternate destination.

Note: The effects of reverse thrust were included in the OPC stopping distance calculation.

The flight was vectored by ATC from the holding pattern to the final approach course for the ILS to runway 31C. The RVR at that time was reported as 4,500 feet variable to 5,000 feet[9] and the ATIS was reporting winds from 100 degrees at 11 knots. In order to commence the ILS approach to runway 31C, the RVR had to be at least 3,000 feet.

The airplane was configured with a flap setting of 40 degrees. The autopilot remained engaged until the captain disengaged it at about 1,400 feet mean sea level (MSL)[10] when he had the runway lead-in lights in sight. The captain stated that when he saw the runway lead-in lights, he could see about one half of the way down the runway. However, he said he did not see any runway touchdown zone markings prior to touchdown. He further stated that there was about a 12-knot tailwind at 1,000 feet MSL, but it decreased to 7-8 knots as they continued to descend. Both pilots stated they were clear of clouds from about 1,400 feet MSL to touchdown and they estimated the RVR to be about 5,000 feet at that time.

When ATC issued the flight a clearance to land, the wind was reported from 090 degrees at 9 knots and the braking action advisory was *FAIR* to *POOR*. Both pilots described the touchdown as firm and they stated that the spoilers[11] deployed

[8] See Sections G and L of this report for additional details.
[9] See ATC Group Chairman's Factual Report for additional details.
[10] Airport elevation was 620 feet MSL.
[11] Panels located on the upper surface of each wing that are used as speed brakes to increase drag and reduce lift, both in flight and on the ground.

automatically. The captain said he initially felt the anti-skid system[12] cycling after touchdown. He said he had difficulty lifting the reverse thrust levers[13] from the stowed position. At about the same time, he felt the anti-skid stop cycling and the airplane seemed to accelerate. He said he immediately applied manual braking and made no further attempts to lift the reverse thrust levers. He estimated that all of this occurred in less than 10 seconds.

About 5-6 seconds after touchdown, the FO said he felt the airplane stop decelerating. He said he told the captain, "brakes, brakes, brakes," and then he (FO) applied manual braking. When he saw that the reverse thrust levers were still in the down position, he said he moved the captain's hand away from them and lifted the reverse thrust levers himself. He stated that he had trouble lifting the reverse thrust levers but eventually was able to get both engines into reverse. A few seconds after the engines developed reverse thrust, he said he felt a "big deceleration" but it was clear then that they would not be able to stop on the remaining runway.

There was an 82-foot runway safety area (RSA)[14] at the end of runway 31C[15]. When the airplane was unable to stop on the runway or the RSA, it rolled through a blast fence, a localizer antenna, across an airport perimeter road, through the airport perimeter fence, and on to an adjacent public roadway. The perimeter fence was approximately 345 feet on the runway centerline from the end of the RSA. The airplane struck an automobile on the public roadway causing one fatality in the automobile[16].

After the airplane came to a stop, the FO said that he performed the emergency evacuation checklist. The captain said that he went back to the cabin to determine an evacuation plan. He said that he decided that, "the passengers should be evacuated forward because the nose was low." The flight attendants evacuated the passengers using the forward left door and right rear door. Airport Rescue and Firefighting (ARFF) personnel were able to assist in evacuating some of the passengers by placing a portable air stair unit at the right rear door. Once the airplane evacuation[17] was complete, the passengers were transported by bus to the terminal.

E. Flight Crew Information

The captain and first officer were certificated, current, and qualified in the B737 in accordance with SWA and FAA requirements. A review of FAA accident / incident and enforcement records indicated that there was no history of FAA certificate actions filed against either crewmember.

[12] A system of hydraulic valves that reduce brake pressure when a skid is detected.
[13] Levers located on each throttle that are lifted to initiate reverse thrust, which is used for rejected takeoffs and after touchdown to slow the airplane, reducing stopping distance and brake wear.
[14] A designated area abutting the edges of a runway or taxiway intended to reduce the risk of damage to an airplane inadvertently leaving the runway or taxiway.
[15] See Section P of this report for additional information.
[16] See Survival Factors Group Chairman's Factual Report for additional information.
[17] See Survival Factors Group Chairman's Factual Report for additional information.

1.0 Captain: Bruce R. Sutherland

Age:	59
Date of Hire:	03/08/1995
FAA Certificates:	**Airline Transport Pilot** (Airplane Multi-Engine Land, B737).

At the time of the accident, Captain Sutherland held a First Class medical certificate dated September 21, 2005, with the following restriction: "Holder must wear corrective lenses." He stated that he was wearing his glasses at the time of the accident.

According to SWA employment and flight records, Captain Sutherland had accumulated / completed the following flight times and training prior to the accident (hours provided by SWA were approximate):

Total Flight Time:	15,000 hours
Total SWA Flight Time:	9,500 hours
Total Time B737:	9,500 hours
Total SWA Time B737:	9,500 hours
Total PIC Time:	9,500 hours
Total SWA PIC Time B737:	4,500 hours
Total flying time last 24 hours:	2:24 hours
Total flying time last 7 days:	14:01 hours
Total flying time last 30 days:	58:27 hours
Total flying time last 60 days:	137:38 hours
Total flying time last 90 days:	198:24 hours
Total flying time last 12 months:	820:11 hours

Initial B737 type rating:	May 1995
Most recent recurrent training prior to the accident:	July 2005
Most recent proficiency check prior to the accident:	July 2005
Most recent line check prior to the accident:	June 2005

Total duty time (day of accident):	6:35 hours
Total duty time last 24 hours:	6:35 hours
Total duty time last 48 hours:	6:35 hours
Total duty time last 72 hours:	6:35 hours

2.0 First Officer: Steven T. Oliver

Age:	34
Date of Hire:	02/17/03
FAA Certificates:	**Airline Transport Pilot** (Airplane Multi-Engine Land, SF-340, B-737)

Commercial Privileges (Airplane Single and Multi-Engine Land)

At the time of the accident, First Officer Oliver held a First Class medical certificate dated October 18, 2005, with the following restriction: "Holder must wear corrective lenses." He stated that he was wearing his glasses at the time of the accident.

According to SWA employment and flight records, FO Oliver had accumulated / completed the following flight times and training prior to the accident (hours provided by SWA were approximate):

Total Flight Time:	8,500 hours
Total PIC Time:	4,000 hours
Total SWA Flight Time:	2,000 hours
Total SWA SIC Time:	2,000 hours
Total SWA SIC Time B737:	2,000 hours
Total flying time last 24 hours:	2:24 hours
Total flying time last 7 days:	8:37 hours
Total flying time last 30 days:	83:24 hours
Total flying time last 60 days:	151:34 hours
Total flying time last 90 days:	243:00 hours
Total flying time last 12 months:	881:39 hours

Initial B737 type rating:	November 2001
Most recent recurrent training prior to the accident:	February 2005
Most recent proficiency check prior to the accident:	February 2005

Total duty time (day of accident):	9:50 hours[18]
Total duty time last 24 hours:	9:50 hours
Total duty time last 48 hours:	9:50 hours
Total duty time last 72 hours:	9:50 hours

F. Airplane Information: Weight and Balance

Operating Empty Weight (OEW)	84661
Passenger Weight	18800
Baggage / Cargo Weight (Manifest)	2304
Zero Fuel Weight	105765
Maximum Zero Fuel Weight	120500
Fuel Weight	23896
Maximum Ramp Weight	155500
Ramp Weight	129661
Taxi Fuel Burn	600

[18] The FO was assigned a reserve line of flying and he was required to report for duty earlier than the captain. Normal report time was one hour prior to scheduled departure time.

Maximum Takeoff Weight	154500
Actual Takeoff Weight	129061
Estimated Fuel Burn to MDW	8700
Maximum Landing Weight	128000
Estimated Landing Weight	119700*
Actual Landing Weight	118280**
Takeoff Trim Units	6.5
Takeoff Trim Units Limits	5.4 - 7.3
Takeoff Stab Trim	5.9
Takeoff Flap Setting	5 degrees
Landing Flap Setting	40 degrees
VREF	125 knots

*Estimated landing weight used by crew to perform OPC calculations.
**Landing weight recorded on flight data recorder.

G. Onboard Performance Computer (OPC)

The SWA B737 Flight Operations Manual (FOM), Chapter 10, pages 10.1.1 through 10.1.10[19], stated in part:

"When using the OPC, confirmation of input parameters and output data by both crewmembers is critically important and must be emphasized.

RUNWAY CONDITIONS

The following are definitions of runway conditions used in the OPC:

WET-FAIR

More than 25% of the runway surface is covered with sufficient moisture to appear reflective, but there are no significant areas of standing water. Treated runways (i.e., grooved, etc.) should not be considered as having standing water. Braking action is reported as FAIR.

WET-POOR

More than 25% of the runway surface is covered with sufficient moisture to appear reflective, but there are no significant areas of standing water. Treated runways (i.e. grooved, etc.) should not be considered as having standing water. Braking action is reported as POOR.

The advisory landing distance information is provided to give an indication of the braking effort necessary to stop the airplane within the available landing length. The 3

[19] See Attachment 2.

distances provided are based on 3 different deceleration rates. Individual Pilot braking technique and experience will provide equivalent braking efforts that can then be related to the OPC output. The MAX distance is based on maximum manual braking (without the use of thrust reversers) at touchdown.

*The approximate stop margins calculated by the OPC are based on three different levels of deceleration as defined by the auto brake system and are based on touching down 1500 feet from the threshold. The MIN(2), MED(3), and MAX(M) values are calculated using the deceleration rates for auto brake settings 2, 3, and Max, respectively. The stop margins include the effects of reverse thrust (**-300/-500**: stop margins do not include the effects of reverse thrust).*

When not using auto brakes, MIN braking can be approximated by accomplishing a normal landing using spoilers and reverse thrust with light manual braking initiated at approximately 80 knots. MED braking can be approximated during a normal landing by initiating manual braking at approximately 100-110 knots. MAX braking can be obtained by smoothly applying full brake pedal pressure immediately after main gear touchdown.

If a runway has brackets ("[ ]") displayed around the MAX stop margin, the required stopping distance for the selected flap setting exceeds the available runway length. DO NOT ATTEMPT TO LAND ON THAT RUNWAY. Use of more flaps may allow landing on the desired runway."

Flight crews at SWA used the OPC, provided in the cockpit of each airplane, to calculate expected landing performance. Specific data was programmed into the OPC to determine the stopping margin. That specific data included the expected landing runway, wind speed and direction, airplane gross weight at touch down, temperature, altimeter setting, and the reported runway braking action[20]. The OPC also alerted the flight crews if the remaining runway distance was not sufficient for the airplane to land and completely stop on the runway available under the selected weather and runway conditions.

The following information in this section and subsequent sections of this report was obtained from interviews conducted with SWA personnel during the course of the investigation:

A Southwest Airlines checkairman said that the pilots had adapted very well to the OPC. Additionally, he said that it "worked as advertised" and pilots were trained to accept the numbers calculated by the OPC. There were no procedures to verify / check the numbers calculated by the OPC with another independent source.

Another Southwest Airlines checkairman said he believed that new-hires had a good understanding of the OPC, and received "just about the right amount" of training time.

[20] See Attachment 15.

A SWA OPC ground instructor said that pilots received dispatch training the day prior to OPC training. During that day, a performance engineer gave a presentation on the FAR requirements and their relation to OPC programming. A SWA dispatcher also gave a presentation regarding the dispatch aspects of a routine flight. He further stated that there were two classroom phases of OPC training (8 hours): Use of the OPC during a normal flight from takeoff to landing and use of the OPC during a non-normal flight from takeoff to landing. When these two phases were completed, he said that every aspect of the OPC had been covered. Every pilot was given an OPC for the class so that they could gain familiarity with it and perform calculations. Following completion of training, the pilots would spend three classroom days with a checkairman instructor who covered the FOM aspects of the OPC. The pilots also received additional instruction and practice on the OPC during that time.

The accident captain stated that he and the FO looked at the weather and continued to retrieve weather updates during the flight. Various parameters were entered into the OPC to see what the performance numbers would be under different scenarios (e.g., runway conditions, visibility, tailwinds, etc.). He said they decided that a landing would not be attempted if the runway conditions were *WET-POOR* or if the tailwind exceeded 10 knots. The captain recollected that the reported winds were within prescribed limitations with a runway condition of *WET-FAIR*. Additionally the captain said that because of the runway remaining calculation of over 500 feet and the fact that another SWA airplane had previously landed on the same runway, he and the FO considered the runway remaining an acceptable margin and neither of them were apprehensive about the landing.

The FO stated that during the enroute and holding flight segments, he calculated OPC numbers for *WET-GOOD*, *WET-FAIR*, and *WET-POOR* runway conditions and he entered an *estimated* landing weight of 119,700[21] pounds into the OPC. The OPC calculated that there would be 560 feet of runway remaining using the autobrakes on the MAX setting with a runway condition of *WET-FAIR*. He further stated that when *WET-POOR* was programmed into the OPC, the runway remaining was about 30 feet and they would not have attempted a landing even though there was a positive stopping distance. However, they made the decision that if ATC advised that the braking action for the entire length of the runway was *POOR*, they would divert to their alternate destination.

After the accident airplane's OPC database was downloaded, it was determined that the accident flight crew correctly entered the current weather data into the OPC and selected *WET-FAIR* as the runway condition and braking action. The OPC calculated that the airplane would be able to land and completely stop on runway 31C under the selected weather, weight[22], and runway conditions with 560 feet of runway stopping margin. The Performance Group determined that the OPC was functioning properly[23].

[21] Actual landing weight recorded on the FDR was 118280.
[22] 119,700 pounds.
[23] See Performance Group Chairman's Factual Report for additional information.

H. Landing Criteria and Procedures

1.0 The SWA B737 Flight Reference Manual (FRM), Chapter 7, pages 7.2.11, 7.2.12[24] stated in part:

Each engine is equipped with a hydraulically operated thrust reverser (TR), consisting of left and right translating sleeves. Aft movement of the reverser sleeves causes blocker doors to deflect fan discharge air forward through fixed cascade vanes producing reverse thrust. The thrust reverser is for ground operations only and is used for rejected takeoffs and after touchdown to slow the aircraft, reducing stopping distance, and brake wear.

When either reverser sleeve moves from the stowed position, the amber REV indication, located on the upper DU, illuminates. As the thrust reverser reaches the deployed position, the REV indication illuminates green and the reverse thrust lever can be raised to detent number 1. A reverse thrust lever position between detent number 1 and detent number 2 provides adequate reverse thrust for normal operations. When necessary, the reverse thrust lever can be pulled beyond detent number 2, providing maximum reverse thrust.

2.0 The SWA B737 FOM, Chapter 3, pages 3.22.1 thru 3.22.3[25] stated in part:

Plan to touch down between 1,000 and 1,500 feet from the landing threshold with the runway centerline between the main landing gear.

If touchdown occurs beyond 1,500 feet[26], the ability to stop on the remaining runway may be compromised.

3.0 The SWA B737 FOM, Chapter 3, pages 3.22.1 thru 3.22.3[27] stated in part:

After the airplane touches down on the runway:

*Initiate reverse thrust**:** Raise the reverse thrust levers to the reverse idle interlocks. After the interlocks release, modulate reverse thrust, as required. Avoid exceeding engine limits. Minimum reverse thrust is 65% N1. When required, reverse thrust to engine limits may be used. Initiating reverse thrust at touchdown is an important factor in minimizing brake temperatures, minimizing brake and tire wear, and reducing stopping distances.*

4.0 The SWA B737 FOM, Chapter 3, pages 3.23.1 and 3.23.6[28] stated in part:

[24] See Attachment 3.
[25] See Attachment 4.
[26] See Flight Data Recorder Group Chairman's Factual Report for touchdown point on runway.
[27] See Attachment 4.
[28] See Attachment 5.

Under braking advisories less than 'GOOD' use Normal Landing Procedures except for the following:

Brakes and thrust reversers should be applied together.

Use thrust reversers as soon as possible during landing roll.

Under emergency conditions, maximum reverse thrust may be used until reaching a complete stop.

Use reverse thrust between a minimum of 85 percent N1 to a maximum of go-around N1

Brakes are effective 3-5 seconds before the thrust reversers reach desired N1.

A SWA checkairman said that pilots were taught to achieve a minimum of 65% reverse thrust on a dry runway and 85% when the braking action was less than *GOOD* on a wet runway. They were also taught to use reverse thrust as soon as the nose wheel was on the runway. He stated crews were never taught to not use reverse thrust when landing.

Another SWA checkairman stated that during line checks on a dry runway, he looked for the FOM requirements for the use of reverse thrust which were: nose wheel on the runway, 65% minimum, brakes at the appropriate time, and a reduction in reverse thrust at 80 knots. Application of reverse thrust was the same whether or not the runway was wet or dry. If the runway was wet with braking action less than *GOOD*, he looked for 85%. He said that pilots could use their emergency authority to stay in reverse thrust after 80 knots.

A SWA simulator instructor said that when the main wheels touched down on the runway during the landing, pilots were taught to lower the nose, begin manual braking, if necessary, bring the thrust levers to idle, and initiate reverse thrust to a minimum of 65%.

The accident captain stated that he "did not feel the engine thrust reversers deploy" as he tried to move the reverse thrust levers with his hand. Handwritten notes[29] (received 2/9/06) that he said he had prepared at the hotel immediately following the accident noted, "I felt the reversers and they hadn't deployed. I tried once to deploy and they wouldn't." At about that time, he said he felt the anti-skid system stop cycling and he started to apply manual braking which "took his attention away from the reversers." When the FO attempted to deploy the thrust reversers, he said, "it took the FO a little work to get the thrust reverse levers back, but he was eventually able to do so."

[29] See Attachment 11.

During his initial interview, the accident captain stated that the thrust reversers deployed "automatically." When asked to provide further details, he explained that, "after the throttles were at idle, normal deployment of the reversers required lifting the reverse levers to the interlock, and then pulling them back." In an irregularity report[30] (received 12/19/05) filed with his domicile chief pilot following his NTSB interview, he noted, "I know how they *(reversers)* function but I did not explain it very well. I think I may have left the impression that the reversers deploy automatically."

The captain stated that, "initially, he could not even raise the *(reverse)* levers." He said that the reverse thrust levers moved only slightly when he attempted to pull them up. There was about ¼ to ½ inch play and then resistance. He further stated that he only made one attempt to raise the thrust reverse levers because, "he was very concerned that they were not stopping and his entire attention went there." In a subsequent interview, he said that, "he felt the lack of deceleration of the aircraft, which felt like an increase in speed, and that was when he stopped thinking about the thrust reverse." Additionally, he said he did not say anything to the FO about not being able to deploy the thrust reversers.

The accident FO stated that pilots were taught to apply reverse thrust immediately after touchdown and, "99.9% of the time, it was almost instantaneous." He said that as soon as reverse thrust was available, "pilots were to use it."

The FO further stated that as he evaluated the rollout after landing, he noticed that, "the airplane was not slowing down as much as he would have liked." He said he "jumped on the brakes" and after observing that the thrust reversers were not deployed, he moved the captain's hands from the reverse thrust levers and deployed the engine thrust reversers himself. He said that when he saw the reverse thrust levers down, "he was surprised; he could not believe it." He stated that "initially" he had trouble raising the thrust reverse levers, but "eventually" was able to do so. Handwritten notes[31] (received 12/9/05) that he said he had prepared at the hotel immediately following the accident noted, "I looked at the TRs. Bruce's hands were on them in the down position. I pulled his hands off and went to max reverse." In comments[32] (received 12/12/05) prepared by the accident crew, the FO stated, "the reverse thrust levers did not allow me to enter reverse until the third or fourth pull on the levers."

In a subsequent interview, the FO stated that he did not see the captain have trouble with the reverse thrust levers and he did not look at his hands. He said the captain did not advise him that that he was having trouble with the reverse thrust levers. He further stated that, "the thrust reverser handles did not release from the fully stowed position and were stuck in the intermediate position. He *(FO)* tried to pull the levers three to four times until he could get them into the interlock position and there was also a delay there *(interlock position)*."

[30] See Attachment 12.
[31] See Attachment 13.
[32] See Attachment 14.

A SWA captain who was a passenger in the cabin of the accident airplane stated that he noticed there was no reverse thrust after the airplane initially touched down on the runway. He said that reverse thrust occurred after the airplane had passed the 1,000 feet runway remaining warning marker located on the side of the runway. He thought that was the time the pilots should have been, "coming out of reverse."

FDR data indicated that engine thrust reversers were not fully deployed until 18 seconds after touchdown. Prior to that time, the engine reverser sleeves remained stowed, which prevented the engines from developing any reverse thrust. FDR data also indicates that the airplane ran off the end of runway 31C at a ground speed of about 50 knots.

I. Difficulties Encountered During Reverse Thrust Operation

The manager of flight training at SWA stated that there were only occasional problems with pilots on the line "moving the reverse thrust levers up" and usually occurred because the pilot tried to get the levers past the interlock position too quickly.

A SWA checkairman stated that he had occasionally seen pilots have trouble using the reverse thrust levers in the simulator. Some pilots tended to act more quickly than others and initially the levers would not come up but there would be no problem after that. He said he had not observed any problems on the line related to initial movement of the reverse thrust levers out of the stowed position.

Another SWA checkairman stated that he had not seen any thrust reverser deployment problems on the line. In his experience, pilots generally did not have a problem with initiating reverse thrust.

A third SWA checkairman stated he had never experienced an occasion when the reverse thrust levers would not come up.

A fourth SWA checkairman stated that he had not seen any problems actuating the thrust reversers on the line. He had seen problems in the simulator during engine failures when the failed engine was on the standby hydraulic system. In his experience, pilots generally did not have a problem with the thrust reversers.

A SWA simulator instructor said that he had not seen anyone have difficulty deploying the thrust reversers in the simulator and he had not heard of any problems on the line.

A SWA captain stated that there was, "a time or two" when the thrust reversers did not work as quickly as he would have liked. However, he could not recall any time when he could not raise the reverse thrust levers.

Another SWA captain stated that he never had any trouble pulling the reverse thrust levers up, and had never noticed anyone else having difficulty. He had never landed without using reverse thrust and would not even contemplate it. Additionally, he said he had never seen anyone else land without using reverse thrust.

A third SWA captain stated that he had never encountered an occasion when he was unable to deploy the thrust reversers.

A fourth SWA captain stated that he experienced a situation where he was unable to deploy the thrust reversers. He was not sure why, but stated that about one time every year, he had to try several times for the "reversers to kick in."

A SWA first officer stated that he never had any trouble deploying the thrust reversers.

Another SWA first officer stated that he never had an occasion when the reverse thrust levers would not come up.

Following the accident, an in-depth inspection and analysis of the reverse thrust levers and the throttle quadrant were initiated[33]. Additionally, the aviation safety and reporting system (ASARS) and Boeing were queried to determine if there were other incidents where pilots had difficulty with the reverse thrust levers in the B737. Those queries confirmed that there was no documentation that indicated previous problems with the B737 reverse thrust levers or the system itself.

J. Monitoring Reverse Thrust Operation

The SWA B737 FOM, Chapter 3, pages 3.1.4 thru 3.1.7[34] stated in part:

Both pilots will monitor systems for warning flags, lights, or out of tolerance conditions.

The FO will advise the captain of deviations from established policies, procedures, and / or regulations.

The manager of flight instruction at SWA stated that pilots were not required to monitor reverse thrust operation. However, he had been required to monitor it when he flew for other airlines. He was not sure why SWA did not require it. He further stated that while employed at another airline, he saw a pilot forget to use reverse thrust after landing.

A SWA checkairman stated that the PNF was not required to monitor thrust reverser deployment.

[33] See Systems Group Chairman's Factual Report for additional information.
[34] See Attachment 6.

Another SWA checkairman stated that both pilots monitored the "amount" of reverse thrust on landing. However, there was no callout.

A third SWA checkairman stated that he did not instruct the PNF to monitor reverse thrust on landing because it was not a SWA procedure and it might not be in the Boeing manual. SWA tried to "stay in line" with that manual.

A SWA simulator instructor stated that he was not sure why it was not the PNF's responsibility to monitor reverse thrust operation. However, he believed that both pilots should be monitoring everything.

Another SWA simulator instructor said that first officers were not required to verify that the thrust reversers had deployed.

The accident captain stated that he did not monitor the *REV* indicator lights on the instrument panel after landing.

The accident FO stated that after landing, he was monitoring the runway distance remaining. He further stated that he did not look at the *REV* lights because there was no procedural requirement to do so.

A review of the training program and pilot manuals confirmed that the PNF was not required to observe or monitor the engine *REV* lights or engine indications during reverse thrust procedures after landing. The FOM only stated that the PNF should verify speed brake deployment and make a callout at 80 knots.

K. Reverse Thrust Abnormal Operation

The SWA manager of flight operations technical stated that he was not aware of what training was given regarding a thrust reverser that did not deploy after landing.

A SWA checkairman stated that there was no reference in the book or training regarding what to do if the thrust reversers did not deploy, however, pilots should always consider a go-around. He said a pilot would know quickly if a thrust reverser did not deploy because he would not be able to get past the interlock. The pilot's intuition was better than having the PNF monitoring for reverser deployment. Pilots were flying day in and day out and would know that a reverser did not deploy before a person monitoring because they would feel it in their hands.

During an interview, another SWA checkairman stated that there was no training for thrust reverser failure. He said that it might be a good idea, but since there was only one avenue at that point, he could not imagine "anyone not getting on the brakes immediately."

The SWA FAA POI stated during his interview that he was not sure how pilots were trained to deal with a thrust reverser that did not deploy after landing. However, he said he had found that the performance numbers were more conservative than those required by regulation.

A review of the training program and pilot manuals confirmed that there was no procedure or training regarding abnormal reverse thrust operation.

L. Braking Action Reports

The SWA B737 FOM, Chapter 3, Pages 3.23.1 thru 3.23. 5[35] stated in part:

When braking action advisories are in effect, ATC will issue the latest braking action report information to each arriving and departing aircraft. Pilots should be prepared for deteriorating braking conditions and should request current runway condition information if it is not given by the controller.

Braking action reports less than GOOD are classified according to the most critical term (FAIR, POOR, NIL, or combinations). Operations are prohibited on all surfaces classified as NIL.

Evaluate landing performance using the OPC. The -700 OPC landing module computes a deceleration rate as a combination of reversers and brakes.

The ATC tower controller issued the following instruction / clearance to the accident flight crew:

- "Southwest 1248, Midway Tower, continue for 31 center. The winds 090 at 9, braking action reported *GOOD* for the first half, *POOR* for the second half."
- Southwest 1248, runway 31 center cleared to land, wind 090 at 9, braking action *FAIR* to *POOR*."[36]

The manager of flight instruction at SWA said that he could not speak to how pilots were specifically trained to analyze braking action reports. However, he said pilots should always be conservative and enter the most conservative scenario. He thought that most pilots had a good understanding of that and it was talked about in new-hire training and recurrent ground school.

A SWA OPC ground instructor stated that a pilot should utilize the "worst condition" when issued a mixed[37] braking report. He went on to explain that if the braking action was reported as *POOR* or *FAIR* to *POOR*, *WET-POOR* should be entered in the OPC. He stated that the pilot should always input into the OPC the worst braking action description given by ATC.

[35]See Attachment 5.
[36] See ATC Group Chairman's Factual Report for additional information.
[37] Two braking action descriptions reported at the same time for one runway.

A SWA checkairman said that if he received a mixed braking action report of *FAIR* to *POOR*, he would enter *WET-POOR* in the OPC to calculate the runway distance remaining after the airplane had come to a stop. However, he said that was not written in the FOM. He thought that most SWA pilots understood how to handle mixed braking reports. He said that he would not normally give a mixed braking report during a checkride. He further stated that he thought most SWA pilots would assume the "worst possible scenario" just as they were required to do during training.

Another SWA checkairman stated that pilots should use the "worst case" when issued a mixed braking action report. He did not specifically know if it was in the manual, but it was talked about and taught in new-hire ground school. He did not know what specific scenarios were used to teach the application of braking action during new-hire training.

A third SWA checkairman said that he considered mixed braking reports a "gray area." However, he would always use the worst description if given a mixed braking action report.

A fourth SWA checkairman stated that there was no crew training on braking action reports; it came through experience. He said that if he were given a mixed braking action report of *FAIR* to *POOR*, he would enter *WET-POOR* in the OPC. However, that was not written in the FOM. He thought that most pilots would understand how to apply mixed braking action reports. He said that he would not normally give a mixed braking report during a checkride, though he thought that he might now.

A SWA first officer said the procedure when receiving a mixed braking report was to, "take the worst case and put it in the box." However, to his knowledge, that was not written anywhere.

Another SWA first officer stated that he did not recall any training regarding a mixed braking report and had never heard a mixed braking report while at SWA. However, he was flying the night of the accident and both he and the captain mutually agreed that the worst braking report received should be entered in the OPC.

A SWA ground instructor said that he did not recall specifically what SWA policy was regarding mixed braking action reports, but he believed pilots were to stay on the conservative side and use the "lower" condition. He was not sure if there was any written guidance concerning that procedure.

The accident captain said that the worst report that he heard on the radio frequency the night of the accident was, "*FAIR* first end and *POOR* at the last end." The captain stated that, "had the braking report been the other way around, he would not have landed." He said he recalled hearing a *FAIR* braking report from a SWA pilot that had already landed.

The FO stated that the last braking action report he heard was *FAIR* to *POOR*. He and the captain had previously briefed that they would not attempt a landing with *POOR* braking action. They decided that if they didn't hear a *POOR* report for the entire runway, they would land.

A review of the training program and pilot manuals confirmed that there was no definitive documentation regarding operations when the flight crew received a mixed braking action report from ATC at the time of the accident. Subsequent to the accident, FOM Revision 1-06, dated April 8, 2006, to Chapter 3, Section 23 (Additional Landing Procedures and Considerations) noted: *If a combination is given (e.g., FAIR to POOR), use the more restrictive of the two.*

L. Autobrakes Training

SWA Flight Operations distributed a home study training package[38] to all pilots on November 7, 2005. One of the subjects covered in that training package was the autobrake system. Additionally, several other procedural changes were also included in that training package. Through the home study training package, SWA was establishing policies and procedures to use the autobrake system during landing. Pilots were instructed to review the training material and were advised that they would be receiving an FOM revision (3-05) that included the new autobrake procedures and other procedural changes. Additionally, new checklists would be updated and placed in the cockpits of the entire fleet.

The director of flight operational safety at SWA stated that the guidance provided to the pilots explained the autobrake system very well. He said he was confident that the pilot workforce could effectively use the autobrake system under adverse conditions based of the information received in the home study package.

The manager of flight instruction at SWA stated that autobrake usage was like a lateral navigation[39] (LNAV) missed approach. It was "not a no-brainer if you had not done one before." He said that training was the proper thing to do. He stated, "it was proper to see it in training if you have never experienced it." He thought that the best way to train pilots on autobrakes was in the airplane on a clear and dry day or in the simulator. He had done it that way at a previous carrier. He said the best way to learn the autobrake system was in the airplane in a safe environment. The first time you use them you did not want it to be during a "blizzard."

A SWA simulator instructor stated that he would want to try out the autobrake system under favorable conditions before trying them out in unfavorable weather conditions.

[38] See Attachment 7.
[39] A function of area navigation (RNAV) equipment, which calculates, displays, and provides lateral guidance to a profile or path.

A SWA simulator checkairman stated that he had allowed crews to try the autobrakes in the simulator, but instructed them not to use them on the line. He said that autobrake training might become part of recurrent ground school, but he was not sure. He stated that autobrakes were "a no-brainer, a nice accessory."

The accident captain said he first read the autobrakes training materials when he received them several weeks prior to the accident. He said that he read the FOM revision on the accident flight. He said the training materials provided a good outline of how the autobrakes worked and he felt that the training materials were sufficient.

The accident captain said that he was uncomfortable with using autobrakes because it was a new procedure. He was also uncomfortable landing at MDW in the current weather conditions and not having used them before. Both he and the FO talked about the new FOM procedures and the use of autobrakes. This would be the first trip where they would be using the autobrakes. He stated that they read the procedures thoroughly as soon as the airplane was stable at cruise altitude. They knew that they would have to use the autobrakes for this landing because of the conditions and runway length.

The accident captain further stated that, once in a while, autobrakes would be used on a landing during simulator proficiency training (PT). On these occasions, an actual comparison was done on the effectiveness of pilot manual braking versus autobrakes on landing. In the particular demonstration scenario he recalled, which was on a clean runway, the "autobrakes won." He said that it was, "amazing how well the system worked." In a written statement[40] following his interview, the captain noted, "During the NTSB questioning, I had indicated that I thought I had done some practice autobrake landings at MDW *(during simulator training)*. After the questioning, I realized that in fact those had been rejected takeoffs that we had practiced at MDW."

The accident FO stated that he read the autobrakes training materials several times after he received it. He read the FOM revision during the accident flight. He said he was comfortable with the information, he understood it, and he did not feel that he needed additional information.

The accident FO further stated that during the enroute segment of the flight, he and the captain talked about the new FOM autobrake procedures since this would be the first time either of them had used the autobrake system. He said they reviewed the procedures thoroughly and "couldn't have covered it any better than they did." He further stated that the autobrakes were set to MAX, as required by the OPC, in order to give them a 500-foot stopping margin.

The majority of pilots interviewed by NTSB investigators agreed that the home study training package issued by the company was sufficient and they would not be

[40] See Attachment 12.

apprehensive about using autobrakes for the first time in the airplane without any additional training, either in the simulator or airplane[41]

M. Autobrakes Implementation

The manager of flight standards stated that some of the autobrake control boxes in the 737-200 models had been removed or their wires had been disconnected. Since the company had now phased out all of the -200s, they wanted to standardize the remaining fleet. The decision was made to develop training and procedures for use of the autobrake system for landing. Up until that time, the autobrake system was only used for takeoffs in the rejected takeoff (RTO) setting. Additionally, he said that the decision to implement the use of autobrakes was also the result of an NTSB recommendation[42] that was issued following the American Airlines accident that occurred in Little Rock, Arkansas.

On October 24, 2005, SWA Flight Operations issued a read before fly (RBF) [43] letter numbered #A-05-108[44]. That RBF advised pilots that the FAA had approved the use of autobrakes for landing. Additionally, it noted, "until the new checklist is installed on our aircraft, do not use autobrakes for landing."
Note: The new checklist was on board the accident airplane.

During the 2005 Thanksgiving holiday weekend, SWA personnel discovered that the new autobrake checklist packets, which were to be prepositioned on all aircraft prior to the official date for the autobrake procedural authorization, had been mistakenly opened and installed on several aircraft. There was no effective way to ensure with 100% accuracy a recall of all of those checklists. The decision was made to continue the installation of the autobrake checklist packets and a cover sheet to the flight release weather package would be developed for all subsequent flights. The cover sheet stated that use of the autobrakes was not authorized until further notice, even though the new checklists might be installed on the aircraft. The weather package cover sheet was produced for all flights until November 29, 2005, when RBF #A-05-116[45] was issued and eliminated the need for these cover sheets.

On November 29, 2005, SWA issued RBF #A-05-116. That RBF noted that FOM revision 3-05 would be distributed in the near future to all crewmembers. Once that FOM revision was distributed, Flight Operations would issue a subsequent RBF authorizing use of the new procedures.

[41] See Attachment 1.
[42] Recommendation A-01-54: "Require Part 121 and Part 135 operators to use automatic brakes, if available and operative, for landings during wet, slippery, or high crosswind conditions, and verify that these operators include this procedure in their flight manuals, checklists, and training programs."
[43] A SWA method used to advise pilots of important, need-to-know, or time critical information.
[44] See Attachment 10.
[45] See Attachment 8.

On December 8, 2005, Flight Operations issued RBF #A-05-121[46]. That RBF noted that at the start of flight operation on Monday, December 12, the new procedures and checklists (including autobrakes) were to be used. Pilots operating flights prior to December 12, 2005, were to continue following the directives in RBF #A-05-116.

A SWA checkairman stated that, based on his knowledge of the autobrake program, the accident pilots should not have been using the autobrakes for landing.

During an interview, a SWA captain stated that he understood autobrakes could be used for landing following issuance of a RBF letter that would authorize their use.

Another SWA captain said that he understood that after pilots had reviewed and understood the training package, a RBF letter would be issued to authorize use of the autobrakes. He had not flown since the day of the accident; however, he had not seen a RBF on the topic of autobrake authorization. He further stated that he was not concerned about not having used the autobrakes before in the airplane. He said he did not receive any autobrake demonstration during his six-month proficiency checkride in October.

A SWA first officer stated that he flew a trip the day after the accident and autobrakes were still not authorized for use. His understanding was there would be a RBF letter issued implementing the policy. He said that to his knowledge, that letter had still not been issued.

Another SWA first officer said that he had read autobrakes would be authorized for landing beginning on December 12, 2005.

The accident captain stated that based on the guidance that he had received, if the FOM revision was in the book and the checklist was in the airplane, the use of autobrakes was required. He further stated that he and the FO discussed whether or not to use the autobrakes for landing. He said he was not comfortable with using the autobrakes, but after a discussion, the FO, "convinced him otherwise." Additionally, the captain said that his understanding of the autobrake system "may have hindered him" during the landing. However, he said that based on the OPC calculations, they were required to use the autobrakes for landing.

The accident FO stated that he believed they were required to use the auto brakes that night because they were told not to use them unless the new checklist was on the airplane and the FOM revision had been inserted in their manual. Both of those conditions had been met. Additionally, he said there used to be a note attached to the weather package about not using the autobrakes. That night, the note was not attached. There was no question in either of their minds that autobrakes were required for landing.

[46] See Attachment 9.

The accident FO further stated that he checked the RBF file before the flight but the RBF that was issued on December 8 had not yet been posted. He said he did not go back and review previous RBFs regarding the autobrakes, but he did recall reading them some time in the past.

The director of flight operational safety at SWA stated that he did not have concerns regarding the overall policy in which autobrakes were to be implemented. He thought all of the possibilities had been evaluated. However, he said he would have liked a more proactive approach in terms of the timing, that is, not implementing their use during winter operations. However, he stated that because of the accident, autobrakes implementation had been delayed for further review.

According to procedures noted in RBF letter dated December 8, 2005, the accident crew was not authorized to use autobrakes for landing prior to December 12, 2005.

N. Reverse Thrust Credit[47]

The SWA B737 FOM, Chapter 10, pages 10.1.1 thru 10.1.10[48], stated in part:

*The stop margins include the effects of reverse thrust (-**300/-500**: stop margins do not include the effects of reverse thrust).* [49]

The director of flight operational safety at SWA stated that there was a significant on-going company discussion regarding the use of reverse thrust credit. His preference was to standardize across the fleet and take the reverse thrust credit on all airplane models. He thought it might provide the pilots with better information than they had before and they would have a better idea of stopping margins.

The director of flight operations technical at SWA stated during his interview that pilots could calculate landing distances without the reverse thrust credit by going to the minimum equipment list (MEL) page in the OPC and entering the thrust reversers as inoperative. The TR selection method in the OPC assumed that both TRs were either operative or inoperative. It was an all or nothing calculation.

The SWA manager of flight standards stated that the company had looked at the reverse thrust credit. He said, “it is what it is, and not much thought is given to the calculation.”

The SWA manager of flight instruction stated that he had looked at the OPC reverse thrust credit and the lack of standardization between the 300/500 and -700 series airplanes. He said it was not an issue because, “the difference was only about 10 feet.” However, it was trained and discussed.

[47] Factoring in the effects of reverse thrust when calculating stopping margins.
[48] See Attachment 2.
[49] See Performance Group Chairman’s Factual Report for additional information.

During an interview, a SWA checkairman stated that he believed instructors understood the reverse thrust credit factored into the OPC. He thought that it was described in the FOM section "landing with braking conditions less than *GOOD*." They didn't make a big deal of it when they received the 737-700. It was not emphasized, but he believed that most people "caught it in differences training." However, now it was taught to all new-hire trainees. He speculated that SWA did not use the reverse thrust credit in the 737-300/500 because the 737-700 was an excellent long haul airplane and, "maybe they needed it for performance, or possibly to tanker fuel."

Another SWA checkairman stated that he believed most instructors were "up to speed" on the OPC reverse thrust credit. He believed that line pilots were as well because it was talked about during training. SWA focused more on how to apply landing data rather than what made up the data. However, it was covered, just not emphasized. He did not know why SWA took the OPC reverse thrust credit in the -700 but not the -300/500. Additionally, he said that a pilot should weigh other factors besides the reverse thrust credit and it probably did not enter into their decision to land.

Another SWA checkairman said that he felt that most pilots did not understand the -700 OPC reverse thrust credit and that it, "caught a lot of people off guard." He thought that pilots wanted to know how much reverse thrust was assumed, so that they could better understand the expected aircraft performance.

The FAA POI stated that the reverse thrust credit was an acceptable performance calculation. He said there had been an in-depth review of the credit following the accident. He said it appeared to provide an acceptable safety margin. There were other carriers that used the credit but he was not aware of the data used in their programs. He said that current FAA guidance supported use of the credit but he was not sure if that would change in the future.

The FAA APM stated that he thought that the majority of the pilots understood the reverse thrust credit. He said it was in the manuals and taught during ground school.

In a report filed with his domicile chief pilot following his NTSB interview, the accident captain noted, "if we had known that thrust reversers were already figured in our landing data, we would have done a 'what if' if one or both did not operate. That could have very likely changed our 'go / no go' plan *(for landing)*."

The FO stated that he and the captain were concerned about the approach and weather, but they both felt as if, "they were within limits." He said that, "the OPC did not take into account thrust reversers, so they felt they had additional room."

The SWA director of flight operational safety said that the company was reviewing the overall runway margin that they wanted to establish for takeoff and landing. The goal of the review was to always have a minimum safety margin included in the OPC calculations. He said that at smaller airports, they might have to reduce payload by blocking seats.

Following the accident, the NTSB issued an urgent recommendation to the FAA to prohibit the effects of reverse thrust in landing distance calculations. Subsequently, the FAA began an in-depth study into operator use of the reverse thrust credit.

O. Weather

The weather condition on the airport terminal information service (ATIS) at MDW airport issued about 20 minutes prior to the accident was:

> *Information Victor at 1853L: Wind from 100 degrees at 11 knots, ½ statute mile visibility in snow and freezing fog. Sky condition: 400 broken, 1400 overcast, temperature minus 3C, dew point minus 5C, altimeter 30.06.*

The ILS to runway 31C was the approach in use and airplanes were departing on runways 4L and 4R.

P. Runway 31C

Runway 31 C at MDW was 6,522 feet in length and 150 feet wide; the runway surface was grooved concrete. It had a displaced threshold[50] of 696 feet, which made the effective runway length for landing 5,826 feet. The runway was equipped with RVR, high intensity runway lights (HIRL), lead in lights (LDIN), and a 3-degree glide slope visual approach slope indicator (VASI) located on the left side of the runway.

The end of runway 31C (and most of Midway's other runways) was in close proximity to neighboring streets. It did not have the FAA mandated 1,000 foot RSA because the airport was constructed prior to that mandate. It was also not equipped with an Engineered Materials Arresting System (EMAS)[51] that uses crushable concrete placed at the end of a runway to stop or greatly slow an aircraft that overruns the runway.[52]

The minimum RVR required for the runway 31C approach was 4,000 feet. However, SWA had an FAA approved special approach (ILS Z) for that runway that allowed SWA pilots to initiate the approach when the RVR was as low as 3,000 feet.

Q. FAA Oversight

[50] A runway threshold located at a point other than the physical beginning of the runway and is most often used to give arriving aircraft clearance over an obstruction.
[51] A new technology designed to provide an added measure of safety during runway overruns.
[52] See Survival Factors Group Chairman's Factual Report for additional information.

The FAA certificate management unit (CMU) for the Southwest Airlines air carrier certificate was located in Dallas, Texas (DFW). The certificate was assigned one principal operations inspector, one assistant principal operations inspector, and two aircrew program managers.

Airline Transport Oversight System (ATOS)[53] documentation and inspection reports provided by the FAA and interviews with CMU personnel indicated that the DFW CMU conducted the FAA Southwest Region's surveillance program at Southwest Airlines in accordance with current FAA guidance, policies, and procedures.

R. Company Information

Southwest Airlines began service on June 18, 1971 with flights to Houston, Dallas, and San Antonio. The company maintained its headquarters in Dallas, Texas, and was the largest air carrier in the USA based on 3,000 scheduled domestic departures each day. The airline had more than 31,000 employees and flew more than 70 million passengers a year to 62 cities in 32 states. The current fleet consisted of 194 B737-300s, 25 B737-500s, and 222 B737-700s with an average age of 9 years.

Submitted by:

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Dave Kirchgessner
Air Safety Investigator, Operations

[53] A systematic, data-driven approach to airline safety surveillance where carriers have a comprehensive surveillance plan tailored to their operation. The carrier is assigned an FAA certificate management team (CMT) to carry out the surveillance program.