NATIONAL TRANSPORTATION SAFETY BOARD
Office of Aviation Safety
Washington, D.C. 20594

May 17, 2006

Group Chairman's Factual Report

Human Performance

DCA06MA009

A. ACCIDENT

Operator:	Southwest Airlines, Inc.(SWA)
Location:	Chicago Midway International Airport (MDW), Chicago, IL
Date:	December 08, 2005
Time:	1914 central standard time
Aircraft:	Boeing 737-7H4, N471WN

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C. SUMMARY

On December 8, 2005, at 1914 central standard time, Southwest Airlines flight 1248, a Boeing 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. There were 98 passengers and 5 crewmembers on board; there was one ground fatality. 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 Marshall Airport (BWI), Baltimore, Maryland.

D. DETAILS OF THE INVESTIGATION

Activities of the Operations/Human Performance Group from December 9, 2005 through February 9, 2006 are detailed in the Operational Factors Group Chairman's Factual Report.[1] In addition, some members also participated in a simulator session on January 24, 2006.[2]

E. FACTUAL INFORMATION

This factual report is organized into Sections. Section F.1 summarizes activities of a simulator session, Section F.2 summarizes accident crew information, Section F.3 contains information regarding autobrakes, Section F.4 contains information regarding braking condition reports, Section F.5 contains information regarding reverse thrust, Section F.6 contains information regarding the Onboard Performance Computer (OPC) and Head-up Guidance System (HGS), Section F.7 describes SWA home study packets, Section F.8 contains information regarding crew resource management (CRM) and decision making, Section F.9 contains historical information of SWA accidents and incidents, and Section F.10 describes a previous NTSB recommendation.

All interviews referenced in this factual report were conducted by the Operations/Human Performance Group and interview summaries are attached to the Operational Factors Group Chairman's Factual Report.

[1] See Section D of the Operational Factors Group Chairman's Factual Report.
[2] See Section F.1 below.

F.1 TRAINING SIMULATOR FAMILIARIZATION SESSION

Group members[3] participated in a 737-700 training simulator familiarization session at SWA headquarters in Dallas, TX on January 24, 2006. The purpose of the session was to allow group members present the opportunity to observe procedures associated with the 31C approach to MDW and the HGS Model 2350.[4]

The session began with a briefing by the manager of flight safety of the cockpit and the HGS that included flight and navigation instruments, the HGS unit, the control box and annunciator, and the HGS AIII mode activation requirements. To approximate the conditions of the accident aircraft and approach, the following simulator default conditions were set for all approaches: aircraft landing weight 119,700 lbs., wind 090/11, RVR 4500, ceiling 400', snow, temperature -5°C, altimeter 30.07, and runway roughness 30%.

Eleven approaches were flown during the session, including seven full stop landings and four planned rejected landings. The HGS AIII mode was used for eight of the approaches, and the landing flare cue followed to touchdown for four approaches. Simulated runway conditions varied for the approaches between snow, patchy ice or ice.

F.2 PILOT INFORMATION[5]

F.2.1 Captain

At the time of the accident, the captain, age 59, held an airline transport pilot certificate with airplane multi-engine land ratings and a type rating in the 737. The captain's most recent Federal Aviation Administration (FAA) first-class airman medical certificate was issued on September 21, 2005.

The captain was hired by SWA in 1995 as a first officer, and upgraded to captain in 2000. Prior to working for SWA, he was an Air Force pilot for 26 years, piloting such aircraft as the B-1, B-52, C-130, T-39, and the trainers T-37 and T-38. He was a flight instructor in the C-130.

The captain reported that during his tenure with SWA he had executed landings between 12 and 15 times where the runway conditions were poor, due to winter weather, although there was never a time in which he thought that he wasn't going to be able to stop. The weather on the accident night was the worst he had experienced.

The captain reported that he was in good health, and that over the past year there had been no changes in his health or financial situation, no noteworthy major life events,

[3] K.L., C.P., and T.T.
[4] The accident aircraft was equipped with HGS Model 2350.
[5] For additional flight crew information see the Operational Factors Group Chairman's Factual Report.

and no changes in his sleeping pattern. He reported feeling rested during the day. He stated that he didn't believe anything affected his performance on the day of the accident.

The captain and first officer had met each other on a prior layover, yet this was the first time they had flown together as a crew. The first officer reported that he was looking forward to flying with the captain, who made him feel very relaxed and comfortable, had an excellent demeanor, was a team player, very open, and a perfect partner. In his briefing, the captain told him, "If you ever see anything, point it out." When asked if the captain was different than other captains at SWA, the first officer said that, "Procedurally, everybody does things according to company guidelines. However, the captain's personality was such that you want to participate." The first officer also reported the captain to have a good rapport with the flight attendants.

Three first officers who had previously been paired with the accident captain were interviewed, and all had similar positive comments about both his interpersonal and piloting skills. The captain was described as approachable, straightforward, pleasant, and detail-oriented. He was reported to put others at ease, both pilots and flight attendants alike, and to provide good briefings.

The accident flight was the first of a scheduled three-day trip for both pilots, with three legs on the first day of duty. The captain resided in Buffalo, NY. From December 4 through 7, 2005, he was off-duty. On December 8 he commuted to BWI from Buffalo, with a scheduled departure and arrival time of 1125 and 1240, respectively. He was on duty that day from 1450 to 2130 eastern standard time (EST[6]; 6 hours 35 minutes duty time, 2 hours 24 minutes flight time).

The captain stated he had received a good night's sleep the night before the accident and awoke about 0830 on the day of the accident. He said he slept through his alarm that morning because he "didn't feel like getting up and liked to make sure he had a good night's sleep prior to his trips, especially if they were PM shifts." He ate breakfast, packed, and left for the airport about 1000.

According to SWA records, during the preceding 30 days the captain had flown approximately 10 days with 20 days off. He accumulated approximately 55 and 12 flight hours in the previous 30 and 7 days respectively. The captain's flight schedule intervals were as follows: 4 days off, 3 days on (AM shift), 9 days off, 4 days on (AM shift), 3 days off, 3 days on (PM shift), 4 days off, 1 day on (PM shift, accident flight). His AM shifts for this period started with a report time between 0525 and 0935 and ended between 1225 and 1735 hours; the PM shift started with a report time between 1115 and 1650 and ended between 2057 and 0045 hours.

A review of the National Driver Register for the captain found no record of suspension or revocation.

[6] All times in this section reference eastern standard time.

A review of the captain's medical records did not reveal any noteworthy issues.

Post-accident drug testing[7] was conducted in accordance with FAR Part 121, Appendix I-J, with negative results. Although not required by law, the captain also volunteered blood samples for analysis[8] within 24 hours of the accident. The results were negative.

F.2.2 First Officer

At the time of the accident, the first officer, age 34, held an airline transport pilot certificate with airplane multi-engine land ratings and type ratings in the 737 and Saab 340, and a commercial certificate with airplane single and multi-engine land ratings. The first officer's most recent Federal Aviation Administration (FAA) first-class airman medical certificate was issued on October 18, 2005.

The first officer was hired by SWA in 2003. Prior to working for SWA, he had flown for Mesaba Airlines in the Saab 340, as a first officer for two years and a captain for four years. Prior to that he worked for Embry Riddle Aeronautical University as the assistant chief flight instructor.

The first officer reported having extensive experience with similar weather conditions as the night of the accident, although these experiences were previous to joining SWA. Since joining SWA he had landed in various conditions of snow with no unusual occurrences, but during this time he had never encountered the weather he encountered the night of the accident. He also stated that the accident approach was less challenging than other approaches in snow conditions that he had made, and he didn't feel uneasy about the conditions, as they were actually better than many restricted visibility landings. They didn't have to try and feel for the runway; they touched down firmly.

The first officer reported that his personal health was good, and that in the past year there had been no financial changes or any significant positive or negative events concerning his family or close friends outside of the birth of his daughter. He said that he did not have trouble going back to sleep when the kids woke him up, that this did not affect him during the day (he did not feel tired). His sleep regime had not changed in the past year. He stated that he didn't believe anything affected his performance on the day of the accident, and that fatigue was definitely not a player in the accident.

The captain's impression upon meeting the first officer was "great," based on his demeanor. He said that the first officer was "awesome to fly with, he was on top of things," and was "one step ahead at all times." The captain also stated that the first officer was very good in terms of checklist protocol.

[7] To include alcohol, amphetamines, cocaine, marijuana, opiates and PCP.
[8] To include alcohol, amphetamines, barbiturates, benzodiazepines, cocaine and metabolite, opiates, phenoyclidine, cannabinoids, methadone, methaqualone, and propoxyphene and metabolite.

Three captains who had previously been paired with the accident first officer were interviewed, and all had only positive comments about his interpersonal and piloting skills. The first officer was described as above average for his experience level, disciplined, professional, conscientious, confident, and with great skills. Further, he was helpful in "staying ahead" of what they needed as a team.

The first officer resided in Albany, New York. From December 3 through 7, 2005, he was off-duty. He commuted to BWI on December 8, 2005. He was on duty that day from 1455 to 2130 (6 hours 35 minutes duty time, 2 hours 24 minutes flight time).

The first officer stated that he had eight hours of sleep the night before the accident flight. He had to be at BWI early for his reserve check-in and went to his crash pad to do laundry, watch television, and take a nap. He stated that he was not tired for the accident flight.

According to SWA records, during the preceding 30 days the first officer had flown approximately 13 days with 17 days off. He accumulated approximately 55 and 12 flight hours in the previous 30 and 7 days respectively. The first officer's flight schedule intervals were as follows: 1 day off, 3 days on (PM shift), 4 days off, 3 days on (PM shift), 3 days off, 4 days on (AM shift), 4 days off, 3 days on (PM shift), 5 days off, 1 day on (PM shift, accident flight). His AM shifts for this period started with a report time between 0500 and 1015 and ended between 1330 and 1723 hours; the PM shifts started with a report time between 1430 and 1710 and ended between 0035 and 0259 hours.

A review of the National Driver Register for the first officer found no record of suspension or revocation.

A review of the first officer's medical records did not reveal any noteworthy issues.

Post-accident drug testing[9] was conducted in accordance with FAR Part 121, Appendix I-J, with negative results. Although not required by law, the first officer also volunteered blood samples for analysis within 24 hours of the accident. The results were negative.

F.3 AUTOBRAKES

This section contains information on autobrakes, to include SWA written guidance,[10] details regarding the autobrakes policy and training program development, interview summary and statements, and information from the Aviation Safety Reporting System (ASRS) database.

[9] Refer to drug test details reported for the captain; testing was identical for both pilots.
[10] Unless otherwise noted, the most current revision at the time of the accident is referred to in this report.

F.3.1 Written Guidance

The following are excerpts from guidance contained in the Flight Operations Manual (FOM) and Flight Reference Manual (FRM)[11] regarding autobrakes.[12]

FOM Chapter 2 - Limitations
Pages 2.1.1 to 2.3.11
- Autobrakes policy described

FOM Chapter 3 – Normal Operations
Pages 3.9.1 to 3.9.9
- OPC Review for Landing: Policy described

Pages 3.22.1 to 3.22.3
- Normal Landing: Manual wheel braking, timing, transition from autobrakes, pressure required

F.3.2 Autobrake Policy and Training Program Development

In August 2004, the vice president of flight operations tasked the Flight Operations Team (FOT) to examine the feasibility of autobrake use in landing, and to present a proposal for such, if warranted. The manager of flight standards led the team and formulated the initial proposal, although the FOT served as the approval authority for the flight operations department. From these efforts, the autobrake operational policy and training package were developed and evaluated.

The following 17 persons served on the FOT: vice president of flight operations, director of flight operations, the assistant director of flight operations, manager of flight operations administration, director of flight operations technical, senior director of standards and training, manager of flight standards, director of standards and publications, manager of flight publications, the director of dispatch, director of flight crew planning and scheduling, senior chief pilot, regional chief pilot, director of flight training center, director of flight training, director of flight operational safety, and manager of flight safety.

According to the manager of flight standards, when he initially started the autobrake project there were pilot misconceptions about its use. He and another checkairman practiced landings with both the 737-300 and 737-700 models to check for

[11] The relevant pages for all FOM and FRM written guidance referenced in this report are included in Appendix 1: FOM Chapter 1, pages 1.2.1 to 1.2.5, Chapter 2, pages 2.1.1 to 2.3.11, Chapter 3, pages 3.1.1 to 3.1.18, 3.9.1 to 3.9.9, 3.13.7 to 3.13.8, 3.15.5 to 3.15.6, 3.16.10 to 3.16.14, 3.20.5 and 3.24.1 to 3.24.8, Chapter 6, pages 6.1.4 to 6.1.7, Chapter 7, Pages 7.2.27 and 7.3.5, Chapter 10, page 10.1.13 and 10.2.15 to 10.2.18, Chapter 11, page 11.1.7, FOM Bulletin 16-05, pages 1-8, FRM pages 8.4.21 to 8.4.25, 8.5.10. FOM guidance prior to and after revision dated November 9, 2005 is included. Additional information is presented in the Operational Factors Group Chairman's Factual Report.

[12] Guidance for use of autobrakes in landing was introduced to the FOM in the November 9, 2005 revision. However, on the date of the accident, autobrakes were not authorized for use at SWA.

aggressiveness and deceleration when using Level 1 through MAX in complete stops.[13] They decided that Level 3 was the best for stopping,[14] ran the numbers, accounted for tailwinds, and "had good correlation." From this, the initial autobrake training package was developed.

The autobrake policy required pilots to use a minimum stopping margin of 500' to determine, in part, if autobrakes are mandatory for a particular landing, and if so, at which setting.[15] The 500' stopping margin was not designed as a minimum requirement to make the landing. According to the FOM, if a 500' stopping margin is not achieved in any autobrake setting, landing is authorized provided a positive stopping margin.

According to the manager of flight standards, several factors were considered for the additional 500'.[16] One was that it provides a "cushion" when autobrakes are used. Through flight tests conducted with the autobrakes under all conditions, they discovered that many of the 140 or so landings were beyond 1500' beyond the threshold, and that for 40% of the landings, the actual touchdown point was approximately 2000' beyond the threshold. Because of this, management decided to use the 500' cushion as the threshold for minimum braking at autobrake Level 2. Another factor for the 500' minimum stopping margin for autobrake selection was the difference in technique and timing between pilots in the transition from auto to manual braking. Finally, braking on the final 500' could be less reliable than on the previous portion of the runway. The manager of flight standards reported pilot survey data indicating perceptions of OPC stopping margins were actually too conservative.[17]

The manager of flight standards stated that he developed the autobrake language, and that much of it was a reprint of the Boeing manual. Boeing guidance for pilots was provided in a two-page section on wheel brakes in the Flight Crew Training Manual (FCTM),[18] and included, in part, the following information:

"MAX: Used when minimum stopping distance is required. Deceleration rate is less than that produced by full manual braking."

"Immediate initiation of reverser thrust at main gear touchdown and full reverse thrust allow the autobrake system to reduce brake pressure to the minimum level. Since the autobrake system senses deceleration and modulates brake pressure accordingly the proper application of reverse thrust results in reduced braking for a large portion of the landing roll. The importance of establishing the desired reverser thrust level as soon as possible after touchdown cannot be overemphasized."

[13] Autobrake settings range from least to greatest rate of deceleration: Level 1, Level 2 = Minimum, Level 3 = Medium, MAX = Maximum)
[14] SWA later added that Level 3 was the best for stopping "in most conditions."
[15] See Appendix 1, FOM Chapter 3.
[16] This line of reasoning is reflected in the autobrakes training materials for checkairmen; see Appendix 2.
[17] See Section F.3.2.1 for breakdown of pilot perceptions.
[18] See Appendix 3; Boeing FCTM pages 6.27 and 6.28.

The autobrake policy and training package were evaluated in two phases, with feedback incorporated prior to each subsequent round. Checkairmen and the first officers they were paired with for revenue flights served as participants in the evaluation process. The first evaluation began in February 2005, and the second evaluation in July 2005.

F.3.2.1 First Evaluation and Results

In the first evaluation, checkairmen were provided with an authorization letter for use of autobrakes, evaluation instructions, FOM/FRM proposed change pages relevant to autobrakes, modified descent checklists, autobrake training handout, autobrake tracking form, autobrake policy and training program evaluations (initial and post), and autobrake landing event summaries (for the pilot flying, PF; and the pilot monitoring, PM). Training flights were excluded and landings were limited to cities with a maintenance base. Checkairmen were instructed to share this information in advance with each of the first officers they were paired with.

After reading the materials and completing an initial survey, checkairmen and their first officers (participants) were instructed to use autobrakes on at least 50% of revenue flights for a period of almost two months (early February 2005 through March 31, 2005). They tracked their landings on a number of dimensions, and completed a post-evaluation survey.

Based on information provided by pilots via the tracking form, there were 1281 landings overall, 1077 (84%) of which were made with the autobrakes. When autobrakes were used, 51% of the landings were made by checkairmen and 49% by first officers. Of the autobrakes landings, 5% were required (based on the proposed policy), and 95% were made at the pilots' discretion. When autobrakes were used, 69% were made at Level 2, 29% at Level 3, 2% at MAX, and less than 1% at Level 1. Minimal feedback was received regarding runway conditions, but at least 28 autobrake landings were made on a wet runway.

For each landing with autobrakes, participants were asked to report if the OPC stopping margin estimates were consistent with the stopping margins achieved. Responses to this question were limited, although there were 224 reports that the estimate was "about right," 25 reports that the estimate was "too conservative," and 10 reports that the estimate was "too small."

Of the autobrakes landings, 44 were made at MDW on runway 31C. Of these MDW autobrakes landings, 27% were required, and 59% were made at the pilots' discretion. Eighty percent of the autobrakes landings were made at Level 3, 16% were made at MAX, 4% at Level 2, and none at Level 1. At least four of the autobrakes landings were made on a wet runway. Of the MDW autobrakes landings, pilots reported on 21 occasions that the stopping distance estimate was "about right," on five occasions that it was "too small," and on three occasions that it was "too conservative."

Initial and Post Evaluations

The initial and post evaluation forms each included five questions. Two hundred fifty pilots responded to the initial evaluation (75 checkairmen, 175 first officers), and 209 pilots responded to the post evaluation (60 checkairmen, 149 first officers). Pilots participated in an average of 6-7 landings (range 2 to 40 landings; 1411 total reported) as either the PF or the PM. Of the checkairmen, 73% reported having no previous experience with autobrakes, 15% reported having minimal previous experience, and 10% were well experienced. Of the first officers, 86% reported having no previous experience with autobrakes, 5% reported having minimal previous experience, and 7% were well experienced.

Participants were asked if the FOM guidance provided clear guidance for safely and accurately performing the PF and PM roles during autobrake landings in the aircraft. Responses were made on a 1-5 Likert scale (1 = strongly agree to 5 = strongly disagree). For the initial survey, 34% reported strong agreement (Likert scale 1) and 60% reported agreement (Likert scale 2). For the post survey, 35% reported strong agreement (Likert scale 1) and 56% reported agreement (Likert scale 2).

Participants were asked if the proposed training materials provided sufficient information to safely and accurately perform the PF and PM roles during autobrake landings. Responses were made on a 1-5 Likert scale (1 = strongly agree to 5 = strongly disagree). For the initial survey, 40% reported strong agreement (Likert scale 1) and 56% reported agreement (Likert scale 2). For the post survey, 42% reported strong agreement (Likert scale 1) and 53% reported agreement (Likert scale 2).

Prior to autobrake use, 18% of participants reported having spoken with someone in advance about the use of autobrakes, to include either the pilot they were paired with or another pilot, and 51% reported that they did not.

At the completion of the evaluation, participants were asked if they had confidence that the average line pilot could successfully perform autobrake landings using the training product. Responses were made on a 1-5 Likert scale (1 = strongly agree to 5 = strongly disagree). Forty six percent reported strong agreement (Likert scale 1) and 48% reported agreement (Likert scale 2).

Landing Event Summaries

After the autobrake evaluation period, pilot participants also completed a summary evaluation form. Pilots each completed two versions, one from the PF and one from the PM perspective. Two hundred sixty five participants (93 checkairmen and 172 first officers) completed the landing event summary as the PF, and 257 participants (96 checkairmen and 161 first officers) completed the landing event summary as the PM.

Pilots flying were asked how the autobrakes affected their lowering the nosewheel to the runway (Likert scale 1 to 3). Eighty three percent reported that there

was no noticeable effect, that they lowered the nosewheel as smoothly as they always do, 15% reported that the effect was smooth, but noticeable, and that they had to use extra back pressure to counter the autobrakes, and 1% reported that the touchdown was firm, and that they autobrakes forced the nosewheel down faster than they wanted.

Pilots flying also were asked about their experience in the transition from autobrakes to manual braking (Likert scale 1 to 3). Sixty seven percent reported that there was no problem, that they used the new FOM procedure and it worked great, 28% reported that they had some problems, that they didn't like some aspect of the stopping procedure, and 5% had problems, in that something didn't work very well at all.

Pilots flying also reported if they heard the PM callout for "Autobrake Disarm," if applicable (Likert scale 1 to 3). When applicable, 15% reported that they did hear the callout, and 14% reported that they did not.

Finally, pilots flying were asked about their experience in transitioning from autobrakes to manual braking on the landing rollout (Likert scale 1 to 3). Sixty six percent reported that they had no problem, that they applied manual braking and the autobrakes disengaged smoothly, and 29% of the pilots had some problems and didn't like some aspect of the transition.

Pilots monitoring were asked about their autobrake landing experience (Likert scale 1 to 3). Eighty percent reported that there was no problem, things worked just as advertised, 17% reported that there were some problems, that it was good except for a minor thing or two, and 2% reported that they had problems, a major glitch that has to be addressed.

Pilots monitoring also were asked about the autobrake disarm light illumination and their callout (Likert scale 1 to 3). Fifty eight percent reported that there was no problem, that it came on, they saw it, and made the required callout, 10% had some problems, that they didn't notice the light coming on so they called it late, and 5% reported that they had problems, that they didn't notice the light or didn't make the required callout.

F.3.2.2 Second Evaluation and Results

For the second evaluation, training and manual guidance materials were revised according to the input received from the first evaluation. In an interview, the manager of flight standards reported the following about the summary of feedback from the first evaluation and differences incorporated in the training materials:[19]

"The biggest problem noted in the feedback from the first survey was that pilots experienced difficulty disarming the autobrakes in the -700 because of the amount of pedal pressure. The other was a pilot disarm call below 80 knots, which changed to any

[19] For details of pilot narrative feedback see Section F.3.2.3 below.

time during the landing roll to monitor failure and promote situational awareness. Other feedback was about the training package. Four of about 250 survey inputs (about 1300 landings) said FOs delayed reverse thrust during their first landing with autobrakes, although it didn't happen with captains. No reason was listed; the interpretation was that it was because they were distracted when paying attention to the reaction of the autobrakes.[20] *There were no complaints that the autobrakes were rough.*

To summarize the first survey, the disarm call was awkward, the text was not clear, and there were instances of delayed thrust reverser input so they came up with a new package.

The second package had new language which expanded on autobrake 1 nonuse, improved language in the training handout and added next generation versus classic disarm emphasis. There was 97-99% satisfaction on the language change.[21]

For the second evaluation, the autobrakes training packet sent to checkairmen included an authorization letter, evaluation instructions, autobrake evaluation results for the first evaluation, FOM/FRM change pages relevant to autobrakes, modified descent checklists, autobrake training handout, autobrake tracking form, and a post evaluation survey. The information also was posted on the company website for both checkairmen and first officers to review.

Training flights were not excluded in this round of evaluations, and pilots in training (Initial Operations Experience, IOE; Upgrade Operations Experience, UOE) received their own package in advance of the evaluation flights. It was the decision of the checkairman to determine when autobrakes would first be used with a pilot in training. Landings were not limited to cities with a SWA maintenance base, and checkairmen were advised to use autobrakes for every landing that was permissible.

Post Evaluation

For the second evaluation, 84 pilots (21 checkairmen, 63 first officers) responded to the post evaluation survey, for a total of 905 reported landings (411 checkairmen, 494 first officers).

Participants were asked if the FOM guidance provided clear guidance for safely and accurately performing the PF and PM roles during autobrake landings. Responses were made on a 1-3 Likert scale (1 = agree, 2 = in the middle, 3 = disagree). Ninety eight percent reported agreement (Likert scale 1) and 2% reported a neutral level of agreement (Likert scale 2).

[20] The manager of flight standards also stated that for the second trial, out of 1000-1200 landings and 100 surveys, there was one FO who delayed, not forgot, the use of thrust reversers; the FO was concentrating on the feel of the autobrakes and forgot or got distracted from using thrust reversers immediately. See Section F.3.2.3 below for specific pilot comments.

[21] According to the director of flight operational safety, there were no changes in the training handout for checkairmen between the first and second evaluations; see Appendix 2.

Participants were asked if the proposed training materials provided sufficient information to safely and accurately perform the PF and PM roles during autobrake landings in the aircraft. Responses were made on a 1-3 Likert scale (1 = agree, 2 = in the middle, 3 = disagree). Ninety nine percent reported agreement (Likert scale 1) and 1% reported disagreement (Likert scale 3).

Pilots also were asked about their experience in the transition from autobrakes to manual braking (1-3 Likert scale). Eighty two percent reported that there was no problem associated with the use of the new FOM procedure and it worked great, and 18% reported that they had some problems, that they didn't like some aspect of the stopping procedure. Of the 18% (15 pilots) who reported some problems, five were checkairmen that may have had experience with the autobrakes in the first evaluation. There were no reports of more serious problems, in that something didn't work very well at all.

Pilots also were asked about the autobrake disarm light illumination and their callout (1-3 Likert scale). Eighty five percent reported that there was no problem, that it came on, they saw it, and made the required callout, 15% had some problems, that they didn't notice the light coming on so they called it late. Of the 15% (13 pilots) who reported some problems, three were checkairmen that may have had experience with the autobrakes disarm light in the first evaluation. Only one pilot, a first officer, reported having problems (not noticing the light or not making the callout).

Pilots also reported if they heard the PM callout for "Autobrake Disarm," if applicable (yes/no response). All but three (96%) reported that they did. Of the three who did not hear it, two were checkairmen and one was a first officer. Finally, pilots were asked if the issues raised in the preliminary evaluation had been adequately addressed (yes/no response). All but three (96%) reported that the issues had been, and the three that did not were all first officers.

F.3.2.3 Evaluation Narrative Responses

For each evaluation form, pilots were encouraged to clarify or expand on their numerical responses in narrative format. There were many positive comments regarding the content of the materials and the autobrakes themselves. Investigators reviewed narrative data for suggestions and constructive feedback on selected topic areas:[22]

Overall concerns prior to use

- Amount of pedal pressure
- Rudder inputs
- Amount of yoke back pressure
- Differences in lowering the nose
- Disconnect method and transition
- Procedures if system fails to disconnect

[22] A selection of specific comments for all autobrake evaluation forms is detailed in Appendix 4.

500' margin guidance
- Confusion in interpreting
- Margin of error in landing distance estimates

Training information summary preferred

Autobrakes disarm light
- Potential distraction of monitoring autobrake disarm light
- Difficulty for captain to see light (especially for taller persons)
- Failure of light to illuminate
- Failure to monitor light

Suggestions for initial use
- Long runway
- Not on a wet runway
- No performance issues (long/dry) with Min(2) setting

Transition from auto to manual braking
- More pressure needed than expected
- Unable to disconnect
- Methods of disconnecting
- Confirming disconnection
- Associated lurch
- Time required to become comfortable with process

Approach and landing flow
- Difficulty of new flow for FOs
- Need to have attention outside (not inside) on the landing roll
- PF versus PM responsibilities
- Need definition of flow when on HGS approach to low minimums
- Possibility of forgetting thrust reversers in process of monitoring autobrakes

The following comments are relevant to thrust reverser issues in the new flow:[23]

"Easy to forget thrust reversers while caught up in the autobrake landing sensations, getting the nose down early, and lightshows."

"Recommend stressing the possibility of 'forgetting' to apply reverse thrust due to aircraft decelerating with autobrakes. At least during initial transition phase, 3 first officers were late in applying reverse thrust (out of 19 landings)."

"I initially forgot to deploy the thrust reversers immediately but (the) check pilot caught it. Thrust reversers were deployed. I seemed to focus on the autobrakes landing."

[23] The number of quotes cannot be said to reflect discrete events.

"I landed hard on first landing and did not do very well (BWI). The second landing was MDW with a nice landing but I failed to apply 65% reverse thrust. I only went to approximately 30%. The brakes, however, worked very well."

"Landing in level 2 on a long, dry runway, pilot flying (FO) was very late to actuate reverse thrust (probably due to his distraction performing his first autobrake landing)."

"Due to my monitoring for 'disarm light' I noticed the lack of reverse later than I normally would have. I will now brief as a reminder to do everything as we always have (e.g., thrust reversers, confirm speedbrake deployment, etc.) Again, I think this occurred simply due to the distraction and anticipation of determining how the aircraft would brake."

"Forgot reverse initially."

"All three FO's when trying autobrakes for the first time were so engrossed with it that they did not apply thrust reversers on landing and had to be reminded. PM's need to be warned and ready for PF's first time to land with autobrakes."

"Trying to take to aircraft I found the FO did not start stowing the thrust reversers. Maybe the speed to transfer control (80kts) is too early."

"Had two FO's seem to forget we still use reverse thrust."

"I used the reverser a little late on the first landing because I was so focused on the procedure. Okay since."

F.3.3 Interview Summaries and Statements

Responses for selected questions related to autobrakes were summarized for interviews conducted with pilot management personnel and SWA pilots other than the accident crew.[24]

All 13 pilots who were asked understood that autobrakes were not authorized for use until further notice. Of the ten pilots who reported having read the training materials, all reported believing that the materials were adequate; this included two checkairmen, who also had not heard any complaints from pilots, and one simulator instructor.[25] Only two pilots reported having previous experience with autobrakes, one in a B-747 aircraft, and one in a B-737 simulator during SWA recurrent training.

[24] See the Operational Factors Group Chairman's Factual Report for a list of interviewees. Not all interviewees were asked all questions.

[25] Training materials for line pilots are referred to in the Operational Factors Group Chairman's Factual Report, Attachment #7; training materials for checkairmen are referred to in Section K of this report.

Of the nine pilots asked, six stated they would feel comfortable using autobrakes for the first time after receiving the training materials, even under adverse weather conditions. One checkairman stated that he was not aware of any apprehension regarding autobrake reliability among the pilots. A different checkairman stated that he would be concerned about using MAX autobrakes during the accident conditions for the first time, although he would do so if required by the OPC. A simulator instructor stated that he would rather try the autobrakes out first in favorable conditions, as with any like system.

F.3.4 ASRS Data

There were seven reports in the ASRS database relevant to autobrakes.[26] One event involved a runway overrun resulting from failure of the autobrakes. For three events the autobrake landing resulted in blown tires because the autobrakes did not work properly or at all. For two events the tires were damaged through the normal autobrake landing process. One event involved a wiring problem with the anti-skid system.

F.4 BRAKING CONDITION REPORTS

This section contains information on the interpretation, use and reporting of braking/surface conditions, to include SWA written guidance, interview summaries and statements, and weather-related ASRS reports for MDW airport.

F.4.1 Written Guidance

The following are excerpts from guidance contained in the Flight Operations Manual (FOM) and Flight Reference Manual (FRM) regarding braking/surface condition reports. [27]

FOM Chapter 2 - Limitations
Pages 2.1.1 to 2.3.11
- Landing is not authorized when braking action reported as NIL by measurement devices or air carrier jets
- Tailwind component maximums for various braking conditions

FOM Chapter 3 – Normal Operations
Pages 3.9.1 to 3.9.9
- OPC Programming for Landing: Enter runway conditions based on braking reports
- Landing not authorized when braking action reported as NIL by measurement devices or air carrier jets

Pages 3.23.1 to 3.22.6[28]
- Braking action, reporting, using, sources

[26] Search request No. 6719. One of these events also was included among the thrust reverser events.
[27] See Appendix 1 and the Operational Factors Group Chairman's Factual Report.
[28] Current guidance regarding classification of mixed braking action reports has been in place since Rev 2-04, dated April 20, 1994.

- Preparation for deteriorating braking conditions
- Reporting conditions to controller
- Runway friction reports and scale conversions for three tests

- Landing under braking advisories less than GOOD
  - Mixed braking action reports

FOM Chapter 6 - Communications
Pages 6.1.4 to 6.1.7
- Communication with dispatch regarding weather
- Pilot responsibility for reporting to ATC when braking condition is less than GOOD

FOM Chapter 7 – Topical Information: Dispatch Responsibilities
Page 7.3.5
- Issuance of a Weather Advisory Message by Dispatch when operation at a particular airport doubtful

FOM Chapter 10 - Performance
Page 10.1.4
- Runway conditions definitions

Pages 10.1.13, 10.2.15 to 10.2.18
- Advisory Information: Landing distance performance charts

FRM – Onboard Performance Computer
Pages 8.4.21 to 8.4.25
- Computing Landing Performance: Runway Condition (no mention of mixed conditions)

F.4.2 Interview Summaries and Statements

Responses for selected questions related to braking condition reports were summarized for interviews conducted with pilot management personnel and SWA pilots other than the accident crew.[29]

Of 11 pilots who were asked, 10 reported that they would revert to the worse of the two braking conditions if it were mixed, and would take the more conservative approach. A few pilots specifically recalled this topic from training, although none recalled it being in the FOM or were certain that the policy was in the written guidance.

One pilot was issued a FAIR/POOR report on the night of the accident, and chose FAIR because "he decided that he and the FO would take advantage of their experience." When subsequently asked what the company procedure was regarding how to handle mixed braking reports, he responded that he believed that you are to revert to the worst condition but that he wasn't sure.

[29] See the Operational Factors Group Chairman's Factual Report for a list of interviewees. Not all interviewees were asked all questions.

One checkairman stated that he considers mixed braking reports a gray area, that there is no exact definition of GOOD/FAIR/POOR when used in braking action reports. He reported believing that most pilots know that they should use the worst condition in a mixed braking action report, and that he would. He further stated, "SWA pilots don't want to be the bad guys and stop the operation with a NIL report." Another checkairman stated that most, if not at all times, pilots say they'd take the worse case scenario.

Four of the five pilots asked offered that braking action reports from a company aircraft would be more meaningful and accurate than would reports from other aircraft. However, there were mixed accounts of how reports from general aviation (GA) jet aircraft would be used. One pilot stated that if a Citation reported FAIR to POOR, he would interpret this as NIL for his aircraft. Another pilot reported that if a GIV landed in front of him and reported the braking action NIL, because the GIV is also heavy, he would not have landed. This same pilot stated that if it were a Citation that reported NIL braking action, he would have waited for another report.

A checkairman stated that there is no crew training on braking action reports; it comes through experience. To the best of his knowledge, there was nothing in the airman's information manual (AIM) that quantified GOOD/FAIR/POOR/NIL values. For him, it is about learning the experience of antiskid cycling and the braking feel on the runway. He stated that if a GA aircraft reported NIL braking action, he wouldn't disregard it, but he also wouldn't shut down the operation because of it.

Another checkairman stated that pilots are taught to consider all the information at their disposal when considering GA braking action reports, but it is up to the captain to make the final decision. If he were in a scenario similar to the accident aircraft, he would give more credence to a SWA aircraft. If a GA aircraft reported NIL, he would look at the parameters. If it was a C421 it would not be as severe but he would consider it. If a NIL braking action report issued by the tower was received from a GA aircraft, he was not sure if he could use this information to land (he would have to look this up in the FOM). As a checkairman, he felt that SWA pays and trains pilots to make correct decisions in the name of safety. "If a scenario was that close, maybe they should be looking to go somewhere else." He further reported that when in the simulator with pilots, he did not give poor braking action scenarios.

In an interview, the OPC flight training instructor spoke about how he teaches pilots to enter surface condition information into the OPC landing performance module. He first stated that there is no toggle for clutter, and that if clutter exceeds the max that dispatch had planned for, pilots would determine if they'd have to go somewhere else by first asking for a braking condition report to determine which to toggle. He further stated that mixed reports are based on the worse condition, that FAIR to POOR or POOR would both be a POOR input. He tells pilots that, "If you hear POOR at all, you put POOR, if you hear FAIR at all, you put FAIR. You put the worse that you hear." He also stated that there is no distinction made between where the braking reports are coming from.

Only three pilots were asked if they recalled the maximum tailwind component limitation for POOR braking conditions. Two correctly recalled that there is a 5kt maximum tailwind component limitation with POOR braking conditions, although one stated that it only had to with visibility (5kts maximum with RVR<4000).[30]

F.4.3 ASRS Data

There were five ASRS reports related to tail wind landings at MDW.[31] Four of the 5 events were on runway 31C, and one event was on runway 4. For the events on runway 31C, one was an overrun (Boeing 757), two were near runway overruns, and one involved an aircraft landing short of the displaced threshold. According to the pilot reporters, the wind direction varied between 100 and 210, at a velocity of between 8 and 15kts. Two of these events were associated with rainy conditions. For the event on runway 4, the pilot reported that preference is given to Chicago O'Hare (ORD) traffic to the detriment of MDW traffic.

There were five other ASRS reports related to weather at MDW.[32] Three of these events are relevant to the current accident, all reported in 2002.[33]

A 737-800 overran runway 4 by 25' when making a night landing in snow. Although the braking action was reported by ATC as FAIR, the pilots found the actual braking action to be between FAIR, POOR and NIL, as the runway progressed. Maximum braking and thrust reverse was used, and the reported surface winds were 080/10. The pilots reported a landing weight of 122,000lbs.

Gusty winds in snowy conditions prompted captains of two different aircraft (B737; same company) to recommend that Dispatch suspend operations at MDW. The pilot reporting was disappointed that the response of Dispatch was only to warn incoming crews of the gusty winds.

A Falcon 2000 aborted a takeoff and overran runway 31C at MDW. The reported wind conditions when retrieved 12 minutes prior to the takeoff were 260/21G30, although the reported winds at brake release were 260/32G41. The pilot did not request nor did he recall receiving an updated weather report prior to the takeoff.

In addition to the takeoff and landing reports filed by pilots, another related report was filed in 1991 by a MDW tower controller, who stated the following:[34]

"At MDW if we use runway 13 ILS we severely impact the operation at ORD. Many supervisors and controllers will either report the wind (or instruct the individual doing the weather to report the wind) to be more in line with our desired runway

[30] FOM Chapter 2 – Limitations, the limitation is 10kts with RVR < 1600 or < 4000; See Appendix 1.
[31] Search request No. 6713. Accession No. 593584, 356176, 319960, 281657 and 96266.
[32] Search request No. 6717.
[33] Accession No. 540644, 540459 and 536786.
[34] Accession No. 168968.

configuration than it really is. This "shading" can be as much as 20-30 degrees and/or up to 10kts… I do not believe that many controllers truly understand the effects that the wind has on aircraft."

F.5 REVERSE THRUST

This section contains information on reverse thrust, including operational guidelines, reverse thrust credit in OPC landing distance calculations, and potential difficulties in deployment. SWA written guidance is provided followed by interview summaries and statements, irregularity reports, and ASRS data.

F.5.1 Written Guidance

The following are excerpts from guidance contained in the Flight Operations Manual (FOM) and Flight Reference Manual (FRM) regarding operational considerations in the use of reverse thrust and reverse thrust credit in landing distance calculations. [35]

FOM Chapter 2 – Limitations
Pages 2.1.1 to 2.3.11
- Landing is not authorized when either thrust reverser is inoperative and braking conditions are less than GOOD.

FOM Chapter 3 – Normal Operations
Pages 3.9.1 to 3.9.9
- Requirements for Landing: Landing is not authorized when either thrust reverser is inoperative and braking conditions are less than GOOD.
- OPC Requirements for Landing: Autobrakes are recommended if either thrust reverser is inoperative

Pages 3.22.1 to 3.22.3
- Normal Landing: Initiation of reverse thrust

Pages 3.23.1 to 3.22.6
- Landing under braking advisories less than GOOD: OPC deceleration for -700 based on a combination of reversers and brakes
- Application of brakes and reverse thrust

FOM Chapter 10 – Performance
Pages 10.1.1 to 10.1.10[36]
- OPC Normal Landing Overview: *"The stop margins include the effects of reverse thrust (-300/-500: stop margins do not include the effects of reverse thrust)."*

[35] See Appendix 1 and the Operational Factors Group Chairman's Factual Report.
[36] Current guidance regarding differences between aircraft models in the inclusion of thrust reverse for advisory landing performance calculations has been in place since Rev 03-05, dated November 9, 2005. From December 1997 through November 2005, guidance stated only that thrust reverse was not included in the advisory landing performance data.

- Approximate Stop Margins: *"The MAX distance based on maximum manual braking (without the use of thrust reversers) at touchdown."*

Page 10.1.13

- Stop Margins (no mention of reverse thrust)

FOM Bulletin 16-05 – Electronic Weight and Balance[37]

Page 8

- Landing Output Screen: Stop margins defined (no mention of reverse thrust)

FRM – Onboard Performance computer

Pages 8.4.21 to 8.4.25

- Landing Output Screen (no mention of reverse thrust)

Page 8.5.10

- Stop Margins (distance for MAX braking is without the use of reverse thrust)

F.5.2 Interview Summaries and Statements

Interviews were conducted with pilot management personnel and SWA pilots other than the accident crew.[38]

Eight pilots, including a simulator instructor and a checkairman, were asked whether the OPC included the use of reverse thrust. Only two reported that reverse thrust was not factored into the landing output, and the remaining reported correctly that the inclusion depended on the model. The checkairman stated he believed most instructors understood reverse credit in the OPC, and that although not emphasized, most pilots caught it in the differences training.

The OPC flight training instructor stated the that there was a slide in the PowerPoint presentation about the differences between thrust reverse in –300/-500 versus –700 landing distance calculations in the OPC.

The simulator instructor reported familiarity with the pilot mentality that because the reverse thrust is not included in the calculations, the stopping margin will be larger when reverse thrust is used. His typical response is to remind pilots that thrust reversers are not guaranteed to work, and that as a personal guideline, he wouldn't factor them in his landing decision. That said, he reported that he did not believe that pilots would look at data for the –700 and consider that they really have no extra margin because thrust reverse is included.

Two of the 17 pilots asked reported having experienced difficulty in deploying thrust reversers. One pilot stated that the difficulty with deployment occurred several times per year, and another stated that sometimes it required a "yank." The remaining 15

[37] Bulletin 16-05 is dated August 9, 2005. Previous to September 2004, landing distances were presented in the OPC as feet required to land, versus stopping margin.

[38] See the Operational Factors Group Chairman's Factual Report for a list of interviewees. Not all pilots were asked all questions.

reported that they have not had difficulty, nor have they heard of others having difficulty with deploying the thrust reversers, aside from occasionally not waiting long enough at the interlock for the delay. A checkairman and the manager of training stated they sometimes see this in the simulator, although it is resolved prior to going on the line; a simulator instructor stated he's never seen it in the simulator.

F.5.3 Irregularity Reports

After learning of the accident, one SWA pilot filed an irregularity report with the company indicating that he was unable to deploy the thrust reverse on the first attempt in landing at MDW at 1730 on December 8, 2005. He was able to do so upon re-attempt with no adverse consequences. He estimated that this resulted in a 4-second delay in deployment.

SWA pilots who had flown the accident aircraft for the ten flights before the accident reported no difficulties in deploying the thrust reversers for that aircraft.

On April 27, 2006, SWA issued a Read Before Fly (RBF) bulletin asking pilots to report any problems initiating movement of one or both of the thrust reverse levers in a B737-700 aircraft.[39]

F.5.4 ASRS Data

There were 15 reports in the ASRS database relevant to thrust reverse.[40] Of the 14 reports for which aircraft type was specified, one involved a 737-300. None of the events were described by the pilots as those in which the thrust reverse levers were difficult to engage or were immovable.

F.6 OPC and HGS

This section contains information on use of the OPC and HGS in general, as well as the HGS/AIII and RVR<4000 selections in the OPC. SWA written guidance is first provided, followed by a summary of and selected pilot comments.

F.6.1 Written Guidance

The following are excerpts from guidance contained in the Flight Operations Manual (FOM) and Flight Reference Manual (FRM) regarding use of the OPC in general and in the HGS AIII or RVR<4000 selections.[41]

FOM Chapter 3 – Normal Operations
Pages 3.9.1 to 3.9.9

[39] See Appendix 5.
[40] Search request No. 6718.
[41] See Appendix 1 and the Operational Factors Group Chairman's Factual Report.

- OPC Inoperative Procedures
- Select HUD/AIII or RVR<4000, if required (complete description)

Pages 3.15.5 to 3.15.6
- HGS ILS Approach Profile: Approach may be continued with Approach Warning if runway is in sight (actual runway)

Pages 3.16.10 to 3.16.14
- HGS ILS Approach Profile: Approach may be continued with Approach Warning if runway is in sight (actual runway)
- Deviation callouts AIII HGS approaches, "company" procedures, crew coordination

Page 3.20.5
- HGS AIII approach guidelines

FOM Chapter 10 – Performance
Pages 10.1.1 to 10.1.10
- Dispatch Landing Module
- OPC Failure Procedure
- Selection of 'HUD/AIII' required for all HGS AIII approaches; 1000' increase in landing distance
- Significance/interpretation of landing advisory data (braking effort)

FOM Bulletin 16-05 – Electronic Weight and Balance
Pages 7 and 8
- OPC inoperative procedures
- Landing Output Screen: Stop margins defined.

FRM – Onboard Performance Computer
Pages 8.4.21 to 8.4.25
- Landing Performance Module: Computing Landing Performance
- Landing Output Screen

F.6.2 Interview Summaries and Statements

Responses for selected questions related to HGS/AIII and RVR<4000 selections in the OPC were summarized for interviews conducted with pilot management personnel and SWA pilots other than the accident crew.[42]

All five pilots that were asked understood that by selecting the HGS/AIII mode on the OPC the required landing distance would be increased by 1000' on account of the landing flare profile. Two pilots reported that if AIII were to be selected on the HGS, the same setting was required in the OPC, although one stated that he doesn't always match the OPC and HGS settings. However, pilots gave varying accounts of whether the pilot could disregard landing and flare cues once visual cues were obtained during an AIII Approach.

[42] See the Operational Factors Group Chairman's Factual Report for a list of interviewees. Not all interviewees were asked all questions.

In an interview, the director of flight operations technical was asked to clarify the effect of selecting RVR<4000. He reported that selecting this box has absolutely no bearing on the stopping margin output, but is simply an operations spec requirement based on weight. It determines if the field length is longer than is available, based on dispatch field length requirements.

The FAA POI for SWA stated that the category for RVR<4000 takes into account the 115% rule that dispatch must follow for landing weight (but does not alter the distance output).

The OPC flight training instructor spoke about what he teaches pilots regarding selection of the HGS/AIII button in the OPC landing performance module. He stated that the HGS/AIII button is only to be selected if, in fact, an AIII approach will be conducted, because in following the flare cue it adds 1000' to the landing. He further stated that the HGS/AIII button should be selected even if the captain chooses not to use the flare cue in an AIII approach. For example, even if when shooting a CAT I approach the AIII mode is chosen, the pilot would still need to select the AIII mode on the OPC.

The OPC flight training instructor spoke about what he teaches pilots regarding selection of the RVR<4000 button in the OPC landing performance module. He stated that pilots have to consider this based on the visibility requirement, and that this may affect your stopping margin. He stated that if DRY plus 15% (ops spec) is still inside of the other stopping margin, then it won't affect it (the stopping margin). He further reported that there are cases where pilots would need to select both the AIII and the RVR<4000 buttons, and that he has not had questions or sensed confusion from pilots on these issues.

F.7 HOME STUDY PACKETS

As a part of recurrent training, SWA requires pilots to complete a home study exam twice per year to increase pilot familiarization with pilot operations.[43] Exams are open-book and the 100 questions are developed from the FOM text. Pilots are provided approximately 30 days to complete the exam, and disqualified from flying status if they have not accomplished the exam by the due date with a passing grade of at least 80%. Responses are completed, submitted and scored on-line through the company website.

Failure of a submitted exam causes an onscreen notification to the pilot, indicating his/her disqualification from flying, to include training. Simultaneously, email notification of the disqualification is sent to the pilot's chief pilot, to crew scheduling and the Flight Training Center. In the event of a failure, the pilot receives feedback regarding the topic areas for the incorrect exam items and where answers are located in the FOM. When a pilot passes the exam, the on-line record-keeping system automatically posts the pass status to the pilot training records, which automatically creates the next recurrent

[43] See page 07.50.01 of the SWA Flight Operations Training Manual, Appendix 6.

due date for the home study exam. Because only passes are recorded, there is no method for SWA to track the failure rate.

A review was conducted on the two home study examinations dated April and October 2005, successfully completed by both accident pilots.[44] Across both exams, there were three questions on thrust reverse, four questions on braking action, two questions on anti-skid, five questions on the HGS, and four questions on the OPC. A selection of relevant questions follows, with the correct answers presented in bold.

If MIN BRK is bracketed on the OPC Landing Output screen, wheel braking should begin:

A) Immediately after nose wheel touchdown
B) At 100 knots
C) At 80 knots
D) At 60 knots

Takeoffs or landings will not be attempted if braking action on the _____ is reported "nil" by air carrier jet aircraft.

A) Taxiways
B) Ramps
C) Any portion of the runway
D) All of the above

The thrust reversers can be deployed if:

A) Air/Ground safety sensor is in the GROUND mode
B) Either radar altimeter senses less than 10 feet
C) Fire switch is down
D) C and either A or B

During a normal landing, reverse thrust should be initiated as the nose wheel touches down, attaining a minimum of ____% N1.

A) 46
B) 55
C) 65
D) 80

When landing on runways with braking action reported less than GOOD, use reverse thrust between a minimum of _____ percent N1 to a maximum of go-around N1.

A) 65
B) 75
C) 85
D) 95

[44] No records of performance details are maintained.

If the AIII mode of the HGS will be used for landing, the "HUD/AIII" button must be selected on the OPC landing input screen. How much will this increase the required touchdown distance?

A) 500 feet
B) 850 feet
C) 1000 feet
D) 2000 feet

If your aircraft's registration number does not match the one on the Onboard Performance System page:

A) You must contact maintenance or Dispatch
B) There is no problem as long as your aircraft is the same model B-737
C) You may change the registration number on the Module Menu page
D) You must click on the "Change..." button to select the correct tail number

If the OPC self-test fails:

A) Make an entry into the Aircraft Logbook and immediately contact Dispatch
B) Reboot the OPC
C) There is no relief in the MEL
D) Ground Ops must reload the software

During landing, the ground spoilers deploy automatically with the Speed Braked ARMED and:

A) The Nose Gear Safety Switch in the Ground mode
B) Any two main wheels spin up
C) The right main landing gear strut compresses
D) The thrust reversers deployed

F.8 CRM AND DECISION MAKING

This section contains information on CRM and decision making, to include SWA written guidance, the CRM training, and interview summaries and statements.

F.8.1 Written Guidance

The following are excerpts from guidance contained in the Flight Operations Manual (FOM) and Flight Reference Manual (FRM) regarding operational priorities and related responsibilities and stopping margins and landing decisions.[45]

Operational Priorities and Related Responsibilities

FOM Chapter 1 – Introduction

[45] See Appendix 1 and the Operational Factors Group Chairman's Factual Report.

Pages 1.2.1 to 1.2.5

- Flight Operations/Flight Dispatch Mission Statement
- Operational priorities (safety first)
- Pilot responsibilities (reasoned decisions; following procedures with occasional deviations accepted if in line with operational priorities)
- "Professionalism vs. Foolish Pride"
- Standardization and coordination

FOM Chapter 3 – Normal Operations
Pages 3.1.1 to 3.1.18

- PF versus PM duties and responsibilities
- Captain responsible for decisions, both responsible to coordinate
- Communicating intentions, deviations, monitoring corrections
- PM can assume responsibility of aircraft if necessary

Pages 3.13.7 to 3.13.8

- Responsibility of either pilot to call for a go-around if approach not stabilized

Pages 3.15.5 to 3.15.6

- Either pilot may call for a go-around

Pages 3.24.1 to 3.24.8

- Joint responsibility of captain and dispatcher for flight

FOM Chapter 7 – Topical Information
Pages 7.2.27

- Crewmembers at controls: For both pilots, seats and rudder pedals must be adjusted prior to final approach

Pages 7.3.5

- Dispatch responsibilities: Dispatch responsibility in diversion process

FOM Chapter 11 – Non-Normal Maneuvers/Profiles
Pages 11.1.7

- Flight Attendant and Passenger Considerations: *Some emergencies may require that passengers deplane a great distance from the terminal area. If, in the Captain's judgment, no danger exists, passengers should be kept onboard the aircraft until stairs are available and deplaning can be accomplished in an orderly manner, with the passengers taking their essential belongings. If passengers remain onboard in these circumstances, at least once door slide must be engaged to provide an immediate passenger egress route."*

Stopping Margins and Landing Decisions

FOM Chapter 1 - Introduction
Pages 1.2.1 to 1.2.5

- Pilots expected to choose runways that meet "safe performance margins," even if the runway is not the primary in use. ("Safe" is not defined.)

FOM Chapter 2 - Limitations

Pages 2.1.1 to 2.3.11
- Aircraft not to land if exceeding OPC or other SWA/FAA approved landing performance data
- 500' and autobrake setting; landing permitted in MAX with positive stopping margin

FOM Chapter 3 – Normal Operations
Pages 3.9.1 to 3.9.9
- Choice of landing runway and prudent decisions
- Aircraft not to land if exceeding OPC landing performance data
- 500' and autobrake setting; landing permitted in MAX with positive stopping margin

Pages 3.15.5 to 3.15.6
- Go-Around Missed Approach Procedures: Initiate if the PIC determines the aircraft will touch down beyond 1500' with an insufficient OPC computed stopping margin

Pages 3.22.1 to 3.22.3
- Touchdown location and OPC computed stopping margins
- *"If touchdown occurs beyond 1500 feet, the ability to stop on the remaining runway may be compromised. Also, if the current conditions are significantly different than the anticipated conditions at the time of OPC programming (e.g., wet runway vs. dry runway, tailwind vs. calm wind), the OPC computed stopping margin may be invalid. If a landing is made in either of these situations, higher than planned braking may be needed to account for the reduced stopping margin. The situation becomes more critical on shorter runways, and in some cases, a go-around may be the better option."*

FOM Chapter 10 – Performance
Pages 10.1.1 to 10.1.10
- OPC Normal Landing Overview
- Approximate Stop Margins
- Significance/interpretation of landing advisory data (braking effort)

Pages 10.1.13, 10.2.15 to 10.2.18
- Advisory Information: Landing distance performance charts

FOM Bulletin 16-05 – Electronic Weight and Balance
Page 8
- Landing Output Screen: Stop margins defined

FRM – Onboard Performance Computer
Pages 8.4.21 to 8.4.25
- Landing Output Screen

Page 8.5.10
- Approximate Stopping Margin

F.8.2 CRM Training

At the time of initial training, the captain and first officer each participated in one full day of ground training specific to CRM. The captain also did the same during

captain upgrade training.[46] The accident captain was hired by SWA in 1995, and completed upgrade training in 2000, and the first officer was hired in 2002. The content is outlined in the Flight Operations Training Manual (FOTM).[47]

Investigators reviewed the 2002 version of the PowerPoint presentations, titled "Captain Leadership," and "First Officer Leadership," for content. Among topics emphasized are the importance of the flight crew "having a game plan," the captain's authority as the one final decision maker, the importance of complying with standard operating procedures, and safety as the number one operational priority.

In the instructor's notes for slides referencing a discussion about authority and decision-making, the instructor is encouraged to emphasize that there is one final decision maker in the airplane, although the entire crew is responsible for doing the right thing, to be personally accountable.

In the instructor's notes for slides referencing a discussion about the crash of United Airlines Flight 173 on December 28, 1978, due to fuel exhaustion, the instructor is encouraged to emphasize the importance and criticality of a shared game plan between the flight crew, and that monitoring or challenging is difficult, if not impossible, without first knowing this game plan.

In the instructor's notes for a slide referencing errors resulting from human limitations, the instructor is encouraged to discuss the cultural issues of pressing to make the schedule or going fast, and how this could lead into a discussion of how SWA pilots have historically behaved differently than other carriers.

In the instructor's notes for a slide listing possible threats, the instructor is encouraged to discuss how the OPC could be a distraction, for example, in the case of a runway change.

In the instructor's notes for a slide listing threat and error countermeasures, the instructor is encouraged to discuss contingency management as a function of planning, and the evaluation of plans as a function of reviewing and modifying.

In the instructor's notes for slides listing types of flight crew errors, the instructor is encouraged to discuss how inadherence to procedures could lead to unnecessarily increased risks, and that deliberate violations and departures from procedure are not tolerated or ignored. "Pressing for the airport" serves as an example of an error that is inconsequential. The manager of CRM clarified and expanded on what is taught in this session:

"*Pressing for the airport is an error that in some cases does have consequences and sometimes does not, as shown by the referenced slides. While that technically makes*

[46] In 2004 changes were made to the Captain Upgrade Training Program; the course was divided into a half- day course at the time of upgrade and a half-day course six months after upgrade.
[47] Appendix 6, FOTM, includes outlines of flight training relevant to CRM.

"pressing for the airport" inconsequential (without consequences) most of the time, in some cases it can indeed be consequential (have consequences.) This is a training example of past error (pressing the airport) which, because of past successes (inconsequential errors), humans can be inclined to repeat. The point of this training module is to teach pilots that when errors are made but do not have consequences, the human tendency is to repeat them. Pilots should learn not to repeat errors simply because they may have made them in the past without consequences."

The manager of CRM stated that the CRM courses for new-hires and captain upgrades cover the same topics, although the leadership aspect is emphasized for the captains, and that assertion receives the most attention in the CRM course, especially for new-hires. He further stated that mixed runway surface braking action reports are not discussed or addressed directly,[48] although SWA takes the approach that safety is the foundation. The CRM courses also do not directly address the issue of legality versus prudence.[49] He thinks that the box SWA pilots operate in is the FOM and "your personal comfort level is within the box, just don't let it go outside the box. In upgrade there is decision-making and its up to you."

The manager of CRM also stated that, "there are many examples of people that didn't want to land that night and didn't. If it doesn't look good, don't do it." He stated that they try to instill in training to be conservative, especially in the first six months. In reference to comfort levels in the cockpit, he stated that, "Between the captain and the first officer, you are looking at multiple experience levels and you will often see someone is more comfortable than the other. Pilots are taught to communicate and find out why one is more comfortable than the other."

F.8.3 Interview Summaries and Statements

Responses for selected questions related to personal limits and company pressure were summarized for interviews conducted with pilot management personnel and SWA pilots other than the accident crew.[50]

All 12 pilots who were asked about their personal limits stated that they would stop short of doing something they felt uncomfortable with, and one pilot specifically stated that he wouldn't make an approach, even if it were legal, if he felt uncomfortable about it. First officers reported that this would involve either communication or, if necessary, taking control of the aircraft. Captains stated that they were responsive to input by the first officer. All pilots asked were aware that either pilot was authorized to initiate a go-around.

[48] According to SWA, runway braking action is addressed in new hire training, recurrent training and upgrade training, as well as in the FOM, pages 3.23.1 to 3.23.4 and 3.9.2 to 3.9.14.
[49] According to SWA, legality vs. prudence is addressed in new hire training, recurrent training and upgrade training, as well as in the FOM, pages 1.2.1 to 1.2.5.
[50] See the Operational Factors Group Chairman's Factual Report for a list of interviewees. Not all interviewees were asked all questions.

Some pilots provided specifics regarding stopping margins and braking categories. One pilot indicated that he would be uncomfortable in making an approach if both the first two braking categories were bracketed (past medium/setting 3). One checkairman stated that with FAIR braking action, he would be uncomfortable with only 800' remaining, and didn't consider 500' an adequate stopping margin in the conditions on the night of the accident. Another checkairman stated that, although dependent on the condition, he would like as much as 200' remaining, but that if only 5' were remaining, he'd take into consideration the tailwind component.

A simulator instructor stated he believed the OPC output to be an approximation, which is why having only several feet remaining wouldn't be sufficient. He further stated, "Even if the pilot did everything by the book, the OPC is a computer model and even though flight test information is valid, it's only a source of information and an approximation."

The crew for a SWA flight that diverted from MDW just prior to the accident was interviewed. They stated that with FAIR in the OPC, they would have had only 500' remaining, and with POOR, only 150' at MAX, with the remaining categories bracketed.[51] It didn't make sense to them to attempt the landing.

All nine pilots asked reported that they have never felt any pressure from the company to complete a flight, to stay on schedule, or to do anything unsafe, nor have they heard of anyone who has. Pilots stated that they believed that SWA supports good decisions. Pilots provided examples of diversions, and reported that at no time were they questioned for these decisions. In fact, one pilot reported routinely increasing the amount of fuel for most flights, as a safety cushion, and has never been questioned about this by the company.

Pilots also acknowledged that this is a business, and like all airlines, they do their best to get customers to where they want to go. One pilot said that he had heard stories where, looking back, the pilot would not have completed the trip in hindsight. However, this was not associated with perceived pressure from the company.

F.9 PREVIOUS NTSB TRAINING RECOMMENDATION (A-00-95)

On August 25, 2000, the NTSB issued Recommendation A-00-095 to the FAA, addressing training for pilots in the use of onboard performance computers. "*The NTSB recommends that the FAA: Require principal operations inspectors assigned to Part 121 carriers that use auxiliary performance computers to review and ensure the adequacy of training and procedures regarding the use of this equipment and the interpretation of the data generated, including landing distance data*."

[51] Differences in stopping margin are, in part, a function of aircraft weight.

This recommendation was generated in association with the investigation of Federal Express Flight 14 in Newark, NJ, on July 31, 1997, involving the crash of an MD-11 in the landing phase. All five occupants received minor injuries, and the airplane was destroyed by impact and a post crash fire. The NTSB determined the probable cause as the captain's overcontrol of the airplane during the landing and his failure to execute a go-around from a destabilized flare. Contributing to the accident was the captain's concern with touching down early to ensure adequate stopping distance. Safety issues include the use of on board computers to determine required runway length for landing.

On November 13, 2000, the FAA responded that that they would issue a flight standards information bulletin to principal operations inspectors as directed by the recommendation. On August 29, 2002, an FAA Flight Standards Information Bulletin for Air Transportation (FASAT) 02-03 was issued to both 14 CFR Part 121 air carrier certificate holders and to principal operations inspectors that oversee them. The bulletin stated, in part, that, "*…the parties are directed to reexamine training and procedures regarding interpretation of the data generated by an auxiliary performance computer, including landing distance data. Inspectors are directed to amend, suspend, or withdraw the authorization in OpSpecs E096 pending effective changes, where necessary, in training and procedures by the certificate holder*." On December 04, 2002, the NTSB classified the recommendation as "Closed – Acceptable Action."

F.10 PREVIOUS SWA ACCIDENTS AND INCIDENTS

The present accident is the first fatal accident for SWA. Including this accident, there have been 39 accidents or incidents involving SWA since 1983. Fourteen events involved encounters with turbulence (all but one during cruise flight, one wake turbulence event), seven involved mechanical issues, three were runway veer-offs and two were runway overruns. The remaining events involved ground collisions (3), evacuation or deplaning (3), loss of separation (2), taxiway misidentification as a runway (2), taxiway overrun (1), impact with geese (1) and laser beam interference (1). Two of the three runway veer-offs were accidents, and one of the two previous runway overruns was an accident. Of these five events, none involved the use of autobrakes. For three of the five, weather was cited as a contributory factor, although only one involved a contaminated runway surface (heavy rain). Summaries and probable causes for these five accidents or incidents are resident in the NTSB database.[52]

[52] Case numbers FTW03MA160, LAX01IA109, DCA00MA030, FTW96IA210 and FTW85FA202.