Crash During Attempted Go-Around After Landing
East Coast Jets Flight 81
Hawker Beechcraft Corporation 125-800A, N818MV
Owatonna, Minnesota
July 31, 2008

Accident Report

NTSB/AAR-11/01
PB2011-910401

National
Transportation
Safety Board

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National Transportation Safety Board. 2011. ***Crash During Attempted Go-Around After Landing, East Coast Jets Flight 81, Hawker Beechcraft Corporation 125-800A, N818MV, Owatonna, Minnesota, July 31, 2008*****. Aircraft Accident Report NTSB/AAR-11/01. Washington, DC.**

Abstract: This accident report discusses the July 31, 2008, accident involving East Coast Jets flight 81, a Hawker Beechcraft Corporation 125-800A, N818MV, which crashed while attempting to go around after landing on runway 30 at Owatonna Degner Regional Airport, Owatonna, Minnesota. The two pilots and six passengers were killed, and the airplane was destroyed by impact forces. The nonscheduled, domestic passenger flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135. An instrument flight rules flight plan had been filed and activated; however, it was canceled before the landing. Visual meteorological conditions prevailed at the time of the accident. The safety issues discussed in this report relate to flight crew actions; lack of standard operating procedures requirements for 14 CFR Part 135 operators, including crew resource management training and checklist usage; go-around guidance for turbine-powered aircraft; Part 135 preflight weather briefings; pilot fatigue and sleep disorders; inadequate arrival landing distance assessment guidance and requirements; Part 135 on-demand, pilot-in-command line checks; and cockpit image recording systems. Fourteen new safety recommendations concerning these issues are addressed to the Federal Aviation Administration.

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Abbreviations

AAIB	Air Accidents Investigations Branch
ABE	Lehigh Valley International Airport
AC	advisory circular
ACY	Atlantic City International Airport
AFM	aircraft flight manual
agl	above ground level
AIM	*Aeronautical Information Manual*
AME	aviation medical examiner
AMJ	advisory material joint
ARC	aviation rulemaking committee
ARG/US	Aviation Research Group/US
ARTCC	air route traffic control center
ATC	air traffic control
AWOS	automated weather observation system
BCAR	*British Civil Aviation Requirements*
CAPS	computerised aircraft performance system
CFIT	controlled flight into terrain
CFME	continuous friction measuring equipment
CFR	*Code of Federal Regulations*
CRM	crew resource management
CS	certification specifications
CVR	cockpit voice recorder
DOT	Department of Transportation

EASA	European Aviation Safety Agency
EGPWS	enhanced ground proximity warning system
EU OPS	European operational regulations
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FBO	fixed-base operator
FCU	flap control unit
FDM	flight data monitoring
FDR	flight data recorder
FL	flight level
FMS	flight management system
FR	*Federal Register*
FSDO	flight standards district office
FSI	Flight Safety International
FSIB	flight standards information bulletin
FSS	flight service station
GOM	general operations manual
Hg	mercury
ICAO	International Civil Aviation Organization
IFR	instrument flight rules
ILS	instrument landing system
InFO	information for operators
JAA	Joint Airworthiness Authorities
MCS	mesoscale convective system
METAR	meteorological aerodrome report

MLG	main landing gear
mm	millimeter
msl	mean sea level
NASA	National Aeronautics and Space Administration
NLG	nose landing gear
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
NWS	National Weather Service
OFD	Owatonna Fire Department
OpSpec	operations specifications
OWA	Owatonna Degner Regional Airport
PF	pilot flying
PIC	pilot-in-command
PM	pilot monitoring
POI	principal operations inspector
psi	pounds per square inch
QRH	quick reference handbook
RST	Rochester International Airport
RWHS	reference wet hard surface
SAFO	safety alert for operators
SFAR	*Special Federal Aviation Regulation*
SIGMET	significant meteorological information
SOPs	standard operating procedures
SPC	Storm Prediction Center
STC	supplemental type certificate

TAF	terminal aerodrome forecast
TALPA	takeoff/landing performance assessment
TCPM	training center program manager
TSO	technical standard order
TTI	Texas Transportation Institute
$\mathbf{V_{ref}}$	reference landing speed
WSR-88D	weather surveillance radar-1988 doppler

Executive Summary

On July 31, 2008, about 0945 central daylight time, East Coast Jets flight 81, a Hawker Beechcraft Corporation 125-800A airplane, N818MV, crashed while attempting to go around after landing on runway 30 at Owatonna Degner Regional Airport, Owatonna, Minnesota. The two pilots and six passengers were killed, and the airplane was destroyed by impact forces. The nonscheduled, domestic passenger flight was operating under the provisions of 14 *Code of Federal Regulations* Part 135. An instrument flight rules flight plan had been filed and activated; however, it was canceled before the landing. Visual meteorological conditions prevailed at the time of the accident.

The National Transportation Safety Board determines that the probable cause of this accident was the captain's decision to attempt a go-around late in the landing roll with insufficient runway remaining. Contributing to the accident were (1) the pilots' poor crew coordination and lack of cockpit discipline; (2) fatigue, which likely impaired both pilots' performance; and (3) the failure of the Federal Aviation Administration (FAA) to require crew resource management (CRM) training and standard operating procedures (SOPs) for 14 CFR Part 135 operators.

The safety issues discussed in this report relate to the following: flight crew actions; lack of SOPs requirements for Part 135 operators, including CRM training and checklist usage; go-around guidance for turbine-powered aircraft; Part 135 preflight weather briefings; pilot fatigue and sleep disorders; inadequate arrival landing distance assessment guidance and requirements; Part 135 on-demand, pilot-in-command line checks; and cockpit image recording systems. Safety recommendations concerning these issues are addressed to the FAA.

1. Factual Information

1.1 History of Flight

On July 31, 2008, about 0945 central daylight time,[1] East Coast Jets flight 81, a Hawker Beechcraft Corporation 125-800A airplane, N818MV, crashed while attempting to go around[2] after landing on runway 30 at Owatonna Degner Regional Airport (OWA), Owatonna, Minnesota. The two pilots and six passengers were killed,[3] and the airplane was destroyed by impact forces. The nonscheduled, domestic passenger flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135. An instrument flight rules (IFR) flight plan had been filed and activated; however, it was canceled before the landing. Visual meteorological conditions prevailed at the time of the accident.[4]

The accident occurred on the second leg of a five-leg trip sequence for the flight crew.[5] According to East Coast Jets, the flight was chartered by Revel Entertainment, Atlantic City, New Jersey, to transport employees from Atlantic City International Airport (ACY) to OWA. The airplane departed ACY about 0713. The captain was the pilot flying (PF), and the first officer was the pilot monitoring (PM).

[1] Unless otherwise indicated, all times in this report are central daylight time based on a 24-hour clock.

[2] The Federal Aviation Administration's (FAA) *Airplane Flying Handbook* FAA-H-8083-3A, Chapter 8, "Approaches and Landings," states the following:

> Whenever landing conditions are not satisfactory, a go-around is warranted. There are many factors that can contribute to unsatisfactory landing conditions. Situations such as air traffic control requirements, unexpected appearance of hazards on the runway, overtaking another airplane, wind shear, wake turbulence, mechanical failure and/or an unstabilized approach are all examples of reasons to discontinue a landing approach and make another approach under more favorable conditions…The go-around is not strictly an emergency procedure. It is a normal maneuver that may at times be used in an emergency situation…Although the need to discontinue a landing may arise at any point in the landing process, the most critical go-around will be one started when very close to the ground. Therefore, the earlier a condition that warrants a go-around is recognized, the safer the go-around/rejected landing will be.

Although a go-around is typically thought of as occurring in flight, during the accident sequence, the landing was discontinued during the landing process and the captain used a standard go-around procedure (for example, he called for flaps) after he opted to discontinue the landing. Therefore, for the purposes of this report, the term "go-around" will be used to describe the event.

[3] The trip sheet for the flight indicated that there would be eight passengers; however, only six passengers were on board the airplane.

[4] The National Transportation Safety Board's (NTSB) public docket for this accident investigation is available online at <http://www.ntsb.gov/info/foia_fri-dockets.htm>. The NTSB is investigating two additional events in which corporate jets ran off the end of the runway during landing. On October 1, 2010, a Cessna 550, registered to Colnan Inc., overran runway 23 during landing at Dare County Regional Airport, Manteo, North Carolina. On October 1, 2010, a Gulfstream Aerospace G-IV, operated by Avenue Capital Management II and managed by General Aviation Flying Service Inc., doing business as Meridian Air Charter Inc., overran runway 6 during landing at Teterboro Airport, Teterboro, New Jersey. The preliminary reports for these accidents, NTSB case numbers ERA11FA001 and ERA11IA006, respectively, are available at <http://www.ntsb.gov/ntsb/query.asp>.

[5] The first flight of the day for the pilots was a 14 CFR Part 91 repositioning flight from Lehigh Valley International Airport, Allentown, Pennsylvania, to Atlantic City International Airport, Atlantic City, New Jersey, and this flight departed about 0600.

About 0922 (a little more than 2 hours into the flight), the Minneapolis Air Route Traffic Control Center (ARTCC) controller cleared the flight to descend to flight level (FL) 240,[6] and the first officer acknowledged the instruction. About 0924, the cockpit voice recorder (CVR) recorded the OWA automated weather observation system (AWOS) information, which indicated, in part, calm winds and visibility of 10 miles in thunderstorms and rain, and the remarks indicated that lightning was detected in the distance in all quadrants.[7]

At 0925:37, the Minneapolis ARTCC controller asked the first officer if he saw extreme precipitation 20 miles straight ahead. The first officer responded, "yeah, we're paintin' it here and…what is the bases (report)?"[8] and then asked the ARTCC controller for a cloud bases report. The controller responded that he did not know what the cloud bases were but did know that the cloud tops were "quite high." The controller added, "I don't recommend you go through it I've had nobody go through it…deviation if you go right you'd probably have to [go] up…sixty miles north of Rochester [International Airport, Rochester, Minnesota]." The first officer responded that he would like to deviate to the right, and the controller approved the deviation. The CVR then recorded the captain stating, "let's hope we get underneath it." The first officer responded, "if he…descended us it probably wouldn't have been an issue…I mean fifty miles out we're still at twenty five thousand feet, twenty four thousand feet."

At 0927:48, the Minneapolis ARTCC controller asked the captain to state his intentions and added, "I can't even give you a good recommendation right now." The captain replied, "I got it clear probably for another forty miles." The controller then cleared the flight to descend to FL 190. At 0928:42, the captain stated, "I didn't really hear what he was sayin'…whether we're on approach control…what difference does it make? All I care is above 10 [thousand feet] and we go fast so we can get around this…thing." Shortly thereafter, the Minneapolis ARTCC controller cleared the flight to descend to 14,000 feet.[9] At 0930:09, the captain stated, "good thing I didn't tell 'em it was gonna be a smooth ride huh? I looked at the radar and there wasn't anything." The first officer responded, "doesn't it figure [weather] pops up right when we get here?" The captain continued, "what do you mean what are my intentions? Get me around this…so I can go to the field…I ain't gonna turn around and go home." About the same time, the CVR recorded the sound of increased background noise consistent with rain impacting the windscreen.

At 0932:21, the captain commented that he could not see the weather "out there anymore," and asked, "is it above us?" The first officer replied, "it might be above us." About

[6] According to the pilot glossary in the *Aeronautical Information Manual*, flight level is a constant atmospheric pressure related to a reference datum of 29.92 inches of mercury. Flight level 240 represents a barometric altimeter indication of 24,000 feet.

[7] The OWA AWOS issues an official meteorological aerodrome report (METAR) about every 20 minutes for dissemination long-line, which is how air traffic control receives its weather information. The AWOS also provides unofficial weather observations every minute, and these observations are available to pilots on a very-high frequency radio frequency. The information recorded by the CVR came from the 0924 AWOS observation. Visibilities in weather observations are reported in statute miles. All other distances in the report are reported in nautical miles. Weather conditions stated to be occurring in the "distance" are occurring within 10 to 25 miles of the airport. See section 1.7 for more information about the weather conditions along the flight route, at OWA, and in the surrounding areas.

[8] The first officer's comment indicates that the weather radar display was operative and indicating precipitation.

[9] All altitudes are reported in mean sea level (msl) unless otherwise noted.

the same time, the Minneapolis ARTCC controller switched the flight to Minneapolis approach control. The first officer contacted Minneapolis approach control and requested a turn toward OWA. The approach controller stated that he would keep the flight in his airspace for 7 more miles and then start the turn.

At 0933:37, the first officer stated that he was "off" to contact the fixed-base operator (FBO) at OWA on the radio, and the captain began handling radio communications. At 0933:41 and 0934:10, the first officer tried unsuccessfully to contact the FBO, and, at 0934:25, he stated, "I'm not gettin' anyone." At 0934:08, the Minneapolis approach controller instructed the captain to turn left to a heading of 250°, and the captain acknowledged the instruction. At 0934:30, the approach controller passed control of the flight to Rochester approach control. Sixteen seconds later, the first officer contacted Rochester approach control and, when asked which approach he would like to conduct at OWA, he responded, "could do the ILS [instrument landing system]." The Rochester approach controller then cleared the flight to descend to 7,000 feet and started to provide vectors for the ILS approach.

At 0935:44, the captain stated, "let's do the approaches real quick," referring to the Approach checklist.[10] The CVR then recorded the first officer calling out and the captain responding to items on the Approach checklist. At 0935:51, the first officer stated, "approach briefing,"[11] and the captain replied, "it's gonna be the ILS to three zero."

At 0936:27, the Rochester approach controller contacted the flight while the pilots were continuing to execute the Approach checklist and, 19 seconds later, instructed the flight to descend to 3,000 feet at the pilots' discretion and turn right heading 190°. At 0937:01, the Rochester approach controller provided the first officer with weather information for OWA, which he stated was about 20 minutes old and indicated winds 320° at 8 knots, visibility 10 miles or more, thunderstorms, clouds scattered at 3,700 feet and overcast at 5,000 feet, and lightning in the distance in all quadrants.[12]

From 0937:41 to 0938:00, the CVR recorded the captain and first officer discussing the weather radar display. The captain stated, "I don't know what…we're looking at on this thing," and the first officer replied, "well neither do I…I don't know if it's not working." The captain stated, "is that ground? 'cause I got it pointed way up in the air. You know I got it goin' down I got it pointed up."[13] The first officer asked whether the display was showing a storm, and the captain replied, "hard to say." At 0938:07, the Rochester approach controller reported that light precipitation existed along almost the entire remaining route and that a couple of heavy storm cells were located about 5 miles north and northeast of OWA. The first officer acknowledged the

[10] Company procedures, including checklist usage, are discussed in section 1.17.1.3.

[11] The content of the approach briefing is the PF's responsibility and should include, but not be limited to, the following: safety altitude; any hazards, including high ground or abnormal weather; navigation aid selection; airfield arrival and approach procedures; and the missed approach procedure. For more information, see section 1.17.1.3.2.

[12] The information provided to the first officer was recorded about 0917, 20 minutes previously, and did not include mention of the moderate rain that was occurring at OWA at that time. Although a METAR was issued at 0935, its availability to the Rochester approach controller via the long-line communications may have been delayed a few minutes.

[13] Given the airplane heading and the range and tilt set on the radar, the captain's comments could indicate that no returns were being displayed at that time.

weather information and then commented to the captain, “the sooner you get us there the better.” At 0938:36, the captain added, “you know when they start sayin’ this stuff it’s like are you trying to tell me something…because I’m not gettin’ it.” The CVR then recorded a sound similar to laughter, which was followed by the first officer stating, “why don’t [they] just get us to the field.”

At 0938:50, the captain stated, “approaches are done.” One second later, the first officer responded, “approaches are done.” Shortly thereafter, the captain stated that they were descending to 3,000 feet and that they would have to “start getting her [the airplane] slowed up.” The first officer then stated that he was “off” to try and contact the FBO again. At 0939:16 and 0939:34, the first officer made two unsuccessful attempts to contact the FBO on the radio.

At 0939:58, the CVR recorded the captain stating, “flaps one,”[14] followed by a sound similar to a mechanical click. The first officer stated, “one and indicating,” to which the captain responded, “why don’t you really quickly go over and…ID that thing? See if the localizer’s even right?” At 0940:21, the Rochester approach controller cleared the flight for the ILS approach to runway 30. The first officer then confirmed that the localizer frequency was correct and stated, “loc’s alive.” The captain then prompted the first officer to try to contact the FBO again. At 0942:00, the captain reported the runway in sight and canceled the flight’s IFR flight plan.

At 0942:09, the first officer successfully contacted the FBO and stated that the flight was about 8 miles out and that they would be dropping off passengers. He then asked what they needed to do for fuel. At the same time, the captain discussed the air traffic in the vicinity of the airport with the Rochester approach controller. At 0942:22, the CVR recorded an increase in background noise consistent with landing gear extension. From 0942:24 to 0942:38, the CVR recorded the FBO talking to the first officer about how the airplane could get fuel when it landed.

At 0942:37, the captain stated, “three green, no red, pressures good, back to zero, steerings clear,” indicating that the three green landing gear annunciators were illuminated (that is, the landing gear were in the down-and-locked position), that the hydraulic pressure was good, that the airbrakes had zero pressurization, and that the nosewheel steering handwheel was clear, all of which were items on the East Coast Jets Before Landing checklist. The first officer subsequently finished talking to the FBO and then discussed with the captain what he was told to do about the passengers and the fuel.

The CVR recorded the captain stating, “flaps two,” at 0943:05, followed by a sound similar to two clicks. He then prompted the first officer to “go through the before landings, make sure you got it all….down indicating down.” The first officer subsequently stated that they had the “before landing shorts to go.”[15] At 0943:36, the CVR recorded an electronic voice stating, “one thousand.”[16]

[14] During postaccident interviews, East Coast Jets pilots referred to flaps 15° as “flaps one,” flaps 25° as “flaps two,” and flaps 45° as “flaps full.”

[15] The East Coast Jets Before Landing checklist has the following three short final steps: recheck the landing gear, turn off the main air valves, and disengage the autopilot and yaw damper.

[16] The electronic voice calls out airplane altitude in feet above ground level. OWA is 1,146 feet above msl.

At 0944:25, the CVR recorded an electronic voice stating, “four hundred.” At 0944:29, the captain stated, “I’m goin’ right to the tiller and the brakes.” Three seconds later, the CVR recorded an electronic voice stating, “three hundred.” Immediately thereafter, the captain stated, “slowin’ to ref [reference landing speed or V_{ref}],” followed by a sound similar to multiple clicks. At 0944:47, the CVR recorded an electronic voice stating, “two minimums minimums,” which was immediately followed by the first officer stating, “air valves are shut [yaw] damper to go,” and then, “damper.” At 0945:04, the CVR recorded a sound consistent with tires rolling on a prepared surface, followed 2.5 seconds later by a sound similar to the airbrakes moving to the OPEN position.[17]

At 0945:08, the first officer stated, “(we’re) dumped,”[18] followed immediately by, “we’re not dumped.” About 1.5 seconds later, the captain replied, “no we’re not,” and, at the same time, the CVR recorded a sound similar to the airbrake handle moving to the DUMP position.[19] Ten seconds later, the CVR recorded a sound similar to the airbrakes moving to the SHUT position. The captain then stated, “flaps,” and, about the same time, the CVR recorded a sound consistent with increasing engine noise. At 0945:27, the captain stated, “here we go….not flyin’…not flyin’.” At 0945:36, the CVR recorded an aural warning stating, “bank angle, bank angle.”[20] The CVR stopped recording at 0945:45.

According to the National Transportation Safety Board’s (NTSB) airplane performance study and on-scene measurements,[21] the airplane ran off the runway end at 0945:29 and lifted off the ground at 0945:34, about 978 feet from the runway end. Subsequently, the airplane collided with the runway 30 localizer antenna support structure, which was about 1,000 feet from the runway end, and it eventually came to rest in a cornfield beyond a dirt access road that borders the airport, which was about 2,136 feet from the runway end.

NTSB investigators either interviewed or received statements from 13 witnesses who indicated that they had observed the accident or circumstances surrounding the time of the accident. Several witnesses stated that the airplane appeared to be flying low while on approach. Other witnesses indicated that the airplane’s landing looked normal at first but that, at the end of the runway, the engines increased in power, and the airplane became airborne and rolled to a 90º right bank. Three of the witnesses reported seeing “mist” spraying up from the rear of the airplane all the way down the runway, and one of these witnesses described it as a 20-foot-long “rooster tail” of water.

[17] The airplane landed about 9 minutes ahead of the scheduled landing time.

[18] The first officer was referring to the deployment of the lift-dump feature of the airbrake and flap systems, which is used to help decelerate the airplane upon landing. The airbrake handle is moved forward to the SHUT position to maintain the airbrakes in the fully closed position and is moved aft to the OPEN position to extend the upper and lower panels. The airbrake and flap systems and the lift-dump feature are discussed in section 1.6.1.

[19] The CVR recorded a sound similar to straining while the captain was stating, “no, we’re not,” and then the sound of slightly elevated breathing.

[20] The “bank angle” alert was issued by the airplane’s enhanced ground proximity warning system, which is discussed in detail in section 1.6.2.

[21] The airplane performance study is discussed in section 1.16.3.

1.2 Injuries to Persons

Table 1. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	2	0	6	0	8
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	2	0	6	0	8

1.3 Damage to Airplane

The airplane was destroyed by impact forces.

1.4 Other Damage

A portion of the OWA runway 30 localizer was destroyed.

1.5 Personnel Information

1.5.1 The Captain

The captain, age 40, was hired by East Coast Jets on January 16, 2005. He held a multiengine airline transport pilot certificate, issued October 3, 2005, with type ratings in HS-125[22] and Learjet airplanes. The captain held a first-class Federal Aviation Administration (FAA) airman medical certificate, dated July 26, 2007, with no limitations. The FAA airman medical certificate listed the captain's height as 5 feet 11 inches and his weight as 192 pounds.

According to the captain's father, the captain's only previous aviation-related employment was working as a flight instructor in Allentown, Pennsylvania, for 1.5 years before being hired by East Coast Jets. According to the captain's logbooks and East Coast Jets records, the captain had accumulated about 3,600 total flight hours, including 2,763 hours as pilot-in-command (PIC), 2,062 hours of which were in turbine-powered aircraft (about 1,188 hours in Hawker Beechcraft 125-800A airplanes and 874 hours in Learjet airplanes). He

[22] HS-125 is the code used on pilot licenses to indicate a type rating in the Hawker Beechcraft 125-800A airplane.

had flown 110, 24, and 0.3 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident flight.

The captain's last recurrent ground training occurred on July 23, 2008; his last PIC Learjet proficiency and line checks occurred on May 6, 2008; and his last PIC Hawker Beechcraft 125-800A proficiency check occurred on October 24, 2007. The 1.5-hour-long line check comprised two flight segments: a flight from Lehigh Valley International Airport (ABE), Allentown, Pennsylvania, to Hazleton Municipal Airport, Hazleton, Pennsylvania, located about 32 miles from ABE, and a return flight to ABE. (See section 1.18.3 for more information about line-check requirements.) A search of FAA records revealed no accident or incident history, enforcement action, pilot certificate or rating failure, or retest history. A review of Pennsylvania Bureau of Motor Vehicles records indicated that the captain had no history of driver's license revocation or suspension.

According to his girlfriend, who lived with him, he typically went to bed about 2200 to 2230.[23] She stated that he sometimes awoke when she did about 0700 and would either stay awake or return to sleep. She stated that, other times, he slept until about 0930 to 1000. She stated that he also liked to nap from about 1200 to 1430 or 1500 and that he did this every day.[24] She added that the captain was healthy during the 12 months before the accident but that he had recently consulted a chiropractor about lower back pain. She stated that the captain did not have a personal physician.

The captain was off duty in the 72 hours before the day of the accident. According to his girlfriend, the captain went to bed about 2200 to 2330 during his 3 days off, but she could not provide his awakening and nap times because he spent much of that time at home alone. She stated that, the night before the accident, the captain went to sleep about 2400 (because he participated in a poker game), which was later than his normal bed time, and that he awoke the next morning about 0445 to 0500.

1.5.2 The First Officer

The first officer, age 27, was hired by East Coast Jets on October 25, 2007. He held single- and multiengine commercial pilot certificates, issued August 27, 2005, and June 8, 2006, respectively, with a type rating in the HS-125 airplane. The first officer held a first-class FAA airman medical certificate, dated March 19, 2008, with the limitation that he "must wear corrective lenses; possess glasses for near/intermediate vision." The FAA airman medical certificate listed the first officer's height as 5 feet 10 inches and his weight as 197 pounds.

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[23] The captain and first officer's awakening, nap, and sleep times are reported in eastern daylight time, which is 1 hour ahead of central daylight time.

[24] The girlfriend's report of the captain's sleeping pattern was supported by statements from two additional witnesses. According to a former roommate of the captain, the captain typically went to bed about 2200 and awoke about 0800, did not have trouble sleeping, often took daytime naps, and snored moderately. According to his father, the captain typically went to bed between 2200 and 2300 and preferred to sleep until 0900 or 1000. The captain had no problem napping in hotels or airports or in the chairs provided at FBOs. In addition, the company chief pilot described the captain as a pilot known for taking naps during the day.

According to the first officer's father, the first officer was hired by Colgan Air in early 2005, and he completed the company's training; however, the first officer left Colgan Air when the company unexpectedly transferred him from Allentown to Pittsburgh, Pennsylvania. For several months after leaving Colgan Air, the first officer worked for a local Allentown corporation flying Cessna airplanes around the East Coast.

According to the first officer's logbooks and East Coast Jets records, the first officer had accumulated about 1,454 total flight hours, including 297 hours as second-in-command in turbine-powered aircraft (about 295 hours in Hawker Beechcraft 125-800A airplanes and 2 hours in Learjet airplanes) and 951 hours as PIC. He had flown 86, 27, and 0.3 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident flight. The first officer's last recurrent ground training occurred on July 30, 2008, and his last Hawker Beechcraft 125-800A proficiency check occurred on November 24, 2007. A search of FAA records revealed no accident or incident history or enforcement action. The FAA records indicated that the first officer was issued a notice of disapproval on July 16, 2001, for a Private Pilot—Airplane practical test, which he subsequently passed. A review of Pennsylvania Bureau of Motor Vehicles records indicated that the first officer had no history of driver's license revocation or suspension.

The first officer did not conduct flights in the 72 hours before the day of the accident. According to his fiancée, who lived with him, he was in bed for about 9.0, 9.5, 7.5, and 6 hours, respectively, in the 4 nights before the accident. She stated that the first officer typically went to bed about 2330 and awoke about 0830. She added that he went to sleep about 2300 the night before the accident,[25] awoke the next morning at 0506,[26] and left for the airport about 0530. She stated that the first officer called her about 0730 from ACY, at which time, he told her that he had "flown really well."

According to his parents, the first officer did not experience any major health changes during the 12 months before the accident. According to his fiancée, the first officer sometimes had trouble sleeping on the night before a trip, but he had not consulted a doctor for sleep issues. She stated that he would take zolpidem (also known by the trade name Ambien) or a nonprescription sleep medication. She indicated that he took zolpidem the night before the accident and that she provided him the medication because he did not have a prescription.

1.6 Airplane Information

The airplane was manufactured by British Aerospace (which is now part of BAE Systems) in the United Kingdom on March 19, 1991, as a BAe 125-800B. On March 6, 1994, Raytheon Corporate Jets, Inc., North Wales, Canada, converted the airplane to a Hawker Beechcraft 125-800A and then exported it to the United States.[27] The airplane had eight previous owners before it was bought by MVA Aircraft Leasing, Inc., Greenwich, Connecticut, in 2003. MVA Aircraft Leasing started leasing the airplane to East Coast Jets on June 27, 2003.

[25] The first officer's fiancée also stated that, on the previous night, he stayed awake until 0100 watching a home video.

[26] The first officer's fiancée stated that his alarm clock was set for 0506.

[27] In 2006, Raytheon sold its Hawker manufacturing business to a company now known as Hawker Beechcraft Corporation.

The accident airplane was equipped with two independent Universal Navigation System-1D flight management system (FMS) control display units, one for each pilot, located on the lower center control panel forward of the thrust levers. The FMS displayed current windspeed in knots and direction in degrees on the lower right side of the display. The airplane had accumulated about 6,570 total flight hours and 5,164 total cycles[28] at the time of the accident. According to the weight and balance form found on the accident airplane and the captain's FMS data, the airplane's landing weight was about 19,912 pounds, including 7,900 pounds of fuel and 120 pounds of baggage. The airplane's landing weight limit is 23,350 pounds. The form also indicated that the airplane's center of gravity was within limits. The airplane was equipped with two Honeywell TFE731-5R-1H turbofan engines.

East Coast Jets used the Hawker Beechcraft Aircraft Flexible Maintenance Schedule to maintain the airworthiness of its airplanes. The accident airplane's maintenance logbooks did not indicate any discrepancies or systemic issues with the airplane's flight control systems or wheel brakes before the accident.

1.6.1 Flaps, Airbrakes, and Anti-Skid Systems

The airplane was equipped with hydraulically operated, mechanically controlled flaps, which were attached to the aft portion of each wing. The flaps pivoted on hinges attached to the rear wing spar and extended by moving rearward and downward. Flap position was controlled by a flap lever located on the right side of the center pedestal in the cockpit (see figure 1). Movement of the flap lever is transmitted to the flap control unit (FCU) through cables and pulleys.

Flap position was indicated in the cockpit by a flaps position indicator on the right side of the center panel. A secondary means of verifying the flaps position was provided by a mechanical flaps indicator just forward of the flap lever on the center pedestal (see figure 2).

[28] An airplane cycle is one complete takeoff and landing sequence.

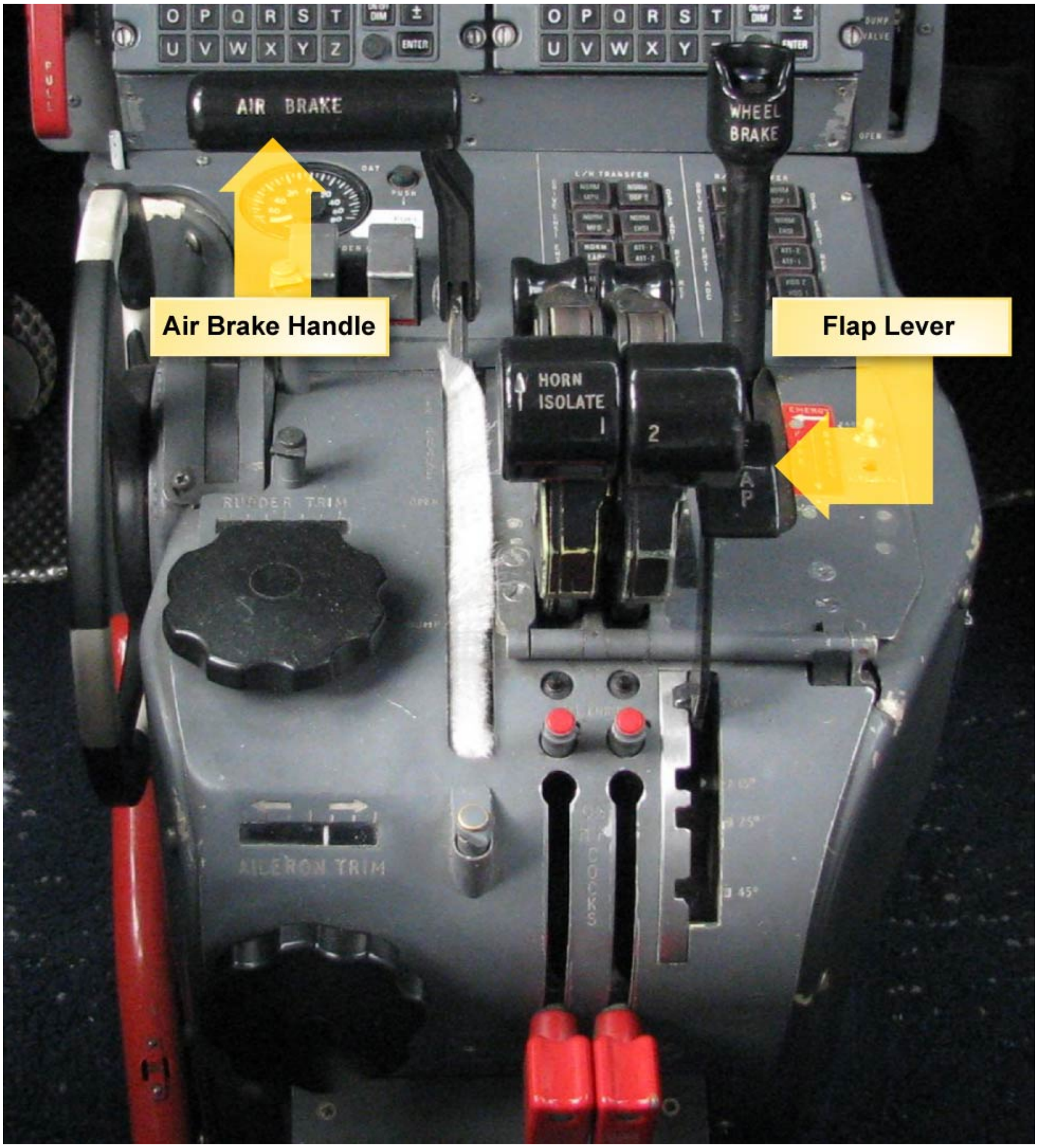

Figure 1. Photograph showing the center cockpit pedestal of a Hawker Beechcraft 125-800A.

Figure 2. Photograph showing the accident airplane's mechanical flaps indicator.

The airplane was equipped with hydraulically operated, mechanically controlled airbrakes, which were panels installed on the upper and lower surfaces of each wing. The panels were attached to the rear spar forward of the flaps and pivoted on hinges into the airstream. The airbrakes were controlled by an airbrake handle located on the left side of the center pedestal (see figure 1). Movement of the airbrake handle was transmitted to the hydraulic actuators through cables and pulleys. The most forward position of the lever was the SHUT position, which was used to maintain the airbrakes in the fully closed position. As the airbrake handle was moved aft, the airbrakes extended proportionately, reaching a maximum extension of 30° and 56° for the upper and lower panels, respectively, when the handle reached the OPEN position.

The airplane incorporated a lift-dump feature,[29] which mechanically interconnected the flaps and airbrakes and allowed both the airbrake panels and flaps to extend beyond their normal ranges. To deploy lift dump, the flaps first had to be set to 45°, and the airbrake handle then had to be moved up out of the OPEN position and fully aft to the DUMP position, which extended the flaps to 75°, the upper airbrakes to 51°, and the lower airbrakes to 75°. To deactivate the lift-dump feature, the airbrake handle had to be moved forward from the DUMP through the OPEN to the SHUT position. The lift-dump position was highlighted within the flap position indicator in yellow.

[29] The lift-dump feature was used in lieu of thrust reversers, which were an optional installation on the Hawker Beechcraft 125-800A airplane. East Coast Jets had two Hawker Beechcraft 125-800A airplanes with thrust reversers installed and two, including the accident airplane, without thrust reversers installed.

The airplane also incorporated an on/off anti-skid system. FAA Advisory Circular (AC) 25-7A Change 1, "Flight Test Guide for Certification of Transport Category Airplanes," defines the on/off anti-skid system as follows:

> (2) On/off systems are the simplest of the three types of anti-skid systems. For these systems, full metered brake pressure (as commanded by the pilot) is applied until wheel locking is sensed. Brake pressure is then released to allow the wheel to spin back up. When the system senses that the wheel is accelerating back to synchronous speed (i.e., ground speed), full-metered pressure is again applied. The cycle of full pressure application/complete pressure release is repeated throughout the stop (or until the wheel ceases to skid with pressure applied).

According to 14 CFR 25.109, "Accelerate-Stop Distance," an on/off anti-skid system has an efficiency value of 30 percent on a wet[30] runway "unless a specific anti-skid system efficiency is determined from a quantitative analysis of the flight testing on a smooth wet runway."

1.6.2 Enhanced Ground Proximity Warning System

The airplane was equipped with an Allied Signal Mark VII enhanced ground proximity warning system (EGPWS), which was manufactured and installed in 2000 in accordance with Gulfstream Aerospace Corporation Supplemental Type Certificate (STC) ST416CH. Manufacturer records indicated that the unit had never been returned for service. At the time of the accident, the terrain database installed in the system was version 421 (released in March 2000). The current terrain database was version 450 (released in April 2008), which was an upgrade to version 421. No change occurred to the OWA data between the old and new versions of the terrain database.

The EGPWS comprised the computer, which received input from the airplane sensors and systems, the cockpit audio system, mode and selector switches, and a terrain display. Six ground proximity warning modes were built into the system, including Mode 1, excessive descent rate; Mode 2, excessive closure to terrain; Mode 3, altitude loss after takeoff; Mode 4, unsafe terrain clearance; Mode 5, excessive glideslope deviation; and Mode 6, bank angle and altitude callouts.

Mode 4 is further separated into three submodes, including Mode 4b, which is active during cruise and approach with the landing gear down. Mode 4b issues a continuous "too low flaps" aural warning if the airplane descends below 245 feet above ground level (agl) at an indicated airspeed below 159 knots with the landing gear down and the flaps not set to 45°. No Mode 4b alert was issued during the accident flight.

[30] According to Safety Alert for Operators 06012, "Landing Performance Assessments at Time of Arrival (Turbojets)," 4(i), the runway surface is either dry, wet, or contaminated. A dry runway is one that is clear of contaminants and visible moisture within the required length and the width being used. A wet runway is one that is neither dry nor contaminated. For a contaminated runway, the runway surface conditions include the type and depth (if applicable) of the substance on the runway surface, for example, standing water, dry snow, wet snow, slush, ice, sanded, or chemically treated. See section 1.18.1 for more information.

For the accident airplane, a Mode 6 warning would have issued a "bank angle, bank angle" warning along a linear range from 30 feet agl and ±10° roll angle to 150 feet agl and ±40° roll angle. A Mode 6 "bank angle" warning was issued at 0945:33. See section 1.16.1 for information about the EGPWS data study.

1.7 Meteorological Information

1.7.1 Area Weather Conditions

The National Weather Service (NWS) Storm Prediction Center (SPC) convective outlook issued at 0739 indicated that severe thunderstorms[31] were expected over the upper Midwest. The outlook indicated that, at 0800, a long-lived bow echo[32] with a history of producing significant damaging winds would be moving across southern Minnesota along a well-defined frontal boundary.

The NWS radar mosaics for the area (southern Minnesota) and time (from about 0830 to 1000) surrounding the accident flight depicted a complex of thunderstorms known as a mesoscale convective system (MCS).[33] The MCS had an intense leading edge squall line[34] with an extensive area of stratified rain and embedded thunderstorms trailing behind it. In this case, the leading edge squall line was further classified as a "bow echo." The leading edge of the bow echo moved through the Owatonna area about 0830 with heavy rain and strong, damaging winds. An extensive area with light to moderate rain trailed behind the leading edge. The NWS Chanhassen, Minnesota, Weather Service Forecast Office, located about 46 miles north of the accident site, documented 56 reports of severe weather for the time surrounding the accident flight.

A geostationary operational environmental satellite number 12 infrared satellite image captured about 0945 depicted a large region of enhanced cloud cover associated with the MCS over southeastern Minnesota and the accident site. Further, the image depicted a satellite radiative cloud top temperature of -61° C, which corresponded to cloud tops near 44,000 feet over Owatonna.

1.7.2 Airport Weather Information

Weather observations at OWA, which has an elevation of 1,146 feet, are made by an AWOS located about 500 feet from the approach end of runway 30. The system was equipped

[31] A severe thunderstorm produces tornadoes, hail larger than 0.75 inch in diameter, and/or strong damaging winds of 50 knots or more. A severe thunderstorm can cause extreme turbulence and severe icing as well as possess a high potential for microbursts.

[32] A bow echo is often associated with swaths of damaging straight-line winds, microbursts, and small tornadoes. Bow echoes can be from 10 to 100 miles long and last from 3 to 6 hours.

[33] An MCS becomes organized on a scale larger than individual thunderstorms and normally persists for several hours or more.

[34] A squall line is a line of thunderstorms preceding a cold front and can be up to 100 miles long. Thunderstorms within a squall line can produce severe weather conditions, such as heavy rain, hail, tornadoes, and strong, gusting winds of 60 miles per hour or more.

with a lightning detection system to report thunderstorms and was not augmented by a weather observer. The AWOS records continuous information on wind speed and direction, cloud cover, temperature, precipitation, and visibility and issues an official meteorological aerodrome report (METAR) about every 20 minutes for dissemination long-line. Table 2 shows the data from several official METARs surrounding the time of the accident.

Table 2. Data from several official METARs surrounding the time of the accident.

METAR time	0835	0935	1035
Wind direction and speed (in knots)	300º at 36 gusting to 55	180º at 3	160º at 6
Visibility (in statute miles)	2 miles with thunderstorms and heavy rain	10 miles with thunderstorms in the vicinity[a] and light rain	10 miles with thunderstorms in the vicinity and light rain
Cloud cover (agl)	Scattered at 200 and 1,400 feet Ceiling broken at 2,200 feet	Scattered at 3,800 and 4,900 feet Ceiling broken at 10,000 feet	Scattered at 2,500 and 5,000 feet
Temperature (in °C)	19º	18º	18º
Dew point (in °C)	17º	16º	16º
Altimeter (in inches Mercury [Hg])	29.84	29.85	29.77
Remarks	Visibility varied from 1 to 5 miles 20-minute precipitation was 0.22 inch Lightning detected in the distance in all quadrants	20-minute precipitation was 0.05 inch Lightning detected in the distance in all quadrants	20-minute precipitation was 0.03 inch Lightning detected in the distance in the southeast

[a] Weather conditions stated to be occurring in the "vicinity" are occurring within 5 to 10 miles of the airport.

The AWOS program manager for the Minnesota Department of Transportation provided the NTSB with the 5-minute observations for OWA.[35] According to this information, about 0945 (near the time of the accident) the AWOS reported winds 170° at 6 knots, visibility 10 miles in moderate rain, scattered clouds at 1,800 feet, scattered clouds at 2,900 feet, ceiling broken at 3,700 feet, temperature 19° C, dew point 17° C, and altimeter 29.83 inches of Hg. The remarks indicated that the 20-minute precipitation was 0.09 inch and that lightning was detected in the distance in the east through south.

AWOS observations made surrounding the time of the accident indicated wind shifts from the north to the south and the south-southeast during the 10 minutes before the accident. A total of about 0.41 inch of precipitation was reported at the time of the accident, consistent with moderate rainfall rates.

1.7.3 Additional National Weather Service Weather Information

The 0645 NWS area forecast (which was valid until 1700)[36] for southeastern Minnesota, which included the Owatonna area, predicted scattered clouds at 5,000 feet, occasional visibility 3 to 5 miles in mist, widely scattered thunderstorms and rain, and possibly severe thunderstorms with cumulonimbus cloud tops to 45,000 feet.

The NWS also issued several severe weather watches before the airplane departed from ACY. Severe weather watch 779 was issued about 0450 and was valid until 0900 for southern Minnesota, including the Owatonna area. The watch indicated that a line of severe thunderstorms was moving east-southeast toward southern Minnesota at 40 knots. The line was identified as a bowing MCS and potential derecho[37] event with damaging winds running along the warm front, which had stalled over the area. Severe weather watch 779 was updated by severe thunderstorm watch 781, which was issued about 0720 and was current at the time of the accident, for southeastern Minnesota, northern Iowa, and southwestern Wisconsin. The advisory continued to warn of a line of severe thunderstorms, hail up to 2 inches in diameter, wind gusts up to 70 knots, and cumulonimbus cloud tops up to 50,000 feet. The advisory further identified a severe MCS with a bow echo that had a history of producing damaging winds.

The NWS Chanhassen, Minnesota, weather surveillance radar-1988 doppler (WSR-88D) system base reflectivity images at 0929 and those for 0946 depicted echoes on descent into OWA and in the immediate vicinity consistent with the presence of light to moderate rain at the surface at OWA. Figures 3 and 4 show the accident airplane's flight track overlaid on the 0929 and 0946 base reflectivity data, respectively.

[35] Five-minute observations are recorded by the AWOS and were provided to the NTSB during the investigation; however, these observations are not available to pilots in flight.

[36] Area forecasts are used to determine forecast en route weather conditions and weather conditions for airports that do not issue terminal aerodrome forecasts (TAF). According to FAA AC-0045G, "Aviation Weather Services," a TAF is a concise statement of the expected meteorological conditions significant to aviation for a specified time period within 5 statute miles of the center of the airport's terminal.

[37] A derecho is a widespread and usually fast-moving windstorm associated with convection. Derechos can produce damaging winds over areas hundreds of miles long and more than 100 miles wide.

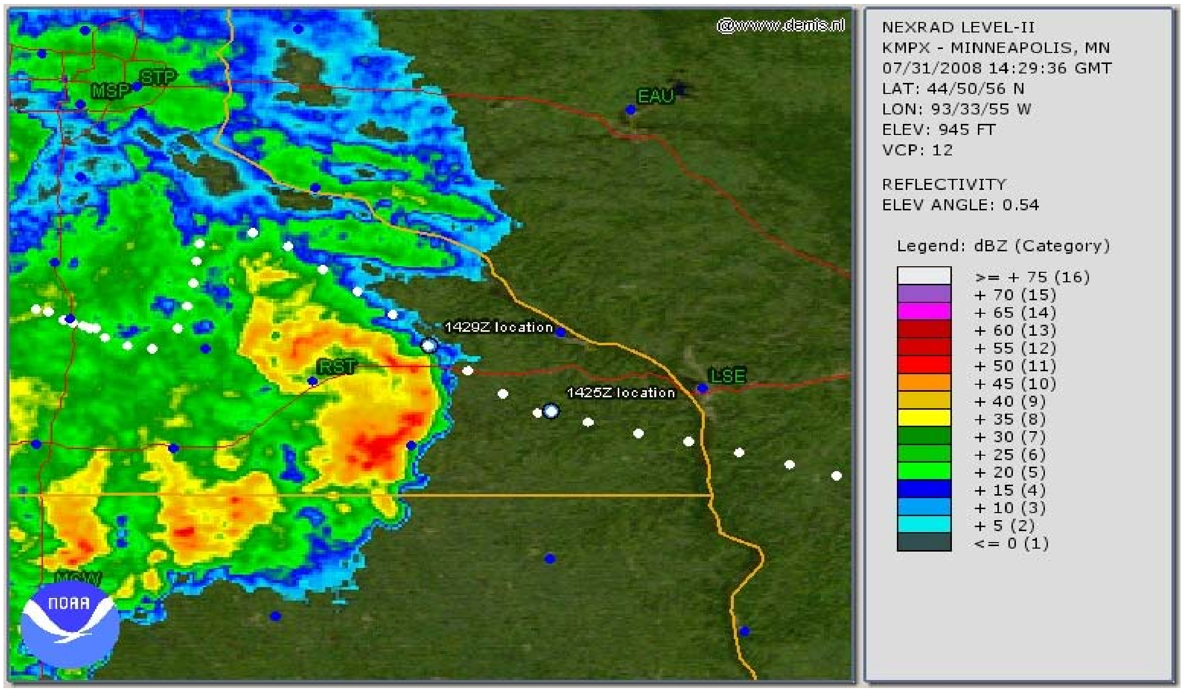

Figure 3. The flight track of the accident airplane overlaid on the 0929 base reflectivity data.

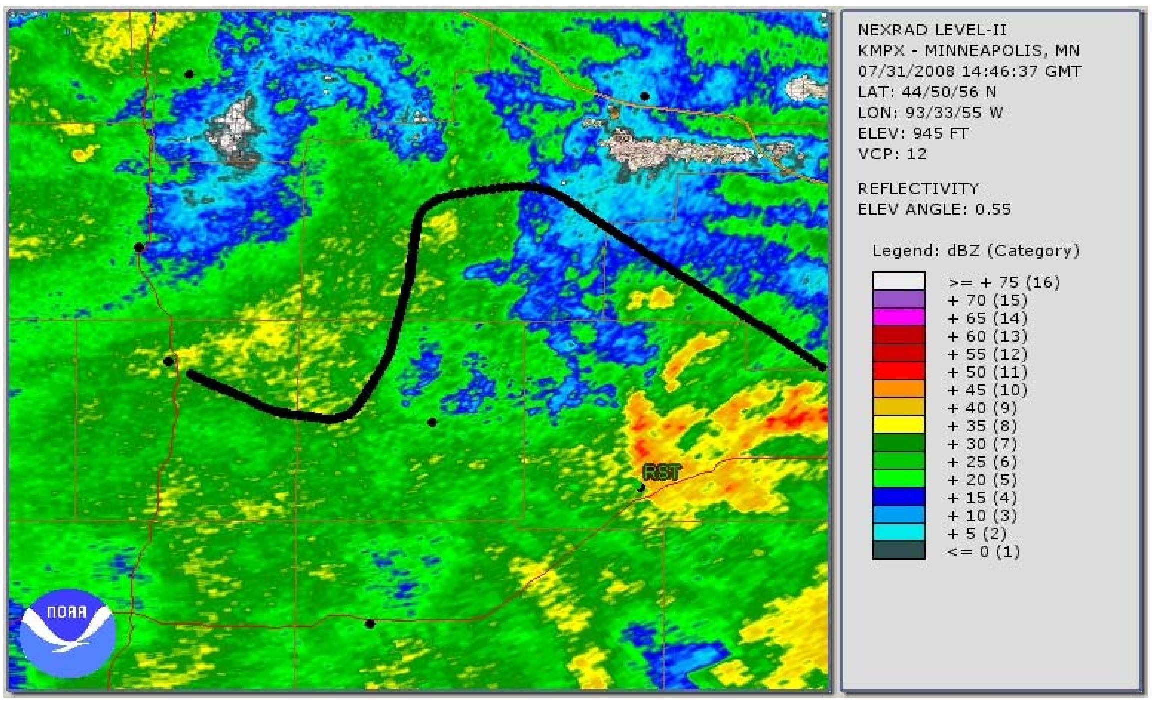

Figure 4. The flight track of the accident airplane overlaid on the 0946 base reflectivity data.

The WSR-88D base velocity data for the same period also showed a band of strong westerly winds behind the intense leading edge associated with the bow echo with maximum winds of 65 knots. The NWS Local Analysis and Prediction System upper air sounding (that is, a vertical profile of atmospheric conditions) for 0930 indicated calm surface winds, winds at

1,774 feet (628 feet agl) from about 280° at 34 knots, and a potential low-level windshear condition over OWA.

The NWS does not issue a terminal aerodrome forecast (TAF) for OWA; the official forecast is the area forecast. The closest TAF location to OWA, Rochester International Airport (RST), Rochester, Minnesota, was about 35 miles east of OWA. The 0633 TAF for RST, which was valid at the time of the accident, indicated, in part, IFR conditions in thunderstorms, heavy rain, and strong gusting winds about the estimated time of arrival.

An in-flight weather advisory, Convective SIGMET [significant meteorological information] 36C,[38] was issued about 0855 and was valid until 1055. The advisory warned of an area, including the flight route and the OWA area, of severe thunderstorms moving from 290º at 45 knots, with cloud tops above 45,000 feet. The advisory indicated that hail 2 inches in diameter and wind gusts to 70 knots were possible.

1.7.4 En Route Weather Services

Select FAA flight service stations (FSS)[39] operate Flight Watch, an en route flight advisory service that offers limited FSS services, including en route weather updates by NWS-certificated weather briefers[40] and the collection and dissemination of pilot reports. The service is available on a common frequency for aircraft operating between 5,000 and 17,000 feet and on discrete frequencies for aircraft operating at higher altitudes. The accident flight plan included a list of appropriate Flight Watch frequencies for the accident flight route. According to Lockheed Martin, a review of FSS records indicated that the accident pilots did not contact any FSS during the flight to request updated weather information, which would have included the severe weather watches and Convective SIGMET 36C, while in flight.

1.7.5 Federal Aviation Administration Weather-Related Guidance

1.7.5.1 Weather Briefings

According to 14 CFR 91.103, "Preflight Action," each PIC "shall, before beginning a flight, become familiar with all available information concerning that flight." The regulation states that, for an IFR flight, this information must include weather reports and forecasts. FAA AC 00-45F, "Aviation Weather Services," states, "all pilots should get a complete weather briefing before each flight. The pilot is responsible for ensuring he/she has all the information needed to make a safe flight."

[38] Convective SIGMETs are issued for thunderstorms affecting an area of 3,000 square miles or more, a line of thunderstorms at least 60 miles long, and/or severe or embedded thunderstorms affecting any area that are expected to last 30 minutes or more.

[39] FSSs are operated by Lockheed Martin and provide information and services to aircraft pilots before, during, and after flights but do not give instructions, clearances, or provide separation.

[40] The NWS office located at the FAA Academy in Oklahoma City, Oklahoma, provides training for FAA air traffic controllers and administers NWS certification examinations for FAA pilot weather briefers. The NWS issues a "Certificate of Authority for Pilot Weather Briefing" to employees who demonstrate proficiency in the following areas: weather analysis, satellite, WSR-88D weather radar, and pilot weather briefer oral examination. The oral examination is administered after the employee completes on-the-job training.

1.7.5.2 Severe Weather Information

Current Parts 121, 135, and 91 subpart K regulations require that pilots be provided sufficient meteorology training and procedures for recognizing and avoiding severe weather situations. The FAA's primary guidance for thunderstorms is included in AC 00-24B, "Thunderstorms," which was published in 1983. The AC describes the hazards of thunderstorms to aviation and provides guidance to help prevent thunderstorm-related accidents. However, the guidance does not reference technical meteorological terms used by the NWS to describe severe weather systems, including, but not limited to, the following: "mesoscale convective complex or systems," "bow echo," and "derecho." These terms are not currently defined in any FAA pilot reference material or in the *Aeronautical Information Manual* (AIM). Current convective SIGMETs and weather watches instruct pilots to reference the latest "convective" outlook and "mesoscale" discussions for the most current information on the area and the reasoning behind the issuance of the advisories; however, neither these technical meteorological terms nor those used in the referred documents to describe severe weather events are explained.

1.7.6 East Coast Jets Weather-Related Guidance

East Coast Jets' FAA-approved operations specifications (OpSpec) state that, before every flight, the PIC is responsible for obtaining and using weather reports and forecasts from the NWS or an FAA-approved source in accordance with company policies and procedures. Internet website records, papers recovered from the airplane, and interviews with company pilots indicated that the captain used <http://www.fltplan.com>, an FAA-approved source, to obtain weather briefing information for the flight.

A weather briefing package was found in the wreckage. The weather information was printed by the captain about 0513 on July 31, 2008 (about 2 hours before departure from ACY), and included weather information for the five planned flight legs (the accident flight was the second leg). The package included METARs and notices to airmen for the departure, destination, and alternate airports,[41] and surrounding stations. However, no TAFs were provided for these airports. A 0025 TAF for RST (issued about 9 hours before the accident) was found in the package, and it indicated that, from 0800 to 1100, conditions were expected to be winds 210° at 3 knots, more than 6 miles visibility, and scattered clouds at 14,000 feet. The weather package indicated that, when the flight departed ACY, OWA weather conditions were calm winds, 10 miles visibility, clear skies, temperature 18° C, dew point 17° C, and altimeter 29.75 inches of Hg.

The weather package contained no weather information for along the flight route. Further, no in-flight weather advisories, en route forecast, or adverse weather information was found in the package. Links to the NWS Aviation Digital Data System, weather radar mosaic, radar summary chart, and high-level significant weather chart websites were available at <http://www.fltplan.com>, but no record was found that either of the accident pilots used these links. A review of CVR and FAA air traffic control (ATC) transcripts revealed that the pilots did

[41] The captain designated Mankato Regional Airport, Mankato, Minnesota, located 29 miles west of OWA, as the alternate airport on the flight plan.

not request information from ATC or an FSS about the weather conditions along the flight route or at OWA during the flight.

1.8 Aids to Navigation

No problems with any navigational aids were reported.

1.9 Communications

No technical communications problems were reported.

1.10 Airport Information

OWA is a noncertificated, noncontrolled, city-owned airport with an elevation of 1,146 feet. OWA has one runway, 12/30, which is 5,500 feet long by 100 feet wide and is constructed of ungrooved concrete. The average longitudinal gradient for runway 30 is -0.7 percent (that is, downhill) from the threshold to the runway end. The cross-slope gradient[42] for runway 30 is 1.0 percent from the center to the edge of the runway. The runway is equipped with high-intensity runway lights along the edges, runway end identifier lights, and precision approach path indicator boxes. Runway 30 has a medium-intensity approach lighting system, precision markings on the runway, and an ILS installed. Both ends of the runway have grass-covered runway safety areas constructed to meet the same dimensional requirements as certificated air carrier runways, which are 500 feet wide and extend 1,000 feet beyond the runway threshold.

The NTSB asked the FAA to inspect runway 30 during or immediately after a heavy rainstorm, similar to the one that occurred on the day of the accident, for evidence of pooling or standing water. The FAA conducted the inspection on August 27, 2008, about 30 minutes after a fairly heavy rainstorm had ended.[43] The inspection revealed that the runway surface was wet, but no evidence of standing or pooling water was found. See section 1.16.2 for information about additional runway measurements.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

The accident airplane was equipped with a Fairchild Model A-100 CVR. The CVR was sent to the NTSB's laboratory in Washington, DC, for readout and evaluation. The exterior of the CVR exhibited no significant heat or structural damage, and the audio information was extracted normally and without difficulty. The recording consisted of three separate channels: the captain

[42] The cross-slope gradient is the slope of the runway measured from the runway crown (centerline) to the runway edge and is symmetrical about the runway centerline.

[43] The OWA AWOS reported a total of 0.55 inch of precipitation about 30 minutes before the inspection was performed.

and first officer audio panels and the cockpit area microphone. All three channels provided excellent quality audio information.[44] A transcript was prepared of the entire 30-minute, 44-second recording and is provided in appendix B of this report.

1.11.2 Flight Data Recorder

The airplane was not equipped, and was not required to be equipped, with a flight data recorder (FDR).[45]

1.12 Wreckage and Impact Information

Distinct tire impressions from the left and right main landing gears (MLG) and nose landing gear (NLG) were found in the grass (within the runway safety area) past the end of runway 30. The MLG impressions were continuous to about 978 feet beyond the runway end. The NLG impression was distinct for about 126 feet beyond the runway end, nonexistent for about 156 feet, faint for about 4,120 feet, and distinct for about 357 feet. All of the landing gear impressions ended before the ILS localizer antenna, which was located about 1,011 feet from the runway end. Three ILS localizer stanchions exhibited impact damage about 4.5 to 5 feet above their bases.

A shallow, elongated impact scar was found at the edge of a cornfield about 1,263 feet from the runway end. A path, angled about 45° to the right, was cut through the corn stalks and was continuous to the edge of the cornfield and a circular depression in the field. A second shallow impact impression was found in the dirt at the edge of the cornfield about 1,464 feet from the runway end. The far side of the circular depression, about 1,617 feet from the runway end, had a larger impact impression. Another path cut through the corn stalks in the field beyond the circular depression, but the cuts in this path were not angled. The corn beyond the third impact area exhibited yellowing of the leaves in a splattered appearance, consistent with chemical burning.

A fourth impact point was found about 1,854 feet from the runway end. Significant disturbed soil and flattened vegetation were found from this impact point forward. The disturbed area was fanned out about 30 feet wide, crossed a dirt road, and contained numerous pieces of wreckage. The main wreckage site was located about 2,136 feet (straight-line distance) from the runway end. No evidence of fire damage was found along the debris path or to any of the pieces found at the main wreckage site.

All of the major structural components of the airplane were located along the debris path and in the main wreckage with no evidence of preimpact structural failure. A majority of the airplane, including the left wing, wing center section, about half of the right wing, the empennage with both engines attached, the cockpit, part of the fuselage structure aft of the

[44] The NTSB rates the quality of CVR recordings according to a five-category scale: excellent, good, fair, poor, and unusable. See appendix B for a description of these ratings.

[45] According to 14 CFR 91.609(c)(1), an approved flight recorder is required for multiengine, turbine-powered airplanes manufactured after October 11, 1991, that have passenger seating configurations of 10 or more. The accident airplane was equipped with eight passenger seats.

cockpit, and the fuselage structure above the wing center section, was found in the main wreckage. Most of the cockpit and cabin seats and furnishings were found separated from the airplane and scattered about the accident site. About 210 and 140 gallons of fuel were drained from the left and right wing tanks, respectively. The engines showed no evidence of preimpact failure.

The main wreckage pieces were found connected together by the wire bundles and control cables running from the empennage to the cockpit. Control continuity was established for the primary flight controls, including the aileron, rudder, and elevators, and their associated trim systems, although some of their associated cables were broken at fuselage separation points. All of the engine control cables were separated near adjacent separations in the airplane structure. All of the cable breaks exhibited a splayed or broomstrawed appearance consistent with tension overload failure.

The left airbrake cable was found broken near the left MLG trunnion, and the break exhibited a splayed appearance. The right airbrake and interconnect cables were found intact.

The four brake assemblies were sent to Goodrich Corporation, Troy, Ohio, for testing under NTSB supervision. All four assemblies appeared normal, passed functional testing, and did not exhibit any warping or discoloration.

Postaccident examination of the flaps indicated that they were fully retracted (that is, set at 0°). The two flap cables were found intact to a point near the structural separation damage, and both cables were broken at this point. The breaks exhibited a splayed appearance. The pedestal exhibited impact damage, and the airbrake handle could not fully deploy to and lock in the DUMP position, but the flap handle could move through its entire range. The FCU was found in its normal position in the aft fuselage, and all hydraulic connections to the FCU remained intact. The FCU was removed and sent to APPH Houston Inc., Houston, Texas, for testing under NTSB supervision. The unit was functionally tested and operated normally throughout the normal and lift-dump ranges and was within specifications for a newly overhauled unit.

The four flap position switches were removed for further testing in the NTSB’s laboratory in Washington, DC. Electrical checks indicated that all four switches were operational with no abnormal short or open circuits. The flap override switch was found intact with the plastic guard closed over it. The flap position indicator and override switch were removed from the airplane and examined in the NTSB’s laboratory. All of the wires were found intact and connected. No slap marks were found on the indicator face or glass. Electrical checks indicated that the flap position indicator and override switch were operational with no abnormal short or open circuits.

The airbrake-flap interconnect cable was found broken near the left MLG. The cable break exhibited a splayed appearance. The functionality of the interaction between the airbrakes and flaps was established.

The two FMS computers were removed and sent to Universal Avionics Systems Corporation, Redmond, Washington, where they were downloaded under NTSB supervision. The first officer’s computer memory was inadvertently erased during the download procedure because of a hardware problem. The captain's computer memory was successfully downloaded. The data extraction from the captain's FMS indicated that the instantaneous wind 12 seconds before landing was 195° at 17 knots, which would have resulted in a 5.6-knot tailwind.[46]

The NLG was found separated from its mounting structure. The left NLG tire was cut through all of its layers and was deflated. The right NLG tire was cut through some of its layers, and the tire pressure was 102 pounds per square inch (psi).[47] The left MLG was found attached to the left wing. The right MLG was found attached to the right wing and in the down-and-locked position. All of the MLG tire pressures were measured and found to be within recommended tolerances. None of the tires exhibited flat spots or evidence of reverted rubber,[48] and all of the tire tread depths were within specified limits.

1.13 Medical and Pathological Information

Tissue and fluid specimens from both pilots were transported to the FAA's Civil Aerospace Medical Institute for toxicological analysis for a wide range of legal and illegal drugs[49] and ethanol. The captain's results were negative for all tested substances. The first officer's specimens tested positive for the drug zolpidem (0.007 micrograms/milliliter detected in blood), a prescription medication used for the short-term treatment of insomnia.

1.14 Fire

No evidence of a preimpact or postcrash fire was found.

1.15 Survival Aspects

According to the Minnesota Regional Medical Examiner's autopsy reports, the captain, first officer, and all of the passengers died as a result of traumatic injuries to the head, neck, chest, and extremities.

The chief deputy of the Steele County Sheriff's Office was notified about the accident by the 911 dispatch operator about 0950. He arrived on scene about 1000 and became the incident commander. Two Owatonna Fire Department (OFD) commanders were also notified about the accident by the 911 dispatch operator and arrived on scene with about 16 additional OFD

[46] The FMS wind is calculated based on filtered data to attenuate noise in the calculation, which results in the calculated wind likely being less than the actual wind.

[47] According to the Simcom Hawker 800A Technical Manual, the airplane's tire pressures should be 135 psi for the MLG tires and 100 psi for the NLG tires, with a recommended tolerance of +10/-0 psi.

[48] According to the FAA's *Airplane Flying Handbook* FAA-H-8083-3A, chapter 8, "reverted rubber (steam) hydroplaning occurs during heavy braking that results in a prolonged locked-wheel skid. Only a thin film of water on the runway is needed to facilitate this type of hydroplaning. The tire skidding generates enough heat to cause the rubber in contact with the runway to revert it to its original uncured state…The water heats and is converted to steam which supports the tire off the runway."

[49] The drugs tested for included, but were not limited to, marijuana, cocaine, phencyclidine, amphetamines, opiates, benzodiazapines, barbiturates, antidepressents, antihistamines, meprobamate, methaqualone, and nicotine.

personnel. Owatonna Police Department, Owatonna Sheriff Office, and local emergency medical services personnel also responded to the scene.

According to the chief deputy, the responders were initially unsure of how many occupants were on board the airplane. He indicated that the total number of occupants was verified about 1400.[50] He stated that one passenger was found alive; however, this passenger was transported by ambulance to a local hospital, and she died at the hospital less than 2 hours after the accident. Responders left the accident site about 1900.

1.16 Tests and Research

1.16.1 Enhanced Ground Proximity Warning System Data Study

The EGPWS computer was found intact in the aft fuselage. The wires supplying the flaps signals to the EGPWS were found intact and wired in accordance with STC ST416CH. The unit was removed and sent to Honeywell, Redmond, Washington, to download the data under NTSB supervision. The data download was accomplished normally and without difficulty.

As noted, a Mode 6 “bank angle, bank angle” alert was issued at 0945:33. The EGPWS computer recorded data starting 20 seconds before and ending 2 seconds after[51] the alert was issued. The data began when the airplane was on the ground at a ground speed of about 101 knots. The data indicated that the ground speed reduced to a minimum of about 78 knots before increasing to about 123 knots and that the pitch angle was initially -1.4°, but that, 1 second before the alert was issued, it increased to 20°. The roll angle was constant at less than 1° for about the first 19 seconds of the recorded data. The roll angle increased to 50° at the time that the alert was issued. The recorded landing gear down discrete signal had a value of 1, which corresponds to the landing gear being in the down position, for the entire 22-second recording. The recorded landing flap discrete signal had a value of 1, which corresponds to the flaps 45º position or activation of the flap override switch, for the first 8 seconds of the recording, and then it changed to and remained at 0 for the next 14 seconds.

As noted, no Mode 4b “too low flaps” alerts were issued during the accident flight. An examination of the actuation history of the Mode 4b alert showed that it had sounded a total of 12 times during the last 308 flights before the accident—most recently, 22 flights before the accident flight.

1.16.2 Runway 30 Measurements

On August 2, 2008, 2 days after the accident, the Minneapolis/St. Paul Metropolitan Airport Commission measured the friction of runway 30 at the request of the NTSB using a Saab vehicle equipped with an airport surface friction tester continuous friction measuring equipment

[50] Initially, responders thought that 10 occupants were on board the airplane because the OWA FBO had ordered 10 meals for the flight. No seating chart was available because the seats were not assigned.

[51] Although the EGPWS should record data for 10 seconds after an alert, the EGPWS only recorded 2 seconds of data after the alert due to the crash.

(CFME). The CFME used for the tests was designed to provide a uniform water depth of 1 millimeter (mm), or 0.04 inch, continuously in front of the friction-measuring tire. During the tests, friction values were measured at two different locations along the runway (10 feet right and left of centerline) and at two different speeds (40 and 60 mph).

The tests showed that the average measured-friction values for 40 mph 10 feet right and left of centerline were 0.53 μ and 0.40 μ and for 60 mph were 0.51 μ and 0.38 μ, respectively. According to Table 3-2, in AC 150/5320-12C, "Measurement, Construction and Maintenance of Skid-Resistant Airport Pavement Surfaces," these values fall between the minimum friction and maintenance planning friction levels. The AC further states that, if the pavement surface is less than the maintenance planning friction level but above the minimum friction level in table 3-2 for a distance of 500 feet and adjacent 500-foot segments are at or above maintenance planning friction level, no corrective action is required.

On August 11, 2009, NTSB investigators, accompanied by a National Aeronautics and Space Administration (NASA) runway friction expert, visited OWA. The NASA friction expert conducted two runway pavement macrotexture depth[52] surface measurements and a cross-slope gradient measurement of runway 30. According to the trip report, the average of the two pavement macrotexture measurements was 0.54 mm (0.02 inch), and the cross-slope gradient was measured to be 1.1 percent.[53]

The report indicated that the runway was generally in "excellent" condition because it had a relatively high macrotexture, consistently adequate cross-slope throughout the runway length, insignificant rubber deposits, and no concrete surface deterioration.

The NASA friction expert also used the CFME friction measurements to estimate the braking coefficients that could be provided by the runway (braking coefficients are discussed in Section 1.16.3.4). Table 3 shows the results of these estimates.

Table 3. Estimates of the accident braking coefficients.

Ground Speed (knots)	Maximum Available Braking Coefficient	Effective Braking Coefficient
19	0.490	0.270
38	0.455	0.239
56	0.406	0.199
75	0.357	0.162
94	0.315	0.134
107	0.273	0.108
132	0.217	0.090

[52] The runway macrotexture depth is the average depth of irregularities in the surface of the runway produced by the coarseness of the surface texture. The deeper these irregularities, the more channels they provide for water to flow through and the higher the rainfall rate required to submerge the peaks of the irregularities.

[53] The cross-slope measured by the NASA friction expert was 0.1 percent more than the runway-designed cross-slope.

The NTSB notes that calculating effective braking coefficients based on ground surface vehicle friction measurements has been a longstanding goal of joint industry and multinational government research efforts, including the Joint Winter Runway Friction Measurement Program led by Transport Canada. However, technical and operational challenges continue to persist despite years of extensive research. As a result, industry debate continues regarding whether ground-based friction measurement devices can be used in an operational environment to quantify available friction characteristics for common non-dry runway surface conditions[54] and, if so, whether these measurements can be reliably correlated to expected turbojet airplane stopping performance. For example, at the 2006 NTSB public hearing for the Southwest Airlines Boeing 737-700 landing overrun investigation, in response to the question, "Is it possible to predict aircraft braking performance from runway friction measurements," the NASA friction expert stated, "Yes, we've demonstrated it's possible to do that with 12 different friction measuring devices."

In the Canadian operational context, Transport Canada provides guidance that can be used to correlate decelerometer-based ground surface vehicle friction measurements to airplane performance on certain winter-contaminant surfaces (including compacted snow, loose snow less than 1 inch deep, ice, and wet ice) in the form of Canadian Runway Friction Index tables in its AIM; however, these tables are not applicable to wet runway surface conditions, including slush-covered conditions. In the U.S. operational context, the FAA stated the following in Safety Alert for Operators (SAFO)[55] 06012, "Landing Performance Assessments at Time of Arrival (Turbojets)," on August 31, 2006:

> Unfortunately, joint industry and multi-national government tests have not established a reliable correlation between runway friction under varying conditions, type of runway contaminants, braking action reports, and airplane braking capability. Extensive testing has been conducted in an effort to find a direct correlation between runway friction measurement device readings and airplane braking friction capability. However, these tests have not produced conclusive results that indicate a repeatable correlation exists through the full spectrum of runway contaminant conditions.

As a result, the FAA does not support operator or flight crew calculation of expected landing distance based solely on runway friction measurement device readings. Due to similar concerns about reliability and repeatability, the proposed runway condition reporting matrix and associated procedures developed by the takeoff/landing performance assessment (TALPA) aviation rulemaking committee (ARC) in 2009 enable runway condition reports to be downgraded (to a more conservative performance basis that equates to longer expected aircraft stopping distance) based on runway friction measurement device readings but never upgraded based solely on data from ground-based friction measurement devices. See section 1.18.2.6 for more information about the TALPA ARC.

[54] Non-dry runway surface conditions include wet runways (ungrooved, grooved, or porous friction course) and runways contaminated with standing water, dry snow, wet snow, slush, ice, and/or wet ice.

[55] A SAFO is not regulatory; however, it "contains important safety information and may include recommended action. SAFO content should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest possible degree of safety in the public interest."

1.16.3 Airplane Performance Study

1.16.3.1 Calculated Airplane Performance and Computer Simulation Results

The NTSB conducted an airplane performance study using data from the CVR, EGPWS, FMS, and RST airport surveillance radar;[56] witness statements;[57] crash site evidence; and meteorological information to estimate the airplane's position, speed, and deceleration during the approach and landing. In addition, the study used the Hawker Beechcraft Computerised Aircraft Performance System (CAPS) to calculate the effect of various airplane configuration, tailwind, and runway surface conditions on the airplane's stopping performance. Because the actual runway condition, tailwind magnitude, lift-dump configuration, touchdown ground speed, and force on the brake pedals are unknown, it is possible that other combinations of these variables could also produce results consistent with the available data.

According to the airplane performance study, assuming that the flight crew applied sufficient braking effort to demand all of the available runway friction,[58] the available data are most consistent with the CAPS simulation-based landing performance calculations for the following conditions:

- Runway flooded with 3-mm (about 0.12-inch) deep water.
- Flaps set at 45°.
- Lift dump not deployed.
- Tailwind of about 8 knots.[59]
- Airspeed over the threshold at the reference landing airspeed of about 122 knots.
- Touchdown about 1,128 feet from the runway threshold at a ground speed of about 130 knots.[60]

Further, the airplane performance study indicated that, if the flight crew had continued applying sufficient braking effort to demand all of the available runway friction to a full stop and not attempted to go around, the airplane likely would have overrun the runway at a ground speed

[56] The CVR, EGPWS, FMS, and RST airport surveillance radar data were synchronized to the CVR time as a common reference time.

[57] A witness who worked at OWA reported that, after being informed of the accident, he glanced at the AWOS monitor and that it indicated 7 to 10 knots. He indicated that the airport wind sock showed winds from the southeast. Another witness who worked at OWA stated that, after he was informed of the accident, he looked at the weather monitor, which indicated that the wind was out of the south at 10 knots and that the runway was reported as wet.

[58] At the accident ground speeds, the friction available on the wet runway was only about 20 to 30 percent of that available on a dry runway. Consequently, less force is required to achieve maximum braking on a wet runway because less braking friction is available.

[59] The 8-knot tailwind was deduced from available performance information, including EGPWS data, CVR timing, runway/grass tire marks, and radar data on approach. The 8-knot tailwind was required to produce a ground speed time history consistent with all of these data sources.

[60] The airplane performance study is referring to the MLG touchdown. The "sound consistent with tires rolling on a prepared surface," which was recorded by the CVR at 0945:04, should be associated with the NLG touchdown rather than the MLG touchdown. Flight test data indicate that derotation after landing takes about 1.6 seconds; therefore, the calculated MLG touchdown occurred at 0945:02.4.

between 23 and 37 knots and stopped between 100 and 300 feet beyond the runway end but within the 1,000-foot runway safety area.

1.16.3.2 Evaluation of Potential Hydroplaning on Runway 30

The airplane performance study then used the Texas Transportation Institute (TTI)[61] pavement drainage model, inputting the runway 30 macrotexture depth and cross-slope gradient measured by the NASA friction expert and the rainfall rates recorded before the accident, to determine whether runway 30 was flooded[62] at the time of the accident. The TTI model indicated that the rainfall rate at any time during the hour before the landing (0945) would not have been sufficient to produce the water depth necessary (3 mm) to consider the runway flooded or to support dynamic hydroplaning.[63] Therefore, the model did not support the CAPS simulation-based landing performance calculations for the accident landing, which indicated that the runway was flooded (that is, contaminated with standing water about 3-mm deep), or the possibility that the airplane experienced dynamic hydroplaning during the landing roll. To reconcile these differences, the airplane performance study considered the effects of braking friction coefficients, or braking coefficient,[64] on wet runways different from those assumed in the CAPS simulation.

1.16.3.3 Airplane Stopping Distances on Wet Runways

The retarding, or braking, force provided by an airplane's MLG tires during the landing roll is equal to the product of the weight on the tires and the braking coefficient. As the weight on the MLG tires or the braking coefficient decrease, the retarding force generated by the tires also decreases, resulting in decreased airplane deceleration and increased stopping distance. As the weight on the tires or the braking coefficient increases, the retarding force and airplane deceleration also increase, reducing the stopping distance.

The maximum available braking coefficient depends on numerous factors, including the runway surface condition (dry, wet, or contaminated with standing water or frozen precipitation), the runway macrotexture, the airplane ground speed, and the tire inflation pressure and tread

[61] B. Gallaway, R. Schiller, Jr., and J. Rose, *The Effects of Rainfall Intensity, Pavement Cross Slope, Surface Texture, and Drainage Length on Pavement Water Depths* (College Station, Texas: Texas Transportation Institute Research Report No. 138-5, 1971).

[62] European operational regulations consider a runway "contaminated" with standing water (that is, "flooded") when more than 25 percent of the runway surface is covered with water more than 3 mm (0.118 inch) deep. This 3-mm value for a flooded runway matches the CAPS model definition for a flooded runway. Therefore, comparing the depth of standing water present on runway 30 at the time of the accident to the 3-mm value can provide a measure of the degree of "flooding" on the runway.

[63] According to the FAA's *Airplane Flying Handbook* FAA-H-8083-3A, chapter 8, "dynamic hydroplaning is a relatively high-speed phenomenon that occurs when there is a film of water on the runway that is at least one-tenth inch deep. As the speed of the airplane and the depth of the water increase, the water layer builds up an increasing resistance to displacement, resulting in the formation of a wedge of water beneath the tire. At some speed, termed the hydroplaning speed (V_P), the water pressure equals the weight of the airplane and the tire is lifted off the runway surface. In this condition, the tires no longer contribute to directional control and braking action is nil."

[64] The braking coefficient is equal to the product of the maximum available braking friction coefficient that can be generated between the airplane tire and the runway and the airplane braking system anti-skid efficiency, which governs its ability to take advantage of the available runway friction.

depth. When the runway is wet, the maximum braking coefficient decreases rapidly with increasing ground speed. The coefficient also decreases if the runway is smoother (that is, if the runway has decreased macrotexture depth or is ungrooved), the tire pressure is higher,[65] or the tire tread depth is lower.

The certification basis of the BAe 125-800A (now referred to as the "Hawker Beechcraft 125-800A") for takeoff from wet and contaminated runways and landing on contaminated runways is the European Joint Airworthiness Authorities (JAA) *Joint Aviation Regulations* Part 25 and the associated guidance material in Advisory Material Joint (AMJ) 25X1591, Change 14.[66] The wet runway braking friction coefficients assumed in the Hawker Beechcraft CAPS simulations and used to compute the wet runway landing distances provided in the BAe 125-800A Aircraft Flight Manual (AFM)[67] are based on ratios of wet-to-dry braking coefficients defined in AMJ 25X1591. These braking coefficients originated in the *British Civil Airworthiness Requirements* (BCAR) "Reference Wet Hard Surface" (RWHS), which defined the performance expected from a "standard" wet, ungrooved runway. A review of wet runway friction research[68] indicated that many wet, ungrooved runways may provide substantially less friction than indicated in the BCAR RWHS and that stopping distances on these runways will consequently be substantially greater than those computed using the braking coefficients defined in AMJ 25X1591. Accordingly, if the wet runway stopping distances provided in airplane AFMs (including the BAe 125-800A AFM) or performance supplemental materials[69] are based on the AMJ 25X1591 friction levels, then the actual stopping distances on some wet, ungrooved runways could be significantly greater than the documented distances.

[65] However, on a runway contaminated with standing water, a higher tire inflation pressure can help maintain contact between the tire and the runway over a larger speed range.

[66] The BAe 125-800A was originally certified by the United Kingdom Civil Aviation Authority under CAR.10 *British Civil Airworthiness Requirements*. The airplane's wet runway certification was accepted to the later JAA standard. The JAA was an associated body of the European Civil Aviation Conference, which represented the civil aviation regulatory authorities of participating European States that agreed to cooperate in developing and implementing common safety regulatory standards and procedures. In 2002, the European Aviation Safety Agency (EASA), a Europe-wide regulatory authority, took over all of the functions of the JAA. On September 28, 2003, EASA took over responsibility for the airworthiness and environmental certification of all aeronautical products, parts, and appliances designed, manufactured, maintained, or used by persons under the regulatory oversight of European Union Member States.

[67] The AFM used for the Hawker Beechcraft 125-800A airplane is titled, "Approved Flight Manual for the British Aerospace BAe. 125 Series 800A;" therefore, when referring to the AFM, the report will refer to it as the BAe 125-800A AFM.

[68] See Engineering Sciences Data Unit, "Frictional and Retarding Forces on Aircraft Tyres: Part II: Estimation of Braking Force (friction data updated–1981)" Engineering Sciences Data Item Number 71026 (United Kingdom: Royal Aeronautical Society, 1971). Additional information is available at <http://www.esdu.com/graphics/dataitem/di _71026d.htm>.

[69] Some AFMs have supplemental materials that have been developed by airplane manufacturers but have not been approved or required by the FAA. The NTSB recommended in Safety Recommendation A-07-57 that landing distance assessments should be conducted based on "existing" performance data. See section 1.18.2.6 for more information.

1.16.3.4 Braking Coefficients

1.16.3.4.1 U.S. and European Braking Coefficient Standards

Although U.S. and European regulations do not require or standardize the calculation and presentation of operational landing distances[70] on wet runways, current regulations do prescribe the calculation of the accelerate-stop distances for rejected takeoffs on wet runways. Title 14 CFR 25.109 and European Aviation Safety Agency (EASA) Certification Specifications 25.109 define the accelerate-stop distance for transport-category airplanes and describe how this distance is to be determined.[71] Title 14 CFR 25.109(c) defines the effective braking coefficient to be assumed in the calculation of the accelerate-stop distance for an ungrooved, wet runway, such as runway 30 on the day of the accident, as the maximum available braking coefficients, multiplied by an anti-skid system efficiency factor. The airplane performance study determined that an anti-skid system efficiency of 47.5 percent,[72] applied to the maximum available braking coefficients defined by 14 CFR 25.109(c) for a tire pressure of 140 psi and assuming that the flight crew applied sufficient braking effort to demand all of the available runway friction before the decision to go around, resulted in a deceleration that best matched the computed performance of the accident airplane. This anti-skid system efficiency, and the resulting effective braking coefficients, which are discussed in more detail below, closely matched the anti-skid efficiency and effective braking coefficients computed by the NASA friction expert based on the CFME friction measurements of the runway 2 days after the accident (see section 1.16.2, table 3, and figure 5 below). The performance study determined that the effective braking coefficients based on 14 CFR 25.109(c) most closely represented the actual braking performance of the airplane during the landing on the wet, ungrooved runway.

[70] The operational landing distance accounts for, in part, the reported meteorological and runway surface conditions, runway slope, airplane weight, airplane configuration, approach speed, and ground deceleration devices planned to be used for the landing. The operational landing distance represents the performance capability of the airplane based on arrival conditions and planned landing technique with no added safety margin.

[71] The accelerate-stop distance is the distance required to accelerate the airplane from a standing start to V_1 and then bring the airplane back to a stop. V_1 is the maximum speed in the takeoff at which the pilot must take the first action (for example, apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance. The FAA did not require airframe manufacturers to account for wet runway rejected takeoff performance for new airplane type certificate applications until 14 CFR 25.109, Amendment 25–92, effective February 18, 1998. The rule was not retroactive. Therefore, many transport-category airplanes certificated under Part 25 are not required to account for wet runway takeoff accelerate-stop performance.

[72] The 47.5 percent anti-skid efficiency determined for the accident airplane exceeds the 30 percent efficiency that Section 25.109(c) assigns to the type of anti-skid system installed on the airplane, but it is within the range of efficiencies defined in Engineering Sciences Data Unit 71026 for this type of system.

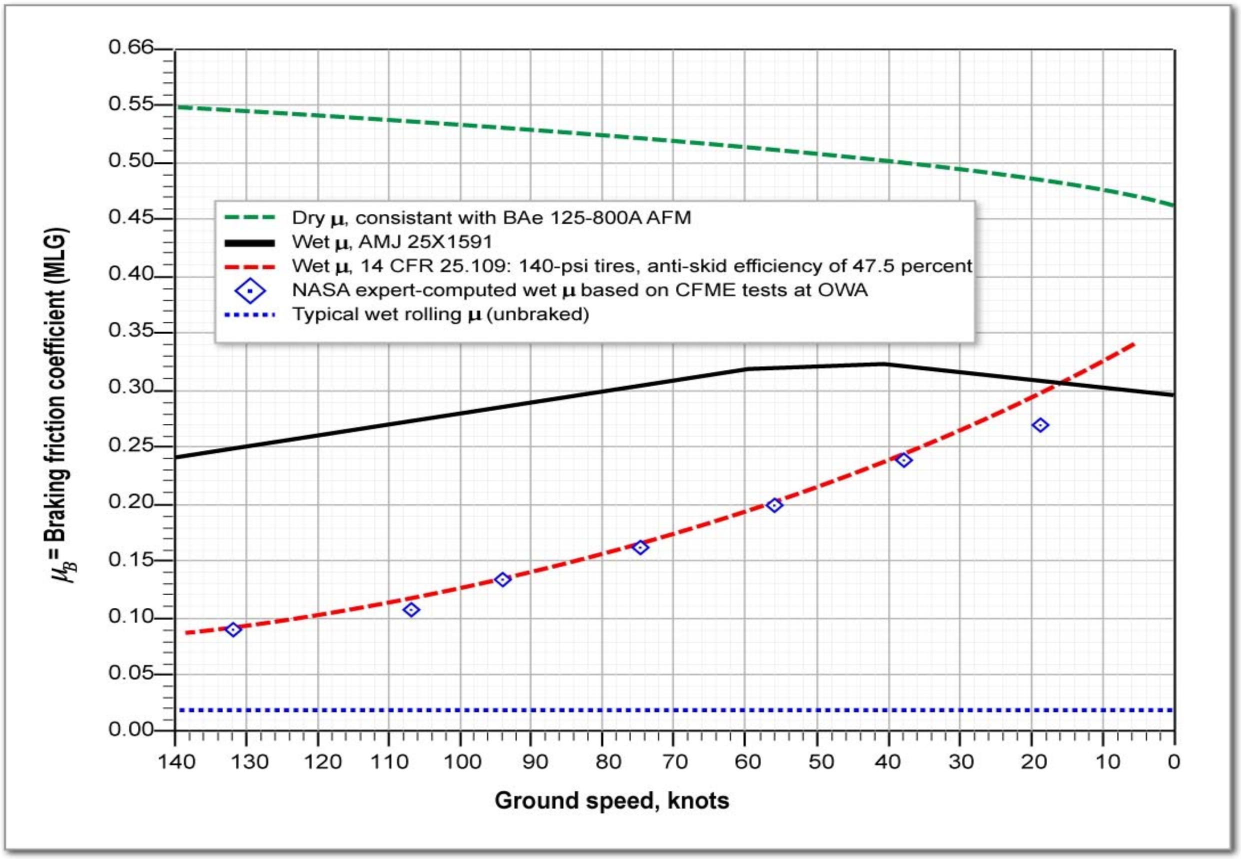

Figure 5. Comparison of calculated wet, ungrooved runway MLG effective braking friction coefficient values as a function of ground speed using the BAe 125-800A AFM, NASA CFME-based, and 14 CFR 25.109 methods. BAe 125-800A AFM dry runway and unbraked rolling friction coefficient values are shown for reference.

1.16.3.4.2 Required Landing Distances Using Different Braking Coefficient Models

The effective braking coefficients determined in the airplane performance study for the accident landing were substantially below those defined in the BCAR RWHS and AMJ 25X1591, assumed in the CAPS simulation, and underlying the wet runway landing distances provided in the BAe 125-800A AFM (see figure 5). As a result, the performance study indicated that the total landing distances computed using the Section 25.109 braking coefficients can be significantly longer than those computed using the AMJ 25X1591 coefficients and provided in the AFM.

For example, as shown in table 4, using the accident landing weight of 19,912 pounds, no wind, the OWA field elevation, outside air temperature on the day of the accident, 140-psi tire pressure, and deceleration device deployment times[73] used to develop the AFM wet runway

[73] The landing distance data presented in the AFM are based on the airbrakes moving to the OPEN position 0.56 second after touchdown and on the lift-dump system being engaged at the same time. Once engaged, it takes about 2 seconds for the lift-dump system to fully deploy. Based on CVR evidence, on the accident flight, the airbrakes moved to the OPEN position about 4.1 seconds after touchdown, and the lift-dump system was engaged about 8.9 seconds after touchdown.

guidance data, the performance study indicated that the total landing distance using the AMJ 25X1591 braking coefficients was 3,338 feet and that the total landing distance using the Section 25.109 braking coefficients was 4,225 feet, which is 26 percent longer. Assuming an 8-knot tailwind, the landing distances were 3,792 and 4,928 feet, respectively.

Table 4. Calculated Hawker Beechcraft 125-800A landing distances as a function of wet runway braking coefficient source (based on accident landing weight of 19,912 pounds, OWA field elevation, 18° C outside air temperature, 140-psi tire pressure, and 0.7 percent downhill runway slope).

Simulation Scenario	Wind Condition	Calculated Landing Distance (in feet)			
		Braking Coefficient Source AMJ 25X1591 or BCAR RWHS		Braking Coefficient Source 14 CFR 25.109	
		Total	+ 15 Percent Margin	Total	+ 15 Percent Margin
AFM air distance; AFM deceleration device deployment times	No wind	3,338	3,840	4,225	4,860
	8-knot tailwind	3,792	4,361	4,928	5,667

The data in table 4 indicate that, if the flight crew had conducted an arrival landing distance assessment using available information (for either wind condition), it would have shown that the airplane could have stopped on the 5,500-foot-long runway with a safety margin of more than 15 percent. The data in table 4 also show that, based on the actual arrival conditions (8-knot tailwind), the Section 25.109 braking coefficient standard, and the BAe 125-800A AFM deceleration device deployment times, the airplane would not be expected to stop on runway 30 with a safety margin of at least 15 percent.

The airplane performance study used the Section 25.109 braking coefficients to compute the stopping distance required by the accident airplane given the 8-knot tailwind, touchdown location, and assuming the accident deceleration device deployment time (airbrakes opened 4.1 seconds after touchdown, and lift dump engaged 8.9 seconds after touchdown). The results, which are shown in table 5, indicate that, after touching down 1,128 feet from the runway 30 threshold,[74] the airplane would have needed an additional 4,669 feet to stop, for a total landing distance of about 5,800 feet, which is 300 feet longer than the available landing distance. The EGPWS data indicated that, about the time that the go-around was initiated, the deceleration of the airplane was slightly better than that predicted by the calculation. Adjusting the calculations to account for this improvement indicates that the airplane would have stopped about 100 feet past the runway end but within the runway safety area.

[74] The landing distance published in the AFM for an 8-knot tailwind includes an air distance of 946 feet.

Table 5. Calculated Hawker Beechcraft 125-800A landing distances (based on accident landing weight of 19,912 pounds, accident air distance of 1,128 feet, touchdown airspeed of 122 knots, OWA field elevation, 18° C outside air temperature, 140-psi tire pressure, and 0.7 percent downhill runway slope).

Simulation Scenario	Wind Condition	Calculated Landing Distance Based on 14 CFR 25.109 Wet, Ungrooved Runway Standard	
		Total Landing Distance (in feet)	Runway Remaining (in feet)
Accident deceleration device deployment time (airbrakes opened 4.1 seconds after touchdown, and lift dump engaged about 8.9 seconds after touchdown)	8-knot tailwind	5,800	-300
Lift dump deployed coincident with opening of airbrakes (about 4.1 seconds after touchdown)		5,530	-30
Accident deceleration device deployment time (airbrakes opened 4.1 seconds after touchdown, and lift dump engaged about 8.9 seconds after touchdown)	8-knot headwind	4,300	1,200
Airbrakes opened about 4.1 seconds after touchdown, lift dump not deployed		4,550	950

The airplane performance study also used the Section 25.109 braking coefficients to compute the landing distances required if lift dump had been deployed at the same time that the airbrakes moved to the OPEN position (4.1 seconds after touchdown) and the landing distances required if the landing had been made on runway 12 (that is, landing with a headwind instead of a tailwind). The results in table 5 indicate that the total landing distance on runway 30 (with an 8-knot tailwind), assuming that lift-dump deployment was coincident with the opening of the airbrakes, was 5,530 feet, or 30 feet past the runway end. The total landing distance on runway 12 (with an 8-knot headwind), assuming the same touchdown point on the runway and the airbrake and lift-dump deployment timing that occurred during the accident, was about 4,300 feet, or about 1,200 feet before the runway end. The total landing distance on runway 12, assuming the accident airbrake deployment timing but with no lift-dump deployment, was about 4,550 feet, or 950 feet before the runway end.

1.17 Organizational and Management Information

East Coast Jets, which is headquartered in Allentown, Pennsylvania, is a Part 135 on-demand charter company that began operations in October 1999. According to the chief pilot, East Coast Jets is a small charter company that provides customized service to more than 5,000 U.S. airports and some international airports. At the time of the accident, East Coast Jets operated four Hawker Beechcraft 125-800A, three Learjet 35, and three Learjet 55 airplanes and employed 22 full-time pilots.

A review of FAA records revealed that East Coast Jets had no previous accidents. The company held a "platinum" rating based on biannual safety audits conducted by the Aviation Research Group/US (ARG/US), an industry-rating group.[75] According to an ARG/US representative, East Coast Jets was noteworthy within the Part 135 on-demand industry for its high pilot retention rate. All of the interviewed pilots, the FAA principal operations inspector (POI), and an ARG/US representative spoke favorably of the company and highlighted the loyalty and lack of pilot turnover when compared to other companies in the industry.

According to East Coast Jets' chief pilot, the company often hired pilots locally from Ace Flight School. He stated that newly hired pilots preferably had 1,500 hours and some multiengine and jet airplane time. He stated that the company would hire pilots who they knew were "ready" for jet operations by hiring the best pilots available from local sources. He stated that the normal progression for pilots after they were hired was to begin as copilot on the Learjet, move to copilot on the Hawker Beechcraft 125-800A, then to captain on the Learjet, before moving to captain on the Hawker Beechcraft. As a result, many of the pilots were dual-qualified. He stated that the goal of the training program was to qualify new pilots as captain within 2 years. One experienced Hawker captain stated that flying with new pilots required a lot of talking and "babysitting" but that, after a period, you could start letting them do their duties with less oversight. The director of operations stated that the progression of new pilots was that, initially, first officers were told to just "sit there" and "not touch anything" and that they were a "detriment to the flight" but that they then became a positive to the flight and were trusted to make landings on empty flight legs and then on flights carrying passengers.

1.17.1 Company Training

East Coast Jets' OpSpec states that company pilots receive all required training on Hawker Beechcraft 125-800A and Learjet airplanes at Simcom International, Orlando, Florida, a Part 142 training school. According to East Coast Jets, at the time of the accident, the company also provided in-house training on general subjects, including crew resource management (CRM) and emergency procedures, twice a year. In accordance with Part 135 requirements, East Coast Jets maintains an FAA-approved training manual.

1.17.1.1 Standard Operating Procedures

At the time of the accident, East Coast Jets pilots were trained to the standard operating procedures (SOPs) contained in Simcom's Technical Manual,[76] which included flow patterns,

[75] ARG/US performs audits for corporate flight departments, charter operators, and commercial airlines. The platinum rating is the highest ARG/US safety rating and is awarded to operators that successfully pass an ARG/US on-site safety audit. A platinum rating requires a functioning safety management system; a clear and workable emergency response plan; appropriate written standards, training, and implementation; and adequate historical records for all major aspects of operations and maintenance within a flight department or charter company.

[76] The guidance contained in part of the Simcom's Technical Manual, which was used as the training manual for East Coast Jets pilots, was in accordance with the guidance contained in the BAe 125-800A AFM.

checklists, checklist discipline, PF and PM responsibilities, and challenges and standard callouts that the flight crew should make while conducting checklists. East Coast Jets General Operations Manual (GOM) does not contain SOPs nor is it required to as an on-demand Part 135 operator. When asked during postaccident interviews, company pilots could not cite or explain Simcom's SOPs consistently.

According to FAA AC 120-71A, "Standard Operating Procedures for Flight Deck Crewmembers," SOPs are universally recognized as basic to safe aviation operations. The AC states that "effective crew coordination and crew performance, two central concepts of CRM, depend upon the crew's having a shared mental model of each task. That mental model, in turn, is founded on SOPs." The AC emphasizes that SOPs should be clear, comprehensive, and readily available in the manuals used by pilots. AC 120-71A, Appendix 1, "Standard Operating Procedures Template," stated that the following issues, in part, should be addressed in the SOPs: checklist usage; radio communications; briefings; cockpit discipline, including sterile cockpit; CRM; and go-around/missed approach procedures. The AC indicated that the guidance was intended for Part 121 operators, which are required to have SOPs, but that Part 135, 125, and 91 operators should also find the guidance useful.

1.17.1.2 Crew Resource Management

AC 120-51E, "Crew Resource Management Training," provides guidelines for developing, implementing, reinforcing, and assessing CRM training for flight crewmembers and other personnel essential to flight safety. CRM training focuses on situational awareness, communication skills, teamwork, task allocation, and decision-making within a comprehensive framework of SOPs. These guidelines are intended for Part 121 certificate holders because they are required by federal regulations to provide CRM training. The AC states that the guidance could also be used by Part 135 operators that chose to train in accordance with Part 121 requirements; however, Part 135 on-demand operators are not currently required to provide CRM training to their pilots.

According to a Simcom instructor, Simcom teaches CRM as a subject, it is addressed in the simulator, and it is graded; however, Simcom does not have a formal curriculum or stated standards for CRM.[77] He stated that failing to conduct any briefing would be considered poor CRM and that, during training, instructors look for good communications between crewmembers. He stated that East Coast Jets pilots exhibited above-average CRM skills. The East Coast Jets GOM does not contain CRM procedures. Although CRM is listed as a general subject in the East Coast Jets training manual, no course content is provided.

1.17.1.3 Checklists

According to the SOPs, "Checklists should be initiated by command from the PF," and, "after completion of any checklist, the…(pilot not flying) should state…checklist is complete.'" The SOPs also state that checklist discipline include using the checklists "verbatim, smartly and professionally." The SOPs stated, "In executing the checklist, the PNF [pilot-not-flying] reads

[77] The CRM training received by the pilots did not meet the standards required by Part 121 regulations.

each checklist item aloud. Items that are the responsibility of the PF are verified as accomplished and the PF verbally confirms this (challenge/response). The items that are the PNF's responsibility are verified as being accomplished and the PNF verbally confirms this (challenge/self response)."

As noted, East Coast Jets pilots were trained to Simcom's SOPs; however, company pilots were not given the checklists contained in the SOPs to use during operations. Instead, East Coast Jets provided its pilots the East Coast Jets Normal Procedures checklist, which was a revised version of the checklist contained in Simcom's SOPs and was to be used during normal operations. Some differences exist between the East Coast Jets and Simcom checklists. For example, none of the checklists contained in Simcom's SOPs were denoted as silent checks, whereas East Coast Jets had several checklists that were denoted as silent checks. In addition, some of the items on the Simcom checklists were different from the items on the East Coast Jets checklists, and some of the items were located in different places on the checklists.

Postaccident interviews with East Coast Jets pilots indicated that sometimes trainee pilots brought the revised checklist to training (the captain did and used it during simulator training) and sometimes they did not do so (the first officer did not). According to an agreement between Simcom and East Coast Jets, the company agreed to use all of Simcom's procedures and checklists unless the company provided a revised checklist to Simcom for use during training. East Coast Jets did not provide the revised Normal Procedures checklist to Simcom.

East Coast Jets pilots were given the Expanded Normal checklist contained in the BAe 125-800A AFM to use during emergency situations. The company also indicated that a Flight Safety International (FSI) Quick Reference Handbook (QRH) was kept on board its airplanes and that it was marked "for training purposes only."[78]

1.17.1.3.1 Descent Checklist

The East Coast Jets Descent checklist is a silent check,[79] which includes, in part, the following steps:

- Open main air valves
- Set pressurization
- Adjust rudder pedals
- Check fuel

The Descent checklist also includes turning on the taxi lights, setting the altimeters, and turning on the no smoking/seat belt signs once the airplane reaches FL 180. A note on the Simcom Descent checklist states to "maintain sterile cockpit below 10,000 feet above airport surface," which is in accordance with 14 CFR 135.100, commonly referred to as the "sterile cockpit rule." No such note was included in the East Coast Jets Descent checklist.

[78] According to the chief pilot, the FSI QRH was kept on board company airplanes because it provided pictures of the annunciator lights and could be used as a reference.

[79] Silent checklists must still be initiated by command from the PF and be conducted and called complete by the PM. However, unlike during other checklists, the items are conducted silently.

1.17.1.3.2 Approach Checklist

The East Coast Jets Approach checklist, includes, in part, completing an approach briefing. According to Simcom's SOPs, the approach briefing should include the type of approach lights, missed approach procedure, and runway conditions. The following items, as applicable, should also be included in the approach briefing: configuration; approach speed; minimum safe altitude; approach course; final approach fix altitude; decision altitude/minimum descent altitude; field elevation; visual descent point; missed approach heading, altitude, and intentions; and abnormal implications. According to the CVR, in response to the first officer calling for the approach briefing, the captain replied, "it's gonna be the ILS to three zero."

1.17.1.3.3 Before Landing and Go-Around Checklists

The East Coast Jets Before Landing checklist includes, in part, the following verbal steps:

- Turn on landing lights, as required
- Check that all three green landing gear annunciators are illuminated to ensure they are locked in the down position
- Check hydraulic pressure
- Check that brakes have zero pressurization
- Set flaps, as required[80]

The Before Landing checklist contains the following three short final steps: recheck the landing gear, turn off the main air valves, and disengage the autopilot and yaw damper.

According to manufacturer and Simcom guidance, the required response to the Landing checklist item "flaps" is "set." During postaccident interviews, a Simcom instructor stated that the "set flaps" step in the East Coast Jets Before Landing checklist allowed pilots to land without the flaps set at 45°. He stated that a pilot may choose to land with flaps set at 25° because of weather conditions or a system malfunction. He stated that, because it was not the normal procedure to land without flaps set at 45°, the captain must brief and plan for a landing with a different flap setting. The East Coast Jets director of operations verified that company pilots state, "set flaps," to allow them to land without flaps set at 45°.

The East Coast Jets Go-Around checklist includes the following verbal steps:

- Set flaps to 15°[81]
- Retract the landing gear
- Engage yaw damper

[80] A note located underneath the "set flaps" item on the Simcom Landing checklist states, "the flaps are normally set to 45° for landing; check [that] the flap gage indicates the correct angle."

[81] Takeoff calculations performed by Hawker Beechcraft indicated that, given the location of the initiation of the go-around, the accident airplane could not have rotated and lifted off before the runway end with the flaps set at either 15° or 0°.

1.17.2 Landing Speed and Distance Calculations Guidance

The accident airplane arrived at OWA with an estimated gross weight of 19,912 pounds. According to the FAA-accepted East Coast Jets Normal Procedures checklist, for an airplane weighing about 20,000 pounds, the reference landing speed (V_{ref}) should be about 122 knots. According to the Simcom Technical Manual, flaps should be set to 45° at the glideslope intercept and the airplane slowed to V_{ref} + 10 knots.

According to East Coast Jets' chief pilot, factored landing distances, which are used for dispatch, are determined preflight using the company's Air Crew Manual, which is kept in the cockpit of company airplanes.[82] Based on a landing speed of 122 knots and an airport elevation of 1,146 feet, the landing distance required for the accident airplane to land on a dry runway would have been about 4,216 feet with no winds, 3,966 feet with a 10-knot headwind component, and 5,059 feet with a 10-knot tailwind component (runway 30 at OWA is 5,500 feet long). No correction for a wet runway is provided in the manual. However, if the destination runway was expected to be wet or slippery, pilots were trained to add a 15-percent safety margin to the required factored dry runway landing distance.

According to East Coast Jets' chief pilot, company pilots used aircraft performance software developed directly from the BAe 125-800A AFM by Ultra Nav, Lubbock, Texas, to precalculate actual (unfactored) landing distances. He stated that pilots could also recalculate the landing distance while in flight for the actual conditions existing at the time of arrival using onboard, handheld computers that had the Ultra Nav software installed. Postaccident landing distance calculations for runway 30 were conducted using the Ultra Nav software. The calculations showed that, assuming, in part, winds 320° at 8 knots (headwind), the actual landing distance on a wet runway would have been 3,140 feet. Assuming a wet runway with an estimated 10-knot tailwind, the actual landing distance on the runway would have been 3,940 feet.

The NTSB notes that the accident flight crew did not conduct an arrival landing distance assessment. However, at the time of the accident, neither the FAA nor the company required flight crews to perform landing distance assessments based on conditions actually existing at the time of arrival.

1.17.3 FAA Surveillance

East Coast Jets' operating certificate was managed by the FAA Allentown Flight Standards District Office (FSDO). According to the FAA, at the time of the accident, the POI was responsible for 12 Part 135 operators. The POI had been overseeing East Coast Jets, with

[82] Dispatch, or factored, landing distance calculations are used during flight planning to ensure that dispatched airplanes will be able to land safely at the intended destination airport or a planned alternate and are based on estimated landing weights and forecast conditions. Factored landing distances, including preflight landing safety margins, are required and standardized by U.S. and international aviation authorities. Specifically, in accordance with 14 CFR 135.385, "Large Transport Category Airplanes: Turbine Engine Powered Landing Limitations: Destination Airport," "no person operating a turbine engine powered large transport category airplane may take off unless its weight on arrival…would allow a full stop landing at the intended destination airport within 60 percent of the effective length of each runway." The data used in East Coast Jets-required landing distance charts are derived from data contained in the BAe 125-800A AFM and are in accordance with 14 CFR 135.385. See section 1.18.1 for more information about landing distance assessment standards.

minor exceptions, since the company began operations in 1999. The POI stated that East Coast Jets had no major operations violations and had taken corrective actions when asked. He characterized the company's safety program as good, noting that it was one of the only Part 135 operators that had a safety officer and held regular safety meetings.[83] Both FAA and company officials characterized the relationship positively.

The POI stated that the East Coast Jets Normal Procedures checklist was an "alternate," revised checklist and that it had been submitted, with pages from the AFM, for acceptance. The checklist was stamped, "Accepted," and signed by the POI. He added that he assumed that this would be the checklist used during training at Simcom but that he had not contacted Simcom or the Orlando FSDO, which had responsibility for oversight of Simcom, to verify that this occurred. Guidance to POIs on outsourced training, contained in FAA Order 8900.1, "Flight Standards Information Management System," Volume 6, "Surveillance," Chapter 8, "Part 142 Inspections: Conduct Surveillance or Inspection of a Training Center," emphasizes the importance of clearly defined SOPs, including checklists, when approving a training center curriculum.

Simcom's operating certificate was managed by the Orlando FSDO. The training center program manager (TCPM), an air safety inspector, for Simcom stated that he did not know which Part 135 operators were using Simcom for training unless an operator or its POI told him and that he learned that East Coast Jets was using Simcom as a result of the accident. He stated that a Part 142 school TCPM controlled all aspects of training but had no authority over the operators that used the training facility. The TCPM stated that he had never observed East Coast Jets pilots during operations. FAA Order 8900.1 states that the TCPM is the best qualified individual to assist the POI with required inspections, proficiency checks, and observations of assigned operators.

1.18 Additional Information

1.18.1 U.S. and European Landing Distance Assessment Standards

As noted, dispatch, or factored, landing distance calculations are used during flight planning; however, current FAA certification standards do not require the AFM to include landing distances on wet runways based on either wet runway flight tests or on an engineering analysis of the airplane's stopping performance on wet runways. Instead, in accordance with federal regulations, the dry and wet/slippery landing performance data used for dispatch calculations are obtained by multiplying the numbers demonstrated[84] during certification

[83] During postaccident interviews, the line captain who served as the East Coast Jets safety officer described a safety management system at East Coast Jets based on feedback, checks and balances, internal evaluation, and external audits.

[84] For these demonstrations, the airplane is decelerated using maximum manual braking and full spoiler deployment but no reverse thrust during the landing roll.

landings on a level, ungrooved, dry, hard-surfaced runway by factors of 1.67 and 1.92, respectively.[85]

U.S. federal regulations do not generally[86] require or standardize arrival, or operational, landing distance assessments, which are conducted by pilots while in flight to determine whether a successful landing can be made at the intended destination and use updated information, including runway conditions, weather, and planned configurations, nor do they specify minimum safety margins for such assessments. Airplane landing performance data for conditions other than bare and dry are typically calculated rather than demonstrated via a flight test.

European operational regulations (EU OPS) 1.400, "Approach and Landing Conditions," require pilots to conduct landing distance assessments; however, other than specifying that the assessment be made "having regard to the performance information contained in the Operations Manual," EU OPS 1.400 does not provide guidance for making the assessment. Challenges pilots may face while conducting a landing distance assessment include evaluating the runway condition based on weather, friction, or braking action reports and selecting a safety margin to apply to landing distances.

Airframe manufacturers are not required to provide guidance data to support arrival landing distance assessments in their FAA-approved AFMs; however, they may choose to provide such guidance material. (The NTSB notes that the BAe 125-800A AFM contained guidance on arrival landing distance performance even though this guidance was not required to be provided, nor used by flight crews, either before or during flight.) Current European regulations require landing performance data on contaminated runways to be published in the AFM if the airplane is to be operated from such runways;[87] however, wet (but not flooded) runways are not considered contaminated. EU OPS 1.400 states the following:

> Before commencing an approach to land, the commander must satisfy himself/herself that, according to the information available to him/her, the weather at the aerodrome and the condition of the runway intended to be used should not prevent a safe approach, landing or missed approach, having regard to the performance information contained in the Operations Manual.

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[85] Airplane manufacturers have not historically demonstrated landing performance on all possible runway surface conditions, including a wet and/or slippery runway, largely because of the difficulties involved in attaining representative and repeatable conditions during a finite flight test program.

[86] For example, Pinnacle Airlines, chose to adopt the arrival landing distance assessment recommendations in SAFO 06012, including adding a minimum safety margin of 15 percent, and requested that the FAA approve OpSpec C382. The FAA subsequently issued OpSpec C382, thus requiring the company and its pilots to comply with the specific arrival landing distance assessment requirements documented in the OpSpec. According to SAFO 06012, "Operators may use Operation/Management Specification paragraph C382 to record their voluntary commitment to this [SAFO 06012-recommended landing distance assessment] practice, pending rulemaking," and it is available to all Part 121, 135, 125, and 91 subpart K turbojet operators.

[87] EASA Certification Specifications (CS) 25.1591 prohibits operations on contaminated runways unless supplemental performance information for those runways is provided in the AFM. Runway contaminants include standing water at least 3 mm deep, or any type of frozen precipitation, covering at least 25 percent of the runway.

EU OPS 1.400 also does not require that wet-runway landing distance information be published in the AFM. Therefore, neither U.S. nor current European regulations[88] require that wet runway landing distances be provided in the AFM or performance supplemental materials nor do they address the methods used to compute and apply these distances if the airplane manufacturer chooses to provide them as optional guidance material.

No equivalent to EU OPS 1.400 exists in the U.S. federal regulations. However, after the Southwest Airlines landing overrun accident involving a Boeing 737-700 at Chicago Midway Airport in December 2005,[89] the FAA performed an internal audit of regulations and guidance information concerning landing distance requirements. As a result of the audit, the FAA issued SAFO 06012. The purpose of SAFO 06012 was stated as follows:

> This SAFO urgently recommends that operators of turbojet airplanes develop procedures for flightcrews to assess landing performance based on conditions actually existing at time of arrival, as distinct from conditions presumed at time of dispatch. Those conditions include weather, runway conditions, the airplane's weight, and braking systems to be used. Once the actual landing distance is determined an additional safety margin of at least 15% should be added to that distance. Except under emergency conditions flightcrews should not attempt to land on runways that do not meet the assessment criteria and safety margins as specified in this SAFO.

The SAFO further stated, "the FAA considers a 15% margin between the expected actual airplane landing distance and the landing distance available at the time of arrival as the minimum acceptable safety margin for normal operations." The SAFO also noted that "the FAA has undertaken rulemaking that would explicitly require the practice described above." The SAFO points out that the dry-runway landing distances established during flight tests, which are the basis for the factored landing distances used for dispatch, are shorter than the landing distances achieved in practice and that AFM landing distances for wet and contaminated runways may also be based on the minimum dry distances obtained during flight tests. Consequently, landing on wet or contaminated runways with little or no safety margin added to the AFM landing distances may be insufficient for normal operations. The SAFO recommends a conservative approach to assessing landing distance requirements, including using the most adverse reliable braking action report or expected runway conditions and using values for air distances and approach speeds representative of actual operations.

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[88] The original BAe-800A certification included a requirement to provide the unfactored wet runway landing distances, assuming the braking friction coefficient produced by the RWHS. This requirement was dropped from the regulations when they were absorbed into the EASA CS.

[89] For more information, see *Runway Overrun and Collision, Southwest Airlines Flight 1248, Boeing 737-7H4, N471WN, Chicago Midway International Airport, Chicago, Illinois, December 8, 2005,* Aircraft Accident Report NTSB/AAR-07/06 (Washington, DC: National Transportation Safety Board, 2007). See section 1.18.2.6 for information about landing distance assessment-related safety recommendations that the NTSB issued to the FAA as a result of this accident.

1.18.2 Previously Issued Related Safety Recommendations

Many previously issued safety recommendations relate to this accident, and these recommendations are summarized in table 6. Sections 1.18.2.1 through 1.18.2.7 discuss these safety recommendations in more detail.

Table 6. Summary of related previously issued safety recommendations, including the safety recommendation number, the accident from which it resulted, the safety issue it addressed, and the current classification.

Safety Recommendation Number(s)	Related Accident(s)	Safety Issue(s)	Current Classification
A-10-15	Colgan Air, Inc., operating as Continental Connection flight 3407	Sterile cockpit procedures	Open—Acceptable Response
A-88-67	Northwest Airlines, Inc., flight 255	SOPs	Closed—Acceptable Action
A-99-35	Gates Learjet 25B	SOPs	Closed—Acceptable Action
A-03-52	Aviation Charter, Inc., King Air A100	CRM	Open—Acceptable Response
A-88-68	Northwest Airlines, Inc., flight 255	Checklist design	Closed—Unacceptable Action
A-09-70 and -71	Spanair flight JK5022	Checklist design	Open—Unacceptable Response
I-89-1	Consolidated Rail Corporation Freight Trains	Fatigue and sleep disorders	Closed—Acceptable Action
A-08-44	Shuttle America flight 6448	Fatigue	Closed—Acceptable Action
A-08-45	Shuttle America flight 6448	Fatigue	Open—Acceptable Response
A-09-63	Mesa Airlines (*go!*) flight 1002	Sleep disorders	Open—Acceptable Response
A-07-57	Southwest Airlines flight 1248	Arrival landing distance assessments	Closed—Unacceptable Action
A-07-61	Southwest Airlines flight 1248	Arrival landing distance assessments	Open—Acceptable Response
A-09-11	Midair collision of helicopters in Phoenix, Arizona	Onboard flight recorder systems	Open—Unacceptable Response

1.18.2.1 Sterile Cockpit Procedures

The NTSB has longstanding concerns about the violation of sterile cockpit procedures. The most recent safety recommendation pertinent to the East Coast Jets accident was issued by the NTSB on February 2, 2010, as a result of the February 12, 2009, accident in which a Colgan Air, Inc., Bombardier DHC-8-400, operating as Continental Connection flight 3407, crashed while on an instrument approach to Buffalo-Niagara International Airport, Buffalo, New York.[90] Safety Recommendation A-10-15 asked the FAA to do the following:

> Develop, and distribute to all pilots, multimedia guidance materials on professionalism in aircraft operations that contain standards of performance for professionalism; best practices for sterile cockpit adherence; techniques for assessing and correcting pilot deviations; examples and scenarios; and a detailed review of accidents involving breakdowns in sterile cockpit and other procedures, including this accident. Obtain the input of operators and air carrier and general aviation pilot groups in the development and distribution of these guidance materials.

On June 22, 2010, the FAA stated that it agreed that providing effective and usable information to pilot groups is an essential component in preventing accidents. The FAA stated that it was reviewing this recommendation to determine how best to address it in a timely and effective manner. On January 25, 2011, the NTSB classified Safety Recommendation A-10-15 "Open—Acceptable Response" pending receipt of additional information and completion of the recommended action.

1.18.2.2 Standard Operating Procedures

The NTSB also has longstanding concerns about pilots not adhering to SOPs and has issued recommendations related to this issue. For example, on June 27, 1988, the NTSB issued Safety Recommendation A-88-67 as a result of the August 16, 1987, Northwest Airlines, Inc., flight 255 accident involving a McDonnell Douglas DC-9-82, which crashed shortly after takeoff from Detroit Metropolitan Wayne County Airport, Romulus, Michigan.[91] Safety Recommendation A-88-67 asked the FAA to do the following:

> Require that all Parts 121 and 135 operators and principal operations inspectors emphasize the importance of disciplined application of Standard Operating Procedures and, in particular, emphasize rigorous adherence to prescribed checklist procedures.

On March 27, 1992, the NTSB stated that the following actions taken by the FAA were responsive to Safety Recommendation A-88-67:

- Issuance of Action Notice A8400.2, "Normal Checklist Review Parts 121 and 135," on December 30, 1988. The action notice required POIs to review the adequacy of checklists and the implementing procedures used by all Part 121 and 135 operators.

[90] For more information, see *Loss of Control on Approach, Colgan Air, Inc., Operating as Continental Connection Flight 3407, Bombardier DHC-8-400, N200WQ, Clarence Center, New York, February 12, 2009,* Aircraft Accident Report NTSB/AAR-10/01 (Washington, DC: National Transportation Safety Board, 2010).

[91] For more information, see *Northwest Airlines, Inc., McDonnell Douglas DC-9-82, N312RC, Detroit Metropolitan Wayne County Airport, Romulus, Michigan, August 16, 1987*, Aircraft Accident Report NTSB/AAR-88/05 (Washington, DC: National Transportation Safety Board, 1988).

- Publication of a *Special Federal Aviation Regulation* (SFAR) to improve air carrier training, evaluation, certification, and qualification requirements for appropriate personnel on October 2, 1990. The SFAR also addressed CRM training and line-oriented flight training and evaluation.
- Ongoing revision of AC 120-51, "Cockpit Resource Management," and retitling it, "Crew Resource Management." The revised AC will include specific observable and measurable markers for in-flight operations, including adherence to checklist and operating procedures.
- Continuing emphasis on proper adherence to prescribed checklist procedures and the disciplined application of SOPs for Part 121 and 135 operators.

As a result of these actions, the NTSB classified Safety Recommendation A-88-67 "Closed—Acceptable Action."

On May 12, 1999, the NTSB issued Safety Recommendation A-99-35 as a result of the January 13, 1998, accident involving a Gates Learjet 25B, which impacted terrain about 2 miles from George Bush Intercontinental Airport, Houston, Texas.[92] Safety Recommendation A-99-35 asked the FAA to, in part, do the following:

> Issue a Flight Standards Information Bulletin [FSIB] to [POIs] assigned to 14 [CFR] Part 135 on-demand air carriers, informing them of the circumstances of this accident and urging them to discuss the accident with their air carriers and encourage the use of the accident as a pilot training case study, to stress the importance of pilots' adherence to [SOPs].

On August 10, 2000, the FAA issued AC 120-71, "Standard Operating Procedures for Flightdeck Crewmembers," which provided guidance to Part 121 and 135 certificate holders on the importance of strict adherence to SOPs. On August 23, 2000, the FAA issued two FSIBs that announced the availability of the AC and directed POIs to promote the development of and strict adherence to SOPs in accordance with the guidance contained in the AC. As a result of these actions, the NTSB classified Safety Recommendation A-99-35 "Closed—Acceptable Action" on March 6, 2001.

1.18.2.3 Crew Resource Management

Between 1980 and 2003, the NTSB repeatedly recommended that the FAA revise Part 135 requirements to require on-demand charter operators that conduct operations with aircraft requiring two or more pilots to establish an FAA-approved CRM training program for their flight crews. Most recently, on December 2, 2003, the NTSB issued Safety Recommendation A-03-52 as a result of its investigation of the October 25, 2002, accident in

[92] The report for this accident, NTSB case number FTW98MA096, is available at <http://www.ntsb.gov/ntsb/query.asp>.

which an Aviation Charter, Inc., King Air A100 airplane lost control and impacted terrain in Eveleth, Minnesota.[93] Safety Recommendation A-03-52 asked the FAA to do the following:

> Require that 14 [CFR] Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement an [FAA]-approved [CRM] training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O.

Safety Recommendation A-03-52 was added to the NTSB's Most Wanted List of Transportation Safety Improvements in November 2006.

In April 2004, the FAA indicated that an ARC had been tasked to revise Part 135 requirements, including a requirement for CRM training for Part 135 operators of airplanes with two pilots. The NTSB classified Safety Recommendation A-03-52 "Open—Acceptable Response" pending completion of the revisions to Part 135. However, in its final report on the May 2, 2006, accident in which a Canadair, Ltd., CL-600-2A12 crashed during takeoff in icing conditions in Montrose, Colorado, the NTSB determined that the captain and first officer demonstrated poor CRM.[94] As a result, the NTSB reiterated Safety Recommendation A-03-52 and classified it "Open—Unacceptable Response."

On May 1, 2009, the FAA issued notice of proposed rulemaking (NPRM), "Crew Resource Management Training for Crewmembers in Part 135 Operations," which proposed to amend the regulations for all certificate holders conducting operations under Part 135 to include CRM for all crewmembers, including pilots and flight attendants, in their training programs. The NPRM stated that, at a minimum, CRM training should address the authority of the PIC; communication processes; how to build and maintain a flight team, manage workload and time, and maintain situational awareness; recognizing and mitigating fatigue and stress; and particular aeronautical decision-making skills tailored to the certificate holder's operations. The NPRM stated that the intended effect of the proposed changes was to reduce the frequency and severity of crew errors, which would reduce the frequency of accidents and incidents in Part 135 operations.

In its comments on the NPRM, the NTSB stated that it supported the proposed rule and believed that it would largely meet the intent of Safety Recommendation A-03-52 because it proposed requiring initial and recurrent CRM training for crewmembers working for Part 135 on-demand operators. The NTSB noted that the proposed rule also specified the minimum course content required for an approved CRM training program. However, the NTSB further stated that it did not support the proposal to allow Part 135 operators to waive the requirement to provide initial CRM training to crewmembers who have previously received initial CRM training from

[93] For more information, see *Loss of Control and Impact With Terrain, Aviation Charter, Inc., Raytheon (Beechcraft) King Air A100, N41BE, Eveleth, Minnesota, October 25, 2002,* Aircraft Accident Report NTSB/AAR-03/03 (Washington, DC: National Transportation Safety Board, 2003). For information on additional CRM-related safety recommendations, see Safety Recommendations A-80-42, A-94-196, and A-02-12, which are available on the NTSB's website at <http://www.ntsb.gov>.

[94] For more information, see *Crash During Takeoff in Icing Conditions, Canadair, Ltd., CL-600-2A12, N873G, Montrose, Colorado, November 28, 2004,* Aircraft Accident Brief NTSB/AAB-06/03 (Washington, DC: National Transportation Safety Board, 2006).

another Part 135 carrier and urged the FAA to withdraw this proposal. On December 29, 2009, the NTSB classified Safety Recommendation A-03-52 "Open—Acceptable Response" pending issuance of the final rule without an allowance for certificate holders to give credit for initial CRM training received from another Part 135 carrier. On January 21, 2011, the FAA published the final rule as proposed but without an allowance for certificate holders to give credit for initial training received from another Part 135 carrier.[95] The rule specifies that, after March 22, 2013, no certificate holder may use a person as a flight crewmember or flight attendant unless that person has completed approved CRM initial training with that certificate holder.

1.18.2.4 Checklist Design

On June 27, 1988, the NTSB issued Safety Recommendation A-88-68 as a result of the Northwest Airlines flight 255 accident. Safety Recommendation A-88-68 asked the FAA to do the following:

> Convene a human performance research group of personnel from…[NASA], industry, and pilot groups to determine if there is any type or method of presenting a checklist which produces better performance on the part of user personnel.

Because the group never convened, the NTSB classified Safety Recommendation A-88-68 "Closed—Unacceptable Action" on September 10, 1991.

Although the intention of Safety Recommendation A-88-68 was not met, the recommendation did influence research studies by NASA and the Volpe National Transportation Systems Center on checklist issues that the NTSB noted could serve as the foundation for a comprehensive human factors examination and evaluation by experts and that resulted in the development of valuable guidance for effective checklist construction. For example, human performance researchers have developed valuable guidance for effective checklist construction, including, in part, that checklist responses should portray the desired status or value of the item being considered (for example, stating flaps 45° not just "set" or "checked.")[96]

As noted in the August 17, 2009, safety recommendation letter that resulted from the NTSB's participation in the ongoing investigation of the August 20, 2008, accident involving Spanair flight JK5022,[97] improved dissemination and industry consideration of "best practices" related to the aforementioned research would yield safety benefits. Therefore, the NTSB issued Safety Recommendations A-09-70 and -71, which asked the FAA to do the following:

> Convene a meeting of industry, research, and government authorities, including international representatives, to develop guidance on industry best practices in

[95] *Federal Register,* vol. 76, no. 14 (January 21, 2011), p. 3831.

[96] For more information, see A. Degani and E. L. Weiner, "Cockpit Checklists: Concepts, Design, and Use," *Human Factors,* vol. 35, no. 2 (1993), pp. 28–43.

[97] The Comisión de Investigación de Accidentes e Incidentes de Aviación Civil of Spain is investigating Spainair flight JK5022's crash after takeoff from Madrid Barajas International Airport, Madrid, Spain, with the assistance of an accredited representative and technical advisors from the NTSB under the provisions of Annex 13 to the International Convention on Civil Aviation.

operational areas (including checklist design, training, and procedures) that relate to flight crews properly configuring airplanes for takeoff and landing.[98] (A-09-70)

Require operators to modify their takeoff and landing checklists to reflect the best practices identified as a result of the meeting recommended in Safety Recommendation A-09-70. (A-09-71)

On October 30, 2009, the FAA stated that numerous references provided excellent guidance on industry best practices in operational areas such as checklist design, training, procedures, and CRM and that it believed that a meeting to develop best practices was not necessary. However, the FAA published Information for Operators (InFO) 10002SUP, "Industries Best Practices Reference List," in March 2010 to better highlight all of the information available on these issues.

On November 29, 2010, the NTSB stated that, although the documents highlighted in the InFO contained information that should be considered when developing guidance on industry best practices, the lack of guidance that specifically related to flight crews' properly configuring airplanes for takeoff and landing was discouraging. The NTSB noted that recent research based on airline observations, pilot event reports, and accident histories has focused on the nature of flight crew task omissions in airline operations, such as the Spanair flight crew's failure to set the takeoff configuration. The NTSB stated that, because the pretakeoff phase of flight is often replete with interruptions, distractions, and unexpected task demands that can negatively affect the efficacy of even the best-designed checklists, it believed that additional guidance for developing checklists related to this critical phase of flight was needed to mitigate the associated risks. The NTSB pointed out that, to develop the most effective guidance, it was important that the FAA include the lessons learned and data available from all sources, including industry, research, and both U.S. and international government authorities. Therefore, the NTSB classified Safety Recommendations A-09-70 and -71 "Open—Unacceptable Response" pending the FAA's convening a meeting with the recommended groups and the NTSB's review of the developed guidance on industry best practices in operational areas that relate to flight crews properly configuring airplanes for takeoff and landing.

1.18.2.5 Pilot Fatigue and Sleep Disorders

The NTSB has long been concerned about fatigue and sleep disorders and associated vehicle operator impairment that results from undiagnosed or untreated sleep disorders in all modes of transportation. More than 20 years ago, on May 12, 1989, the NTSB issued Safety Recommendation I-89-1, which asked the U.S. Department of Transportation (DOT) "to expedite a coordinated research program on the effects of fatigue, sleepiness, sleep disorders, and

[98] Past meetings of this type have helped to create industry- and government-wide consensus about checklist improvements. For example, meetings of the 2004 Cockpit Smoke/Fire/Fumes Taskforce led to the development of an internationally approved template for checklists dealing with in-flight fire. The template was the basis for Information for Operators 08034 and the closing of an NTSB safety recommendation. For more information, see *In-Flight Cargo Fire, United Parcel Service Company Flight 1307, McDonnell Douglas DC-8-71F, N748UP, Philadelphia, Pennsylvania, February 7, 2006,* Aircraft Accident Report NTSB/AAR-07/07 (Washington, DC: National Transportation Safety Board, 2007).

circadian factors on transportation system safety."[99] The NTSB classified Safety Recommendation I-89-1 "Closed—Acceptable Action" on July 19, 1996, based on the DOT's efforts to organize and follow through on a departmentwide coordinated fatigue research effort.

Since 1996, the NTSB has issued many safety recommendations related to fatigue and sleep disorders to individual transportation modes, including aviation, a few of which will be discussed in this section. For example, on June 12, 2008, the NTSB issued Safety Recommendations A-08-44 and -45, which asked the FAA to do the following:

> Develop guidance, based on empirical and scientific evidence, for operators to establish fatigue management systems, including information about the content and implementation of these systems. (A-08-44)
>
> Develop and use a methodology that will continually assess the effectiveness of fatigue management systems implemented by operators, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accidents. (A-08-45)

These safety recommendations were made, in part, as a result of the February 18, 2007, runway overrun of Shuttle America, Inc., doing business as Delta Connection flight 6448.[100] The investigation revealed that the captain had been suffering from intermittent insomnia in the months preceding the accident.

With regard to sleep disorders, the NTSB noted that medical screening and treatment are among the strategies employed by fatigue management systems as part of their comprehensive, tailored approach to the problem of fatigue within an industry or a workplace. Both of these recommendations are on the NTSB's Most Wanted List.

On August 3, 2010, the FAA issued AC 120-103, "Fatigue Risk Management Systems for Aviation Safety," which provided guidance recommended for operators to establish a fatigue management system. On January 11, 2011, Safety Recommendation A-08-44, was classified "Closed—Acceptable Action" based on the issuance of the AC. The NTSB noted that the AC also provided guidance on the types of data and assessment techniques that operators should use to continually assess the effectiveness of their fatigue management systems, as discussed in Safety Recommendation A-08-45. However, the NTSB clarified that, although the AC recommends that operators collect and analyze the data discussed in the AC, the intent of the recommendation was for the FAA to also collect this data to evaluate the effectiveness of fatigue management systems in use by operators. The NTSB suggested that, through existing and developing FAA activities, such as the Aviation Safety Information Analysis and Sharing program, which shares and analyzes data voluntarily collected by carriers to identify emerging aviation safety issues, the FAA could collect and analyze the fatigue data discussed in the AC.

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[99] For more information, see *Head-End Collision of Consolidated Rail Corporation Freight Trains UBT-506 and TV-61 Near Thompsontown, Pennsylvania, January 14, 1988,* Railroad Accident Report NTSB/RAR-89/02 (Washington, DC: National Transportation Safety Board, 1989).

[100] For more information, see *Runway Overrun During Landing, Shuttle America, Inc. Doing Business as Delta Connection Flight 6448, Embraer ERJ-170, N862RW, Cleveland, Ohio, February 18, 2007,* Aircraft Accident Report NTSB/AAR-08/01 (Washington DC: National Transportation Safety Board, 2008).

The NTSB classified Safety Recommendation A-08-45 "Open—Acceptable Response" pending the FAA's provision of a description of its plan to assemble and evaluate the data being collected in response to the AC and completing action to address the recommendation.

In addition, on August 7, 2009, the NTSB issued safety recommendations concerning a common sleep disorder, obstructive sleep apnea, as a result of the February 13, 2008, incident when Mesa Airlines, a Bombardier CL-600-2B19 (operated as *go!* flight 1002), flew past its destination airport, General Lyman Field, Hilo, Hawaii, after both the captain and first officer fell asleep during the flight. [101] Safety Recommendation A-09-63 asked the FAA to do the following:

> Develop and disseminate guidance for pilots, employers, and physicians regarding the identification and treatment of individuals at high risk of obstructive sleep apnea, emphasizing that pilots who have obstructive sleep apnea that is effectively treated are routinely approved for continued medical certification.

On October 23, 2009, the FAA stated that it planned to take the following actions in response to Safety Recommendation A-09-63:

- Develop and implement an aviation medical examiner (AME) education program on obstructive sleep apnea and update the *AME Guide* to address the diagnosis of obstructive sleep apnea.
- Produce an Office of Aerospace Medicine pilot safety brochure about obstructive sleep apnea.
- Revise Chapter 8, "Medical Facts for Pilots," Section 1, "Fitness for Flight," of the AIM to include an explanation of sleep hygiene and sleep apnea and their relation to fatigue and fitness to fly.

On June 8, 2010, the NTSB classified Safety Recommendation A-09-63 "Open—Acceptable Response" pending completion of these actions.

In 2009, the NTSB also issued safety recommendations in the highway, marine, and rail transportation modes to identify and treat vehicle operators who are at high risk of obstructive sleep apnea and other sleep disorders. These Safety Recommendations included H-09-15 and -16, M-09-14 through -16, and R-09-9 through -11.[102]

The FAA has addressed some aspects of fatigue through its issuance of an NPRM titled, "14 CFR Parts 117 and 121: Flightcrew Member Duty and Rest Requirements," on September 14, 2010. The NPRM proposes to amend Part 121 and establish Part 117 to create a single set of flight time limitations, duty-period limits, and rest requirements for pilots in Part 121 operations. Regarding sleep disorders, the NPRM proposes that each certificate holder must develop and implement a fatigue-based education and training program that must include, among other topics, "familiarity with sleep disorders and their possible treatments."

[101] More information about this incident, SEA08IA080, is available on the NTSB's website at <http://www.ntsb.gov/ntsb/query.asp>

[102] More information about these safety recommendations is available online at <http://www.ntsb.gov/Recs.>

On November 15, 2010, the NTSB commented on the NPRM and stated, "if adopted, the proposed rule will provide substantial benefits towards reducing the hazards associated with flight crew fatigue in Part 121 operations." Further, the NTSB stated that it strongly supported the concept of requiring a fatigue education and training program for all flight crewmembers, employees involved in the operational control and scheduling of flight crewmembers, and personnel having management oversight of these areas, noting that the concept of fatigue education is among the foundational elements of an effective fatigue management system.

1.18.2.6 Arrival Landing Distance Assessments

The NTSB has longstanding concerns about the lack of a requirement for pilots to conduct arrival landing distance assessments before every landing. In its final report on the Southwest Airlines flight 1248 accident, the NTSB concluded that, "although landing distance assessments incorporating a landing distance safety margin are not required by regulation, they are critical to safe operation of transport-category airplanes on contaminated runways." On October 16, 2007, the NTSB issued Safety Recommendation A-07-61, which asked the FAA to do the following:

> Require all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to accomplish arrival landing distance assessments before every landing based on a standardized methodology involving approved performance data, actual arrival conditions, a means of correlating the airplane's braking ability with runway surface conditions using the most conservative interpretation available, and including a minimum safety margin of 15 percent.

The NTSB recognized that the standardized methodology recommended in Safety Recommendation A-07-61 would take time to develop. As a result, the NTSB also issued Urgent Safety Recommendation A-07-57 on October 4, 2007,[103] which asked the FAA to do the following until the standardized methodology could be developed:

> Immediately require all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to conduct arrival landing distance assessments before every landing based on existing performance data, actual conditions, and incorporating a minimum safety margin of 15 percent.

The NTSB's Most Wanted List includes the need for landing distance assessments with an adequate safety margin for every landing.

In response to both recommendations, the FAA stated that, since the Southwest Airlines flight 1248 accident, it had taken several actions to address the safety issues discussed in these recommendations, including the issuance of SAFO 06012. The FAA also stated that a survey of Part 121 operators indicated that "92 percent of U.S. airline passengers are now being carried by air carriers in full or partial compliance with the practices recommended in SAFO 06012."

[103] Safety Recommendation A-07-57 superseded Urgent Safety Recommendation A-06-16 and retained the older recommendation's classification of "Open—Unacceptable Response" because the FAA had not yet required landing distance assessments that incorporated a minimum safety margin of 15 percent.

The FAA pointed out that the broader mandate that the NTSB had recommended would require rulemaking. In October 2007, the FAA issued Order 1110.149, which established the TALPA ARC, to review regulations affecting certification and operation of airplanes and airports for airplane takeoff and landing operations on contaminated runways. The notice stated that the ARC would provide advice and recommendations to establish airplane certification and operational requirements (including training) for takeoff and landing operations on contaminated runways; establish landing distance assessment requirements, including minimum landing distance safety margins, to be performed at the time of arrival; and establish standards for runway surface condition reporting and minimum surface conditions for continued operations.

The NTSB addressed both of these recommendations in its June 27, 2008, letter to the FAA issuing safety recommendations as a result of the February 18, 2007, Shuttle America runway overrun. The NTSB noted that, at the time of the accident, Shuttle America did not require landing distance assessments based on conditions at the time of arrival despite the FAA's issuance of SAFO 06012 6 months before the accident. The final report for this accident concluded that "pilots needed to perform landing distance assessments because they accounted for conditions at the time of arrival and added a safety margin of at least 15 percent to calculated landing distances."

The NTSB noted that the FAA had not indicated the percentage of Part 121 carriers that had fully adopted the SAFO or those parts of the SAFO that had not been adopted by other Part 121 carriers (such as Shuttle America). The NTSB stated that it was especially concerned that among those parts of the SAFO that have not yet been adopted was the minimum 15-percent landing distance safety margin. The NTSB also noted that the FAA did not provide any information regarding whether SAFO 06012 had been adopted in full or in part by Part 135 and 91 subpart K operators or describe the actions that it would take to encourage those operators that had not complied with the SAFO to do so. In addition, the NTSB noted that, to date, not all Part 121, 135, and 91 subpart K operators had fully complied with SAFO 06012 and rulemaking that required arrival landing distance assessments with a 15-percent minimum safety margin had not been implemented.

The NTSB also noted that, although the FAA had formed an ARC to review regulations affecting certification and operation of airplanes and airports for takeoff and landing operations on contaminated runways and recognized that ARCs were part of the rulemaking process, these committees had historically taken a long time to complete their work, and the FAA had not always acted in a timely manner after it received recommendations from the committees. Therefore, the NTSB classified Safety Recommendation A-07-61 "Open—Acceptable Response" pending the prompt completion of the ARC's work and the FAA's timely action in response to the ARC's recommendations.

The TALPA ARC issued its recommendations to the FAA in 2009.[104] The regulatory changes proposed by the TALPA ARC would codify many of the provisions of SAFO 06012 and

[104] The recommendations were transmitted in separate documents prepared by each working group of the TALPA ARC, corresponding to distinct areas of regulation, including Parts 23, 25, 26, 91 subpart K, 121, 125, 135, and 139. Each of the separate documents notes that the regulations addressed by each working group are affected by the work of the others and that, consequently, substantial agreement and cooperation between the groups were necessary to generate working proposals. Accordingly, the recommendations from the different working groups are harmonized and crafted to work together as a whole. However, the NTSB notes that the working group responsible

introduce a new "Runway Condition and Braking Action Reports" table. In addition, pursuant to the recommendations, new rules would be added to 14 CFR Part 25, "Airworthiness Standards: Transport Category Airplanes," which would require that the braking coefficients on wet, ungrooved runways be calculated in accordance with Section 25.109. Further, pilots would be required to perform arrival landing distance assessments before landing. The assessment would "consider the runway surface condition, aircraft landing configuration, and meteorological conditions, using approved operational landing performance data in the Airplane Flight Manual supplemented as necessary with other data acceptable to the Administrator." A safety margin of at least 15 percent would be added to the Part 121 computed operational landing distance to determine the runway length required for landing.[105]

Regulations would also be added to 14 CFR Part 26, "Continued Airworthiness and Safety Improvements for Transport Category Airplanes," which would require the type-certificate holders of transport-category, turbine-powered airplanes with a type certificate issued after January 1, 1958, and operated under Parts 121, 125, 135, and 91 subpart K, to publish performance data to meet the intent of the new landing distance assessment regulations. The methods and assumptions for producing the data would be those specified in the additions to Part 25. The proposed timetable for compliance would be within 2 years of the approval of the regulations for airplanes still in production and within 4 years for airplanes out of production, including the Hawker Beechcraft 125-800A.

On August 23, 2010, the FAA stated that it had received the TALPA ARC's recommendations and that it was evaluating them with the intention to initiate and complete rulemaking in 2011. The FAA stated that, in the interim, it was continuing to encourage operators to incorporate the safety elements contained in SAFO 06012 pending the completion of the rulemaking process.

On January 31, 2011, the NTSB stated that the investigation of the East Coast Jets accident revealed that the company did not require its pilots to perform landing distance assessments based on conditions actually existing at the time of arrival. The NTSB further stated that it was concerned that accidents continued to occur in which pilots have not conducted arrival

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for Parts 91 subpart K, 125, and 135 operations expressed concerns about the applicability of the recommendations made by the other groups to the operations covered by Parts 91 subpart K, 125, and 135. As stated in this group's recommendation document, "As of the time of the drafting of these introductory comments, it appears that, indeed, some representatives of the FAA, a majority of the Part 121 Working Group, and others believe that there should be one landing performance assessment rule for all operations. This working group rejects the 'one size fits all' direction that the FAA appears to be following in this rulemaking process…. Sufficient differences exist among aircraft operations conducted under Parts 91, subpart K, 125, 135 and 121 in the types of aircraft flown, airports used, expectation of passengers, economic factors, and accident history to justify differing rules."

[105] The changes to the operational regulations proposed by the Parts 91 subpart K, 125, and 135 operations subgroup are different from those proposed by the Part 121 subgroup. The proposed Part 135 regulations would also require pilots to perform an arrival landing distance assessment but would require either an 11 percent safety margin (for authorized eligible on-demand operations) or an 18 percent safety margin (for other Part 135 turbojet operations). These safety margins would not be required if the landing distance assessments did not take credit for the effect of reverse thrust and conditions that make the effective use of reverse thrust more dependable are present. In addition, the subgroup proposed that Part 135 certificate holders meeting certain criteria, including, in part, turbine airplane experience, training programs, and go-around and crew coordination procedures, could alternately develop their own landing distance assessment programs. Further, the dispatch requirements of 14 CFR 135.385 would be amended to be consistent with the proposed 11 or 18 percent safety margin, which would replace the historic dispatch factors of 1.67 and 1.92 for forecast dry and wet/slippery arrival operations, respectively.

landing distance assessments, which would have provided them with crucial information about the landing conditions upon arrival and either prevented or seriously reduced the severity of the accidents. The NTSB pointed out that Safety Recommendation A-07-57 was issued as an interim solution because it recognized that the standardized methodology asked for in Safety Recommendation A-07-61 would take time to develop but that, to date, the FAA's actions had not been responsive. Therefore, the NTSB classified Safety Recommendation A-07-57 "Closed—Unacceptable Action." Regarding Safety Recommendation A-07-61, the NTSB stated that the FAA's efforts to address the recommendation were responsive; however, it encouraged the FAA to initiate and complete rulemaking in a timely manner. The NTSB classified Safety Recommendation A-07-61 "Open—Acceptable Response" pending the FAA's prompt action to address the recommendation.

1.18.2.7 Onboard Flight Recorder Systems

The NTSB has issued numerous recommendations addressing the need for recording information on all turbine-powered, nonexperimental airplanes not required to be equipped with an FDR and operating under Part 135 (such as the accident airplane). In addition, the NTSB included "automatic information recording devices" on its Most Wanted List from 2001 to 2010 and has also included "require image recorders" on its Most Wanted List. The NTSB noted these issues in its January 28, 2009, report on the midair collision involving electronic news gathering helicopters in Phoenix, Arizona, and expressed concern about the FAA's lack of progress.[106] In its report, the NTSB classified several previous safety recommendations[107] "Closed—Unacceptable Action/Superseded" and replaced them with updated recommendations, including Safety Recommendation A-09-11, which asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a cockpit voice recorder is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment [EUROCAE] document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued.

[106] For more information, see *Midair Collision of Electronic News Gathering Helicopters, KTVK-TV, Eurocopter AS350B2, N613TV, and U.S. Helicopters, Inc., Eurocopter AS350B2, N215TV, Phoenix, Arizona, July 27, 2007,* Aviation Accident Report NTSB/AAR-09/02 (Washington, DC: National Transportation Safety Board, 2009). These issues were also discussed in the following report: *Runway Overrun During Rejected Takeoff, Global Exec Aviation, Bombardier Learjet 60, N999LJ, Columbia, South Carolina, September 19, 2008,* Aviation Accident Report NTSB/AAR-10/02 (Washington, DC: National Transportation Safety Board, 2010).

[107] Among these previous recommendations was Safety Recommendation A-03-65, which asked the FAA to do the following: "require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with [an FDR] and that are operating under…Parts 135 and 121 or that are being used full-time or part-time for commercial or corporate purposes under Part 91 to be retrofitted with a crash-protected image recording system by January 1, 2010."

On April 17, 2009, the FAA described its participation in two proof-of-concept studies that evaluated the installation of image recorders on (1) an FAA aircraft that was compliant with EUROCAE document ED-112, "Minimum Operational Performance Specifications for Crash-Protected Recorder Systems," and (2) a transport-category airplane using a Boeing 737 flight simulator. The findings that resulted from these studies provided valuable information on the potential uses of a cockpit image recording systems on aircraft that are currently not required to carry any type of data-recording equipment. The working group incorporated this information into EUROCAE document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," which was published in August 2009.

On May 25, 2010, the FAA stated that it had reviewed ED-155 and decided to develop and publish a technical standard order (TSO) for a lightweight recording system that invokes certain requirements of ED-155. The FAA stated that the TSO would standardize the design and production certification requirements for equipment manufacturers to streamline aircraft installation and integration. The FAA stated that the general aviation community is continuing to develop flight data monitoring (FDM) systems and that it had met with two rotorcraft manufacturers and three airplane manufacturers to promote the installation of FDM systems. One rotorcraft manufacturer has indicated that all future production models will be equipped with an FDM system. The other rotorcraft manufacturer and three airplane manufacturers are making an FDM system available as optional equipment on future aircraft deliveries. The FAA stated that it had no plans to mandate the equipage of these recording systems on all turbine-powered, nonexperimental, nonrestricted-category aircraft. However, the FAA stated that it is considering mandating equipage of ED-155-like recording systems on certain aircraft based on specific types of operation (for example, air ambulance operations).

On December 23, 2010, the NTSB stated that it was pleased with the FAA's plan to develop and publish a TSO for a lightweight recording system that will incorporate certain requirements documented in EUROCAE ED-155 but that it was disappointed that the FAA was considering a requirement for this system only for certain aircraft, based on specific types of operation. The NTSB emphasized that retrieving valuable recorded data from all turbine-powered aircraft during an accident investigation is essential, regardless of the aircraft's type of operation or the number of engines, pilots, or passenger seats. The NTSB stated that it was encouraged by one rotorcraft manufacturer's plan to voluntarily include FDM systems as standard equipment on all future U.S.-produced models and the efforts of other manufacturers to make FDM systems available as optional equipment and pointed out that these developments show that data recording, as well as audio and image recording, are available and affordable for smaller aircraft. The NTSB urged the FAA to mandate the equipage of TSO-approved lightweight recording systems for all turbine-powered aircraft, as recommended, upon the FAA's issuance of a TSO. Pending the FAA's reconsidering its position and completing the recommended actions in a timely manner, the NTSB classified Safety Recommendation A-09-11 "Open—Unacceptable Response."

On February 12, 2011, the FAA stated that it published TSO C197, "Information Collection and Monitoring Systems," for lightweight recording systems. The FAA stated that the TSO invokes certain requirements of EUROCAE document ED-155 and standardizes the design and production certification requirements for equipment manufacturers in an effort to streamline aircraft installation and integration. The FAA stated that, in light of this effort, it did not intend to mandate the equipage of additional recording systems on all turbine-powered, nonexperimental, nonrestricted-category aircraft. The NTSB is currently evaluating this response.

1.18.3 Line Check Information

In accordance with 14 CFR 135.299, "Pilot in Command: Line Checks: Routes and Airports," no certificate holder may use a pilot, nor may any person serve as a PIC of a flight, unless that pilot has passed an annual line check in one of the aircraft types that pilot will fly. The regulations require that the line check be given by an FAA-approved check pilot, consist of at least one flight over one route segment, and include takeoffs and landings at one or more representative airports. In addition, pilots authorized to conduct IFR operations must conduct at least one flight over a civil airway, an approved off-airway route, or a portion of either of them. As noted, the captain's most recent annual line check was accomplished on May 6, 2008.

According to FAA Order 8900.1, Volume 6, Chapter 2, "Part 121, 135 and 91 Subpart K Inspections," Section 19, "Line Check Inspections for Part 121 and 135," the operator is responsible for administering both initial and recurrent line checks, although, in some cases, they may be conducted by FAA inspectors, especially if the operator does not have a check airman. The order also states the following:

> The inspector must observe at least one flight segment, including a takeoff and landing. The flight must be over a typical route served by the operator and must allow the inspector to observe the PIC perform duties and responsibilities associated with the conduct of a revenue flight.

Order 8900.1 states that the majority of the elements that comprise a line check are identical to those that comprise a cockpit en route inspection and refers to Chapter 2, Section 9, "Cockpit En Route Inspections," change 22, dated May 1, 2008, for general inspections practices and procedures.[108] The order indicates that inspectors typically request that, at a convenient time, pilots present flight information, including weather documents. Order 8900.1 further states that inspectors should observe and evaluate "adherence to approved procedures and a proper use of all checklists" and adherence to sterile cockpit procedures. Volume 3, Chapter 19, "Training Programs and Airman Qualifications," states that it might not be practical for certain Part 135 operations to conduct a line check during revenue operations. In these cases, the POI may authorize that the line check be conducted during the same flight period that the proficiency check is conducted, as was the case with the accident captain. If the line check is conducted in this manner, the line-check portion of this flight period is required to include the requirements previously discussed. In addition, chapter 19 refers line-check inspectors to an en route inspection checklist, which contains a list of specific inspection areas that should be observed and evaluated, including weather, descent planning, use of checklists, and sterile cockpit adherence.

[108] Although similar elements comprise en route inspections and line checks, the purpose of the inspections are different.

1.18.4 Go-Around After Landing or Lift-Dump Deployment

A review of company, manufacturer, and Simcom manuals revealed no procedures for attempting a go-around after landing or after deploying lift dump. During postaccident interviews, East Coast Jets personnel indicated that, if required, they would follow normal go-around procedures to conduct a go-around after landing and lift-dump deployment. An East Coast Jets captain who was qualified in Hawker Beechcraft and Learjet airplanes (like the accident captain) stated that the Learjet 35 was a “rocket” during a go-around. He stated that the Hawker responded quickly but that it did not climb as well as the Learjet.

During postaccident interviews, one of the Simcom instructors who had trained the accident pilots stated that he had never conducted a go-around after deploying lift dump and that he did not teach or recommend doing such a maneuver. He further stated that conducting a go-around after deploying lift dump was a good way to “crumple the airplane.” The accident captain’s most recent simulator instructor stated that, once you have deployed the speed brakes or lift dump on landing, you must “ride it out.” However, one Simcom instructor stated that he had conducted a go-around after deploying lift dump.

2. Analysis

2.1 General

The investigation found that the pilots were properly certificated and qualified under federal regulations.

The investigation found that the accident airplane was properly certificated, equipped, and maintained in accordance with federal regulations. Examinations of the recovered components revealed no evidence of any preimpact structural, engine, or system failures. The airplane was within normal weight and balance limitations.

The airplane was destroyed by impact forces and sustained a complete loss of survivable space for the flight crew and passengers. In addition, most of the cockpit and cabin seats and furnishings were found separated from the airplane. Although one passenger initially survived the crash, she died less than 2 hours later as a result of injuries similar to those sustained by the other airplane occupants. On the basis of this evidence, the NTSB concludes that the accident was not survivable.[109]

This analysis discusses the accident sequence, including flight crew actions; lack of SOPs requirements for Part 135 operators, including CRM training and checklist usage; go-around guidance for turbine-powered aircraft; Part 135 preflight weather briefings; pilot fatigue and sleep disorders; inadequate arrival landing distance assessment guidance and requirements; Part 135 on-demand, PIC line checks; and cockpit image recording systems. Safety recommendations concerning these issues are addressed to the FAA.

2.2 Accident Sequence of Events

2.2.1 Flight Crew's Performance During the Descent and Approach

The preflight weather briefing package that the captain printed about 2 hours before departure from ACY and 4.5 hours before the accident indicated OWA weather conditions as calm winds, with 10 miles visibility and clear skies at the time of departure from ACY. (Section 2.4 discusses the captain's preflight weather planning.) As a result, the pilots' first indication that the weather would be worse than they expected was about 0924, 2 hours 11 minutes into the flight and 20 minutes before the intended landing, when the AWOS recorded by the CVR indicated thunderstorms and rain. About 1 minute later, the Minneapolis ARTCC controller asked the pilots if they were seeing the "extreme" precipitation about 20 miles ahead

[109] Title 49 CFR Part 830 states that a survivable accident is "an accident in which the forces transmitted to the occupant(s) through the seat and restraint system do not exceed the limits of human tolerance to abrupt accelerations and in which the structure in the occupants' immediate environment remains substantially intact to the extent that a livable volume is provided for the occupants throughout the crash sequence." This definition is in accordance with the following: R. E. Zimmerman and N. A Merritt, *Aircraft Crash Survival Design Guide*, Volume 1, "Design Criteria and Checklists" sponsored by the U.S. Army Research and Technology Laboratories, Fort Eustis, Virginia (Tempe, Arizona: Simula, 1989).

and stated that he did not recommend that the flight go through the weather. The first officer then requested a deviation to the right, which the controller approved.

About 0927, the first officer had indicated that they were at 24,000 feet and 50 miles from OWA. A common jet airplane descent rule of thumb is to allow 3 nautical miles for every 1,000 feet of vertical descent. A descent of 23,000 feet would require about 70 miles; therefore, to have been on a normal approach profile, the pilots should have started the descent about 20 miles further from OWA than they did. At 0927:48, the controller asked the captain to state his intentions and added that he could not provide a good recommendation at that time; however, the captain responded that it looked clear ahead for another 40 miles. At 0928:49, the captain stated to the first officer, "all I care is above ten [thousand feet] and we go fast so we can get around this…thing," likely meaning that he wanted to maintain an indicated airspeed of more than 250 knots, which is the maximum airspeed allowed below 10,000 feet by 14 CFR 91.117, "Aircraft Speed." At 0930:09, the captain stated during a conversation with the first officer, "good thing I didn't tell 'em it was gonna be a smooth ride huh? I looked at the radar and there wasn't anything." The first officer responded, "doesn't it figure [weather] pops up right when we get here?" The captain continued, "what do you mean what are my intentions? Get me around this…storm so I can go to the field…I ain't gonna turn around and go home."

About 0935, the pilots started the descent to 7,000 feet; however, according to the CVR recording neither pilot commanded the initiation of the Descent checklist. Even though the East Coast Jets Descent checklist is a silent checklist, it must still be initiated by command from the PF and be conducted and called complete by the PM. About 44 seconds later, the captain called for the Approach checklist, which, in accordance with company procedures, should have been preceded by an approach briefing that included the missed approach procedure, the runway conditions, and any "potential problems, such as weather."[110] However, according to the CVR, in response to the first officer's calling for the approach briefing, the captain only replied, "it's gonna be the ILS to three zero."

About 0937, the Rochester approach controller provided the first officer with weather information for OWA, which he stated was about 20 minutes old and indicated, in part, winds 320° at 8 knots (indicating headwinds for the intended runway). About 1 minute later, he added that light precipitation existed along almost the entire remaining route and that a couple of heavy cells were located within 5 miles of OWA. Despite this information indicating possible severe weather conditions, the CVR did not record either pilot verbally monitoring the wind information, which would have been displayed on each of the pilots' electronic horizontal situation indicators and FMS displays. Data extraction of the captain's FMS indicated that the instantaneous wind 12 seconds before landing was 195° at 17 knots, which would have resulted in a 5.6-knot tailwind.

The presence of rain, changing winds, and the controller's comments should have alerted the pilots to the fact that the weather was worse than anticipated and that they might experience

[110] According to FAA AC 120-51E, Appendix 1, "Crew Resource Management Training," the approach briefing should also include "guidelines for crew actions centered on…SOPs; division of labor and crew workload." However, this AC is used as the basis for training currently required for Part 121 and 91 subpart K operations but not for Part 135 operations, such as the accident flight. See section 2.3.1 for further discussion about Part 135 CRM training requirements.

difficulty during the landing; however, evidence indicates that the pilots did not consider these factors or reassess the landing situation. The captain's failure to conduct an approach briefing is especially problematic given the unexpected adverse weather conditions, including the tailwind, the flight encountered during the descent and approach. An approach briefing would have helped the captain and first officer develop a shared mental model of the coming landing operations, which would have encouraged the first officer's coordination and support in monitoring external factors, such as weather and runway conditions, and would have mentally prepared the pilots to properly deal with an abnormal or emergency situation. For example, the missed approach procedure would have been included in the approach briefing and clarified the captain's intended actions in the event of a go-around. If a PIC does not do this and a go-around becomes necessary, pilots might become confused about what actions to take. Further, briefing the expected runway conditions would have clarified whether the captain expected to land on a wet runway. In addition, a well-briefed and coordinated flight crew should have realized that changing winds would be possible as a result of the weather conditions and, therefore, gotten more current wind information from the AWOS or the flight instruments after the Rochester approach controller indicated that the weather information he had provided the first officer was 20 minutes old. If the pilots had obtained current wind information, they would have been prepared for the possibility of landing on runway 12 with a headwind rather than landing on runway 30 with a tailwind.

At 0938:27, the captain stated, "the sooner you get us there the better," and then the first officer stated, "why don't (they) just get us to the field?" These statements and those made earlier in the flight indicate that the pilots were impatient to land. Although no apparent reason existed for the pilots to feel rushed (for example, they landed 9 minutes ahead of schedule and no evidence was found that the passengers or the company were placing undue pressure on the pilots to land early on the day of the accident), they repeatedly expressed impatience with ATC and the weather radar displays. During postaccident interviews, other company pilots did not indicate that East Coast Jets pressured them to rush to get to the destination airport.

The captain's impatience during the flight was contrary to descriptions of his flying provided by other company pilots who described him as a serious and meticulous pilot. Specifically, the pilots described instances in which the captain carefully monitored weather during a flight and altered landing plans despite pressure from passengers.[111] The captain could have reasonably opted to hold, divert, or attempt to land on runway 12 with a headwind. However, the captain's focus on completing the flight degraded his attention to the changing weather situation and prevented him from recognizing that alternatives to landing on runway 30 were available.

At 0938:50, the captain stated that the Approach checklist was complete, and, 1 second later, the first officer responded, "approaches are done," even though he had been interrupted about 2 minutes 24 seconds before making this statement and had not completed the checklist.

[111] One pilot described a flight with the accident captain in which a high-ranking official was a passenger. The flight was scheduled to land at Cedar Rapids, Iowa. Although the weather forecast was legal for IFR conditions, it was marginal. According to the pilot, the captain called FSSs repeatedly during the trip, determined that the weather was deteriorating, and decided to divert to the next scheduled stop at Des Moines, Iowa. The captain maintained his decision even though the travel arranger, who was also a passenger, came up to the cockpit, indicated that the high-ranking official was unhappy with the decision, and tried to talk the pilots into landing at Cedar Rapids despite the weather.

Further, as the PM, the first officer should have verified that the checklist was complete, not the captain. At 0939:16, the CVR recorded the first officer trying to contact the FBO for nonessential reasons, such as asking about how to get fuel upon landing, with the captain's approval at a time when he should have been completing the Approach checklist and monitoring the flight instruments. These calls were further interrupted by more critical communications with the captain, radio calls, and ATC and were not in accordance with 14 CFR 135.100, the "sterile cockpit rule," which states that pilots may not make nonsafety-related radio calls during flight below 10,000 feet. The captain, as PIC, should not have allowed the first officer to make nonessential calls to the FBO during such a high workload period.

At 0940:12, the captain told the first officer to identify the localizer frequency and then answered a radio call from Rochester approach control, both of which are typically PM duties. The captain had to remind the first officer to identify the localizer frequency because of inadequate adherence to SOPs and prioritization of cockpit workload, which allowed the first officer to fall behind on conducting his duties, including executing checklists and making radio calls, during a critical phase in flight. (SOPs are discussed in section 2.3.) At 0941:47, the first officer responded to Rochester approach control and then finally contacted the FBO on the third attempt. While the first officer was talking with the FBO, the captain continued talking to Rochester approach control. During this time, the landing gear was extended. After the first officer talked to the FBO, he briefed the captain on the parking and fueling plan. At that point, the airplane was about 2 minutes from touchdown.

At 0942:37, the captain stated, "three green no red pressures good back to zero steering's clear," which was a compressed version of three of the required challenge and response Before Landing checklist items. However, the captain had not yet called for the checklist and was not responding to a challenge. At 0943:05, the captain called for "flaps two" (25°) and then for the Before Landing checklist; however, as noted, the CVR recorded him starting the checklist earlier. Neither pilot called out the final checklist item, "flaps," or responded with the selected setting as required by the checklist. However, the captain did use the nonstandard terminology, "down indicating down," at 0943:14, most likely to confirm that he had set full flaps (45°) for landing. Neither pilot verified that the checklist was complete.

Both pilots repeatedly failed to conduct checklists appropriately and verify verbally that the checklists had been completed, demonstrating that neither was focused on proper checklist execution. Checklists should be accomplished crisply, using the precise challenge and response checklist items. The captain had the ultimate responsibility to demand a more professional and disciplined tone in the cockpit and to manage workload so that secondary tasks, such as contacting the FBO, were not a distraction during critical phases of flight when crew coordination is necessary. The first officer was fully qualified to support the captain in areas of weather observation and monitoring, and the captain should have made better use of the first officer.

The NTSB concludes that the captain allowed an atmosphere in the cockpit that did not comply with well-designed procedures intended to minimize operational errors, including sterile cockpit adherence, and that this atmosphere permitted inadequate briefing of the approach and monitoring of the current weather conditions, including the wind information on the cockpit instruments; inappropriate conversation; nonstandard terminology; and a lack of checklist discipline throughout the descent and approach phases of the flight. The NTSB further concludes that the flight crewmembers exhibited poor aeronautical decision-making and managed their resources poorly, which prevented them from recognizing and fully evaluating alternatives to landing on a wet runway in changing weather conditions, eroded the safety margins provided by the checklists, and degraded the pilots' attention, thus increasing the risk of an accident.

On February 2, 2010, the NTSB issued Safety Recommendation A-10-15 as a result of the Colgan Air accident near Buffalo, New York. Safety Recommendation A-10-15 asked the FAA to do, in part, the following:

> Develop, and distribute to all pilots, multimedia guidance materials on professionalism in aircraft operations that contain standards of performance for professionalism; best practices for sterile cockpit adherence…and a detailed review of accidents involving breakdowns in sterile cockpit… . Obtain the input of operators and air carrier and general aviation pilot groups in the development and distribution of these guidance materials.

On June 22, 2010, the FAA stated that it agreed that providing effective and usable information to pilot groups is an essential component in preventing accidents. The FAA stated that it was reviewing this recommendation to determine how best to address it in a timely and effective manner. On January 25, 2011, the NTSB classified Safety Recommendation A-10-15 "Open—Acceptable Response," pending receipt of additional information once the FAA determines how it will proceed and completion of the recommended action.

2.2.2 Flight Crew's Performance During the Landing

At 0944:29, the captain stated, "I'm goin' right for the tiller and the brakes," indicating that he was aware that the runway was short and wet and that a high level of deceleration would be required to stop the airplane on the runway. The NTSB notes that because the runway was ungrooved and wet, the friction it could provide would have been lower than that achievable on a dry runway, and it would not have required maximum braking effort to achieve the maximum available braking forces on the tires. An increase in brake pressure beyond that required to achieve maximum available braking forces would only tend to lock the wheels, and the brake anti-skid system would then release brake pressure to avoid this situation.

The CVR recorded the sound of the airplane touching down at 0945:04 and, at 0945:07, a sound consistent with the airbrake handle moving to the OPEN position. One second later, the first officer stated, "we're dumped," and, immediately after, "we're not dumped." In response to the first officer's last statement, the captain stated, "no, we're not," while simultaneously making straining sounds, consistent with physically attempting to move a cockpit control. The CVR then recorded a sound consistent with the airbrake handle moving into the DUMP position. According to the airplane performance study, the airplane's airspeed over the threshold was the reference landing airspeed of about 122 knots, and the airplane touched down about 1,128 feet from the runway threshold, which is within the target touchdown zone.[112]

East Coast Jets procedures call for the immediate deployment of full lift dump upon touchdown. However, the CVR evidence indicates that upon touchdown the captain only moved the airbrake handle to the OPEN position instead of fully aft to the DUMP position and likely did not fully deploy the lift-dump system (full flaps and airbrake deflection) until about 7 seconds after touchdown, which was not in accordance with company procedures (or the deceleration device deployment times used to develop the BAe 125-800A AFM wet runway guidance material). (See section 2.6.) The captain should have deployed lift dump by moving the airbrake handle in one motion to the DUMP position, not partially deploying the airbrakes and then fully deploying lift dump. The first officer most likely stated, “we’re dumped,” as an automatic callout upon landing when he saw the captain move the airbrake handle aft. The latter callout, “we’re not dumped,” likely resulted from the first officer’s required check of the flap position indicator and provides an example of effective monitoring by the first officer.

The NTSB concludes that the airplane touched down within the target touchdown zone and at the recommended touchdown speed and that the captain likely applied sufficient pressure on the brakes during the initial part of the landing roll to take full advantage of the available runway friction, but he failed to immediately deploy the lift-dump system after touchdown in accordance with company procedures, which negatively affected the airplane’s deceleration.

None of the tires exhibited flat spots or evidence of reverted rubber, and all of the tire tread depths were within specified limits. Therefore, the investigation ruled out the occurrence of reverted rubber hydroplaning. The NASA friction expert reported that the runway was generally in “excellent” condition because it had a relatively high macrotexture, consistently adequate cross-slope throughout the runway length, insignificant rubber deposits, and no concrete surface deterioration. Further, pavement drainage models indicated that the runway was fully capable of draining the rainfall reported throughout the morning of the accident; therefore, there was not sufficient standing water on the runway at the time of the accident to have caused the airplane to experience dynamic hydroplaning.

The NTSB concludes that no evidence exists that reverted rubber or dynamic hydroplaning occurred.

2.2.3 Captain’s Decision and Subsequent Attempt to Go Around

The pilots remained silent for 10.5 seconds after the captain stated, “no we’re not” (acknowledging that the airbrake handle was not in the DUMP position before moving it to that position), until the captain called out “flaps” at 0945:22. About the same time (more than 17 seconds after touchdown), the CVR recorded a sound consistent with increasing engine noise and the initiation of a go-around. The results of the airplane performance study indicated that, at the time that the go-around was initiated, the deceleration rate was such that the airplane would have exited the runway end at a ground speed of between 23 and 37 knots and stopped between

[112] According to the pilot/controller glossary in the AIM, the touchdown zone is “the first 3,000 feet of the runway beginning at the threshold.”

100 and 300 feet into the 1,000-foot-long runway safety area. Therefore, it can be reasonably assumed that, at some point during the landing roll, the captain likely became concerned that the airplane would run off the runway end and had to decide whether it was preferable to overrun the runway or attempt a go-around.

However, as discussed, no evidence indicates that the captain was prepared for the possibility of a go-around. Specifically, he did not conduct an approach briefing, which would have included briefing a missed approach. It is possible that the captain's decision to go around was delayed because it took time for him to realize that the airplane was not decelerating as he expected and the possibility of a runway overrun was increasing. In addition, he might have been waiting, expecting the airplane's deceleration to improve. His expectations for the airplane's deceleration may have been unrealistic because he may have confused the accident airplane's performance with that of other company airplanes that were equipped with thrust reversers and previously flown by the captain, or he did not properly account for the tailwind and consequent higher ground speed at touchdown because he was unaware of the changing wind conditions during the approach and landing.

According to the East Coast Jets Go-Around checklist, the correct command to set the flaps for a go-around is "flaps 15."[113] Postaccident examination of the flaps indicated that they were fully retracted (that is, set at 0°), not set to 15° as required for a go-around. Takeoff calculations performed by Hawker Beechcraft indicated that, given the location of the initiation of the go-around, the airplane could not have rotated and lifted off before the runway end with the flaps set at either 15° or 0°. Further, ground scars in the grass beyond the runway end (within the runway safety area) indicated that the airplane lifted off about 978 feet beyond the threshold and subsequently impacted the ILS localizer antenna about 5 feet agl. The airplane then continued to roll to the right and descend, impacting the ground.

The NTSB concludes that, if the captain had continued the landing and accepted the possibility of overrunning the runway instead of attempting to execute a go-around late in the landing roll, the accident most likely would have been prevented or the severity reduced because the airplane would have come to rest within the runway safety area.

A review of the manufacturer, East Coast Jets, and Simcom guidance found no procedures on how to execute a go-around after landing. Further, East Coast Jet pilots were not trained to execute a go-around after landing. However, none of the guidance explicitly states that a go-around should only be conducted before landing or identifies a committed-to-stop point (that is, a point in the landing sequence beyond which a go-around should not be attempted). The captain's decision to go around more than 17 seconds after touchdown left insufficient runway available to configure the airplane and accelerate to become airborne before reaching the runway end and clearing obstacles. If the captain had conducted an approach briefing that included a committed-to-stop point (for example, in the case of the Hawker Beechcraft 125-800A airplane, once lift dump has been deployed), he may not have decided to attempt a go-around late in the

[113] Despite the captain's use of incorrect terminology, it is clear that his statement, "flaps," at 0945:22 was part of a go-around attempt and led to a required increase in engine thrust. The flaps were found in the wreckage set to the fully retracted position (flaps 0°), which was an incorrect setting for a go-around and would have made it more difficult for the airplane to lift off, and this setting may reflect the confusion and lack of crew coordination that can follow from unprofessional compliance with use of nonstandard terminology.

landing roll. The NTSB notes that other recent overrun accidents have not been as catastrophic because the flight crews did not attempt to go around after landing.[114]

The NTSB has previously investigated accidents during which the pilots did not commit to the landings and made a delayed decision to go around. For example, on October 5, 2005, a Beechcraft 58 overran the runway in Jacksonville, Florida, after attempting a go-around late in the landing roll on a wet, ungrooved runway. During postaccident interviews, the pilot stated that the airplane touched down on the first quarter of the runway at about 100 knots. He stated that, past the midfield point, "the airplane still had a lot more momentum to bleed off," so, with only one quarter of the runway left, he attempted a go-around. He stated that, when he noticed that the airplane was not climbing, he aborted the go-around and overran the departure end of the runway. In addition, on July 15, 2005, a Cessna 525A collided with a localizer antenna in Newnan, Georgia, after the pilot conducted a go-around late in the landing roll on a wet, ungrooved runway. The pilot stated that he applied brakes upon landing and that the airplane then hydroplaned. He stated that he chose to abort the landing with 2,300 feet of runway remaining (the runway was 5,500 feet long). As a result of the pilot's delayed decision to go around, the airplane became airborne only 300 feet from the runway end. Both of these accidents might have been prevented if the pilots had committed to the landings or better understood where the committed-to-stop point was rather than attempting to go around with insufficient runway available to lift off and clear obstacles.[115]

The NTSB concludes that establishing a committed-to-stop point in the landing sequence beyond which a go-around should not be attempted for turbine-powered aircraft would eliminate ambiguity for pilots making decisions during time-critical events. Therefore, the NTSB recommends that the FAA require manufacturers of newly certificated and in-service turbine-powered aircraft to incorporate in their AFMs a committed-to-stop point in the landing sequence (for example, in the case of the Hawker Beechcraft 125-800A, once lift dump is deployed) beyond which a go-around should not be attempted. The NTSB further recommends that the FAA require 14 CFR Part 121, 135, and 91 subpart K operators and Part 142 training schools to incorporate the information from the revised manufacturers' AFMs asked for in Safety Recommendation A-11-18 into their manuals and training.

2.3 Standard Operating Procedures

SOPs are universally recognized as basic to safe aviation operations. Well-designed cockpit procedures are an effective countermeasure against operational errors, and disciplined compliance with SOPs, including strict checklist discipline, provides the basis for effective crew coordination and performance. SOPs should address, in part, checklist usage; radio

[114] For example, see (a) *Runway Overrun During Landing, Pinnacle Airlines Flight 4712, Bombardier/Canadair Regional Jet CL600-2B19, N8905F, Traverse City, Michigan, April 12, 2007,* Aircraft Accident Report NTSB/AAR-08/02 (Washington, DC: National Transportation Safety Board, 2008) and (b) AAR-08/01.

[115] The reports for these accidents, NTSB case numbers MIA06CA003 and ATL05CA131, respectively, are available online at <http://www.ntsb.gov/ntsb/query.asp>. Because airplane performance studies were not conducted for these accidents, it cannot be stated explicitly that the accidents would have been prevented if the pilots had committed to the landings.

communications; briefings; cockpit discipline, including sterile cockpit; stabilized approach criteria; CRM; and go-around/missed approach procedures.

Operational data confirm the importance of strict compliance with SOPs for safe operations.[116] For example, industry data show that pilots who intentionally deviated from SOPs were three times more likely to commit other types of errors, mismanage errors, and find themselves in undesired situations compared with pilots who did not intentionally deviate from procedures. According to AC 120-71A, in its study of controlled flight into terrain (CFIT) accidents, the Commercial Aviation Safety Team, which included FAA, industry, and union representatives, found that almost 50 percent of the studied CFIT accidents related to the flight crew's failure to adhere to SOPs or the certificate holder's failure to establish adequate SOPs. The NTSB has repeatedly cited casual cockpit discipline and inadequate compliance with SOPs as contributing factors to accidents.[117]

Further, the International Civil Aviation Organization (ICAO) has recognized the importance of SOPs for safe flight operations. Recent amendments to ICAO Annex 6 established that each member state should require that SOPs for each phase of flight be contained in the operations manuals used by pilots. Although the FAA requires SOPs for Part 121 operators and provides guidance on SOPs in AC 120-71A, it does not require Part 135 operators such as East Coast Jets to have SOPs.

Although both accident pilots had good training and safety records and were described favorably by other company pilots and managers and the FAA POI, the CVR revealed that the atmosphere in the cockpit during the accident flight permitted inappropriate conversation, nonstandard terminology, failure to execute checklists as required, ineffective coordination and division of responsibility, and inadequate pilot briefings to enhance communications, promote effective teamwork, and plan for contingencies to mitigate hazards that can arise during key phases of operation. These are all examples of practices that would be unacceptable if adequate SOPs, such as those provided in AC 120-71A, have been established and adherence to them is required.

As will be discussed in section 2.5, evidence indicated that the performance of both pilots was degraded by fatigue. The NTSB notes that careful adherence to SOPs and division of responsibility in the cockpit can significantly help pilots limit the degrading effects of fatigue. However, the flight crew's lack of adherence to the SOPs to which they were trained was so

[116] The data came from the LOSA Collaborative, which is a network of researchers, safety professionals, pilots, and airline representatives collaborating to provide, among other things, oversight and implementation of line operational safety audits (LOSA) and a forum of information exchange regarding these audits. More information is available at <http://losacollaborative.org/>.

[117] For more information, see (a) *Collision with Trees and Crash Short of the Runway, Corporate Airlines Flight 5966, BAE Systems BAE-J3201, N875JX, Kirksville, Missouri, October 19, 2004,* Aircraft Accident Report NTSB/AAR-06/01 (Washington, DC: National Transportation Safety Board, 2006); (b) *Attempted Takeoff From Wrong Runway, Comair Flight 5191, Bombardier CL-600-2B19, N431CA, Lexington, Kentucky, August 27, 2006,* Aircraft Accident Report NTSB/AAR-07/05 (Washington, DC: National Transportation Safety Board, 2007); and (c) *Crash of Pinnacle Airlines Flight 3701, Bombardier CL-600-2B19, N8396A, Jefferson City, Missouri, October 14, 2004,* Aircraft Accident Report NTSB/AAR-07/01 (Washington, DC: National Transportation Safety Board, 2007).

pervasive that, although fatigue might have degraded the pilots' performance on the day of the accident, it most likely was not the only factor affecting their performance.

Consequently, the NTSB's investigation also looked at company issues, such as training and effective enforcement of SOPs that might have affected the pilots' performance. The accident pilots were trained to the SOPs contained in the Simcom Technical Manual, and these procedures were reflected in Simcom's training materials. However, East Coast Jets did not incorporate any clear and explicit description of Simcom's SOPs in its GOM, the required manual carried by pilots in the cockpit, nor is it required to as an on-demand Part 135 operator. When asked during postaccident interviews, company pilots could not cite or explain Simcom's SOPs consistently.

As noted by the FAA in AC 120-71A, the lack of established procedures in some manuals used by flight crews or the lack of a firm implementation by management pose a danger in that flight crews "too easily become participants in an undesirable double standard condoned by instructors, check airmen, and managers. Flight crews may end up doing things one way to satisfy training requirements and checkrides but doing them another way in 'real life' during line operations." The accident pilots' performance represents an example of the risk described by the AC because, although they successfully used SOPs to pass their training, they did not strictly adhere to the SOPs during the last 30 minutes of the flight and instead tried to handle the situation differently.

Although as a Part 135 operator East Coast Jets is not required to incorporate SOPs in its operations manual, if the company had voluntarily incorporated SOPs into its guidance, it may have supported the accident pilots in establishing cockpit discipline and, therefore, a safer cockpit environment. In Part 121 operations, airline management is responsible for designing SOPs to optimize safe aircraft operations and to emphasize the critical importance of always complying with these SOPs, and a company's incorporation of SOPs in the operations manuals used by pilots in the cockpit can be a necessary component of reinforcing this emphasis and establishing a strong company safety culture. Further, when flight crewmembers understand the underlying reasons for SOPs, they are generally better prepared to handle an in-flight problem that may not be explicitly or completely addressed in their operating manuals. Flight crew adherence to SOPs promotes vigilance to situational changes, solicitation of all relevant information, and readiness to properly deal with unfamiliar situations.

The NTSB has previously addressed the need for Part 135 operators to have SOPs. For example, as a result of the Northwest Airlines flight 255 accident, the NTSB issued Safety Recommendation A-88-67, which asked the FAA to require that all Part 121 and 135 operators and POIs emphasize the importance of disciplined application of SOPs and, in particular, emphasize rigorous adherence to prescribed checklist procedures. In response to Safety Recommendation A-88-67, the FAA issued Action Notice A8400.2, "Normal Checklist Review Parts 121 and 135," which required POIs to review the adequacy of checklists and the implementation of procedures used by all Part 121 and 135 operators; published an SFAR to improve air carrier training, evaluation, certification, and qualification requirements for appropriate personnel; revised AC 120-51, "Cockpit Resource Management," to include specific observable and measurable markers for in-flight operations, including adherence to checklist and operating procedures; and continued to emphasize proper adherence to prescribed checklist procedures and the disciplined application of SOPs for Part 121 and 135 operators. As a result of these actions, the NTSB classified Safety Recommendation A-88-67 "Closed—Acceptable Action" on March 27, 1992.

Further, as a result of the Gates Learjet 25B accident in Houston, Texas, the NTSB issued Safety Recommendation A-99-35, which asked the FAA to, in part, issue an FSIB to POIs assigned to Part 135 on-demand air carriers to stress the importance of pilots' adherence to SOPs. On August 10, 2000, the FAA issued AC 120-71, "Standard Operating Procedures for Flightdeck Crewmembers," which advocated the use of SOPs as "basic to safe aviation operations" and provided guidance on the importance of its application to any type of operation, including Parts 121, 135, and 91. Further, on August 23, 2000, the FAA issued two FSIBs that announced the availability of the AC and directed POIs to promote the development of and strict adherence to SOPs in accordance with the guidance contained in the AC. As a result of these actions, the NTSB classified Safety Recommendation A-99-35 "Closed—Acceptable Action" on March 6, 2001. Although these safety recommendations resulted in the FAA taking some commendable actions, this accident clearly demonstrates that some Part 135 operators are still not establishing and requiring their pilots to adhere to SOPs like those required for Part 121 operators.

According to a July 2009 DOT report,[118] Part 135 operations occur in a higher risk operating environment than Part 121 operations as a result of, in part, the following: operating shorter flights; performing more frequent takeoffs and landings, which are the most dangerous parts of flight; operating with less experienced pilots; flying into smaller airports with no ATC; operating on less familiar routes into less familiar airports, making the flights more vulnerable to terrain and weather obstacles; and operating without the assistance of flight dispatchers. Even though Part 135 on-demand operators have a higher risk operating environment than Part 121 air carriers, these operations have less stringent safety requirements, including a lack of required SOPs, which would include CRM training and strict checklist discipline. This accident shows that, to counter the risk factors noted above, companies like East Coast Jets would benefit from an on-going emphasis on and adherence to SOPs and the resultant development of higher safety margins in the cockpit.

The NTSB concludes that, if, as a Part 135 operator, East Coast Jets had been required to develop SOPs and its pilots had been required to adhere to them, many of the deficiencies demonstrated by the pilots during the accident flight (for example, inadequate checklist discipline and failure to conduct an approach briefing) might have been corrected by the resultant stricter cockpit discipline. Therefore, the NTSB recommends that the FAA require 14 CFR Part 135 and 91 subpart K operators to establish, and ensure that their pilots adhere to, SOPs.

2.3.1 Crew Resource Management

As noted, the important concept of CRM is typically addressed by SOPs. The pilots exhibited poor CRM during the last 30 minutes of the flight as evidenced by their inadequate

[118] For more information, see *On-Demand Operators Have Less Stringent Safety Requirements and Oversight Than Large Commercial Air Carriers,* Report No. AV-2009-066 (Washington, DC: Department of Transportation, Office of Inspector General, 2009).

communications, task allocation, distribution of workload, coordination, and their poor decision-making.

Both pilots had excellent performance records as individual pilots but functioned less effectively as a crew. The first officer was treated as a trainee, delegated minor tasks such as contacting ground operations and resetting the transponder at critical times during the approach when both pilots should have been attentive to the landing. The captain provided unorganized mentoring comments during short final approach rather than fully briefing his expectations during the required approach briefing and allowed a nonsterile cockpit environment to exist (that is, he allowed the first officer to make calls to the FBO and casual conversational remarks below 10,000 feet that were not necessary to the safe operation of the flight) during the high workload phases of approach and landing. Further, the captain performed many duties assigned to the first officer, serving as a single pilot without the full benefit of a second professional pilot who was able to monitor his actions and prevent errors. In addition, neither the first officer nor the captain adequately conducted required checklists or briefings, which, if conducted, might have prevented the accident. For example, the captain never discussed the first officer's role in initiating or supporting a go-around decision, a role which may have provided a decisive advantage in the accident situation.

AC 120-51E, "Crew Resource Management Training," discusses training new first officers in the role of PM, training captains in giving and receiving challenges of errors, and recognizing each pilot's experience level. However, these guidelines are intended for Part 121 certificate holders because Part 121 airlines are required by federal regulations to provide CRM training. The AC states that the guidance could also be used by Part 135 operators that chose to train in accordance with Part 121 requirements; however, Part 135 on-demand operators are not currently required to provide CRM training to their pilots, and the number of Part 135 operators that do provide such training is unknown. Therefore, it is uncertain how many Part 135 PICs are receiving adequate training on how to interact with and mentor entry-level professional pilots.

Simcom taught CRM as a subject and East Coast Jets listed it as a general topic in its FAA-approved training manual; however, Simcom did not have a formal curriculum or stated standards, and East Coast Jets provided no course content. The poor CRM skills exhibited by the pilots indicate that they did not receive adequate CRM training, which is not required or emphasized in Part 135 operations. Further, the CRM training received by the pilots did not meet the standards required by Part 121 regulations because it did not have a formal curriculum. Therefore, even when CRM training is provided to Part 135 pilots, as it was at Simcom, it may not meet the standards required by Part 121 regulations.

The NTSB notes that the pilots' had significantly different flight experience, particularly in Part 135 turbine-powered aircraft operations,[119] and that the first officer had only been with East Coast Jets for 9 months. According to East Coast Jets' chief pilot, the company often hired local pilots (a flight school was located across the street from East Coast Jets in Allentown) with about 1,500 total flight hours. The goal of the company training program was to have pilots

[119] Specifically, the captain had about 2,062 flight hours in turbine-powered aircraft operations, 1,188 hours of which were in the Hawker Beechcraft 125-800A airplane, whereas the first officer had only 297 flight hours in turbine-powered airplanes, 295 hours of which were in the Hawker Beechcraft 125-800A airplane.

typically start as Learjet first officers and then become Hawker Beechcraft 125-800A first officers, progressing to captains within 2 years. Although the director of operations statement during postaccident interviews that first officers are initially considered a detriment to the flight indicates an attitude contrary to good CRM principles, he did state that they then became a positive to the flight and were trusted to make landings on empty flight legs and then on flights carrying passengers.

As a result of the company's hiring pilots with no prior professional charter jet experience, which is fairly typical for Part 135 operators, experienced captains are almost always paired with entry-level professional pilots; therefore, it is essential that these captains learn how to adequately communicate and coordinate with low-flight-time pilots and to develop strategies to prevent getting behind on checklist execution, missing radio calls, and other problems that tend to occur with entry-level professional pilots. Within the company, the accident captain had a reputation of being supportive of new first officers. However, in the accident situation, the more experienced captain did not adequately support, communicate, or coordinate with the first officer, and his use of the first officer did not reflect the crew coordination principles emphasized in effective CRM training.

The NTSB has longstanding concerns about the need for CRM training in Part 135 operations. As a result of the Part 135 on-demand charter flight accident at Eveleth, Minnesota, the NTSB issued Safety Recommendation A-03-52, which asked the FAA, in part, to require that Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement an FAA-approved CRM training program. In addition, Safety Recommendation A-03-52 was reiterated as a result of a Part 135 on-demand charter flight accident at Montrose, Colorado, on November 28, 2004, and has been on the NTSB's Most Wanted List since 2006. On April 3, 2008, the FAA informed the NTSB that it intended to publish an NPRM that would call for rulemaking action, including CRM requirements, by the end of 2008; however, because the FAA failed to take the stated action, the NTSB classified Safety Recommendation A-03-52 "Open—Unacceptable Response."

On May 1, 2009, the FAA issued and NPRM, titled "Crew Resource Management Training for Crewmembers in Part 135 Operations," which proposed to amend the regulations for all certificate holders conducting operations under Part 135 to include in their training programs CRM for all crewmembers, including pilots and flight attendants. The NPRM stated, in part, that CRM training must address the authority of the PIC; communication processes; and how to build and maintain a flight team, manage workload and time, and maintain situational awareness. The intended effect of the NPRM was to reduce the frequency and severity of crew errors, which would reduce the frequency of accidents and incidents in Part 135 operations.

In its comments to the FAA on the NPRM, the NTSB stated that it supported the proposed rule and believed that it would largely meet the intent of Safety Recommendation A-03-52 because it proposed requiring initial and recurrent CRM training for crewmembers working for Part 135 on-demand operators and specified the minimum course content required for an approved CRM training program. On December 29, 2009, the NTSB classified Safety Recommendation A-03-52 "Open—Acceptable Response" pending issuance of the final rule without an allowance for certificate holders to give credit for initial CRM training received from another Part 135 carrier. On January 21, 2011, the FAA published the final rule, "Crew Resource Management Training for Crewmembers in Part 135 Operations," in 76 *Federal Register* (FR) 3831 but without an allowance for certificate holders to give credit for initial training received from another Part 135 carrier. The rule specifies that, after March 22, 2013, no certificate holder may use a person as a flight crewmember or flight attendant unless that person has completed approved initial CRM training with that certificate holder. Therefore, the NTSB classifies Safety Recommendation A-03-52 "Closed—Acceptable Action."

Recurrent, operator-specific CRM training is critical to cockpit safety because it teaches pilots to familiarize themselves with each other's procedures and expectations. As noted, the accident pilots did not work together well as a crew; specifically, the captain did not adequately support, communicate, or coordinate with the first officer or use him effectively, and, therefore, could have benefitted from CRM training similar to that proposed in the NPRM.

The NTSB concludes that the first officer might have been used more effectively and the pilots might have performed better during the accident flight if they had received formalized CRM training with stated standards like those required for Part 121 operations and that, if the final rule, "Crew Resource Management Training for Crewmembers in Part 135 Operations," published on January 21, 2011, in 76 FR 3831, had been in place before the accident flight, it might have addressed the CRM deficiencies exhibited by the flight crew.

2.3.2 Checklist Usage

2.3.2.1 Checklists Training

East Coast Jets pilots were not provided the Simcom checklists that they were taught and used during training for use during actual flight operations. East Coast Jets pilots were expected to use the East Coast Jets Normal Procedures checklist, which was a revised Simcom checklist, during normal flight operations. Some differences exist between the East Coast Jets and Simcom checklists. For example, none of the checklists contained in Simcom's SOPs were denoted as silent checks, whereas East Coast Jets had several checklists that were denoted as silent checks. In addition, some of the items on the Simcom checklists were different from the items on the East Coast Jets checklists, and some of the items were located in different places on the checklists. Further, during abnormal and emergency situations, company Hawker Beechcraft pilots were expected to use the Raytheon Expanded Normal checklist. In addition, the FSI QRH was carried on board company airplanes because it provided pictures of the annunciator lights in the cockpit and could be used as a reference.

The Simcom director of training stated that, if operators revised checklists, they needed to provide Simcom a copy of the revised checklists to use during training; however, East Coast Jets did not follow this procedure for any of its checklists. The simulator instructor who had worked with the accident first officer stated that the first officer had not brought a company checklist to training, but the instructor who had worked with the accident captain stated that the captain had brought a company checklist and used it during simulator training. All of these varying factors might have confused East Coast Jets pilots about which checklists to perform and how to perform them.

The POI for East Coast Jets stated that the East Coast Jets Normal Procedures checklist had been submitted to him and that he had accepted it. He added that he assumed that this would be the checklist used during training at Simcom but that he had not contacted Simcom or the Orlando FSDO, which was responsible for the oversight of Simcom, to verify that this occurred. The POI had no contact with Simcom's director of training and the instructors who were teaching East Coast Jets pilots nor did he discuss with them which Normal checklist could be used during training. He also did not observe East Coast Jets pilots when they were attending ground school or simulator training. Most importantly, the POI did not monitor whether all of the training received by East Coast Jets pilots was consistent and unified. Although FAA Order 8900.1, which contains guidance to POIs on outsourced training, emphasizes the importance of clearly defined SOPs, including checklists, when approving a training center curriculum, it does not require POIs to communicate with its operators and the training school TCPMs to ensure that the checklists used during training are consistent with those used during operations.

The NTSB concludes that the POI for East Coast Jets was not familiar with the company's out-sourced training and that his oversight of the company could have been improved by communicating with Simcom and the FAA TCPM for Simcom and ensuring that the checklists used during training were consistent with those used during operations. Given the pilots' lack of adherence to checklist execution, the inconsistency between the checklists used during training and those used during operations by East Coast Jets pilots most likely did not contribute to the pilots' poor performance. Regardless, the NTSB is concerned that having inconsistent checklists may create unnecessary confusion for pilots. The NTSB concludes that maintaining consistency between the checklists used during training and those used during actual Part 135 and 91 subpart K operations is essential to avoiding confusion about checklist usage and execution. Because the East Coast Jets POI was not required to communicate with the training school or the FAA personnel that provided oversight of the training school, the NTSB is concerned that numerous operations may exist in which pilots are trained to use a standard checklist during training but then use another checklist during actual operations. Therefore, the NTSB recommends that the FAA require POIs of 14 CFR Part 135 and 91 subpart K operators to ensure that pilots use the same checklists in operations that they used during training for normal, abnormal, and emergency conditions.

2.3.2.2 Flap Setting Callouts

The investigation revealed that both the airplane manufacturer and Simcom guidance stated that the required response to the Landing checklist item "flaps" is "set" and that the East Coast Jets Normal Procedures checklist states that the response to "flaps" is "as required." According to Simcom and East Coast Jets, using nonspecific terminology for the flap position allowed company pilots to land at a flap setting other than 45°. For example, a pilot may choose to land with flaps set at 25° because of weather conditions or a system malfunction. Because it is not the normal procedure to land without flaps set at 45° and the approach speeds and landing distances are affected by different flap settings, the PIC should brief and plan for a landing with a different flap setting. Most importantly, the lift dump, which is required to decelerate the airplane, cannot be deployed unless the flaps are set to 45°; therefore, a clear statement of the intended flap setting, rather than just "set" or "as required," would help ensure safer landings.

On June 27, 1988, as a result of the Northwest Airlines flight 255 accident, the NTSB issued Safety Recommendation A-88-68, which asked the FAA to convene a human performance research group of personnel from NASA, industry, and pilot groups to determine if any method of presenting a checklist produced better pilot performance. Because the group never convened, the NTSB classified Safety Recommendation A-88-68 "Closed—Unacceptable Action" on September 10, 1991. However, the recommendation influenced research studies that resulted in the development of valuable guidance for effective checklist construction, including that pilots should not just state "checked" or "set" but should state the desired status or value of the item being considered, including the flap position.[120]

In the August 17, 2009, safety recommendation letter that resulted from the NTSB's participation in the Spanair flight JK5022 accident investigation, the NTSB issued Safety Recommendation A-09-70, which recommended, in part, that the FAA convene a meeting of industry, research, and government authorities to develop guidance on industry best practices in operational areas (including checklist design, training, and procedures) that relate to flight crews properly configuring airplanes for takeoff and landing. Further, the NTSB issued Safety Recommendation A-09-71, which recommended that the FAA require operators to modify their takeoff and landing checklists to reflect the best practices identified as a result of the meeting recommended in Safety Recommendation A-09-70.

On October 30, 2009, the FAA stated that numerous references provided excellent guidance on industry best practices in operational areas such as checklist design, training, procedures, CRM, and error trapping and that it believed that a meeting to develop best practices was not necessary. However, the FAA published InFO 10002SUP, "Industries Best Practices Reference List," in March 2010 to better highlight all of the information available on these issues.

On November 29, 2010, the NTSB stated that, although the documents highlighted in the InFO contain information that should be considered when developing guidance on industry best practices, it was discouraged by the lack of guidance that related specifically to flight crews properly configuring airplanes for takeoff and landing. The NTSB noted that recent research based on airline observations, event reports by pilots, and accident histories has focused on the nature of flight crew task omissions in airline operations, such as the Spanair flight crew's failure to set the takeoff configuration. The NTSB stated that, because the pretakeoff phase of flight is often replete with interruptions, distractions, and unexpected task demands that can negatively affect the efficacy of even the best-designed checklists, it believed that additional guidance for developing checklists related to this critical phase of flight was needed to mitigate the associated risks and pointed out that, to develop the most effective guidance, it was important that the FAA include the lessons learned and data available from all sources, including industry, research, and both U.S. and international government authorities. Therefore, the NTSB classified Safety Recommendations A-09-70 and -71 "Open—Unacceptable Response" pending the FAA's convening a meeting with the recommended groups and the NTSB's review of the developed guidance on industry best practices in operational areas that relate to flight crews properly configuring airplanes for takeoff and landing. The NTSB urges the FAA to take timely action on these two important safety recommendations. Similar to takeoff checklists, it is critical that

[120] Degani and Weiner, pp. 28-43.

airplanes be configured correctly for landing and that the pilots confirm this configuration while conducting checklists.

The NTSB concludes that clearly stating and responding to the intended flap setting, rather than just stating, “set” or “as required,” during all checklists would eliminate confusion about an airplane’s configuration during critical phases of flight, such as landing. Therefore, the NTSB recommends that the FAA require manufacturers and 14 CFR Part 121, 135, and 91 subpart K operators to design new, or revise existing, checklists to require pilots to clearly call out and respond with the actual flap position, rather than just stating, “set” or “as required.”

2.4 Weather Planning

As discussed previously, the 0513 weather package printed by the captain contained information indicating that, at that time, OWA weather conditions were calm winds with 10 miles visibility and clear skies. The weather package did not contain any forecast information for the flight route or surrounding area near OWA. The only forecast information in the weather package was for RST, located about 35 miles away, and was issued 9 hours before the accident (0025 on July 30), and it predicted winds from 210° at 3 knots, visibility of more than 6 miles, and clouds scattered at 14,000 feet at the time of the accident flight. Meteorological evidence[121] shows that these conditions changed drastically between that time and the time of the accident, but the captain was not aware of the changing conditions because he did not obtain a more recent forecast before departure.

Although OWA did not produce forecast information in the form of TAFs, other forecast information was available before departure for the surrounding areas that would have provided a better picture of conditions in the Owatonna area at the time of the flight. For example, the captain could have obtained the 0645 area forecast (issued about 0.5 hour before departure) for southeastern Minnesota, which was valid until 1700 and predicted cumulonimbus cloud tops to 45,000 feet and possible severe thunderstorms in the area. The weather package also did not contain any adverse weather information, such as the Convective SIGMETs or severe weather watches current for the flight route or the area surrounding OWA, even though <http://www.fltplan.com>, the FAA-approved weather briefing service used by East Coast Jets pilots, provided links to many NWS products that contained this information. The captain could have obtained severe weather watch 779, issued at 0450 (before he accessed <http://www.fltplan.com>), which indicated that a line of severe thunderstorms was moving east-southeast at 40 knots. Although severe weather watch 779 was only valid until 0900, it still would have given the captain some indication that thunderstorms might be in the area. Weather conditions typically change rapidly throughout the day in the Midwest, especially in the summer; therefore, it is important that pilots have current and thorough weather information when flying into that area.

East Coast Jets’ OpSpec and federal regulations state that pilots are responsible for obtaining and using weather reports, forecasts, or any combination of these items to assess weather conditions before each flight and for ensuring that all of the information needed to make

[121] The 0633 TAF for RST, which was valid at the time of the accident, predicted, in part, IFR conditions in thunderstorms, heavy rain, and strong gusting winds about the estimated time of arrival.

a safe flight has been obtained. As PIC, the captain was responsible for being aware of the developing severe weather conditions. However, he relied on basic, meteorological reports for a destination airport that did not produce NWS forecast information, and the information he obtained was not sufficient to alert the pilots to the actual weather conditions that would exist along the flight route or at OWA upon arrival.

The NTSB concludes that the captain did not obtain any forecast weather information for the flight route or the area surrounding OWA; therefore, he did not have all of the weather information he needed to ensure that he could make a safe flight into OWA.

Part 121 PICs may contact a licensed dispatcher about weather conditions at the destination airport. Dispatchers are able to access the most recent weather reports and forecasts and to interpret them for the PIC. Part 135 PICs do not have access to dispatchers, but NWS-certificated weather briefers, such as FSS personnel, can provide a similar service. Further, select FAA FSSs operate Flight Watch, an en route flight advisory service, which offers limited FSS services. However, Part 135 PICs are not required to contact an NWS-certificated weather briefer for weather information and, as a result, Part 135 pilots, who are not weather experts, are expected to rely heavily on getting weather information from the Internet and appropriately interpret it for a safe flight. If the captain had been required to contact an NWS-certificated weather briefer, he would have been informed that severe thunderstorms were forecast along the flight route and that rain, lightning, low visibilities, and winds gusting as high as 55 knots were forecast near OWA. Such information would have better prepared the pilots for a successful landing because they would have known that they might be conducting a landing on a wet runway. Although this information might not have changed the pilots' decision to land at OWA, it likely would have alerted them of the need to monitor wind conditions on approach and have a contingency plan for either selecting a different runway and/or performing a go-around. When the destination airport, such as OWA, does not produce forecast information, it is especially important for pilots to receive area forecast information because it provides a better overall picture of what the weather conditions will be at the destination airport.

The NTSB concludes that, if the captain had obtained a weather briefing from an NWS-certificated weather briefer, the pilots would have had a more complete outlook of weather conditions along the flight route and at the destination airport, and they would have been alerted to the possibility that they would have to land on a wet runway in severe weather conditions.

The investigation also revealed that neither FAA weather-related guidance, including AC 00-24B, "Thunderstorms," nor NWS products reference or explain technical meteorological terms, such as "MCS," "bow echo," and "derecho," which relate to severe weather systems. Convective SIGMETs and weather watches instruct pilots to reference the latest "convective" outlook and "mesoscale" information; however, neither these terms nor those used in the referred documents to describe severe weather events are explained.

The NTSB notes that, if the captain had obtained severe weather watch 779, he would have known that the line of severe thunderstorms was identified as a bowing MCS (a complex of thunderstorms that becomes organized on a scale larger than individual thunderstorms and normally persists for several hours or more) and potential derecho (a widespread and usually fast-moving windstorm that can produce damaging winds) and that it had stalled over the area. In addition, severe weather watch 781 further identified a severe MCS with a bow echo (often associated with swaths of damaging straight-line winds and microbursts) in the area. However, even if the captain had obtained the severe weather watches, he might not have known the true significance of the weather he would be flying in, especially the strong possibility of damaging winds, because the terms “MCS,” “derecho,” and “bow echo” are not defined in the guidance. Weather products lacking definitions of terms related to severe thunderstorm conditions are less effective as planning tools that help pilots make better-informed decisions. Pilots need to be provided guidance that explains these terms because without such guidance they will not be able to fully understand the weather condition information provided in convective outlooks and mesoscale information products nor the effects such weather phenomena, such as rapidly changing winds, can have on the flying environment.

The NTSB concludes that guidance that explains terms related to severe thunderstorm conditions would help pilots better understand such conditions, which would allow them to make better-informed decisions regarding taking off or continuing flight when these types of conditions exist. Therefore, the NTSB recommends that the FAA work with the NWS to revise AC 00-24B, “Thunderstorms,” by including explanations of the terms used to describe severe thunderstorms, such as “bow echo,” “derecho,” and “MCS.”

2.5 Pilot Fatigue

The NTSB’s investigation considered whether fatigue contributed to the pilots’ poor performance during the last 30 minutes of the flight. The captain was off duty and the first officer did not conduct flights for several days before the accident, and both pilots had only been awake about 6 hours at the time of the accident, which occurred at a time of morning normally associated with alertness. However, the accident trip involved an early reporting time,[122] and evidence indicates that both pilots got less than their typical amount of sleep the night before the accident.

According to his girlfriend, the captain typically went to bed about 2200 to 2230 and received between 8.5 to 12 hours of overnight sleep. However, on the night before the accident, the captain did not get to bed until about 2400 (because he participated in a poker game). He awoke about 0445 to 0500; therefore, he only had a total sleep opportunity of no more than 5 hours. Scientific literature has shown that as little as 2 hours less sleep than normal is associated with impairment of performance and alertness.[123]

Available evidence showed that the captain had a very high need for sleep. His girlfriend reported that, in addition to his overnight sleep, the captain normally took a daily afternoon nap of 2.5 to 3 hours, resulting in a total sleep time of about 11 to 15 hours per day. A pilot who

[122] The first flight of the trip sequence departed at 0600. Both pilots learned about the accident trip assignment on the preceding afternoon (July 30).

[123] For more information, see M. A. Carskadon, “Sleep Restriction,” ed., *Sleep, Sleepiness and Performance*, T. H. Monk, ed. (Chichester, England: John Wiley & Sons, 1991), pp. 155–167. For comparison, evidence exists showing that a 2-hour sleep debt produces performance decrements comparable to those produced by a blood alcohol level of 0.045 percent and that a 4-hour sleep debt produces performance decrements comparable to a blood alcohol level of 0.095 percent. T. Roehrs, E. Burduvali, A. Bonahoom and others, “Ethanol and Sleep Loss: A ‘Dose’ Comparison of Impairing Effects,” *Sleep,* vol. 26, no. 8 (2003), pp. 981-985.

formerly roomed with the captain and the captain's father both provided corroborating evidence that the captain normally slept 10 or more hours overnight and supplemented this by daytime napping. Although all of the interviewed witnesses described the captain's health as excellent, the high sleep needs they described would be classified in medical literature as a sleep disorder[124] that would warrant professional evaluation for treatment possibilities and identification of any conditions that could limit the pilot's performance in a safety-sensitive position. Given that the captain obtained no more than half of his normal sleep time on the night before the accident and his early awakening time, he was likely impaired by fatigue at the time of the accident, especially given his high sleep needs.

According to his fiancée, the first officer typically went to bed about 2330 and awoke about 9 hours later. She stated that he went to sleep about 2300 the night before the accident and awoke the next morning at 0506, which reduced his overnight sleep time by about 3 hours. In addition, the first officer stayed up until 0100 the previous night watching a home video, which contributed to his cumulative sleep debt of about 4.5 hours.[125] Therefore, the first officer was also likely impaired by fatigue at the time of the accident due to his sleep debt and early awakening time. Further, the investigation revealed that the first officer sometimes had trouble sleeping the night before a trip and that, on these occasions, he self-medicated with his fiancée's prescription sleep medication zolpidem because he did not have a prescription.[126] His fiancée reported that he took zolpidem the night before the accident.

Both pilots showed evidence of untreated sleep difficulties that would have made them especially vulnerable to fatigue thereby increasing the likelihood of fatigue at the time of the accident. Specifically, the captain had high sleep demands, and the first officer had periodic instances of insomnia. However, no evidence was found indicating that either pilot sought medical assistance for sleep difficulties before the accident.

Fatigue degrades many aspects of cognitive performance. Further, fatigue is especially impairing when a pilot has to perform under time pressure, such as during a difficult landing sequence. Accident investigations have shown that fatigue can cause pilots to make risky, impulsive decisions and be late at changing plans, such as recognizing the need to discontinue a landing, which was demonstrated by the captain's decision to go around late in the landing roll.[127] Similarly, scientific evidence indicates that "skills involved in decision making that are affected by sleep loss include assimilation of changing information, updating strategies based on

[124] For more information, see *International Classification of Sleep Disorders–Second Edition* (West Chester, Illinois: American Academy of Sleep Medicine, 2005).

[125] Although the first officer went to bed about 2300, 30 minutes earlier than his usual bedtime, this was not sufficiently early to compensate for his 4.5-hour sleep debt.

[126] The first officer's use of zolpidem, which was self-administered without a physician's supervision, was less than 8 hours before he assumed duty as a pilot, contrary to current FAA and Army guidelines, which are discussed below.

[127] For example, see (a) *Collision With Trees on Final Approach, Federal Express Flight 1478, Boeing 727-232, N497FE, Tallahassee, Florida, July 26, 2002,* Aviation Accident Report NTSB/AAR-04/02 (Washington, DC: National Transportation Safety Board, 2004) and (b) *A Review of Flightcrew-Involved, Major Accidents of U.S. Carriers, 1978 through 1990,* Safety Study NTSB/SS-94/01 (Washington, DC: National Transportation Safety Board, 1994).

new information, [and]…risk assessment" and that "time pressure increases cognitive errors."[128] Further, the evidence shows that sleep deprivation, combined with attention-intensive situations, such as the unexpected runway stopping difficulties that the pilots experienced at OWA, causes performance "to become unstable with increased errors of omission (lapses) and commission (wrong responses)." The captain's performance during the landing, including his error of omission when he partially deployed lift dump, and his error of commission when he delayed the go-around, provide examples of how fatigue impairment can contribute to operational shortcomings when facing high workload demands, such as those associated with the landing rollout, and lead to serious errors and poor decision-making.

As noted, the investigation determined that the first officer used the prescription sleep medication zolpidem. The level of the medication detected in his blood was consistent with a typical dose of zolpidem, which generally results in short-term sedation and impairment (for a period of 4 to 5 hours) but does not result in persistent performance decrement or "hangover" effects.[129] Therefore, it is unlikely that the use of zolpidem itself added to the degradation of the first officer's psychomotor or cognitive skills at the time of the accident.

The NTSB concludes that both pilots' performance was likely impaired by fatigue that resulted from their significant acute sleep loss, early start time, and possible untreated sleep disorders and that fatigue might have especially degraded the captain's performance and decision-making abilities when he had to decide while under time pressure whether to continue the landing or initiate a go-around. The NTSB further concludes that, although the first officer took a prescription sleep aid for which he did not have a prescription the night before the accident, because of the short duration of its effects for most individuals, it is unlikely that the use of this medication degraded the first officer's performance at the time of the accident, which occurred about 12 hours after he took the medication.

FAA guidance currently allows the use of zolpidem under restricted conditions that include grounding a pilot for 24 hours after taking the medication.[130] Therefore, pilots are prohibited from taking this medication before an assignment, when the safety benefits might be greatest. As a result, current restrictions may inadvertently encourage self-medication without proper supervision, such as found with the accident first officer. In contrast, U.S. military guidelines permit pilots to perform flight duties 6 hours (Navy and Air Force) and 8 hours (Army) after using zolpidem, and a recent position paper by the Aerospace Medical Association, which discussed the military guidelines, has recommended that the FAA reevaluate its current restrictions on zolpidem.[131] Further, the FAA does not provide guidance for the use of other

[128] For more information, see N. Goel, H. Rao, J. S. Durmer, and D. F. Dinges, "Neurocognitive Consequences of Sleep Deprivation," *Seminars in Neurology*, vol. 29, no. 4 (2009), pp. 320–339.

[129] For more information, see C. S. Ramsey and S. E. Mcglohn, "Zolpidem as a Fatigue Countermeasure," *Aviation, Space, and Environmental Medicine*, vol. 68, no. 10 (1997), pp. 926–931.

[130] In the Fall 2003 FAA *Federal Air Surgeon's Medical Bulletin* (a quarterly periodical distributed to FAA aviation medical examiners and available on the FAA's website), an article noted, "The AMCD [Aerospace Medical Certification Division] has allowed the use of this sedative—providing the airman is not taking it more than twice a week. It cannot be used for circadian adjustment. An airman should not operate an aircraft for 24 hours after taking Ambien." W. S. Siberman, "Certification Issues and Answers," *Federal Air Surgeon's Medical Bulletin* no. 02-1 vol. 41, no. 3 (2003), p. 4.

[131] J. A. Caldwell, J. L. Mallis, J. L. Caldwell, and others, "Fatigue Countermeasures in Aviation," *Aviation, Space, and Environmental Medicine*, vol. 80, no. 1 (2009), p. 41. The position paper, written for the Aerospace

sleep-promoting medications, including some like zaleplon (which has a shorter half-life than zolpidem), which is also currently approved for military aviation. Once they are proven safe and effective, medications can be a valuable component of a treatment for insomnia by a qualified professional, as noted in the Aerospace Medical Association position paper, which states, "facilitating quality sleep with the use of a well-tested, safe pharmacological compound is far better than having pilots return to duty when sleep deprived or having them return to duty following a sleep episode that has been induced with alcohol." The NTSB notes that, even though the first officer took zolpidem the night before the accident, his use of the medication would not have negated the fatigue caused by his sleep debt and early awakening time.

The NTSB concludes that allowing civil aviation pilots who have occasional insomnia to use prescription sleep medications that have been proven safe and effective would improve these pilots' sleep quality and operational abilities. Therefore, the NTSB recommends that the FAA revise regulations and policies to permit appropriate use of prescription sleep medications by pilots under medical supervision for insomnia.

Pilots and physicians might have limited knowledge about sleep disorders and the availability of treatment for such disorders. Currently, the FAA provides little guidance to pilots or their physicians on these issues. For example, although the AIM describes fatigue as "one of the most treacherous hazards to flight safety," it does not discuss sleep disorders, and an FAA brochure regarding fatigue in aviation briefly describes major sleep disorders, but it does not discuss or recommend treatment.[132] In addition, the 2009 *Guide for Aviation Medical Examiners* provides certification guidance only for obstructive sleep apnea and periodic limb movements but not for the much more common sleep-related complaint of insomnia, while a summary article in the Spring 2002 *Federal Air Surgeon's Medical Bulletin* on sleep disorders[133] provides a fairly detailed overview of common sleep disorders but does not identify FAA aeromedical policy regarding the conditions other than to note prohibited medications. Such disorders can often be effectively treated through means that cause minimal disruption of personal and professional activities,[134] but, without appropriate FAA guidance, many pilots who would benefit from medical treatment for sleep disorders may hesitate to obtain it (or, like the accident first officer, resort to unsupervised self-medication).

Medical Association by the Fatigue Countermeasures Subcommittee of the Aerospace Human Factors Committee, states, "it is our position that zolpidem be authorized for civilian commercial pilots a maximum of 4 times per week in situations where natural sleep is difficult or impossible due to circadian or other reasons provided that: 1) the pilot has checked for any unusual reactions to the medication during an off-duty period; 2) the dose does not exceed 10 [milligrams] in any given 24-[hour] period; and 3) there is a minimal interval of 12 [hours] between the ingestion of the medication and the return to duty."

[132] The brochure stated, "A variety of medical conditions can influence the quality and duration of sleep. To name a few: sleep apnea, restless leg syndrome, certain medications, depression, stress, insomnia, and chronic pain." The brochure makes no further mention of sleep disorders and, although the brochure concludes with lifestyle recommendations, it does not discuss seeking medical treatment for sleep disorders. "Medical Facts for Pilots, Fatigue in Aviation." Publication No. OK-07-193 (Oklahoma City, Oklahoma: Federal Aviation Administration, Civil Aeronautical Institute, 2007).

[133] V. D. Wooten, "Sleep Disorders in Pilots," *Federal Air Surgeon's Medical Bulletin* no. 02-1 (Spring 2002), pp. 8–9.

[134] For example, see C. M. Morin, " Psychological and Behavioral Treatments for Primary Insomnia," in M. H. Kryger, T. Roth, W. C. Dement, *Principles and Practice of Sleep Medicine* (Fourth Edition), (Philadelphia, Pennsylvania: Elsevier, Inc., 2005), pp. 726–737.

The NTSB has longstanding concerns about sleep disorders and associated vehicle operator impairments that result from undiagnosed or untreated sleep disorders in all modes of transportation. For example, in 1989, the NTSB issued Safety Recommendation I-89-1, which asked the DOT to "expedite a coordinated research program on the effects of fatigue, sleepiness, sleep disorders, and circadian factors on transportation system safety." The NTSB classified Safety Recommendation I-89-1 "Closed—Acceptable Action" on July 19, 1996, based on the DOT's efforts to organize and follow through on a departmentwide coordinated fatigue research effort. In 2009, the NTSB issued safety recommendations in the highway, marine, and rail transportation modes, in addition to aviation, to identify and treat vehicle operators who are at high risk of obstructive sleep apnea and other sleep disorders.[135]

The NTSB has also issued several safety recommendations related to fatigue and sleep disorders and their effect on aviation operations. For example, on June 12, 2008, the NTSB issued Safety Recommendations A-08-44 and -45, which asked the FAA to, in part, develop guidance for operators to establish fatigue management systems, including information about the content and implementation of these systems (A-08-44) and develop and use a methodology that will continually assess the effectiveness of fatigue management systems implemented by operators, including their ability to improve sleep and alertness, mitigate performance errors, and prevent incidents and accidents (A-08-45). With regard to sleep disorders, the NTSB noted that medical screening and treatment are among the strategies employed by fatigue management systems as part of their comprehensive, tailored approach to the problem of fatigue.

On August 3, 2010, the FAA issued AC 120-103, "Fatigue Risk Management Systems for Aviation Safety," which provided guidance recommended for operators to establish a fatigue management system. On January 11, 2011, Safety Recommendation A-08-44, was classified "Closed—Acceptable Action" based on the issuance of the AC. The NTSB noted that the AC also provided guidance on the types of data and assessment techniques that operators should use to continually assess the effectiveness of their fatigue management systems, as discussed in Safety Recommendation A-08-45. However, the NTSB clarified that, although the AC recommends that operators collect and analyze the data discussed in the AC, the intent of the recommendation was for the FAA to also collect this data to evaluate the effectiveness of fatigue management systems in use by operators. The NTSB classified Safety Recommendation A-08-45 "Open—Acceptable Response" pending the FAA providing a description of its plan to assemble and evaluate the data being collected in response to the AC and completing action to address the recommendation.

In addition, on August 7, 2009, as a result of the Mesa Airlines Bombardier CL-600-2B19 (operated as *go!* flight 1002) event during which both the captain and first officer fell asleep during the flight, the NTSB issued Safety Recommendation A-09-63, which asked the FAA to, in part, "develop and disseminate guidance for pilots, employers, and physicians regarding the identification and treatment of individuals at high risk of obstructive sleep apnea." On October 23, 2009, the FAA stated that it planned to develop and implement an AME education program on obstructive sleep apnea and update the *AME Guide* to address the diagnosis of obstructive sleep apnea, produce an Office of Aerospace Medicine pilot safety brochure about obstructive sleep apnea, and revise the FAA AIM to include an explanation of

[135] See Safety Recommendations H-09-15 and -16, M-09-14 through -16, and R-09-9 through -11.

sleep hygiene and sleep apnea and their relation to fatigue and fitness to fly. On June 8, 2010, the NTSB classified Safety Recommendation A-09-63 "Open—Acceptable Response" pending the completion of these actions. However, the NTSB notes that Safety Recommendation A-09-63 only applied to obstructive sleep apnea and that other common sleep disorders, such as insomnia (which is the most common form of sleep disturbance), have not yet been addressed.

The NTSB notes that the FAA has also addressed some aspects of fatigue through its issuance of the NPRM titled, "14 CFR Parts 117 and 121: Flightcrew Member Duty and Rest Requirements." The NPRM proposes to amend Part 121 and establish Part 117 to create a single set of flight time limitations, duty-period limits, and rest requirements for pilots in Part 121 operations. The NTSB notes that, at the time of the accident, the pilots had logged about 3 hours of flight time and were less than 5 hours into their duty day, which was well within current and proposed hours of service standards for Part 135 operations.[136] Therefore, hours of service regulations provide a necessary but not sufficient framework for eliminating fatigue from flight operations, and personnel and company issues must also be addressed for effective fatigue management.

Regarding sleep disorders, the NPRM proposes that each certificate holder must develop and implement a fatigue-based education and training program that must include, among other topics, "familiarity with sleep disorders and their possible treatments." On November 15, 2010, the NTSB commented on the NPRM and stated, "if adopted, the proposed rule will provide substantial benefits towards reducing the hazards associated with flight crew fatigue in Part 121 operations." The NTSB stated that it strongly supported the concept of requiring a fatigue education and training program for all flight crewmembers, employees involved in the operational control and scheduling of flight crewmembers, and personnel having management oversight of these areas, noting that the concept of fatigue education is among the foundational elements of an effective fatigue management system. The NTSB notes that, although the NPRM proposes positive changes related to fatigue in Part 121 operations, it does not address Part 135 operations. The accident pilots' sleep history indicates that Part 135 pilots also need to be educated on factors relating to fatigue to prevent operating flights while impaired by fatigue.

The NTSB concludes that educating and training pilots on fatigue-related issues could prevent pilots from operating flights while impaired by fatigue. Therefore, the NTSB recommends that the FAA require 14 CFR Part 135 and 91 subpart K pilots to receive initial and recurrent education and training on factors that create fatigue in flight operations, fatigue signs and symptoms, and effective strategies to manage fatigue and performance during operations.

The OWA accident also shows the need for a more comprehensive approach to addressing common sleep disorders, including excessive sleep needs and insomnia, which might have applied to the accident captain and first officer, respectively. If common sleep disorders

[136] In accordance with 14 CFR 135.265, "Flight Time Limitations and Rest Requirements: Scheduled Operations," Part 135 operations, such as the accident trip, are limited to a 16-hour duty period with a maximum of 8 hours flight time. The NPRM, "14 CFR Parts 117 and 121: Flightcrew Member Duty and Rest Requirements," would establish new limits for operations like the accident trip, which began at 0600 and had five scheduled legs, to an 11.5-hour duty period with a maximum of 9 hours flight time. The NPRM was proposed for Part 121 operations, but the FAA noted that it anticipated a rulemaking initiative for Part 135 operations that would closely resemble this proposal.

were more readily recognizable by the aviation industry, both pilots might have addressed and treated their sleep issues and possibly prevented the fatigue that they experienced on the day of the accident. For example, they would have been more aware of sleep issues and, therefore, would likely have been getting more and better quality sleep during the nights before a flight to minimize sleep loss. In addition, the NTSB notes that both the Mesa Airlines captain, who was subsequently diagnosed with severe sleep apnea, and the Shuttle America captain, who was found to have been suffering from intermittent insomnia, had complained to their personal physicians before their incident and accident, respectively, but that they had not received treatment for their sleep difficulties. The history of these three events clearly indicates that greater awareness about common sleep disorders among physicians treating airline pilots, as well as among the pilots themselves, would be valuable.

The NTSB concludes that formal guidance on how pilots can be treated for common sleep disorders while retaining their medical certification could help mitigate fatigue-related accidents and incidents. Therefore, the NTSB recommends that the FAA review the policy standards for all common sleep-related conditions, including insomnia, and revise them in accordance with current scientific evidence to establish standards under which pilots can be effectively treated for common sleep disorders while retaining their medical certification. Further, the NTSB recommends that the FAA increase the education and training of physicians and pilots on common sleep disorders, including insomnia, emphasizing the need for aeromedically appropriate evaluation, intervention, and monitoring for sleep-related conditions.

2.6 Landing Distance Assessments

As noted, no available evidence indicates that the pilots reassessed the landing situation while in flight. As a result, they had no clear idea what they might encounter when the airplane landed on the wet runway. Federal regulations do not generally require or standardize arrival landing distance assessments or specify minimum safety margins for such assessments.

In October 2007, the NTSB issued two safety recommendations to the FAA regarding landing distance assessments. Urgent Safety Recommendation A-07-57 asked the FAA to do the following:

> Immediately require all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to conduct arrival landing distance assessments before every landing based on existing performance data, actual conditions, and incorporating a minimum safety margin of 15 percent.
>
> Safety Recommendation A-07-61 asked the FAA to do the following:
>
> Require all 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to accomplish arrival landing distance assessments before every landing based on a standardized methodology involving approved performance data, actual arrival conditions, a means of correlating the airplane’s braking ability with runway surface conditions using the most conservative interpretation available, and including a minimum safety margin of 15 percent.

The need for landing distance assessments with an adequate safety margin for every landing is currently on the NTSB's Most Wanted List.

For both recommendations, the FAA stated that it had taken several actions to address the safety issues discussed in these recommendations, including the issuance of SAFO 06012. The FAA also stated that a survey of Part 121 operators indicated "92 percent of U.S. airline passengers are now being carried by air carriers in full or partial compliance with the practices recommended in SAFO 06012." Further, the FAA formed the TALPA ARC to review regulations affecting certification and operation of airplanes and airports for airplane takeoff and landing operations on contaminated runways.

On June 27, 2008, the NTSB noted that the FAA had not indicated the percentage of Part 121 carriers that had fully adopted the SAFO or those parts of the SAFO that had not been adopted by other Part 121 carriers. The NTSB stated that it was especially concerned that among those parts of the SAFO that had not yet been adopted was the minimum 15-percent landing distance safety margin. The NTSB also noted that the FAA did not provide any information regarding whether SAFO 06012 had been adopted in full or in part by Part 135 and 91 subpart K operators or describe the actions that it would take to encourage those operators that have not complied with the SAFO.

The TALPA ARC issued its recommendations to the FAA in 2009. The regulatory changes proposed by the TALPA ARC group would codify many of the provisions of SAFO 06012 and add new regulations to Part 25 to require that the braking coefficients on wet, ungrooved runways be calculated in accordance with Section 25.109. Further, pilots would be required to perform arrival landing distance assessments before landing, which would "consider the runway surface condition, aircraft landing configuration, and meteorological conditions, using approved operational landing performance data in the Airplane Flight Manual supplemented as necessary with other data acceptable to the Administrator." The TALPA ARC working group responsible for Parts 125, 135, and 91 subpart K operations expressed concerns about the applicability of the recommendations made by the other groups to the operations covered by Parts 125, 135, and 91 subpart K. Specifically, the group's recommendation document stated that sufficient differences existed among aircraft operations conducted under Parts 125, 135, and 91 subpart K in the types of aircraft flown, airports used, expectations of passengers, economic factors, and accident history to justify different rules. However, the NTSB notes that the TALPA ARC recommended that Part 121, 135, and 91 subpart K operators conduct arrival landing distance assessments before every landing based on actual arrival conditions and incorporate a minimum safety margin (of 15 percent for Part 121 operations and of either 11 or 18 percent, with exceptions, for Part 135 and 91 subpart K operations).

The TALPA ARC also recommended that regulations be added to Part 26, which would require the type-certificate holders of transport-category, turbine-powered airplanes with a type certificate issued after January 1, 1958, and operated under Parts 121, 125, 135, and 91 subpart K, to publish performance data to meet the intent of the new landing distance assessment regulations. The methods and assumptions for producing the data would be those specified in the additions to Part 25. Therefore, if the TALPA ARC's recommendations were codified, the braking coefficients used to determine landing distances on wet runways would be based on the methods defined in Section 25.109, which would result in more conservative distances than those based on AMJ 25X1591. The BAe 125-800A AFM would be required to be updated with these more conservative distances.

On August 23, 2010, the FAA stated that it had received the TALPA ARC's recommendations and that it was evaluating them with the intention to initiate and complete rulemaking in 2011. The FAA stated that, in the interim, it was continuing to encourage operators to incorporate the safety elements contained in SAFO 06012 pending the completion of the rulemaking process.

On January 31, 2011, the NTSB stated that the investigation of the East Coast Jets accident revealed that the company did not require its pilots to perform landing distance assessments based on conditions actually existing at the time of arrival. The NTSB further stated that it was concerned that accidents continued to occur in which pilots have not conducted arrival landing distance assessments, which would have provided them with crucial information about the landing conditions upon arrival and either prevented or seriously reduced the severity of the accidents. The NTSB pointed out that Safety Recommendation A-07-57 was issued as an interim solution because it recognized that the standardized methodology asked for in Safety Recommendation A-07-61 would take time to develop but that, to date, the FAA's actions had not been responsive. When issuing an urgent recommendation, such as Safety Recommendation A-07-57, the NTSB believes that the actions need to be completed within 1 year of the recommendation issuance date. Therefore, because more than 3 years had passed since the recommendation was issued and the FAA had not taken the recommended action, the NTSB classified urgent Safety Recommendation A-07-57 "Closed—Unacceptable Action." Regarding Safety Recommendation A-07-61, the NTSB stated that the FAA's efforts to address the recommendation were responsive; however, it encouraged the FAA to initiate and complete rulemaking in a timely manner. The NTSB classified Safety Recommendation A-07-61 "Open—Acceptable Response" pending the FAA's prompt action to address the recommendation.

The NTSB is aware that several companies, including Airbus, Boeing, and Honeywell, have developed, or are in the process of developing, runway overrun protection systems. The NTSB recognizes the safety benefits of such systems in preventing runway overruns and notes that the installation of such systems on all airplanes would be partially responsive to its existing recommendations related to landing accidents and, accordingly, may support the FAA's response to Safety Recommendation A-07-61. Therefore, the NTSB recommends that the FAA actively pursue with aircraft and avionics manufacturers the development of technology to reduce or prevent runway excursions and, once it becomes available, require that the technology be installed.

The effective braking coefficients determined in the airplane performance study for the accident landing were substantially below those defined by the BCAR RWHS and AMJ 25X1591, assumed in the CAPS simulation, and underlying the wet runway landing distances provided in the BAe 125-800A AFM guidance material. The study also determined that the braking coefficients most representative of the actual performance of the airplane during the landing closely matched those calculated by a NASA friction expert using the CFME measurements made on the runway 2 days after the accident. The performance study also indicated that the total landing distances computed using the Section 25.109 braking coefficients can be significantly longer than those computed using the AMJ 25X1591 coefficients and provided in the AFM.

For example, using the accident landing weight of 19,912 pounds, no wind, the OWA field elevation, the outside air temperature on the day of the accident, 140-psi tire pressure, and deceleration device deployment times, the airplane performance study indicated that the total landing distance using the AMJ 25X1591 braking coefficients was 3,338 feet and that the total landing distance using the Section 25.109 braking coefficients was 4,225 feet, which is 26 percent longer.[137] (See table 4 in section 1.16.3.4.2) Assuming an 8-knot tailwind, the total landing distances were 3,792 and 4,928 feet, which is 32 percent longer, respectively. Adding the 15-percent safety margin recommended by SAFO 06012 to these distances, the required runway lengths with an 8-knot tailwind would be 4,361 feet using AMJ 25X1591 data and 5,667 feet using Section 25.109 data. Therefore, even if the accident flight crew had conducted an arrival landing distance assessment using the existing AMJ 25X1591-based AFM data (for either wind condition), it would have shown that the airplane could have stopped on the 5,500-foot runway with a safety margin of more than 15 percent.

As shown, a landing distance assessment using Section 25.109 data would have indicated that the runway length was insufficient for landing with at least a 15-percent safety margin with an 8-knot tailwind. The airplane performance study indicated that the airplane would have exited the runway at between 23 and 37 knots and stopped between 100 and 300 feet beyond the runway end, but within the 1,000-foot runway safety area. The Section 25.109 calculations are consistent with current knowledge about wet runway braking performance, which is reflected in the engineering data used by the FAA to update regulations governing the calculation of accelerate-stop distances for wet, ungrooved runways[138] and by the TALPA ARC in drafting new recommendations to require and support arrival landing distance assessments.

The NTSB concludes that the wet runway landing distances provided in AFMs or performance supplemental materials that are based on the braking coefficients defined by the BCAR RWHS or AMJ 25X1591 can be significantly shorter than the actual distances required to stop on some wet, ungrooved runways. The NTSB notes that the FAA is expected to initiate rulemaking in 2011 and that, even if the rulemaking is begun this year, it will likely be several years until final adoption and implementation. The NTSB further notes that, although the investigative findings indicated that the airplane would have overrun the runway but remained within the runway safety area if the captain had continued with the landing roll rather than attempted to go around, not all airports with ungrooved runways have safety areas. Therefore, until the FAA has completed the rulemaking, the NTSB recommends that the FAA inform operators of airplanes that have wet runway landing distance data based on the BCAR RWHS or AMJ 25X1591 that the data contained in the AFMs (and/or performance supplemental materials)

[137] The NTSB notes that the calculations made in the study assumed that the pilots applied sufficient braking effort to demand all of the available runway friction. If the pilots did not apply sufficient braking effort to demand all of the available runway friction, the landing distances would have been longer than the computed landing distances.

[138] The regulations governing the calculation of accelerate-stop distances also provide airframe manufacturers (and ultimately operators) with an option to account for wet, grooved or porous friction course, runway accelerate-stop performance. However, to take this improved wet runway stopping performance credit, a given operator must assume the burden of ensuring (via periodic inspections) that the runway is adequately maintained.

may underestimate the landing distance required to land on wet, ungrooved runways and work with industry to provide guidance to these operators on how to conduct landing distance assessments when landing on such runways.

2.7 Line Checks

According to 14 CFR 135.299, PICs operating under Part 135 must complete an annual line check. The annual line check must be given by an FAA-approved check pilot and consist of at least one flight over one route segment; include takeoffs and landings at one or more representative airports (that is, an airport that the pilot typically flies into); and be flown over a civil airway, an approved off-airway route, or a portion of either. FAA Order 8900.1 states that line check inspectors should observe and evaluate "adherence to approved procedures and a proper use of all checklists" and sterile cockpit procedures and that line checks should be used to emphasize adherence to SOPs and aeronautical decision-making commensurate with commercial standards. Although the order provides a checklist that contains a list of specific inspection areas that should be observed and evaluated during a line check, including weather, descent planning, use of checklists, and sterile cockpit adherence, inspectors are not required to use the checklist.

In accordance with 14 CFR 135.293, "Initial and Recurrent Pilot Testing Requirements," and 135.297, "Pilot in Command: Instrument Proficiency Check Requirements," pilots must also meet annual competency check and semiannual instrument proficiency check requirements. Annual competency checks are intended to test pilot flying skills (for example, single-engine approaches) in each type of airplane that they fly. Semiannual instrument proficiency checks are intended to test instrument flying skills (for example, missed approaches, holding, and low-visibility takeoffs.)

The investigation revealed that the accident captain's most recent line check was accomplished on May 6, 2008, in conjunction with his annual proficiency check. Conducting line checks simultaneously with competency and proficiency checks is an accepted practice for Part 135 operators; however, this is not allowed in Part 121 operations. This practice essentially allows inspectors to conduct three required inspections simultaneously, which minimizes the surveillance opportunities presented by these inspections and, therefore, the efficacy of such surveillance.

During the line check, the captain flew from ABE to Hazleton Municipal Airport, Hazleton, Pennsylvania, located about 32 miles away, and then back to ABE. The line check took a total of 1.5 hours and included instrument approaches and landings. The captain's line check adhered to the line-check requirements because the captain flew on an airway route to a representative airport. However, the line check was only 1.5 hours, which was too short to be representative of a typical flight (customers do not typically charter flights for such short distances), and the airplane would not have reached a typical jet high-cruise altitude in that amount of time. Performing part of the line check during the cruise portion of flight is critical because it allows the inspector to see how a pilot responds to situations in real-time and under conditions representative of a typical revenue flight. During the cruise portion of flight, the inspector can discuss issues such as flight planning, diversions, alternates, and weather dynamics. Further, when line checks are not conducted in an environment that is truly representative of operations, the inspector has a limited opportunity to evaluate the pilot's practical application of his knowledge to company operations and to identify and address any performance issues with the pilot.

The check airman who conducted the captain's last line check would not have had sufficient time to conduct a thorough and complete inspection or adequately address all of the inspection items. If the check airman had adhered to the FAA's guidelines and conducted the line check on a truly representative revenue flight, using the full checklist provided in FAA Order 8900.1, he might have been able to provide valuable feedback to the captain on how to properly conduct checklists and a missed approach—two areas the captain handled inadequately during the accident flight. The accident captain also would have benefitted from a more thorough knowledge and awareness of convective weather and the use of forecasts and related reports, and a line check conducted on a truly representative flight would have been an appropriate means to reinforce that knowledge and awareness and improve the captain's overall performance as a PIC.

The NTSB concludes that 14 CFR Part 135 PIC line-check requirements are not adequate because they allow more than one required inspection to be conducted simultaneously and do not require that the line checks be conducted on flights that truly represent typical revenue operations; thus, the efficacy of line checks to promote and enhance safety is minimized, and pilots have limited opportunities to demonstrate their ability to manage weather information, checklist execution, sterile cockpit adherence, and other variables that might affect revenue flights. Therefore, the NTSB recommends that the FAA require that 14 CFR Part 135 PIC line checks be conducted independently from other required checks and be conducted on flights that truly represent typical revenue operations, including a portion of cruise flight, to ensure that thorough and complete line checks, during which pilots demonstrate their ability to manage weather information, checklist execution, sterile cockpit adherence, and other variables that might affect revenue flights, are conducted.

2.8 Enhanced Ground Proximity Warning System

At the time of the accident, the terrain database installed in the system was version 421 (released in March 2000). The current terrain database was version 450 (released in April 2008), which was an upgrade to version 421. However, no change occurred to the OWA data between the old and current versions of the EGPWS terrain database.

The NTSB concludes that, although the EGPWS terrain database had not been updated to the current version, the outdated database was not a factor in the accident. Although the outdated EGPWS terrain database did not factor in the accident, the NTSB notes that it is critical to have updated information in the EGPWS (also known as a "terrain avoidance warning system") to maximize the safety benefits of such a system because terrain and obstacle data may change over time. Therefore, the NTSB recommends that the FAA require Part 121, 135, and 91 subpart K operators to ensure that terrain avoidance warning system-equipped aircraft in their fleet have the current terrain database installed.

2.9 Flight Recorders

The airplane was not required by FAA regulations to have an FDR installed. In the NTSB's January 28, 2009, report on the midair collision involving electronic news gathering helicopters in Phoenix, Arizona, the NTSB issued Safety Recommendation A-09-11, which asked the FAA to do the following:

> Require all existing turbine-powered, nonexperimental, nonrestricted-category aircraft that are not equipped with a flight data recorder and are operating under 14 *Code of Federal Regulations* Parts 91, 121, or 135 to be retrofitted with a crash-resistant flight recorder system. The crash-resistant flight recorder system should record cockpit audio (if a cockpit voice recorder is not installed), a view of the cockpit environment to include as much of the outside view as possible, and parametric data per aircraft and system installation, all to be specified in European Organization for Civil Aviation Equipment document ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," when the document is finalized and issued.

On February 12, 2011, the FAA stated that it published TSO C197 for lightweight recording systems. The FAA stated that the TSO invokes certain requirements of EUROCAE document ED-155 and standardizes the design and production certification requirements for equipment manufacturers in an effort to streamline aircraft installation and integration. The FAA stated that, in light of this effort, it did not intend to mandate the equipage of additional recording systems on all turbine-powered, nonexperimental, nonrestricted-category aircraft. The NTSB is currently evaluating this response.

The NTSB concludes that a lightweight recording system conforming to EUROCAE ED-155 would have helped determine the flight crew's actions during the landing and subsequent go-around attempt, including, but not limited to, whether they silently conducted checklists (partially or completely), which flap settings they selected, and how much braking effort they made upon landing.

3. Conclusions

3.1 Findings

1. The investigation found that the pilots were properly certificated and qualified under federal regulations.

2. The investigation found that the accident airplane was properly certificated, equipped, and maintained in accordance with federal regulations. Examinations of the recovered components revealed no evidence of any preimpact structural, engine, or system failures. The airplane was within normal weight and balance limitations.

3. The accident was not survivable.

4. The captain allowed an atmosphere in the cockpit that did not comply with well-designed procedures intended to minimize operational errors, including sterile cockpit adherence, and this atmosphere permitted inadequate briefing of the approach and monitoring of the current weather conditions, including the wind information on the cockpit instruments; inappropriate conversation; nonstandard terminology; and a lack of checklist discipline throughout the descent and approach phases of the flight.

5. The flight crewmembers exhibited poor aeronautical decision-making and managed their resources poorly, which prevented them from recognizing and fully evaluating alternatives to landing on a wet runway in changing weather conditions, eroded the safety margins provided by the checklists, and degraded the pilots' attention, thus increasing the risk of an accident.

6. The airplane touched down within the target touchdown zone and at the recommended touchdown speed, and the captain likely applied sufficient pressure on the brakes during the initial part of the landing roll to take full advantage of the available runway friction, but he failed to immediately deploy the lift-dump system after touchdown in accordance with company procedures, which negatively affected the airplane's deceleration.

7. No evidence exists that reverted rubber or dynamic hydroplaning occurred.

8. If the captain had continued the landing and accepted the possibility of overrunning the runway instead of attempting to execute a go-around late in the landing roll, the accident most likely would have been prevented or the severity reduced because the airplane would have come to rest within the runway safety area.

9. Establishing a committed-to-stop point in the landing sequence beyond which a go-around should not be attempted for turbine-powered aircraft would eliminate ambiguity for pilots making decisions during time-critical events.

10. If, as a 14 *Code of Federal Regulations* Part 135 operator, East Coast Jets had been required to develop standard operating procedures and its pilots had been required to adhere to them, many of the deficiencies demonstrated by the pilots during the accident flight (for example,

inadequate checklist discipline and failure to conduct an approach briefing) might have been corrected by the resultant stricter cockpit discipline.

11. The first officer might have been used more effectively and the pilots might have performed better during the accident flight if they had received formalized crew resource management (CRM) training with stated standards like those required for 14 *Code of Federal Regulations* Part 121 operations, and, if the final rule, "Crew Resource Management Training for Crewmembers in Part 135 Operations," published on January 21, 2011, in 76 *Federal Register* 3831, had been in place before the accident flight, it might have addressed the CRM deficiencies exhibited by the flight crew.

12. The Federal Aviation Administration (FAA) principal operations inspector for East Coast Jets was not familiar with the company's out-sourced training, and his oversight of the company could have been improved by communicating with Simcom and the FAA training center program manager for Simcom and ensuring that the checklists used during training were consistent with those used during operations.

13. Maintaining consistency between the checklists used during training and those used during actual 14 *Code of Federal Regulations* Part 135 and 91 subpart K operations is essential to avoiding confusion about checklist usage and execution.

14. Clearly stating and responding to the intended flap setting, rather than just stating, "set" or "as required," during all checklists would eliminate confusion about an airplane's configuration during critical phases of flight, such as landing.

15. The captain did not obtain any forecast weather information for the flight route or the area surrounding Owatonna Degner Regional Airport (OWA); therefore, he did not have all of the weather information he needed to ensure that he could make a safe flight into OWA.

16. If the captain had obtained a weather briefing from a National Weather Service-certificated weather briefer, the pilots would have had a more complete outlook of weather conditions along the flight route and at the destination airport, and they would have been alerted to the possibility that they would have to land on a wet runway in severe weather conditions.

17. Guidance that explains terms related to severe thunderstorm conditions would help pilots better understand such conditions, which would allow them to make better-informed decisions regarding taking off or continuing flight when these types of conditions exist.

18. Both pilots' performance was likely impaired by fatigue that resulted from their significant acute sleep loss, early start time, and possible untreated sleep disorders, and fatigue might have especially degraded the captain's performance and decision-making abilities when he had to decide while under time pressure whether to continue the landing or initiate a go-around.

19. Although the first officer took a prescription sleep aid for which he did not have a prescription the night before the accident, because of the short duration of its effects for most individuals, it is unlikely that the use of this medication degraded the first officer's

performance at the time of the accident, which occurred about 12 hours after he took the medication.

20. Allowing civil aviation pilots who have occasional insomnia to use prescription sleep medications that have been proven safe and effective would improve these pilots' sleep quality and operational abilities.

21. Educating and training pilots on fatigue-related issues could prevent pilots from operating flights while impaired by fatigue.

22. Formal guidance on how pilots can be treated for common sleep disorders while retaining their medical certification could help mitigate fatigue-related accidents and incidents.

23. The wet runway landing distances provided in aircraft flight manuals or performance supplemental materials that are based on the braking coefficients defined by the *British Civil Air Regulations* Reference Wet Hard Surface and Advisory Material Joint 25X1591 can be significantly shorter than the actual distances required to stop on some wet, ungrooved runways.

24. Title 14 *Code of Federal Regulations* Part 135 pilot-in-command line-check requirements are not adequate because they allow more than one required inspection to be conducted simultaneously and do not require that the line checks be conducted on flights that truly represent typical revenue operations; thus, the efficacy of line checks to promote and enhance safety is minimized, and pilots have limited opportunities to demonstrate their ability to manage weather information, checklist execution, sterile cockpit adherence, and other variables that might affect revenue flights.

25. Although the enhanced ground proximity warning system terrain database had not been updated to the most current version, the outdated database was not a factor in the accident.

26. A lightweight recording system conforming to European Organization for Civil Aviation Equipment ED-155, "Minimum Operational Performance Specification for Lightweight Flight Recorder Systems," would have helped determine the flight crew's actions during the landing and subsequent go-around attempt, including, but not limited to, whether they silently conducted checklists (partially or completely), which flap settings they selected, and how much braking effort they made upon landing.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the captain's decision to attempt a go-around late in the landing roll with insufficient runway remaining. Contributing to the accident were (1) the pilots' poor crew coordination and lack of cockpit discipline; (2) fatigue, which likely impaired both pilots' performance; and (3) the failure of the Federal Aviation Administration to require crew resource management training and standard operating procedures for Part 135 operators.

4. Recommendations

4.1 New Safety Recommendations

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

> Require manufacturers of newly certificated and in-service turbine-powered aircraft to incorporate in their Aircraft Flight Manuals a committed-to-stop point in the landing sequence (for example, in the case of the Hawker Beechcraft 125-800A airplane, once lift dump is deployed) beyond which a go-around should not be attempted. (A-11-18)
>
> Require 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators and Part 142 training schools to incorporate the information from the revised manufacturers' Aircraft Flight Manuals asked for in Safety Recommendation A-11-18 into their manuals and training. (A-11-19)
>
> Require 14 *Code of Federal Regulations* Part 135 and 91 subpart K operators to establish, and ensure that their pilots adhere to, standard operating procedures. (A-11-20)
>
> Require principal operations inspectors of 14 *Code of Federal Regulations* Part 135 and 91 subpart K operators to ensure that pilots use the same checklists in operations that they used during training for normal, abnormal, and emergency conditions. (A-11-21)
>
> Require manufacturers and 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to design new, or revise existing, checklists to require pilots to clearly call out and respond with the actual flap position, rather than just stating, "set" or "as required." (A-11-22)
>
> Work with the National Weather Service to revise Advisory Circular 00-24B, "Thunderstorms," by including explanations of the terms used to describe severe thunderstorms, such as "bow echo," "derecho," and "mesoscale convective system." (A-11-23)
>
> Revise regulations and policies to permit appropriate use of prescription sleep medications by pilots under medical supervision for insomnia. (A-11-24)
>
> Require 14 *Code of Federal Regulations* Part 135 and 91 subpart K pilots to receive initial and recurrent education and training on factors that create fatigue in flight operations, fatigue signs and symptoms, and effective strategies to manage fatigue and performance during operations. (A-11-25)

> Review the policy standards for all common sleep-related conditions, including insomnia, and revise them in accordance with current scientific evidence to establish standards under which pilots can be effectively treated for common sleep disorders while retaining their medical certification. (A-11-26)

> Increase the education and training of physicians and pilots on common sleep disorders, including insomnia, emphasizing the need for aeromedically appropriate evaluation, intervention, and monitoring for sleep-related conditions. (A-11-27)

> Actively pursue with aircraft and avionics manufacturers the development of technology to reduce or prevent runway excursions and, once it becomes available, require that the technology be installed. (A-11-28)

> Inform operators of airplanes that have wet runway landing distance data based on the *British Civil Air Regulations* Reference Wet Hard Surface or Advisory Material Joint 25X1591 that the data contained in the Aircraft Flight Manuals (and/or performance supplemental materials) may underestimate the landing distance required to land on wet, ungrooved runways and work with industry to provide guidance to these operators on how to conduct landing distance assessments when landing on such runways. (A-11-29)

> Require that 14 *Code of Federal Regulations* Part 135 pilot-in-command line checks be conducted independently from other required checks and be conducted on flights that truly represent typical revenue operations, including a portion of cruise flight, to ensure that thorough and complete line checks, during which pilots demonstrate their ability to manage weather information, checklist execution, sterile cockpit adherence, and other variables that might affect revenue flights, are conducted. (A-11-30)

> Require 14 *Code of Federal Regulations* Part 121, 135, and 91 subpart K operators to ensure that terrain avoidance warning system-equipped aircraft in their fleet have the current terrain database installed. (A-11-31)

4.2 Previously Issued Safety Recommendation Classified in this Report

As a result of its investigation of the October 25, 2002, accident in which an Aviation Charter, Inc., King Air A100 airplane lost control and impacted terrain in Eveleth, Minnesota, the National Transportation Safety Board issued the following safety recommendation to the Federal Aviation Administration (FAA) on December 2, 2003:

> Require that 14 *Code of Federal Regulations* (CFR) Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement an [FAA]-approved crew resource management training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O. (A-03-52)

Safety Recommendation A-03-52 (previously classified “Open—Unacceptable Response”) is classified “Closed—Acceptable Action” in this report, and this classification is discussed in section 2.3.1.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

DEBORAH A.P. HERSMAN
Chairman

ROBERT L. SUMWALT
Member

CHRISTOPHER A. HART
Vice Chairman

MARK R. ROSEKIND
Member

EARL F. WEENER
Member

Adopted: March 15, 2011

Vice Chairman Hart filed the following statement on March 21, 2011.

Board Member Statement

Vice Chairman Christopher A. Hart, concurring in part and dissenting in part:

Concurrence. The discussion in the report about Crew Resource Management (CRM) is fine as far as it goes, but I don't believe it goes far enough. This accident involves a PIC and an SIC with very disparate experience levels – the PIC had about 3,600 hours of total flight time, with almost 1,200 hours in type, while the SIC had less than 1,500 hours of total flight time, with less than 300 hours in type. Query whether the concept of CRM is fundamentally different in this context, which is actually more akin to an instructor-student relationship, than in a context in which the experience levels of the two crew members are less disparate. It seems to me that there would necessarily be a significant difference in the relationship between two crewmembers whose background and experience are roughly comparable, as opposed to an instructor-student relationship, and the report is not complete, in my view, without exploring instructor-student situations in more depth.

For example, the absence of team cooperation between the crewmembers in this accident is very contrary to good CRM practice in general, but would not be quite as surprising in an instructor-student context. I would be surprised and disappointed if two crew members of roughly comparable background and experience did not discuss that this landing was going to be pretty tight, and everything had to go exactly right in order to complete the landing successfully; I would not, however, be so surprised about the lack of such conversation in an instructor-student context, because the instructor, being by far the most seasoned, would probably plan to accomplish most the important steps alone in such a difficult maneuver. The absence of real engagement in the landing process by the SIC was also demonstrated by the fact that, less than three minutes before their touchdown, the SIC was on the radio to the FBO about matters that could easily have waited until after the landing.

One major aspect of an instructor-student relationship that is not discussed in the report is that a person may be an excellent pilot but not necessarily be a good instructor; indeed, the pilot may have not even have any *desire* to teach. The report does not state whether this PIC had an instructor rating and if so, whether he kept it current or whether he enjoyed and was proficient at teaching. The PIC's desire and ability to teach are particularly crucial, given the statement in the report from an "experienced Hawker captain" that "flying with new pilots required a lot of talking and 'babysitting,'" along with the statement from the director of operations of the company that "initially, first officers were told to just 'sit there' and 'not touch anything' and that they were a 'detriment to the flight'" (p. 49). Given that this practice is apparently not unusual for this type of operator, query whether, for example, PICs in such situations should be required to be current instructors.

The ultimate question, of course, is whether this type of instructor-student scenario should be permitted in revenue operations. Most passengers would not be pleased to learn that one of the two pilots of their two-pilot airplane is a "detriment to the flight."

Dissent. In the meeting, the Board decided, 4-1, to include the following recommendation to the FAA:

> Actively pursue with aircraft and avionics manufacturers the development of technology to reduce or prevent runway excursions and, once it becomes available, require that the technology be installed.

The concept of developing better ways to inform pilots if their landing plans are marginal or undoable under the existing conditions is a good one, but I voted against including this recommendation in this report because it is not supported by the facts in this accident. The report notes that the calculation of landing distance, even with the 8-knot tailwind and the more conservative friction coefficients, showed that the runway was adequate, not including the 15 percent safety margin that we have recommended but the FAA has not required (Table 4). Instead, the report makes very clear that the problem was not the runway length, as such, but the considerable (7 second) delay in fully deploying the lift-dump system (p. 91). Thus, I am opposed to this recommendation because, if the calculations described in the report showed that the runway was adequate, an onboard device to determine adequate runway length would presumably have reached the same conclusion and would not have warned this crew not to land.

Moreover, even though the NTSB does not engage in quantitative cost-benefit analyses, the NTSB has a long history of recommending some technologies on larger airplanes first because the cost of the technology relative to the cost of the airplane is more favorable for larger airplanes. For example, the NTSB has made progressive recommendations, starting with larger airplanes and later moving to smaller airplanes, regarding cockpit voice recorders, flight data recorders, and terrain awareness warning systems. Similarly, this recommendation would have been less unacceptable, in my opinion, if it had been limited to Part 121, Part 135, and Part 91 Subpart K operations. This phased-in approach would be a good idea in any event, but even more so because it is not clear from the available data that landing overruns in Part 91 operations are enough of a problem, either in likelihood or extent of harm, to warrant an FAA requirement at this time.

5. Appendixes

Appendix A

Investigation and Public Hearing

Investigation

The National Transportation Safety Board (NTSB) was notified about this accident on July 31, 2008. A go-team was assembled in Washington, DC, and traveled to the accident scene. The go-team was accompanied by former Board Member Steven R. Chealander.

The following investigative groups were formed: Aircraft Airworthiness (Systems and Structures), Aircraft Performance, Witnesses, Survival Factors and Airports, Meteorology, Air Traffic Control, Powerplants, Operations and Human Performance, and Maintenance Records. Also, a specialist was assigned to transcribe the cockpit voice recorder at the NTSB's laboratory in Washington, DC.

Parties to the investigation were the Federal Aviation Administration, East Coast Jets, Hawker Beechcraft Corporation, and Honeywell. In accordance with the provisions of Annex 13 to the Convention on International Civil Aviation, the NTSB's counterpart agency in the United Kingdom, the Air Accidents Investigations Branch (AAIB), participated in the investigation as the representative of the State of Design and Manufacture (Airframe). BAE Systems participated in the investigation as a technical advisor to the AAIB, as provided for in Annex 13.

Public Hearing

No public hearing was held for this accident.

Appendix B

Cockpit Voice Recorder Transcript

The following is a transcript of the Fairchild Model A-100 cockpit voice recorder, serial number 60249, installed on the Hawker Beechcraft 125-800A airplane that crashed during an attempted go-around at Owatonna Degner Regional Airport, Owatonna, Minnesota, on July 31, 2008.

LEGEND

CAM	Cockpit area microphone voice or sound source
HOT	Flight crew audio panel voice or sound source
RDO	Radio transmissions from N818MV
CTR	Radio transmission from Minneapolis center controller
APR	Radio transmission from the Minneapolis and Rochester approach controllers
FBO	Radio transmission from the Rare Air FBO at Owatonna
AWOS	Radio transmission from Automated Weather Observation System at Owatonna
-1	Voice identified as the captain
-2	Voice identified as the first officer
-?	Voice unidentified
*****	Unintelligible word
#	Expletive
@	Non-pertinent word
( )	Questionable insertion
[ ]	Editorial insertion

Note 1: Times are expressed in central daylight time (CDT).

Note 2: Generally, only radio transmissions to and from the accident aircraft were transcribed.

Note 3: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

Note 4: A non-pertinent word, where noted, refers to a word not directly related to the operation, control or condition of the aircraft.

CVR Quality Rating Scale

The levels of recording quality are characterized by the following traits of the cockpit voice recorder information:

Excellent Quality Virtually all of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate only one or two words that were not intelligible. Any loss in the transcript is usually attributed to simultaneous cockpit/radio transmissions that obscure each other.

Good Quality Most of the crew conversations could be accurately and easily understood. The transcript that was developed may indicate several words or phrases that were not intelligible. Any loss in the transcript can be attributed to minor technical deficiencies or momentary dropouts in the recording system or to a large number of simultaneous cockpit/radio transmissions that obscure each other.

Fair Quality The majority of the crew conversations were intelligible. The transcript that was developed may indicate passages where conversations were unintelligible or fragmented. This type of recording is usually caused by cockpit noise that obscures portions of the voice signals or by a minor electrical or mechanical failure of the CVR system that distorts or obscures the audio information.

Poor Quality Extraordinary means had to be used to make some of the crew conversations intelligible. The transcript that was developed may indicate fragmented phrases and conversations and may indicate extensive passages where conversations were missing or unintelligible. This type of recording is usually caused by a combination of a high cockpit noise level with a low voice signal (poor signal-to-noise ratio) or by a mechanical or electrical failure of the CVR system that severely distorts or obscures the audio information.

Unusable Crew conversations may be discerned, but neither ordinary nor extraordinary means made it possible to develop a meaningful transcript of the conversations. This type of recording is usually caused by an almost total mechanical or electrical failure of the CVR system.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:15:01.0 Start of Recording			
09:15:28.4 Start of Transcript			
		09:15:28.4 **RDO-2**	center East Coast Jet eighty one three four zero.
		09:15:31.2 **CTR**	East Coast Jet eighty one three four oh roger.
		09:15:45.5 **CTR**	and East Coast Jet eight one reset your transponder squawk code two four seven two.
		09:15:49.4 **RDO-2**	two four seven two East Coast eighty one.
09:15:55.9 **HOT**	[sound of single chime].		
09:16:54.3 **HOT-1**	I was readin' (the) article in a magazine in Atlantic City about flight- flight options, (the) company flight option their top ten destinations and and Minneapolis was on there I guess there's sixteen fortune five hundred f- companies there we go there quite a bit you know?		
09:17:10.1 **HOT-2**	really?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:17:11.3 HOT-1	we go there quite a bit you know?		
09:17:12.9 HOT-2	yeah.		
09:17:14.1 HOT-1	seems like kinda out of the way compared to like Chicago and 'cause usually we go to Minneapolis we go to Chicago Milwaukee.		
09:17:19.9 HOT-2	yeah er.		
09:17:22.5 HOT-2	yeah (we) do get out there quite a bit.		
09:17:26.2 HOT-1	there are worse places to be than Minneapolis I guess.		
09:17:28.1 HOT-2	yeah Minneapolis is alright.		
09:17:48.6 HOT-2	is this nearby Minneapolis?		
09:17:51.6 HOT-1	I'm not sure how far.		
09:17:59.4 HOT-1	ahm.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:18:01.9 **HOT-1**	M M ah M-S-P or S-T-P in in your VORs find out, what's that?		
09:18:10.2 **HOT-1**	probably M-S-P or S-T-P.		
09:18:25.5 **HOT-1**	VOR section.		
09:18:28.9 **HOT-1**	I don't know where it is but.		
09:18:30.6 **HOT-2**	*.		
09:18:36.1 **HOT-1**	there ya go.		
09:18:56.0 **HOT-2**	Minneapolis one fifteen point three.		
09:19:07.4 **HOT-1**	hundred and forty miles right over there so looks like it's about hundred only about twenty miles from there. that right?		
09:19:12.8 **HOT-2**	yeah it shouldn't be too far.		
09:19:15.9 **HOT-2**	I wonder if that's where they're goin' then Minneapolis?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:19:18.1 HOT-1	naw I think there's a casino that they're goin' to 'cause this is Revel, Entertainment I think the build casinos.		
09:19:23.0 HOT-2	oh.		
09:19:26.7 HOT-1	so I think there's an Indian casino in Owatonna or whatever.		
09:19:29.8 HOT-2	yeah.		
09:19:30.7 HOT-1	Owatonna.		
09:19:31.9 HOT-2	Owatonna I wonder if it's like an Indian ah.		
09:19:34.5 HOT-1	probably.		
09:19:39.1 HOT	[unintelligible external transmission].		
09:20:13.9 HOT-2	I'm not gettin' it yet.		
09:20:15.4 HOT-1	okay.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:21:05.3 HOT-1	think we're gonna have to deal with any of that.		
09:21:14.2 HOT-1	'cause we should be comin' down here pretty soon.		
09:21:16.4 HOT-2	yeah.		
		09:22:03.6 CTR	East Coast Jet eight one descend at your discretion and maintain flight level two four zero.
		09:22:07.9 RDO-2	two four zero East Coast eighty one.
09:23:07.0 HOT	(* * Celsius dewpoint one six altimeter * niner eight six remarks lightening distance all quadrants*)		
		09:23:17.9 AWOS	Celsius. * niner.
09:23:19.2 HOT-2	twenty four.		
		09:23:21.9 AWOS	* (municipal airport) automated weather observation (one four two three Zulu).

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:23:30.3 HOT-2	I'm gonna go off for a second.		
		09:23:32.5 AWOS	one zero thunderstorms rain three thousand five hundred scattered two four thousand five hundred broken six thousand zero hundred overcast temperature one eight Celsius * dewpoint one six altimeter (two niner eight six) remarks lightening distance all quadrants * * .
09:23:57.7 HOT	[unintelligible external transmission].		
		09:24:02.4 AWOS	Owatonna Municipal Airport automated weather observation one four two four Zulu weather winds calm visibility one zero thunderstorms rain three thousand five hundred scattered (two) four thousand five hundred broken niner thousand five hundred overcast temperature (one) six Celsius dewpoint one six altimeter (two niner eight six) remarks lightening distance all quadrants.
		09:24:36.2 AWOS	Zulu wind two three zero at zero eight visibility.

INTRA-COCKPIT COMMUNICATION TIME and SOURCE	INTRA-COCKPIT COMMUNICATION CONTENT	AIR-GROUND COMMUNICATION TIME and SOURCE	AIR-GROUND COMMUNICATION CONTENT
		09:24:41.2 **AWOS**	Owatonna Municipal Airport automated weather observation one four two four Zulu weather winds calm visibility one zero thunderstorms rain three thousand five hundred scattered (ceiling) (four) thousand.
09:24:57.6 **HOT-2**	well.		
09:25:00.4 **HOT-2**	calm te- calm ten miles two nine eight six forty five hundred scattered.		
09:25:09.0 **HOT-1**	alright.		
09:25:11.0 **HOT-2**	couldn't get the temperature.		
09:25:12.7 **HOT-1**	that's cool.		
		09:25:20.3 **CTR**	East Coast Jet eighty one contact Minneapolis center on ah one three four point two five.
09:25:20.4 **CAM**	[sound similar to hi-lo chime].		
		09:25:24.5 **RDO-2**	thirty four twenty five East Coast Jet eighty one.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:25:33.1 **RDO-2**	Minneapolis center East Coast Jet eighty one descending two five zero to two four zero.
09:25:36.7 **HOT-1**	two six zero.		
		09:25:37.2 **CTR**	East Coast Jet eighty one Minneapolis center roger you seeing that ah extreme precip at your twelve o'clock twenty miles?
09:25:43.1 **HOT-2**	yeah they're paintin' it what's the bases?		
		09:25:45.6 **RDO-2**	ah w- we're paintin' it here and wha- what is the bases (report)?
		09:25:49.9 **CTR**	say again?
		09:25:50.6 **RDO-2**	the bases.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:25:52.3 CTR	I have no idea what the bases are ah I know the tops are quite high, ahm I don't recommend you go through it I've had nobody go through it, ahm deviation if you go right you'd probably have to up oh maybe ah probably sixty miles north of Rochester if you go southwest you'd have to go down south of Mason City Iowa.
09:26:05.5 CAM	[sound similar to altitude alerter tone].		
		09:26:13.9 RDO-2	(I would) like to deviate to the right East Coast eighty one.
		09:26:16.4 CTR	East Coast eighty one roger deviation right of course approved.
09:26:19.5 HOT-1	any lower?		
		09:26:20.2 RDO-2	than- East Coast eighty one any lower for us?
		09:26:22.7 CTR	ah standby.
		09:26:25.2 CTR	and East Coast Jet eighty one how much of a right turn are you gonna make?

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:26:28.4 **HOT-1**	ah we're about a three ten heading.		
		09:26:30.8 **RDO-2**	* about a three ten heading 'bout twenty- ah twenty five degrees.
		09:26:35.9 **CTR**	East Coast Jet eighty one roger deviation right of course approved.
		09:26:39.0 **RDO-2**	deviation right East Coast eighty one.
09:26:45.3 **HOT-1**	let's hope we get underneath it.		
09:26:46.7 **HOT-2**	yeah that's what I was thinkin' too.		
09:26:51.4 **HOT-2**	if he woulda descended us it probably wouldn't have been an issue.		
09:26:59.2 **HOT-2**	I mean fifty miles out we're still at twenty five thousand feet, twenty four thousand feet.		
09:27:04.5 **HOT-1**	I know.		
		09:27:31.7 **CTR**	East Coast Jet eighty one contact Minneapolis center one three four point eight five for lower.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:27:36.7 RDO-2	one thirty four eighty five East Coast Jet eighty one.
		09:27:43.8 RDO-2	Minneapolis center East Coast Jet eighty one two four zero three ten heading.
		09:27:48.4 CTR	East Coast Jet tw- ah eighty one Minneapolis center roger and ah I guess I gotta ask you to say intentions what would you like to do? 'cause I can't even give you a good recommendation right now.
		09:27:57.7 RDO-1	well looks like ah we are on a three ten heading around it here looks ah I got it clear probably for another forty miles before we can * left turn to the field.
		09:28:10.6 CTR	alright what altitude do you wanna go to because ah any lower altitude(s) than eighteen you're gonna go into Minneapolis, approach controls airspace which I could certainly do if you want just let me know if you wanna go ah above that altitude I can take you around that.
		09:28:26.4 RDO-1	ah whatever's easiest you know I don't really have a, preference.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:28:31.5 CTR	East Coast Jet eighty one ah descend and maintain flight level one niner zero let me know if that works if you want another altitude let me know.
		09:28:37.9 RDO-2	one nine zero and ah we'll let you know when we get there East Coast Jet eighty one.
09:28:41.9 HOT-1	I didn't really hear what he was sayin' on the ah, whether we're on approach control or what I mean * what # difference does it make?		
09:28:47.2 HOT-2	yeah who what the # do what do we care?		
09:28:49.6 HOT-1	all I care * is above ten and we go fast so we can get around this # thing.		
09:28:53.0 HOT-2	right.		
09:28:55.3 HOT-2	I don't think * I mean he said he couldn't climb us but why would we wanna climb?		
09:28:59.0 HOT-1	exactly so he can.		
09:29:00.3 HOT-2	so we get more in it?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:29:00.3 **HOT-1**	yeah.		
09:29:03.9 **HOT-1**	ah #.		
		09:29:07.9 **CTR**	East Coast Jet descend and maintain one ah four fourteen thousand and ah I'll get you a local altimeter on Owatonna in a minute.
		09:29:15.5 **RDO-2**	fourteen thousand East Coast Jet eighty one.
09:29:17.5 **HOT-2**	got twenty nine eighty six.		
		09:29:17.9 **CTR**	East Coast Jet eighty one Owatonna altimeter's two niner eight eight.
		09:29:21.6 **RDO-2**	two nine eight eight East Coast Jet eighty one.
09:29:26.6 **HOT-1**	ice is on ignitions are on, wings are on.		
09:30:09.1 **HOT-1**	good thing I didn't tell 'em it was gonna be a smooth ride huh? I looked at the radar and there wasn't anything.		
09:30:10.8 **HOT-2**	[sound similar to laughter].		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:30:15.3 HOT-2	but doesn't it figure pops up right when we get here?		
09:30:17.7 HOT-1	yeah.		
09:30:20.4 HOT-1	what do you mean what are my intentions? get me around this # storm so I can go to the field.		
09:30:23.9 HOT-2	right.		
09:30:24.8 HOT-1	I ain't gonna turn around and go home.		
09:30:25.0 CAM	[sound of increased background noise consistent with rain impacting the windscreen].		
09:30:26.5 HOT-2	[sound similar to laughter].		
09:30:32.4 HOT-1	ah another twenty five miles and we can make the turn probably 'er twenty probably less than that we'll make a cut here in a second.		
09:30:34.8 HOT-2	yeah.		
09:30:37.9 HOT-2	yeah we can (cut).		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:30:49.9 **HOT-1**	* on how's your wing look?		
09:30:53.3 **HOT-2**	ah there's a little bit out there.		
09:30:56.0 **HOT-1**	teeny teeny bit?		
09:30:57.0 **HOT-2**	yeah just a li- little bit.		
09:31:11.7 **HOT-1**	(know) what the #.		
09:31:28.3 **HOT-2**	ah it's gone.		
09:31:53.7 **HOT-2**	* call I'm off I'm gonna call FBO.		
09:31:55.8 **HOT-1**	alright.		
09:32:21.0 **HOT-1**	I just don't see that out there anymore. where the # did it go? is it above us?		
09:32:28.7 **HOT-2**	it might be above us.		

INTRA-COCKPIT COMMUNICATION | AIR-GROUND COMMUNICATION

TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:32:31.1 **CTR**	East Coast Jet eighty one contact Minneapolis approach one two four point seven we'll see ya.
		09:32:36.4 **RDO-2**	twenty four seven East Coast Jet eighty one see ya.
09:32:41.0 **HOT-2**	it must be.		
09:32:46.1 **HOT-1**	* we * turn toward the field then.		
09:32:49.8 **HOT-2**	should I tell 'em we're starting our turn toward the field?		
09:32:52.9 **HOT-1**	yeah.		
		09:32:53.7 **RDO-2**	Minneapolis East Coast Jet eighty one descending one six thousand to one four thousand we're gonna be starting our left turn towards a Owatonna.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:33:01.2 **APR**	East Coast Jet eighty one Minneapolis approach Minneapolis altimeter two niner seven eight and you said the center has turned you towards oracon- Owatonna (or) you requesting a turn?
09:33:07.5 **HOT-1**	nah hold on.		
		09:33:10.0 **RDO-1**	no we're requestin' a turn there we're not paintin' what we we're previously painting there so we show it's fairly clear between us and them we're ready whenever.
		09:33:17.2 **APR**	* Jet eighty one roger be about seven miles there's just ah 'bout four different boundaries of airspace come together there with three different facilities involved so I'm gonna take you another ah seven northwest then I'll start your turn in to the southwest.
09:33:20.4 **HOT**	[sound similar to an electronic warning horn]		
		09:33:29.0 **RDO-1**	okay no problem and we're out of fourteen five for one four thousand.
		09:33:32.1 **APR**	* I'll have you lower in about six miles out so.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:33:37.0 **HOT-2**	alright * I'm off.		
09:33:38.1 **HOT-1**	okay.		
		09:33:40.5 **RDO-2**	Rare Air at Owatonna this is Hawker eight one eight Mike Victor.
		09:33:44.8 **APR**	East Coast eighty one fly heading two eight zero.
		09:33:48.2 **RDO-1**	two eight zero eighty one.
		09:34:08.1 **APR**	East Coast eighty one turn left heading two five zero descend and maintain seven thousand.
		09:34:10.0 **RDO-2**	Rare Air Owatonna Hawker eight one eight Mike Victor.
		09:34:12.0 **RDO-1**	two five zero down to seven thousand eighty one.
09:34:22.5 **HOT-1**	I got the ground, that's a plus.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:34:24.9 HOT-2	I'm not ta- I'm not gettin' anyone.		
09:34:26.5 HOT-1	okay.		
09:34:28.6 HOT-2	what did he give us?		
09:34:29.7 HOT-1	down to ah seven thousand.		
		09:34:30.3 APR	East Coast eighty one descend and maintain six thousand contact approach one ah three four point seven.
		09:34:36.9 RDO-2	thirty four seven six thousand East Coast Jet eighty one.
09:34:41.2 HOT-2	down to six.		
		09:34:46.0 RDO-2	approach East Coast Jet eighty one one three thousand to six thousand.
		09:34:50.4 APR	East Coast Jet eighty one * approach * ah roger and ah what approach do you wanna ah do at Owatonna?

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:34:56.0 **RDO-2**	* * could do the ILS.
		09:34:58.2 **APR**	East Coast Jet eighty one roger descend and maintain a six thous- descend and maintain seven thousand turn a left a heading of one eight zero.
		09:35:06.7 **RDO-2**	seven thousand one eight zero East Coast Jet eighty one.
09:35:10.7 **HOT-1**	seven thousand. I fixed it. one eighty.		
09:35:12.4 **HOT-2**	* * *.		
09:35:18.6 **HOT-1**	and it's the ILS to three zero?		
09:35:20.3 **HOT-2**	ILS to three zero one oh nine five five.		
09:35:27.4 **HOT-2**	ah three oh two final approach course glideslope intercept two thousand eight hundred six. down to one thousand three hundred and forty six which is two hundred foot on the ah yeah radio altimeter.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:35:40.0 **HOT-1**	so you alright you're gettin' nobody on ah the ground there?		
09:35:43.5 **HOT-2**	no.		
09:35:44.2 **HOT-1**	okay let's do the approaches real quick.		
09:35:46.0 **HOT-2**	alright harnesses?		
09:35:47.3 **HOT-1**	left.		
09:35:48.0 **HOT-2**	fuel?		
09:35:48.5 **HOT-1**	balanced and plenty.		
09:35:49.6 **HOT-2**	flight deck heat.		
09:35:50.4 **HOT-1**	closed.		
09:35:51.2 **HOT-2**	approach briefing.		
09:35:52.6 **HOT-1**	it's gonna be the ILS to three zero at Owatomba somethinish.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:35:58.4 **HOT-2**	landing data twenty two thirty two.		
09:36:01.2 **HOT-1**	thirty two set.		
09:36:02.4 **HOT-2**	nav info.		
09:36:05.8 **HOT-1**	ah ahm fifty five three oh two two hundred.		
09:36:06.4 **HOT-2**	radio set one oh nine five five.		
09:36:10.8 **HOT-2**	ah radar altimeter.		
09:36:12.6 **HOT-1**	whooa just cleared my ears and I'm totally dizzy. I'm in a left turn right now. [sound similar to laughter].		
09:36:18.6 **HOT-2**	ah *.		
09:36:20.6 **HOT-1**	its goin' away okay sorry.		
09:36:22.7 **HOT-2**	alright radar altimeter.		
09:36:23.5 **HOT-1**	two hundred feet.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:36:24.5 **HOT-2**	brake handle.		
09:36:26.1 **HOT-1**	forward.		
09:36:26.9 **HOT-2**	steering.		
		09:36:26.9 **APR**	East Coast Jet eighty one contact * approach one oh niner point eight.
09:36:27.4 **HOT-1**	clear.		
		09:36:31.4 **RDO-2**	one one nine eight East Coast Jet eighty one.
		09:36:39.9 **RDO-2**	Rochester East Coast Jet eighty one descending eight for seven thousand.
		09:36:45.5 **APR**	East Coast eighty one Rochester approach descend at pilot's discretion maintain three thousand turn right heading one niner zero vector ILS runway three zero at Owatonna.
09:36:48.3 **HOT**	[sound similar to electronic warning horn].		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:36:54.8 RDO-2	three thousand one nine zero vectors for the ILS three zero.
		09:37:01.5 APR	and East Coast Jet eighty one ah I just picked up the weather for you at Owatonna it's about ah twenty minutes old now they're showing the wind three two zero at eight visibility ten or greater thunderstorms three thousand seven hundred scattered ceiling four thousand five hundred broken five thousand overcast temperature one eight dewpoint one six altimeter two niner eight eight and they're showing lightening in the distance all quadrants.
09:37:31.7 HOT-1	thank you.		
		09:37:32.6 RDO-2	alright thank you very much East Coast Jet eighty one.
09:37:40.7 HOT-1	I don't know what the # we're looking at on this thing.		
09:37:42.9 HOT-2	well neither do I.		
09:37:43.3 HOT-1	right now.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:37:44.2 HOT-2	I don't know if it's not working.		
09:37:45.7 HOT-1	is that ground?		
09:37:47.8 HOT-1	'cause I got it pointed way up in the air.		
09:37:51.1 HOT-1	you know I got it we're goin' down I got it pointed up.		
09:37:52.8 HOT-2	pointed up yeah.		
09:37:55.1 HOT-1	and ish you know.		
09:37:56.5 HOT-2	you would think that.		
09:37:56.5 HOT-1	* *. I don't know what we're lookin' at.		
09:37:57.9 HOT-2	is that the storm or is it?		
09:37:59.7 HOT-1	hard to say.		
09:38:00.7 HOT-2	but * if you look out the window which I think maybe right now is best.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:38:04.9 **HOT-1**	[sound similar to laughter].		
		09:38:07.3 **APR**	and East Coast Jet eighty one ah I am showing light precip for you uhm pretty much your whole route into Owatonna and then there's just a couple of heavy cells uhm about ah five miles north and north east of Owatonna.
09:38:24.9 **HOT-1**	roger.		
		09:38:25.8 **RDO-2**	roger East Coast eighty one.
09:38:27.3 **HOT-1**	the sooner you get us there the better.		
09:38:30.9 **HOT-2**	yeah.		
		09:38:31.8 **APR**	East Coast Jet eighty one turn right heading two zero zero.
		09:38:34.1 **RDO-2**	two zero zero East Coast eighty one.
09:38:35.9 **HOT-1**	you now when they start sayin' this stuff it's like are you trying to tell me somethieing?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:38:39.1 HOT-2	right.		
09:38:40.1 HOT-1	because I'm not gettin' it.		
09:38:40.6 HOT-2	*.		
09:38:41.6 HOT-2	[sound similar to laughter].		
09:38:42.4 HOT-1	[sound similar to laughter].		
09:38:44.2 HOT-2	why don't just get us to the field.		
09:38:45.6 HOT	[sound similar to altitude alerter warning tone].		
09:38:46.4 HOT-2	one to go.		
09:38:47.6 HOT-1	one (bar).		
09:38:49.5 HOT-1	so approaches are done.		
09:38:51.0 HOT-2	approaches are done.		
09:38:52.8 HOT-2	except that notices yeah they're on.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:38:55.1 **HOT**	[sound similar to passenger notice chime].		
09:39:00.2 **HOT-1**	down to three.		
09:39:07.5 **HOT-1**	start gettin' her slowed up.		
09:39:10.4 **HOT-2**	I could try to get ahold of 'em again *.		
09:39:12.1 **HOT-1**	yeah go for it I got it.		
09:39:13.0 **HOT-2**	alright I'm off.		
		09:39:16.3 **RDO-2**	Rare Air Owatonna Hawker eight one eight Mike Victor.
		09:39:33.8 **RDO-2**	Owatonna Hawker eight one eight Mike Victor anybody there?
09:39:45.3 **HOT-2**	no one.		
		09:39:55.3 **APR**	East Coast Jet eighty one turn right heading two five zero.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:39:57.7 **HOT-1**	flaps one.		
		09:39:58.7 **RDO-2**	two five zero East Coast Jet eighty one.
09:40:02.9 **CAM**	[sound similar to mechanical click].		
09:40:04.5 **HOT-2**	one and indicating.		
09:40:12.2 **HOT-1**	why don't you really quickly go over and ah ID that thing? see if the localizer's even right?		
		09:40:21.2 **APR**	East Coast Jet eighty one is ah seven miles from TONNA turn right heading two niner zero maintain ah three thousand until established on the localizer cleared ILS runway three zero approach.
09:40:22.9 **HOT**	[sound of Morse code for OWA].		
09:40:24.0 **HOT-1**	I got it.		
		09:40:31.0 **RDO-1**	two nine zero three thousand 'till established cleared for the ILS ah three zero eighty one.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:40:36.3 **HOT-2**	and it's right.		
09:40:37.2 **HOT-1**	okay good.		
09:41:19.3 **HOT-1**	loc's alive.		
09:41:20.9 **HOT-2**	ah loc's alive.		
09:41:24.8 **HOT-1**	why don't you make a call out on twenty two seven?		
09:41:27.0 **HOT-2**	alright.		
09:41:27.4 **HOT-1**	see if anything's goin' on let 'em know we're comin' in on ILS three zero. get the # outta the way.		
09:41:31.7 **HOT-2**	[sound similar to laughter].		
		09:41:32.9 **RDO-2**	Owatonna this is a Hawker on a ten mile f-.
09:41:37.7 **HOT-1**	wrong f- wrong freq. man.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:41:38.6 APR	* * correction * East Coast Jet eighty one report canceling IFR this frequency in the air or with Princeton flight service on the ground change to advisory is approved.
09:41:40.4 HOT-1	change your.		
09:41:41.1 HOT-2	* *.		
		09:41:47.7 RDO-2	East Coast Jet eighty one we will report canceling with you or on the ground.
		09:41:54.1 RDO-2	Owatonna this a Hawker on a ah ten mile final the ILS three zero anyone around?
		09:41:59.8 RDO-1	and East Coast eighty one we'll cancel now we have the runway in sight.
		09:42:04.2 APR	East Coast eight eighty one roger IFR cancellation is received squawk VFR frequency change approved.
		09:42:04.4 FBO	this is Owatonna UNICOM go ahead please.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:42:08.9 **RDO-2**	Owatonna there's a Hawker eight one eight Mike Victor about eight miles out comin' inbound gonna be droppin' off eight passengers stayin' with you for about two hours and ah, what what do we need to do for fuel do we need to taxi somewhere for the fuel?
		09:42:09.4 **RDO-1**	squawkin' VFR change approved and you don't show any traffic in the area of Owatto-tona do ya?
		09:42:15.7 **APR**	East Coast jet eighty one no no traffic reported or observed in the vicinity.
		09:42:19.1 **RDO-1**	thank you.
09:42:21.9 **CAM**	[increase in background noise consistent with gear extension].		
		09:42:24.3 **FBO**	affirmative we do have a ah * * * * * * * there's a there's a red box that's the AVGAS pump but the white box is the jet fuel.
09:42:37.4 **HOT-1**	three green no red pressures good back to zero steering's clear.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
		09:42:38.1 **FBO**	or if you wanna park just park in front of it that's fine ahm and then we'll we can get your fuel order inside.
09:42:43.9 **HOT**	[sound similar to autopilot disconnect warning].		
		09:42:45.5 **RDO-2**	alright thank you we'll do that East Coast Je- ah Hawker eight one eight Mike Victor.
09:42:49.4 **HOT-2**	alright.		
09:42:52.5 **HOT-2**	he said that we're gonna drop 'em off and then le- leave one runnin' or whatever and then we could go park in front of the ah fuel thing and they'll come over and take our order.		
09:42:59.2 **HOT**	[sound similar to altitude alerter warning tone].		
09:43:01.8 **HOT-1**	oh okay do we know where the fuel thing is are they gonna meet us out there?		
09:43:04.9 **HOT-2**	I * *.		
09:43:05.2 **HOT-1**	flaps two.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:43:06.9 CAM	[sound similar to two clicks].		
09:43:07.6 HOT-1	why don't you go through the before landings make sure you got it all.		
09:43:13.6 CAM	[sound similar to click].		
09:43:14.4 HOT-1	down indicatin' down.		
09:43:25.7 CAM	[sound similar to click].		
09:43:28.1 HOT-2	and before landing shorts to go.		
09:43:30.0 CAM	[sound similar to double click].		
09:43:36.4 HOT	one thousand [electronic voice].		
09:44:02.4 HOT-1	squawk twelve hundred real quick would ya?		
09:44:07.9 HOT-2	did you cancel?		
09:44:09.0 HOT-1	yeah.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:44:25.2 HOT	four hundred [electronic voice].		
09:44:26.1 CAM	[sound similar to click].		
09:44:29.3 HOT-1	I'm goin' right to the tiller and the brakes.		
09:44:31.2 HOT-2	okay.		
09:44:32.1 HOT	three hundred [electronic voice].		
09:44:42.2 CAM	[sound similar to click].		
09:44:45.7 HOT-1	slowin' to ref.		
09:44:46.8 CAM	[sound similar to multiple clicks].		
09:44:46.8 HOT	two minimums minimums [electronic voice].		
09:44:47.2 HOT-2	air valves are shut damper to go.		
09:44:56.0 HOT-1	birds.		
09:45:01.0 HOT-2	damper.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:45:02.2 **CAM**	[sound similar to one click].		
09:45:04.0 **CAM**	[sound consistent with tires rolling on a prepared surface].		
09:45:04.7 **CAM**	[sound similar to kachunk].		
09:45:06.5 **CAM**	[sound similar to airbrakes going to open].		
09:45:07.7 **HOT-2**	(we're) dumped.		
09:45:09.4 **HOT-2**	we're not dumped.		
09:45:11.0 **HOT-1**	no we're not. [sounds similar to straining while saying “not’].		
09:45:11.3 **CAM**	[sound similar to airbrakes/lift dump handle going to lift dump position].		
09:45:18.1 **CAM**	[sound similar to slightly elevated breathing].		
09:45:19.4 **CAM**	[multiple sounds similar to mechanical clicks].		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:45:20.3 **CAM**	[sound similar to airbrakes going to shut].		
09:45:21.1 **CAM**	[sound similar to kachunk].		
09:45:21.5 **HOT-1**	flaps.		
09:45:22.0 **CAM**	[sound consistent with increasing engine noise].		
09:45:23.1 **HOT-1**	#.		
09:45:27.0 **HOT-1**	here we go.		
09:45:30.0 **HOT-1**	not flyin' not # flyin'.		
09:45:30.2 **CAM**	[sound of increasing impulsive background noise].		
09:45:36.4 **HOT**	bank angle bank angle [electronic voice].		
09:45:36.7 **HOT-1**	#.		
09:45:37.1 **HOT-2**	(over here).		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME and SOURCE	CONTENT	TIME and SOURCE	CONTENT
09:45:37.9 **HOT-2**	*.		
09:45:38.0 **HOT-1**	#.		
09:45:38.5 **HOT-?**	*.		
09:45:39.0 End of Transcript			
09:45:44.5 End of Recording			