National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: March 29, 2011

In reply refer to: A-11-18 through -31

The Honorable J. Randolph Babbitt
Administrator
Federal Aviation Administration
Washington, D.C. 20591

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 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 (NTSB) determined 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

[1] Unless otherwise indicated, all times in this letter 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 letter, 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.

resource management (CRM) training and standard operating procedures (SOPs) for 14 CFR Part 135 operators.[4]

Accident Sequence of Events

Flight Crew's Performance During the Descent and Approach

The preflight weather briefing package that the captain printed about 2 hours before departure from Atlantic City International Airport (ACY), Atlantic City, New Jersey, 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. 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 automated weather observation system (AWOS) recorded by the cockpit voice recorder (CVR) indicated thunderstorms and rain. About 1 minute later, the Minneapolis Air Route Traffic Control Center controller asked the pilots if they were seeing the "extreme" precipitation about 20 miles ahead 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 pilot flying and be conducted and called complete by the pilot monitoring (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

[4] For more information, see *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: National Transportation Safety Board, 2011), which will be available on the NTSB's website at <http://www.ntsb.gov/publictn/2011/AAR1101.pdf>.

weather."[5] 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 [instrument landing system] 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 flight management system (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 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 pilot-in-command (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

[5] According to FAA Advisory Circular (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.

pilots to land early on the day of the accident), they repeatedly expressed impatience with air traffic control (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.[6] 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. 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 fixed-based operator (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, commonly referred to as 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. 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.

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[6] 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 FAA flight service stations 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.

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.

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.[7]

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 Airplane Flight Manual [AFM] wet runway guidance material, which is discussed below). 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.

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 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

[7] According to the pilot/controller glossary in the *Aeronautical Information Manual*, the touchdown zone is "the first 3,000 feet of the runway beginning at the threshold."

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.”[8] 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 International (a Part 142 training school in Orlando, Florida) 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 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.[9]

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

[8] 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.

[9] 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) *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 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.[10]

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.

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 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.[11] 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

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[10] 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.

[11] 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/>.

procedures. According to Advisory Circular (AC) 120-71A, "Standard Operating Procedures for Flight Deck Crewmembers," 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.[12]

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 principal operations inspector (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 below, 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 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 General Operations Manual, the required manual carried by pilots in the cockpit, nor is it required to as an

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[12] 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).

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 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,[13] 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 a *Special Federal Aviation Regulation* 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.

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[13] 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).

Further, 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,[14] the NTSB issued Safety Recommendation A-99-35, which asked the FAA to, in part, issue a flight standards information bulletin 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 flight standards information bulletins (FSIB) 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 Department of Transportation (DOT) report,[15] 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.

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

[15] 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).

Checklist Usage

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 Flight Safety International Quick Reference Handbook 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 Flight Standards District Office, 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, "Flight Standards Information Management System," 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 training center program managers (TCPM)[16] 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

[16] 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.

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.

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 August 16, 1987, Northwest Airlines, Inc., 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 the National Aeronautics and Space Administration (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.[17]

In the August 17, 2009, safety recommendation letter that resulted from the NTSB's participation in the Spanair flight JK5022 accident investigation,[18] the NTSB issued Safety

[17] 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.

[18] 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

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 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 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 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."

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assistance of an accredited representative and technical advisors from the NTSB under the provisions of Annex 13 to the International Convention on Civil Aviation.

Weather Planning

As discussed previously, the 0513 weather package printed by the captain did not contain any adverse weather information, such as the Convective significant meteorological information (SIGMET) 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 National Weather Service (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. Severe weather watch 779 also identified the line of thunderstorms as a bowing mesoscale convective system (MCS)[19] and potential derecho[20] and indicated that it had stalled over the area. Severe weather watch 781 further identified a severe MCS with a bow echo[21] 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. The investigation revealed that neither FAA weather-related guidance, including AC 00-24B, “Thunderstorms,” nor NWS products reference or explain technical meteorological terms, such as “mesoscale convective system,” “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.

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.”

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

[19] An MCS is a complex of thunderstorms that becomes organized on a scale larger than individual thunderstorms and normally persists for several hours or more.

[20] A derecho is a widespread and usually fast-moving windstorm that can produce damaging winds.

[21] 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.

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,[22] 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.[23]

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 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[24] 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.[25] 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

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

[23] 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.

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

[25] 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.

sleep medication zolpidem because he did not have a prescription.[26] 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.[27] 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 new information, [and]…risk assessment" and that "time pressure increases cognitive errors."[28] 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.[29] 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

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[26] 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 later in this letter.

[27] 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).

[28] 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.

[29] 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.

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.[30] 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.[31] Further, the FAA does not provide guidance for the use of other 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

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[30] 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.

[31] 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 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."

or their physicians on these issues. For example, although the *Aeronautical Information Manual* (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.[32] In addition, the 2009 *Guide for Aviation Medical Examiners* (*AME Guide)* 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[33] 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,[34] 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).

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 do the following:

> Expedite a coordinated research program on the effects of fatigue, sleepiness, sleep disorders, and circadian factors on transportation system safety.[35]

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.[36]

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

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[32] 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).

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

[34] 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.

[35] 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).

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

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.[37] 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."[38] 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 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 notice of proposed rulemaking (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,

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[37] For more information, see AAR-08/01.

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

which was well within current and proposed hours of service standards for Part 135 operations.[39] 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 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.

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[39] 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.

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.

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 Safety Alert for Operators (SAFO) 06012, "Landing Performance Assessments at Time of Arrival (Turbojets)," on August 31, 2006. 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 Takeoff/Landing Performance Assessment (TALPA) aviation rulemaking committee (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, "Accelerate-Stop Distance," which would result in more conservative distances than those based on Advisory Material Joint (AMJ) 25X1591. The BAe 125-800A AFM would be required to be updated with these more conservative distances. (See below for further discussion of this issue.)

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 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. The NTSB recognizes the safety benefits of such systems in preventing runway overruns. 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 *British Civil Airworthiness Requirements* (BCAR) "Reference Wet Hard Surface" (RWHS) and AMJ 25X1591, assumed in the Hawker Beechcraft Computerised Aircraft Performance System 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 continuous friction measuring equipment 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-pounds-per-square-inch 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.[40] 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[41] 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) 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.

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

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[40] 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.

[41] 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.

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 Lehigh Valley International Airport (ABE), Allentown, Pennsylvania, 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.

Enhanced Ground Proximity Warning System

At the time of the accident, the terrain database installed in the airplane's enhanced ground proximity warning system (EGPWS) 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.

Therefore, 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)

In response to the recommendations in this letter, please refer to Safety Recommendations A-11-18 through -31. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN and Members SUMWALT, ROSEKIND, and WEENER concurred with these recommendations. Vice Chairman HART concurred with all recommendations except Safety Recommendation A-11-28. He filed a statement in which he concurred in part and dissented in part, which is attached to the aviation accident report for this accident.

[Original Signed]

By: Deborah A.P. Hersman
Chairman