National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: February 7, 2006

In reply refer to: A-06-7 through -11

Honorable Marion C. Blakey
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On October 19, 2004, about 1937 central daylight time,[1] Corporate Airlines (doing business as American Connection)[2] flight 5966, a BAE Systems BAE-J3201, N875JX, struck trees on final approach and crashed short of runway 36 at the Kirksville Regional Airport (IRK), Kirksville, Missouri. The flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a scheduled passenger flight from Lambert-St. Louis International Airport (STL), in St. Louis, Missouri, to IRK. The captain, first officer, and 11 of the 13 passengers were fatally injured, and 2 passengers received serious injuries. The airplane was destroyed by impact and a postimpact fire. Night instrument meteorological conditions (IMC) prevailed for the flight, which operated on an instrument flight rules flight plan.[3]

The National Transportation Safety Board determined that the probable cause of the accident was the pilots' failure to follow established procedures and properly conduct a nonprecision instrument approach at night in IMC, including their descent below the minimum descent altitude (MDA)[4] before required visual cues were available (which continued unmoderated until the airplane struck the trees) and their failure to adhere to the established division of duties between the flying and nonflying (monitoring) pilot.

Contributing to the accident was the pilots' failure to make standard callouts and the current Federal Aviation Regulations that allow pilots to descend below the MDA into a region in

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

[2] In February 2005, Corporate Airlines was renamed Regions Air, Inc. For the purposes of this letter, the name Corporate Airlines will be used.

[3] For more information about this accident, see National Transportation Safety Board, *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: NTSB, 2006).

[4] The MDA (minimum descent altitude) is a specified altitude in a nonprecision approach or circling approach below which descent must not be made unless the pilots have visual contact with the runway environment. The MDA at IRK was 1,320 feet msl. The Corporate Airlines flight manual defines visual contact with the runway environment as visual contact with any of the following: the approach light system; the visual approach slope indicator; runway end identification lights; the runway threshold, threshold markings, or threshold lights; runway lights; touchdown zone lights; touchdown zone or zone markings; or the runway or runway markings.

which safe obstacle clearance is not assured based upon seeing only the airport approach lights. The pilots' unprofessional behavior during the flight and their fatigue likely contributed to their degraded performance.

The Accident Sequence

Examination of the cockpit voice recorder (CVR) and flight data recorder (FDR) data indicated that the en route portion of the accident flight from STL to IRK was routine. The captain had thoroughly briefed the nonprecision instrument approach, including the MDA and missed approach procedures. The Safety Board notes that Corporate Airlines' flight manual indicates that a 1,200 feet per minute (fpm) descent rate from 1,000 feet above ground level (agl) down to 300 feet agl is consistent with a stabilized approach. Although this descent rate is not prohibited by the Federal Aviation Administration (FAA), it is not consistent with the FAA's guidance, which indicates that one of the criteria for a stabilized approach is a descent rate no greater than 1,000 fpm below 1,000 feet agl. The initiation of the approach was consistent with company procedures; when the airplane passed the final approach fix (FAF) on the approach, the pilots began a 1,200 fpm rate of descent to the MDA. The Safety Board concludes that while the accident airplane's 1,200 fpm rate of descent was consistent with company procedures, it varied from current FAA guidance that recommends a descent rate of no more than 1,000 fpm below 1,000 feet agl.

As the approach continued, however, neither pilot followed standard company nonprecision approach procedures. CVR evidence indicated that just before the GPWS announced that the airplane was at the MDA (at 1936:36.8), the captain stated, "I can see ground there."[5] About 6 seconds later, the captain stated that he could see the approach lights. The captain's statements indicated that, contrary to company procedures, he was looking outside the cockpit for visual references. Corporate Airlines' procedures dictated that if the nonflying/monitoring pilot (the first officer) did not see the required visual cues when the airplane reached the MDA (and in this case, his comment at 1936:41.9 indicated that he did not), the flying pilot (the captain) should level off and remain at the MDA until those cues came into sight or until the airplane reached the missed approach point (MAP).[6]

As the airplane was about 170 feet below the MDA (about 194 feet agl, 8 seconds after the airplane descended through the MDA), the first officer stated, "in sight…continue." CVR evidence clearly indicates that both pilots were referring to external cues and not referencing the necessary cockpit instrumentation. In fact, although company procedures dictated descents of no more than 900 fpm below 300 feet agl, the airplane was still descending at a rate of about 1,200 fpm as it descended through about 100 feet agl.

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[5] It is not clear what the captain was looking at when he reported seeing the ground. On the basis of IRK automated surface observation system weather observations and other pilot reports, it is likely that the airplane was skimming the bottom of the clouds as it descended through the MDA. The approach path was over farmland and woods, and postaccident interviews with local residents and other pilots indicated that there were few, if any, light sources (except the airport lights) or other ground references that were visible at night in the area.

[6] At the MAP, if the pilots do not see the approach lights or runway environment, company and published approach procedures require a missed approach.

As the airplane descended through about 100 feet agl, the first officer suggested selecting landing flaps (35°); the captain turned down the suggestion. The decision not to extend landing flaps suggests that the captain was not completely committed to a landing, although he said he saw the approach lights. However, the captain's failure to stop or slow the airplane's descent indicates that he was not aware of the airplane's excessive descent rate and/or significantly misjudged its proximity to the ground.

Although current FAA regulations permit pilots to descend below the MDA to 100 feet above the touchdown zone elevation (TDZE) after they observe the approach lights, such a descent may not be advisable under all circumstances. During an approach at night, in reduced visibility, approach lights alone would not provide an adequate sight picture for the pilots to make an appropriate approach to the runway. With only an approach light or lights for approach path reference, a pilot could focus on those lights while flying into the ground. Pilots who had flown into IRK at night told investigators that, other than the airport's lighting systems, there were minimal lights or ground references beneath the approach course that would have helped the pilots judge the airplane's position relative to the runway or height above terrain.[7]

The Safety Board concludes that the pilots failed to follow established procedures to effectively monitor the airplane's descent rate and height above terrain during the later stages of the approach and relied too much on minimal external visual cues. Although descent rate and altitude information were readily available through cockpit instruments, both pilots were largely preoccupied with looking for the approach lights.

Crew Performance/Professionalism

Cockpit communications recorded by the CVR indicated that the pilots frequently engaged in conversation that lacked a professional tone during the accident flight. The Board considered whether these unprofessional communications (some of which were made during a critical phase of flight below 10,000 feet mean sea level (msl) and therefore were not consistent with FAA and Corporate Airlines sterile cockpit procedures) were a factor in this accident.

CVR evidence indicated that the pilots appeared to be comfortable with each other and enjoyed flying and joking together. To an extent, this working relationship might have been a benefit in the cockpit. Humor can play an important function in promoting crew cohesion, coordination, and tension reduction; it is reasonable to expect that a crew that works together for several days may develop an effective interaction style that involves humor. However, research has shown that flight crews that focus more on social cohesion than on-task team work may not perform as effectively as other flight crews and may be distracted from standard procedures.[8]

When the relationship between colleagues is excessively relaxed, there may be a tendency for professionalism to be compromised and pilot responsibilities to be adversely

[7] On the basis of the airplane's altitude, its distance from the runway, the relative brightness of the approach lights, and the fact that the visual approach slope indicator (VASI) glidepath does not intercept the MDA until closer to the airport, the VASI lights would have appeared solid red and therefore would not have provided the pilots with much usable information.

[8] D. Druckman and J.A. Swets, *Enhancing Human Performance: Issues, Theories, and Techniques*, National Academy Press (1988): 159-163.

affected. Flight crewmembers must be alert to these possibilities to avoid degraded situational awareness and adhere to standard operating procedures and professionalism. Also, in an excessively relaxed relationship, there may be a tendency for overconfidence and over-reliance on each other. The pilots' professional demeanor was probably degraded as a result of their relationship and relaxed behavior; these factors may also have detracted from the pilots' adherence to company standard procedures and callouts.

Federal regulations regarding sterile cockpit procedures[9] are intended to prevent casual crew interactions from interfering with the careful execution of critical pilot actions, such as altitude and course control during nonprecision instrument approaches. These rules allow more casual flight crew interactions during operations above 10,000 feet msl, when the workload is relatively low, while expressly prohibiting nonessential flight crew conversations/interactions below 10,000 feet msl, when the workload is relatively high.

The captain, as the pilot-in-command, had the authority and responsibility to set the cockpit tone for the approach. However, the accident captain was known among coworkers for his sense of humor and CVR evidence indicated that he emphasized fun in the cockpit. Had he emphasized the pilots' goals and strategies as they prepared for the nonprecision approach in night IMC, it is likely that the accident pilots would have suspended their humorous banter and engaged in only operationally relevant conversation below 10,000 feet msl. The captain's continued joking during this period established an inappropriate cockpit orientation for this phase of the flight and was not consistent with standard operating procedures. Both pilots' attitudes and inattention during subsequent operations demonstrated a lack of regard/respect for their responsibilities and duties.

Despite the pilots' unprofessional verbal behavior throughout much of the flight, CVR, FDR, air traffic control, and radar information indicated that they were generally attentive to required flight-related duties until shortly before the accident. For example, the pilots were very attentive to the weather conditions (low ceilings and reduced visibility) at IRK, checking and rechecking the IRK automated surface observation system observations as they approached the airport. Additionally, the captain provided a thorough landing briefing in which he stated the MDA and runway TDZE (1,320 and 964 feet, respectively) and reviewed the missed approach procedures. He also restated the MDA as he began the approach.

However, despite their apparent awareness of proper approach procedures and altitudes, the pilots continued their 1,200 fpm descent below the MDA without an appropriate visual reference. The captain should have leveled off and focused on the flight instruments and the first officer should have instructed him to level off. It was apparent that they did not have the requisite visual cues needed to descend further at that time. Instead, about 2 seconds after the airplane descended through the MDA, still descending about 1,200 fpm, the captain asked the

[9] The sterile cockpit regulation (14 CFR 121.542) states, in part, "No flight crewmember may engage in, nor may any pilot in command permit, any activity during a critical phase of flight which could distract any flight crewmember from the performance of his or her duties or which could interfere in any way with the proper conduct of those duties. Activities such as eating meals, engaging in non-essential conversations within the cockpit and non-essential communications between cabin and cockpit crews, and reading publications not related to the proper conduct of the flight are not required for the safe operation of the aircraft."

first officer, “what do you think?” About 4 seconds later, the first officer responded, “I can’t see [expletive].”

Corporate Airlines’ procedures dictated that the first officer was to monitor the approach and report deviations from standard company approach procedures. During the accident approach, the first officer occasionally provided the captain with appropriate nonflying/monitoring pilot support (such as when he prompted the approach checklist, provided distance measuring equipment [DME] callouts, repeated the MDA, and prompted landing flaps). However, there were several instances in which the first officer failed to provide company-required callouts or provided nonstandard callouts. For example, he was required to callout “100 feet above minimums” and “minimums,” as the airplane descended through those altitudes, but instead he made a single callout of “thirteen twenty” as the airplane approached the MDA. Most significantly, the first officer did not challenge the captain’s failure to level off at or reduce the airplane’s rate of descent around the MDA, despite the fact that the first officer did not see any ground references and was responsible for monitoring the progress of the approach.[10]

The first officer appeared to be engaged in appropriate nonflying/monitoring pilot activities during the later stages of the approach; he was looking for external visual references and stated, “in sight, continue” when he eventually observed the approach lights (about 11 seconds after the airplane descended through the MDA). He also prompted the captain regarding the landing flap configuration late in the approach. However, when the descent continued below the MDA, the first officer did not aggressively express concern even though he did not yet see the approach lights. It is possible that the first officer was not aware that the airplane had not leveled off at the MDA because, as the nonflying/monitoring pilot, he was primarily looking for external visual references. However, it is also possible that the first officer did not challenge the captain because he was hesitant to be perceived as criticizing him. The Safety Board’s 1994 safety study[11] of flight-crew-involved major accidents of U.S. carriers showed that accidents that involve human performance deficiencies are much more likely to occur when the captain is the flying pilot. This finding has been widely interpreted as indicative of the difficulty that first officers may have in challenging a captain because of the difference in experience and cockpit authority gradient between the two crewmembers.

The Safety Board concludes that the pilots’ nonessential conversation below 10,000 feet msl was contrary to established sterile cockpit regulations and reflected a demeanor and cockpit environment that fostered deviation from established standard procedures, crew resource management (CRM) disciplines, division of duties, and professionalism, reducing the margin of safety well below acceptable limits during the accident approach and likely contributing to the pilots’ degraded performance. Further, the Safety Board concludes that compliance with sterile cockpit rules likely would have resulted in an increased focus on standard procedures and professionalism during the accident flight. Further, there is no evidence to indicate that this flight

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[10] The Safety Board notes that careful adherence to standard procedures and division of responsibility in the cockpit can significantly help pilots limit the degrading effects of fatigue. The role of fatigue in this accident is discussed later in this letter.

[11] For additional information, see National Transportation Safety Board, *A Review of Flightcrew-Involved Major Accidents of U.S. Carriers, 1978 through 1990*, Safety Study NTSB/SS-94/01 (Washington, DC: NTSB, 1994).

crew was unique in their behavior. Therefore, the Safety Board believes that the FAA should direct the principal operations inspectors of all 14 CFR Part 121 and 135 operators to reemphasize the importance of strict compliance with the sterile cockpit rule.

Nonprecision Instrument Approach Techniques

Industry nonprecision instrument approach practices include two basic techniques: a traditional technique in which pilots descend rapidly to the MDA, level off, and fly to the MAP; and a constant-angle-of-descent technique in which the pilots establish a more moderate rate of descent calculated to reach the MDA just before the MAP. Corporate Airlines trained its pilots to use a traditional approach technique when performing nonprecision instrument approaches. Thus, when the airplane crossed the FAF, the pilots were to establish the airplane in a descent that allowed it to reach the MDA well before the MAP, then level off. The approach flown by the accident pilots was consistent with a traditional-method nonprecision instrument approach until they continued their descent below the MDA. The Safety Board reviewed the constant-angle-of descent approach technique (which is recommended where practicable by the FAA and Flight Safety Foundation[12]) to determine whether it might have helped the pilots avoid this accident.

Unlike a traditional approach, a constant-angle-of-descent approach technique involves establishing and maintaining a constant descent angle and moderate descent rate from the FAF toward the approach end of the runway and arriving and leveling off at the MDA at a point at or slightly before reaching the MAP. (Although the accident pilots maintained a relatively consistent angle of descent, their descent was steeper than that involved in a constant-angle, moderate-rate descent; as a result, the airplane reached the MDA almost 2 miles before the MAP and then did not level off.)

The use of the constant-angle-of-descent technique is typically dependent on the use of position and altitude information (for example, DME and the altimeter) to determine the necessary vertical flightpath. If used for the accident approach, the constant-angle-of-descent approach would likely have provided a stabilized flightpath with a relatively shallow angle of descent such that the airplane would reach the MDA at or slightly before the MAP.[13] The accident captain would likely have needed only minimal adjustments to maintain the correct descent profile to land within the touchdown zone on the runway. The pilots would have been closer to the airport when they reached the MDA, which would have facilitated their acquisition of visual cues indicating the airport environment, so they could maintain a normal descent to the runway and thus avoid obstacles during the descent from the MDA to the runway. The Safety Board concludes that the use of a constant-angle-of-descent approach technique, with its

[12] The FAA has endorsed the constant-angle-of-descent approach technique in numerous publications (including FAA-H-8083-3A Airplane Flying Handbook and Air Traffic Bulletin #2001-3), stating that "…for a nonprecision approach…[constant-angle-of-descent procedures] facilitate stabilized approaches….other procedures that require abnormally high descent rates inhibit a pilot's ability to descend toward the runway in a stabilized constant descent configuration." The Flight Safety Foundation stated in its "Approach and Landing Accident Reduction" Briefing Note #7.2 (August—November 2000) that a constant-angle-of-descent approach profile "provides a more stabilized flightpath, reduces pilot workload, and reduces the risk of error."

[13] Additionally, use of the constant-angle-of-descent approach technique would eliminate the need to descend to 100 feet above the touchdown zone before reaching the runway. In marginal weather conditions, the procedure permitting descent to 100 feet above the TDZE could have a potential for attracting pilots into an unsafe environment.

resultant stabilized, moderate rate-of-descent flightpath and obstacle clearance, would have better positioned the accident airplane for a successful approach and landing. Therefore, the Safety Board believes that the FAA should require all 14 CFR Part 121 and 135 operators to incorporate the constant-angle-of-descent technique into their nonprecision approach procedures and to emphasize the preference for that technique where practicable.

Current Federal regulations permit pilots to descend below the MDA to 100 feet above the runway TDZE if the airport approach lights are in sight.[14] However, pilots must positively maintain obstacle clearance without the electronic vertical profile guidance that they would receive during a precision approach or the proper vertical profile they would maintain if performing a nonprecision constant-angle-of-descent approach. According to the FAA, published nonprecision approach procedures ensure obstacle clearance throughout the descent to the MDA but do not ensure obstacle clearance below this altitude. Therefore, it is critical that pilots refrain from descending below the MDA unless at least one of several very specific approach lighting or runway environment items is “distinctly visible and identifiable” to them, to provide guidance to the runway.

This accident occurred after the pilots continued their descent through the MDA and even through 100 feet above the TDZE (1,064 feet msl), without adequate visual reference to the approach lights or runway environment. At night with low ceilings, reduced visibility, and limited visual cues (ground lights, etc.), it would have been very difficult for the pilots to detect obstacles along the approach path through external visual cues, let alone visually assess the airplane’s descent rate, distance from the airport, and height above the ground. The pilots (whom CVR evidence indicated wanted to land at IRK at the end of a long day and who likely began to see that they were breaking out of the clouds around the MDA) were apparently motivated to descend below the MDA to acquire visual cues that would allow them to continue the approach. The accident airplane initially impacted trees about 996 feet msl, which was about 62 feet below the “100 feet above TDZE” altitude.

The Safety Board concludes that current regulations permitting pilots to descend below the MDA into a region where obstacle clearance is not assured results in reduced margins of safety for nonprecision approaches, especially in conditions of low ceilings, reduced visibility, and/or at night. Further, these regulations can have the unintended effect of encouraging some pilots to descend below the MDA in an attempt to acquire visual cues that will permit them to continue the approach, as occurred in this case. Therefore, the Safety Board believes that the FAA should revise applicable 14 CFR Part 121 and 135 regulations to prohibit pilots from descending below the MDA during nonprecision instrument approaches unless conditions allow for clear visual identification of all obstacles and terrain along the approach path or vertical guidance to the runway is available and being used.

[14] Evidence (interviews with other Corporate Airlines pilots, examination of Corporate Airlines’ operations, and review of FDR data from the accident pilots’ previous approach to IRK) indicates that the accident pilots were aware of the Federal regulations allowing them to descend below the MDA if they had the approach lights in sight and took advantage of it if necessary.

Pilot Flight and Duty Time and Fatigue Issues

The Safety Board evaluated fatigue as a possible factor in this accident and looked at the various circumstances present the day of the accident that may have contributed to the pilots' fatigue, including hours of rest, waking time, length of the duty day, and workload. The pilots' available rest time (from about 2100 to about 0400) did not correspond favorably with either pilot's reported usual sleeping hours, resulting in much earlier than normal times to go to sleep and awaken.[15] Additionally, their early wakeup call times[16] on the day of the accident would have been challenging to both pilots because the human body is normally physiologically primed to sleep between 0300 and 0500.

Other important factors that would facilitate the development of fatigue in the accident pilots included the length of their duty day and the type of flying throughout that day (and the two previous days). At the time of the accident, it had been more than 15 hours since the pilots' last significant sleep period, and they had been on duty for 14 1/2 hours. The captain was observed resting on a small couch in the company crew room in STL between flights; however, the quality of rest the captain obtained during this time could not be determined, and company pilots stated that the crew room was a noisy meeting area that was not ideal for sleeping. Further, although naps are a recognized countermeasure for fatigue, research indicates that the effect of a nap would only last a few hours. Therefore, any sleep the captain got during this rest period probably had little fatigue-reducing effect by the time of the accident.[17]

The Safety Board's 1994 study of flight crew-related major aviation accidents indicated that fatigue related to lengthy periods of wakefulness can contribute to accidents. Specifically, the Board's study found that captains who had been awake for more than about 12 hours made significantly more errors than those who had been awake for less than 12 hours; such errors included failing to discontinue a flawed approach.[18] Further, accident data show that long duty days significantly increase the likelihood of human factors-related accidents. Pilots who flew schedules involving 13 or more hours of duty time had accident rates several times higher than pilots who flew shorter schedules.[19] Additionally, the pilots' high workload during their long day may have increased their fatigue. The accident occurred during the sixth flight segment of the day while the pilots were performing a nonprecision approach in low ceilings and reduced visibility.

[15] According to the captain's fiancée, when he did not have work demands, the captain normally went to sleep about midnight and awoke about 0630 or 0700; further, he had indicated that he had difficulty sleeping the night before the accident. The first officer's mother reported that when he did not have work demands, the first officer's sleep schedule was variable, depending on social and flight instruction obligations; however, she was often asleep before he returned home.

[16] Records indicate that the captain and first officer received hotel wakeup calls at 0410 and 0430, respectively.

[17] The CVR recorded yawning sounds from both the captain (about 1915:03) and the first officer (about 1923:43, 1925:44, and 1929:27) during the flight.

[18] For example, in its investigation of the June 1, 1999, accident involving American Airlines flight 1420 at Little Rock, Arkansas, in which the pilots continued a flawed approach, the Safety Board noted that the pilots had been continuously awake for at least 16 hours.

[19] J.H. Goode, "Are Pilots at Risk of Accidents Due to Fatigue?," *Journal of Safety Research*, Vol. 34 (2003): 309-313.

The pilot deficiencies observed in this accident could be consistent with fatigue impairment. Research and accident history indicate that fatigue can cause pilots to make risky, impulsive decisions, to become fixated on one aspect of a situation, and to react slowly to warnings or signs that an approach should be discontinued. Fatigue especially affects decision-making, and research shows that people who are fatigued become less able to consider options and are more likely to become fixated on a course of action or a desired outcome.[20] Among pilots, this may appear as errors such as failing to discontinue a flawed approach.

Consistent with the degrading effects of fatigue, the captain made a risky decision to continue the approach based on inadequate visual cues, fixated on visual information to the exclusion of critical information on descent rate and altitude available on the airplane's instruments, and failed to discontinue the flawed approach although he was unable to acquire external visual cues that would assure a safe landing. Similarly, although the first officer's junior status with the company may have been an issue in his failure to challenge the captain during the approach, he may also have been suffering from fatigue; his failure to monitor and react to the captain's deviations from nonprecision approach procedures was consistent with the degrading effects (slowed reactions and/or tunnel vision) of fatigue.

The Safety Board concludes that, on the basis of the less-than-optimal overnight rest time available, the early reporting time for duty, the length of the duty day, the number of flight legs, the demanding conditions (nonprecision instrument approaches flown manually in conditions of low ceilings and reduced visibilities) encountered during the long duty day (and the two previous days), it is likely that fatigue contributed to the pilots' degraded performance and decision-making.

Despite repeated recommendations from the Safety Board (including Safety Recommendation A-99-45),[21] the FAA has not revised its pilot flight and duty time regulations. The Safety Board notes that regulations such as those adopted by Great Britain[22] provide clear,

[20] J.A. Caldwell, "Fatigue in the Aviation Environment: An Overview of the Causes and Effect as well as Recommended Countermeasures," *Aviation, Space, and Environmental Medicine*, Vol. 68 (1997): 932-938.

[21] On the Safety Board's "Most Wanted" list of transportation safety improvements, Safety Recommendation A-99-45 was issued in May 1999 as a result of the Board's evaluation of the Department of Transportation's (DOT) efforts to address operator fatigue in transportation. This recommendations asked the FAA to "establish, within 2 years, scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest." Frustrated by the FAA's lack of progress on this safety issue, the Board classified A-99-45 "Open—Unacceptable Response" in April 2001. In addition, the Board issued Safety Recommendations I-89-2 and -3 to the DOT addressing upgraded regulations regarding hours of service, as well as the development and dissemination of educational materials regarding work and rest schedules and proper regimens of health, diet, and rest to personnel in all modes of transportation. Safety Recommendation I-89-2 is currently classified "Open—Acceptable Response," and Safety Recommendation I-89-3 is classified "Closed—Unacceptable Action/Superseded." The Board also issued Safety Recommendation A-95-113, which asked the FAA, in part, to "finalize the review of current flight and duty time regulations and revise the regulations, as necessary, within 1 year to ensure that flight and duty time limitations take into consideration research findings in fatigue and sleep issues." Safety Recommendation A-95-113 is currently classified "Open—Unacceptable Response."

[22] The aviation regulatory authorities of Great Britain have adopted flight and duty time regulations that reflect information from fatigue and sleep-related research. These British regulations take into consideration a pilot's starting time and number of flight legs, as well as the total duty time. For more information, see Civil Aviation Authority of Great Britain, *The Avoidance of Fatigue in Aircrews: Guide to Requirements*. CAP 371, Section B (2004): 9.

easy-to-understand limits with which industry can develop schedules to optimize pilot utilization while respecting factors identified in current scientific literature as conducive to fatigue. The Safety Board concludes that existing FAA pilot duty regulations do not reflect recent research on pilot fatigue and sleep issues, increasing the possibility that pilots will fly in a fatigued condition. Therefore, the Safety Board believes that the FAA should modify and simplify the flight crew hours-of-service regulations to take into consideration factors such as length of duty day, starting time, workload, and other factors shown by recent research, scientific evidence, and current industry experience to affect crew alertness. Further, because the FAA has not taken suitable action regarding Safety Recommendation A-99-45 since it was issued in 1999, the Safety Board classifies Safety Recommendation A-99-45 "Closed—Superseded."

Although the FAA revised Advisory Circular 120-51, "Crew Resource Management Training," Appendix 3, "Appropriate CRM Training Topics," to encourage operators to provide pilots with information about the detrimental effects of fatigue and strategies for avoiding and countering its effects as part of their CRM training programs, such training is not required by current regulations. Although many airlines have incorporated such training into their programs, at the time of the accident, Corporate Airlines did not provide its pilots with fatigue-related instruction in its CRM or other training modules.[23]

The Safety Board notes that the FAA participated (with other transportation modal administrations) in a Department of Transportation (DOT) Operator Fatigue Management Program effort to develop a fatigue management reference guide. The reference guide was intended to provide basic information to operators in all transportation modes about how to develop an effective fatigue management program using available scientific evidence and industry best practices. In addition, the DOT program has developed additional products for industry use, such as software to aid in designing work schedules that promote alertness. Such products can provide useful guidelines and tools for companies that are willing to go beyond current regulations by developing and implementing a fatigue management program. DOT personnel are currently developing a tool to aid company safety managers in building a case for support of fatigue management activities.

The circumstances of this accident demonstrate the continuing need for fatigue management in the aviation industry. The Safety Board concludes that providing pilots with additional fatigue-related training, such as that being developed by the DOT Operator Fatigue Management Program, may increase their awareness and use of fatigue avoidance techniques and thus improve safety margins. Therefore, the Safety Board believes that the FAA should require all 14 CFR Part 121 and 135 operators to incorporate fatigue-related information similar to that being developed by the DOT Operator Fatigue Management Program into their initial and recurrent pilot training programs; such training should address the detrimental effects of fatigue and include strategies for avoiding fatigue and countering its effects.

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[23] Corporate Airlines' CRM training was a 6-hour session that addressed CRM concepts and policies of cockpit responsibility and duties during flight, as required by regulation.

Flight Recorder Requirements

Current 14 CFR Part 121 FDR standards for newly manufactured airplanes require FDRs to record 88 parameters of data. The accident airplane was in a category that was not required to be so equipped. Given the limited predicted life of these airplanes, the FAA allowed exceptions to this rule, indicating that upgrading existing FDR equipment to record additional parameters on older airplanes would require extensive modifications and was not cost effective.

The Safety Board notes that the FDR is an important investigative tool that can be used to determine operational actions and an airplane's performance. Because the information that investigators learn from FDR data can help prevent accidents and incidents from recurring, FDRs that record only a limited number of parameters can adversely affect safety. However, new technology (specifically, onboard image recorders) provides an economical means of supplementing parametric information on airplanes operating with FDRs recording fewer parameters. Image recorders have the added advantage of providing additional information that would not be readily obtained from the CVR and/or FDR, such as the environment within the cockpit and outside the cockpit window and the manipulation of controls and switches in the cockpit.

In April 2000, the Safety Board issued Safety Recommendation A-00-30 to the FAA, asking the FAA to require that all aircraft operated under 14 CFR Parts 121, 125, or 135 and currently required to be equipped with a CVR and FDR be retrofitted by January 1, 2005, with a crash-protected cockpit image recording system. Despite the Board's recommendation, a February 2005 notice of proposed rulemaking titled, "Revisions to Cockpit Voice Recorder and Digital Flight Data Recorder Regulations," did not address image recorders.

During this investigation, the Safety Board learned that several aircraft like the BAE-J3201 are currently used in Part 121 passenger-carrying operations with minimal, if any, recorded data,[24] which is unacceptable. The Safety Board understands that the cost of retrofitting these aircraft with FDRs to meet the current standard for newly manufactured aircraft may be cost-prohibitive. However, image recorder technology that is currently available offers a cost-effective solution and would capture important data that would otherwise be lost in an investigation. For example, in this accident, an image recorder might have provided information regarding where the pilots were looking and what they might have seen through the windshield as they descended below the MDA. The Safety Board concludes that capturing the maximum recorded data possible is necessary for a more effective reconstruction of the events that lead to accidents and the issuance of more timely safety recommendations to prevent similar accidents from recurring. Therefore, the Safety Board reiterates Safety Recommendations A-00-30 and A-03-65 for airplanes that are currently required to be equipped with both a CVR and FDR and Safety Recommendation A-03-65 for airplanes that are required to be equipped with a CVR.

[24] It is possible that some airplanes that entered the U.S. registry before October 11, 1991, and are currently used in Part 121 passenger-carrying operations might only be equipped with a CVR and not an FDR. The Safety Board previously recommended image recorders for airplanes that are only equipped with a CVR in Safety Recommendation A-03-65, which is currently classified "Open—Unacceptable Response."

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> Direct the principal operations inspectors of all 14 *Code of Federal Regulations* Part 121 and 135 operators to reemphasize the importance of strict compliance with the sterile cockpit rule. (A-06-7)
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> Require all 14 *Code of Federal Regulations* Part 121 and 135 operators to incorporate the constant-angle-of-descent technique into their nonprecision approach procedures and to emphasize the preference for that technique where practicable. (A-06-8)
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> Revise applicable 14 *Code of Federal Regulations* Part 121 and 135 regulations to prohibit pilots from descending below the minimum descent altitude during nonprecision instrument approaches unless conditions allow for clear visual identification of all obstacles and terrain along the approach path or vertical guidance to the runway is available and being used. (A-06-9)
>
> Modify and simplify the flight crew hours-of-service regulations to take into consideration factors such as length of duty day, starting time, workload, and other factors shown by recent research, scientific evidence, and current industry experience to affect crew alertness. (A-06-10) (This recommendation supersedes Safety Recommendation A-99-45.)
>
> Require all 14 *Code of Federal Regulations* Part 121 and 135 operators to incorporate fatigue-related information similar to that being developed by the Department of Transportation Operator Fatigue Management Program into their initial and recurrent pilot training programs; such training should address the detrimental effects of fatigue and include strategies for avoiding fatigue and countering its effects. (A-06-11)

In addition, the National Transportation Safety Board reiterates the following recommendations to the Federal Aviation Administration:

> Require that all aircraft operated under Title 14 CFR Part 121, 125, or 135 and currently required to be equipped with a cockpit voice recorder (CVR) and flight data recorder (FDR) be retrofitted…with a crash-protected cockpit image recording system. The cockpit image recorder system should have a 2-hour recording duration, as a minimum, and be capable of recording, in color, a view of the entire cockpit including each control position and each action (such as display selections or system activations) taken by people in the cockpit. The recording of these video images should be at a frame rate and resolution sufficient for capturing such actions. The cockpit image recorder should be mounted in the aft portion of the aircraft for maximum survivability and should be equipped with an independent auxiliary power supply that automatically engages and provides 10 minutes of operation whenever aircraft power to the cockpit image recorder and associated cockpit camera system ceases, either by normal shutdown or by a

> loss of power to the bus. The circuit breaker for the cockpit image recorder system, as well as the circuit breakers for the CVR and the digital FDR, should not be accessible to the flight crew during flight. (A-00-30)
>
> Require all turbine-powered, nonexperimental, nonrestricted-category aircraft that are manufactured prior to January 1, 2007, that are not equipped with a flight data recorder, and that are operating under 14 *Code of Federal Regulations* Parts 135 and 121 or that are being used full-time or part-time for commercial or corporate purposes under Part 91 to be retrofitted with a crash-protected image recording system by January 1, 2010. (A-03-65)

In addition, the following previously issued recommendation is classified "Closed—Superseded:"

> Establish, within 2 years, scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest. (A-99-45)

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS, HERSMAN, and HIGGINS concurred with these recommendations.

[Original Signed]

By: Mark V. Rosenker
Acting Chairman

Safety Recommendation Reiteration List

SR Number	Reiteration Number	Report Number	Report Date	Accident Description	Accident City	Accident State	Accident Date
A-06-010	1	AAR-08-02	6/10/2008	Runway Overrun During Landing Pinnacle Airlines Flight 4712 Bombardier/Canadair Regional Jet CL600-2B19, N8905F	Traverse City	MI	4/12/2007