National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: January 23, 2007

In reply to refer to: A-07-1 through -11

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

On October 14, 2004, about 2215:06 central daylight time, Pinnacle Airlines flight 3701 (doing business as Northwest Airlink), a Bombardier CL-600-2B19,[1] N8396A, crashed into a residential area about 2.5 miles south of Jefferson City Memorial Airport (JEF), Jefferson City, Missouri. The airplane was on a repositioning flight from Little Rock National Airport, Little Rock, Arkansas, to Minneapolis-St. Paul International Airport, Minneapolis, Minnesota. During the flight, both engines flamed out after a pilot-induced aerodynamic stall and were unable to be restarted. The captain and the first officer were killed, and the airplane was destroyed. No one on the ground was injured. The flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 91 on an instrument flight rules flight plan. Visual meteorological conditions prevailed at the time of the accident.

The accident flight crew decided to climb the airplane to an altitude of 41,000 feet. The airplane arrived at 41,000 feet at an airspeed that was below the minimum airspeed required and then slowed to its stall speed. An aerodynamic stall followed, which resulted in a loss of control of the airplane. The flight data recorder (FDR) and the cockpit voice recorder indicated that the engines were operating normally before the upset. The flight crew recovered the airplane from the upset at an altitude of 34,000 feet. However, during the upset, the airflow to the engine inlets was disrupted, and both engines flamed out. The rotation of both engines' cores continued to decrease. Before the airplane descended to an altitude of 28,000 feet, the core rotation speed of both engines had reached 0 rpm. The flight crew attempted to restart the engines several times but was unable to do so. The flight crew then attempted to make an emergency landing at JEF, but the airplane crashed before reaching the airport.

The National Transportation Safety Board determined that the probable causes of this accident were (1) the pilots' unprofessional behavior, deviation from standard operating procedures, and poor airmanship, which resulted in an in-flight emergency from which they were unable to recover, in part because of the pilots' inadequate training; (2) the pilots' failure to

[1] The accident airplane was a Canadair regional jet (CRJ) -200 model, which is one of three models in the CL-600-2B19 series. (The other two models are the CRJ-100 and CRJ-440.) Bombardier acquired Canadair in December 1986.

prepare for an emergency landing in a timely manner, including communicating with air traffic controllers immediately after the emergency about the loss of both engines and the availability of landing sites; and (3) the pilots' improper management of the double engine failure checklist, which allowed the engine cores to stop rotating and resulted in the core lock engine condition. Contributing to this accident were (1) the core lock engine condition, which prevented at least one engine from being restarted, and (2) the airplane flight manuals that did not communicate to pilots the importance of maintaining a minimum airspeed to keep the engine cores rotating.[2]

Flight Crew Training

High Altitude Training

High altitude[3] climbs were not practiced during Pinnacle Airlines' simulator training. The circumstances of the accident flight and the actions taken by Pinnacle Airlines and Bombardier after the accident to increase awareness of Canadair regional jet (CRJ) performance capabilities and limitations during high altitude operations[4] indicate that high altitude training at regional jet operators may not be adequate.

Regional airlines are typically the journeyman career step for professional pilots seeking employment with major air carriers. Until the advent of the regional jet, pilots at regional airlines typically operated turboprop airplanes. Because turboprop airplanes do not have the performance capabilities of, or operate at the same speeds and flight levels as, a regional jet, it is possible that some regional airline pilots were not adequately trained to make the transition to a turbojet airplane. Also, regional airline pilots with military flight training may have received more thorough high altitude training compared with civilian pilots; however, the number of regional airline pilots who had previously received military flight training has decreased since the 1980s.[5]

Because of advances in airplane equipment (turboprop to turbojet airplanes) at regional airlines and changes in the pilot force transitioning to regional jet operations, the current training methods and syllabuses for high altitude training at these operators may be in need of an industrywide revision. The Safety Board concludes that revised high altitude training syllabuses for pilots who operate regional jet airplanes would help ensure that these pilots possess a

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[2] For more information, see *Crash of Pinnacle Airlines Flight 3701, Bombardier CL-600-2B19, N8396, Jefferson City, Missouri, October 14, 2004*, Aircraft Accident Report NTSB/AAR-07/01 (Washington, DC: NTSB, 2007).

[3] High altitude is 25,000 feet and above.

[4] Bombardier issued an all operator message to remind pilots of the importance of adhering to prescribed performance charts when operating at high altitudes and to inform them that climbing at a too-slow airspeed might result in performance deterioration once altitude is achieved. Pinnacle Airlines revised its Flight Crew Operating Manual to limit the minimum climb speed above 10,000 feet to 250 knots/0.70 Mach, whichever was lower. The company also placed altitude and climb capability charts into its Quick Reference Handbook for easy access during flight and issued guidance to pilots regarding the need to limit operation of the airplane to 37,000 feet or below. In addition, the company's ground training now includes additional emphasis on these issues in the performance and high altitude training segments and a demonstration of these areas during simulator training.

[5] During the 1980s, about 80 percent of the pilots hired by all commercial airlines had military flight training, but, according to the Federal Aviation Administration in 2001, this number has decreased to about 40 percent.

thorough understanding of the airplanes' performance capabilities, limitations, and high altitude aerodynamics. Therefore, the Safety Board believes that the Federal Aviation Administration (FAA) should work with members of the aviation industry to enhance the training syllabuses for pilots conducting high altitude operations in regional jet airplanes. The syllabuses should include methods to ensure that these pilots possess a thorough understanding of the airplanes' performance capabilities, limitations, and high altitude aerodynamics. The Safety Board further believes that the FAA should determine whether the changes to be made to the high altitude training syllabuses for regional jet airplanes, as requested in Safety Recommendation A-07-1, would also enhance the high altitude training syllabuses for all other transport-category jet airplanes and, if so, require that these changes be incorporated into the syllabuses for those airplanes.

Stall Recognition and Recovery Training

The stall recognition and recovery training at Pinnacle Airlines, as well as elsewhere in the aviation industry, focuses on approach to stalls and recovery with minimum loss of altitude. Because most stalls occur when the airplane is maneuvering at lower altitudes,[6] recoveries are practiced during training by applying power to restore the energy state of the airplane and maintaining pitch. Although this strategy can be effective at lower altitudes where the airplane has excess thrust, it is not effective when the airplane is at high altitudes, as demonstrated by the circumstances of this accident, or when a full stall has developed with resulting disruption of airflow to the engines, as demonstrated by the circumstances of the 1996 ABX Air accident in Narrows, Virginia.[7]

After the accident, Pinnacle Airlines added to its simulator training a high altitude buffet demonstration that emphasizes the need to get the airplane's nose down to increase airspeed when engine thrust is marginal. Also, Bombardier's all operator message that was issued after the accident stated, in part, the following: "in the event that a stick shaker[8]/approach to stall occurs, the crew should expect that a deliberate loss of altitude will likely be required to restore the aircraft to a normal energy state and to prevent an aerodynamic stall and possible departure from controlled flight."

The Safety Board concludes that, because most training for stalls occurs with the airplane at low altitudes, the training methods may introduce a bias in stall recovery techniques by

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[6] At the time of the accident, Pinnacle Airlines conducted its stall recognition and recovery simulator training at an altitude of 10,000 feet.

[7] During that accident investigation, the Safety Board found that the flying pilot applied inappropriate control column back pressure during the stall recovery attempt and that his performance of the stall recovery procedure, which was established in the company's operations manual, was inadequate. In its final report on the accident, the Safety Board stated that the probable causes included "the inappropriate control inputs applied by the flying pilot during a stall recovery attempt" and "the failure of the nonflying pilot-in-command to recognize, address, and correct these inappropriate control inputs." For more information, see National Transportation Safety Board, *Uncontrolled Flight Into Terrain, ABX Air (Airborne Express), Douglas DC-8-63, N827AX, Narrows, Virginia, December 22, 1996*, Aircraft Accident Report NTSB/AAR-97/05 (Washington, DC: NTSB, 1997).

[8] The stick shaker produces vibrations in the control columns to warn pilots of an impending stall. After stick shaker activation, if the angle of attack continues to increase, the stick pusher moves the control columns forward (nose down) automatically to prevent an aerodynamic stall, which can occur afterward.

encouraging pilots to minimize altitude loss and not fully recognizing other available recovery techniques. Therefore, the Safety Board believes that the FAA should require that air carriers provide their pilots with opportunities to practice high altitude stall recovery techniques in the simulator during which time the pilots demonstrate their ability to identify and execute the appropriate recovery technique.

Another factor that might have contributed to the improper control inputs during the stall event[9] was the flight crew's unfamiliarity with the stick pusher system on this airplane. The crew would have been exposed to stick pusher activation during systems training and the first-flight-of-the-day operational checks of the system, and, in the case of the accident flight, the crew experienced the system's activation during one of the pitch-up maneuvers made during the climb.[10] However, it is unclear the extent to which either pilot had experience with the stick pusher system during simulator training because the industry standard for stall training was to initiate recovery at the onset of the stick shaker, which, during a proper recovery, would preclude stick pusher activation.

During the Safety Board's public hearing on this accident, a Bombardier training pilot testified that he had seen pilots during training respond incorrectly to stick pusher activation because "they are scared, and they don't know what to do [or] how to react." He added, "proper training is a huge factor, to make sure that if you end up on a pusher, this is what you need to do."

The Safety Board acknowledges that additional training may be required to improve pilot response to stick pusher activation. However, current training protocols and FAA standards train pilots to initiate stall recovery before stick pusher activation. As a result, there may be unintended consequences and negative transfer associated with the inclusion of stick pusher training into simulator training protocols without careful and deliberate study. Because of these concerns, the Safety Board concludes that additional training might improve pilot response to stick pusher activation, but such training, if not provided correctly, could have an adverse impact on existing stall recognition and recovery protocols. Therefore, the Safety Board believes that the FAA should convene a multidisciplinary panel of operational, training, and human factors specialists to study and submit a report on methods to improve flight crew familiarity with and response to stick pusher systems and, if warranted, establish training requirements for stick pusher-equipped airplanes based on the findings of this panel.

[9] The stick shaker activated five times, and the stick pusher activated four times, pushing the control column forward automatically. The flight crew responded to the stick pusher each time by pulling back on the control column. These control column inputs caused the airplane's pitch angle to increase to a maximum airplane-nose-up value of 29º, and then the airplane entered an aerodynamic stall. Afterward, the airplane's pitch angle decreased to a maximum airplane-nose-down value of 32º. While the pitch angle was decreasing, a left rolling motion began, which eventually reached 82º left wing down.

[10] About 5 seconds after takeoff, when the airplane was at an altitude of about 450 feet mean sea level (about 190 feet above ground level), the first of three separate pitch-up maneuvers during the ascent occurred when the flight crew moved the control column to 8º airplane nose up, causing the airplane's pitch angle to increase to 22º and resulting in a vertical load of 1.8 Gs. (G is a unit of measurement that is equivalent to the acceleration caused by the earth's gravity [32.174 feet/second^2].) The rate of climb during this pitch-up maneuver was 3,000 feet per minute Immediately afterward, the flight data recorder recorded stick shaker and stick pusher activations, a full airplane-nose-down control column deflection, a decrease in pitch angle, and a drop in vertical load to 0.6 G.

Double Engine Failure Training

At the time of the accident, double engine failure scenarios were not practiced during Pinnacle Airlines' simulator training. After the accident, the company incorporated a double engine failure scenario into its simulator training syllabus. During this scenario, a double engine failure occurs at an altitude of 35,000 feet, and flight crews are required to use the windmill restart procedure to relight the engines. The Pinnacle Airlines CRJ program manager stated that this scenario would help familiarize the crew with the emergency power-only procedures and the effects of an air-driven generator deployment.

Also, in May 2005, Pinnacle Airlines made changes to its double engine failure checklist based on the changes made by Bombardier earlier that month. These changes highlighted the airspeeds required for the procedure. For example, the revised checklist stated that a minimum (rather than target) airspeed of 240 knots must be maintained until the pilot was ready to restart the engines. The revised checklist also indicated that 300 knots or greater was required to achieve a sufficient N_2 (engine core speed) for the windmill restart and that this airspeed must be maintained until at least one engine was restarted or restart attempts were abandoned. Further, the revised checklist recognized the need to sacrifice altitude for airspeed by indicating that the 5,000-foot altitude loss that could be expected when accelerating from 240 to 300 knots might require pitch attitudes of 10º airplane nose down and that pilots should start accelerating to achieve 300 knots at an altitude of 21,000 feet.

In addition, Pinnacle Airlines' revised double engine failure checklist placed the following information in a box labeled "CAUTION": "failure to maintain positive N_2 may preclude a successful relight. If required, increase airspeed to maintain N_2 indication." According to the FAA's guidance on checklist design,[11] a caution is defined as "an instruction concerning a hazard that if ignored could result in damage to an aircraft component or system – which would make continued safe flight improbable." The FAA's guidance defines a warning as "an instruction about a hazard that, if ignored, could result in injury, loss of aircraft control, or loss of life." Because of the circumstances of this accident, the Safety Board questions the appropriateness of placing information about the consequences of not maintaining positive N_2 into a cautionary note when the FAA's definitions suggest that a warning box would be a more appropriate transmission of that information to pilots.

Pinnacle Airlines' revised simulator training provides company pilots with an opportunity to reinforce the knowledge they obtained in ground school on the double engine failure checklist items, and the company's revised checklist generally highlights the information that is necessary for pilots to successfully perform the double engine failure procedure. The Safety Board concludes that some of the changes made by Pinnacle Airlines to its double engine failure training and checklist guidance would benefit pilots at other air carriers that operate the CRJ because such training would provide pilots with the opportunity to practice double engine failure restart procedures in the simulator and the guidance would ensure that pilots were aware of the

[11] Federal Aviation Administration, *Human Performance Considerations in the Use and Design of Aircraft Checklists* (Washington, DC: FAA, 1995).

minimum airspeeds needed during the procedures. Therefore, the Safety Board believes that the FAA should verify that all CRJ operators incorporate guidance in their double engine failure checklist that clearly states the airspeeds required during the procedure and require the operators to provide pilots with simulator training on executing this checklist.

Flight Crew Professionalism

Part 91 Operations

The accident flight, a Part 91 repositioning flight with no passengers or other crewmembers on board, presented the pilots with an opportunity to aggressively maneuver the airplane and operate it at the CRJ maximum operating altitude. These behaviors were examples of optimizing violations, which occur when someone disregards defined procedures intentionally to make a job more interesting or engaging, to push limits, or to impress another. Although Pinnacle Airlines had protections in place for minimizing errors and unprofessional behavior during line operations,[12] the company did not have effective protections in place for preventing optimizing violations during Part 91 operations. For example, even though the accident pilots were generally described favorably by instructors, check airmen, and other pilots,[13] the FAA's operations supervisor of the Memphis, Tennessee, Flight Standards District Office stated, during the Safety Board's June 2005 public hearing on the accident, that, before this accident, "we had no idea that anybody would ever switch seats during a flight and not operate in accordance with the standard operating procedures for the company."[14]

After the accident, Pinnacle Airlines began to review FDR data for all nonrevenue flights.[15] The company's decision to examine FDR data from these flights directly addressed the vulnerability of these operations to optimizing violations. During the Safety Board's public hearing for this accident, the company's chief pilot stated that the review of FDR data would serve as oversight for Part 91 flights because "the pilots will know that they're being monitored."

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[12] These protections included pilot selection criteria, pilot training, company policies and procedures, and pilot oversight (line checks and pilot reports).

[13] There were a few exceptions to these favorable comments. For example, the simulator instructor who conducted part of the captain's upgrade training stated that, in addition to the captain's problems performing checklists in accordance with company procedures, his biggest weaknesses were his critical decision-making and judgment. Also, the first officer was described as average by the captain who flew with him during his last trip before the accident flight.

[14] The Safety Board notes that, during the investigation of the January 1983 takeoff accident at Detroit Metropolitan Wayne County Airport, Detroit, Michigan, involving United Airlines flight 2885 (a cargo flight), the Board determined that the second officer had occupied the seat of the first officer and conducted the takeoff. The Board also determined that, on the basis of postaccident interviews with United Airlines pilots, seat swapping was not a prevalent practice at the airline. In its final report on this accident, the Board stated its concern about the flight crew's "disregard of federal and company rules and regulations." The Board determined that the probable cause of the accident included the flight crew's failure to follow procedural checklist requirements. Contributing to the cause of the accident was the captain's decision to allow the second officer, who was not qualified to act as a pilot, to occupy the seat of the first officer and to conduct the takeoff. For more information, see National Transportation Safety Board, *United Airlines Flight 2885, Detroit, Michigan, January 11, 1983, N8053U, McDonnell Douglas DC-8-54F*, Aircraft Accident Report NTSB/AAR-83/07 (Washington, DC: NTSB, 1983).

[15] In October 2006, Pinnacle Airlines stated that it was sampling random Part 91 flights and that a review of these data showed no abnormalities associated with these flights.

Also, the company's vice president of safety and regulatory compliance testified, "we want to make sure the aircraft is being operated in non-revenue operations exactly the way it's being operated in [Part] 121 operations."

During the investigation of this accident, a management pilot from another company with a CRJ fleet stated that "repositioning flights seemed to bring out the worst in their company's pilots." This pilot also stated that a review of FDR data from his company's repositioning flights showed that high bank angles and steep descents occurred often and that pilots were taking the opportunity to perform excessive maneuvers that they could not perform with passengers on board.

The Safety Board investigated an April 1993 accident in which an airplane operated by two GP Express Airlines pilots (with no passengers or other crewmembers aboard) crashed during a Part 91 training flight while the pilots were attempting to execute a prohibited aerobatic maneuver at night. The Board determined that the probable causes of that accident included the pilots' deliberate disregard for company and Federal procedures and the company's failure to instill in their pilots professionalism that is consistent with the highest levels of safety.[16]

The circumstances of the Pinnacle Airlines and the GP Express Airlines accidents and the statements of a management pilot from another company with a CRJ fleet demonstrate the opportunity for pilots to behave unprofessionally during Part 91 operations that are conducted without passengers or other crewmembers. Even when protections are in place to mitigate risks during regional airline operations, unprofessional behavior by pilots during Part 91 flights still occurs for multiple reasons, including the perception of a low risk of detection.

The airplanes used by regional airlines are lighter, smaller, and more agile than those used by larger air carrier operators, which may increase the potential for unprofessional behavior during Part 91 flights. For regional operators that have the ability to download FDR data, routine monitoring of Part 91 flights can be an effective method to ensure that the flights are conducted according to standard operating procedures. For those operators that do not have the ability to review FDR data from Part 91 flights, alternative methods to mitigate risk include specific guidance to pilots on the expectations of performance for these flights and additional oversight for flight crews conducting the flights.

The Safety Board concludes that more scrutiny of regional air carrier pilots during nonrevenue flights would minimize the opportunity for unprofessional behavior to occur. Therefore, the Safety Board believes that the FAA should require regional air carriers operating under 14 CFR Part 121 to provide specific guidance on expectations for professional conduct to pilots who operate nonrevenue flights. The Safety Board further believes that, for those regional air carriers operating under 14 CFR Part 121 that have the capability to review FDR data, the FAA should require that the air carriers review FDR data from nonrevenue flights to verify that the flights are being conducted according to standard operating procedures.

[16] National Transportation Safety Board, *Controlled Flight Into Terrain, GP Express Airlines, Inc., N115GP, Beechcraft C-99, Shelton, Nebraska, April 28, 1993*, Aircraft Accident Report NTSB/AAR-94/01 SUM (Washington, DC: NTSB, 1994).

Industrywide Issues

In addition to the Pinnacle Airlines accident, the Safety Board has investigated recent accidents involving the lack of cockpit discipline and adherence to standard operating procedures. These accidents include the following:

- Corporate Airlines flight 5966, Kirksville, Missouri, October 19, 2004. The flight crew did not follow established procedures for a nonprecision approach at night in instrument meteorological conditions, did not adhere to the established division of duties between the flying and nonflying pilot, and did not adhere to the sterile cockpit rule.[17]
- Air Tahoma flight 185, Covington, Kentucky, August 13, 2004. The captain did not follow crossfeed procedures for balancing the fuel in the airplane's fuel tanks, which led to fuel starvation in the left tank.[18]
- Executive Airlines flight 5401, San Juan, Puerto Rico, May 9, 2004. The captain failed to execute proper techniques to recover from bounced landings and failed to execute a go-around.[19]
- Aviation Charter King Air A100, Eveleth, Minnesota, October 25, 2002. The flight crew was not adhering to company approach procedures and was not effectively applying crew resource management (CRM) techniques during the approach segment of the flight.[20]
- Federal Express Flight 1478, Tallahassee, Florida, July 26, 2002. The flight crew failed to adhere to company procedures for flying and monitoring a stabilized approach.[21]

Pilots and operators have responsibility for a flight crew's cockpit discipline and adherence to standard operating procedures, as discussed in the next sections.

[17] In its final report on this accident, the Safety Board concluded 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 discipline, 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." For more information, 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).

[18] National Transportation Safety Board, *Crash During Approach to Landing, Air Tahoma, Inc., Flight 185, Convair 580, N586P, Covington, Kentucky, August 13, 2004,* Aircraft Accident Report NTSB/AAR-06/03 (Washington, DC: NTSB, 2006).

[19] National Transportation Safety Board, *Crash During Landing, Executive Airlines (doing business as American Eagle) Flight 5401, Avions de Transport Regional 72-212, N438AT, San Juan, Puerto Rico, May 9, 2004,* Aircraft Accident Report NTSB/AAR-05/02 (Washington, DC: NTSB, 2005).

[20] National Transportation Safety Board, *Loss of Control and Impact With Terrain, Aviation Charter, Inc., Raytheon (Beechcraft) King Air A100, N41BE, Eveleth, Minnesota, October 25, 2002,* Aircraft Accident Report NTSB/AAR-03/03 (Washington, DC: NTSB, 2003).

[21] National Transportation Safety Board, *Collision With Trees on Final Approach, Federal Express Flight 1478, Boeing 727-232, N497FE, Tallahassee, Florida, July 26, 2002,* Aircraft Accident Report NTSB/AAR-04/02 (Washington DC: NTSB, 2004).

Pilot Responsibilities

The Safety Board has long been concerned about issues of crew professionalism and adherence to standard operating procedures. For example, on October 8, 1974, as a result of several fatal air carrier accidents involving pilot performance,[22] the Board issued Safety Recommendation A-74-85, which asked the FAA to initiate a movement among pilot associations to form new, and regenerate old, professional standards committees to promote crew discipline and professionalism. (The Safety Board classified Safety Recommendation A-74-85 "Closed—Acceptable Action" on March 10, 1977.)

Most pilot unions have professional standards committees, which are peer consultation programs that are designed to, among other things, provide counseling and support to pilots who have demonstrated behavior that might adversely affect their ability to perform their duties in a professional manner. Trained volunteer pilots who are members of these committees provide peer support, counseling, intervention, and mediation to pilots at the airlines that the unions represent. Airline pilots can seek these services on their own, or they can be referred to the professional standards committee by, for example, company managers who have become aware of a potential problem.

Pilot union professional standards committees appear to be an effective structure to help promote and ensure professionalism among pilots. However, not all air carrier pilots have access to these professional standards committees. For those pilots without such access, communications about the importance of professionalism can be delivered through company and FAA personnel.

It is clear, on the basis of the overall safety and reliability of the National Airspace System, that most pilots conduct operations with a high degree of professionalism. Nevertheless, a problem still exists in the aviation industry with some pilots acting unprofessionally and not adhering to standard operating procedures, as demonstrated by the recent accidents investigated by the Safety Board that are previously cited.

After a series of six accidents between October and November 2004,[23] the FAA issued Notice N8000.296, "Pilot Judgment and Decisionmaking." The notice, among other things, highlighted the pilot's role in ensuring safety of flight. Specifically, the notice recommended that individual pilots examine their own decision-making habits in terms of professionalism, thoroughness of preparation, and adherence to standard operating procedures. The FAA stated that it has since incorporated soft skills into Part 121 CRM training requirements and that a

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[22] These accidents were the September 27, 1973, Texas International Airlines flight 655 accident in Mena, Arkansas; the September 11, 1974, Eastern Air Lines flight 212 accident in Charlotte, North Carolina; and five others (Martha's Vineyard, Massachusetts, 1971; Fort Lauderdale, Florida, 1972; New Haven, Connecticut, 1972; Toledo, Ohio, 1973; and Boston, Massachusetts, 1973).

[23] These accidents were Pinnacle Airlines flight 3701, Corporate Airlines flight 5966, and accidents involving a Learjet 35A at San Diego, California; a King Air 200 at Stuart, Virginia; a Challenger 600 at Montrose, Colorado; and a Gulfstream III at Houston, Texas.

rewrite of FAA Order 8400.10, *Air Transportation Operations Inspector's Handbook*, would emphasize soft skills.[24]

Pilots are ultimately responsible for safely conducting a flight and for recognizing the importance of adhering to standard operating procedures and acting professionally. Although broad, systemwide interventions can be applied to help address the problem of pilots not adhering to standard operating procedures or acting unprofessionally, the most direct intervention is to address any deficiencies in these areas at the level of the pilot. Because pilot unions have expertise in safety, training, and operations and have a vested interest in advancing professional standards among the pilots they represent, these groups are well positioned to take a leadership role to establish new educational approaches for reinforcing professionalism in the aviation industry. The Safety Board concludes that providing additional education to pilots on the importance of professionalism could help reduce the instances of pilots not maintaining cockpit discipline or not adhering to standard operating procedures. Therefore, the Safety Board believes that the FAA should work with pilot associations to develop a specific program of education for air carrier pilots that addresses professional standards and their role in ensuring safety of flight. The program should include associated guidance information and references to recent accidents involving pilots acting unprofessionally or not following standard operating procedures.

Operator Responsibilities

Operators also are responsible for monitoring their pilots' adherence to standard operating procedures and reinforcing expectations for professional standards of behavior. Operators have traditionally identified nonstandard performance in line operations during check rides or line observations conducted by company check airmen or management personnel. A problem with this method of oversight is that pilots might perform differently during a check ride or a line observation because of the presence of a company check airman in the cockpit.

To help evaluate pilot performance during line operations, air carriers can implement voluntary safety programs, such as the Flight Operational Quality Assurance (FOQA) program.[25] This program is especially well suited for detecting exceedances that may occur during flight, such as high bank angles and unstabilized approaches, and assessing whether crews are conducting flights according to standard operating procedures. However, the FOQA program requires equipment and support structures that some air carriers may not be able to maintain, such as the capability to download FDR data. According to the FAA, as of November 2006, 18 air carriers operating under Part 121 had implemented approved FOQA programs.

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[24] The FAA defined soft skills as those that go beyond the technical knowledge and psychomotor skills that are necessary to fly an airplane. Such skills include adherence to standard operating procedures, decision-making, judgment, CRM, and professionalism.

[25] A traditional FOQA program is an FAA-approved, voluntary program for the routine collection and analysis of FDR data gathered during aircraft operations. At the time of the accident, Pinnacle Airlines did not have a traditional FOQA program in place; instead, the program was designed to manage the check airmen through flight monitoring. At the time of the June 2005 public hearing for this accident, Pinnacle Airlines was working toward the deployment of a traditional FOQA program. In October 2006, the company reported that it was operating an FAA-approved FOQA program and was collecting an average of 2,000 hours of data each month.

Another FAA-approved, voluntary safety program is the Aviation Safety Action Program (ASAP). This program encourages pilots to report safety concerns in a nonpunitive environment, which allows the air carrier and the FAA to act on this information before an accident or an incident occurs.[26] Although an ASAP does not have the technical requirements associated with a FOQA program, an ASAP depends on the willingness of pilots to voluntarily submit reports about other pilots or themselves. The FAA stated that, as of November 2006, it had accepted 51 ASAP memorandums of understanding for pilots.[27] (Of these ASAP memorandums of understanding, 49 were for Part 121 operators, and 2 were for Part 135 operators.)

In addition to the FOQA program and the ASAP, operators can assess pilot performance during line operations with the Line Operations Safety Audit (LOSA), which was developed in 1994 through FAA-sponsored research, known as the Human Factors Research Project, at the University of Texas at Austin.[28] The LOSA program is an observational process that assesses CRM practices, the management of threats to safety, and human error during flight operations. Trained personnel associated with the project conduct line observations under conditions of confidentiality so that the operator is provided only with details of the observations and no information about the pilots who were involved. As a result, in contrast to a company line check, LOSA observations do not result in adverse actions against pilots who did not perform well during their observation.

LOSA methodology is well suited to assess the soft skills used by air carrier pilots, and the observations can be used to identify intentional deviations from standard operating procedures or prescribed rules and allow the operator to identify reasons for these deviations. Notably, LOSA can address and document these issues to a greater extent than the FOQA program or the ASAP because, as previously stated, FOQA programs require the capability to download FDR data and an ASAP requires the willingness of pilots to submit reports about fellow pilots or themselves.[29] Also, LOSA observations have identified rule violations and deviations from procedures, which suggests that the pilots being observed do not view the LOSA observers as a threat (as they might view company check airmen) and would be likely to perform in the same manner as they would without an observer present.

After the accident, and as a result of a high initial failure rate for upgrading captains before the accident, Pinnacle Airlines made several changes to its training program to address professionalism.[30] These changes included increasing the minimum number of hours (from 10 to

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[26] At the time of the June 2005 public hearing, Pinnacle Airlines had committed to establishing an ASAP for its pilots. In October 2006, the company reported that it was operating an FAA-approved ASAP for its pilots.

[27] The ASAP also includes dispatchers, flight attendants, and mechanics. Pinnacle Airlines reported that it planned to expand its ASAP to the company’s maintenance department during 2007.

[28] For more information, see <http://homepage.psy.utexas.edu/homepage/group/HelmreichLAB>.

[29] Despite these issues, the Safety Board recognizes that the FOQA program and the ASAP provide air carriers with valuable information about the quality of their operations.

[30] Pinnacle Airlines had a target of 10 percent for its captain upgrade first-time failure rate. In July 2004, the rate was 22 percent. Afterward, changes to the company’s training program were implemented, and, in October 2006, Pinnacle Airlines reported that about 92 percent of the pilots upgrading to captain passed the training the first time and that the overall captain upgrade training pass rate was 95 percent.

25) that are required for upgrade operational experience,[31] restructuring CRM training to provide additional focus on decision-making and the need to adhere to standard operating procedures, and placing additional emphasis on leadership during upgrade training. However, the effectiveness of these changes in increasing professionalism, leadership, and adherence to standard operating procedures would be difficult to evaluate fully without LOSA observations.[32]

On April 27, 2006, the FAA issued Advisory Circular (AC) 120-90, Line Operations Safety Audits. The AC provides the rationale and procedures for conducting a LOSA observation at an air carrier and explains that the program is distinct from, but complementary to, the FOQA program and the ASAP. By incorporating LOSA observations into their internal oversight programs, Part 121 air carriers would have another method to monitor their pilots' adherence to standard operating procedures and standards of professionalism. The Safety Board concludes that LOSA observations can provide operators with increased knowledge about the behavior demonstrated by pilots during line operations. Therefore, the Safety Board believes that the FAA should require that all 14 CFR Part 121 operators incorporate into their oversight programs periodic LOSA observations and methods to address and correct findings resulting from these observations.

In addition to the need for air carriers to incorporate LOSA observations into their oversight methods, air carriers need to ensure safety through a formalized system safety process. One such process is a safety management system (SMS) program, which incorporates proactive safety methods for air carriers to identify hazards, mitigate risk, and monitor the extent that the carriers are meeting their objectives. Program components include safety policy, safety risk management, safety assurance, and safety promotion. Tools such as the FOQA, ASAP, and LOSA programs are relevant to the safety assurance component of an SMS program because they provide a direct means for air carriers to evaluate the quality of their training and operations. These tools can also be used in the safety risk management component of an SMS program because they can help uncover hazards to system operation.

SMS program initiatives have been developed in the international aviation industry. For example, the European Joint Aviation Authorities recommend, but do not require, air carriers to establish an SMS program. Also, in June 2005, Transport Canada passed regulations requiring that air carriers operating under *Canadian Aviation Regulations* Part 705 (Part 121 equivalent) fully implement an approved SMS program by September 2008. In addition, International Civil Aviation Organization (ICAO) Annex 6, "Operation of Aircraft," states the following: "from January 1, 2009, [Member] States shall require, as part of their safety program, that an operator implements a safety management system acceptable to the State of the Operator that, at a minimum: (a) identifies safety hazards; (b) ensures that remedial action necessary to maintain an acceptable level of safety is implemented; (c) provides for continuous monitoring and regular

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[31] Upgrade operational experience, which occurs after a new captain has completed upgrade training, is when the new captain conducts flight operations in the presence of a check airman.

[32] The LOSA program samples all activities in normal operations, whereas the FOQA program and the ASAP rely on outcomes (flight parameter exceedances and adverse pilot-reported events, respectively) to generate data.

assessment of the safety level achieved; and (d) aims to make continuous improvement to the overall level of safety."[33]

In June 2006, the FAA published AC 120-92, "Introduction to Safety Management Systems for Air Operators." The AC provides guidance for SMS program development for air carriers and others in the aviation industry. The guidance was based on the FAA's review of existing SMS programs worldwide, its own internal SMS programs, and other system safety approaches. An appendix to the AC contains a listing of functional requirements for operators to use as minimum standards when creating an SMS program.

During a December 14, 2006, briefing to the Safety Board, the FAA stated that it intended to comply with the ICAO requirement for Member States to require that operators implement an SMS program by January 1, 2009. A rulemaking project team has been formed, and the rulemaking project team leader stated that the team's first meeting was held in December 2006. In addition to these initial rulemaking activities, the FAA stated that it planned to initiate a series of SMS proof-of-concept trials in late 2007. During these trials, the FAA intends to work with a few operators that have voluntarily implemented SMS to gather the data needed for additional guidance material and to support the agency's rulemaking efforts. The Board is encouraged by the FAA's initial activities to implement an SMS program. However, until the FAA issues a notice of proposed rulemaking, the Board cannot fully evaluate whether the FAA will meet ICAO's minimum requirements for an SMS program.

Historically, the FAA's approach to its oversight of air carriers has emphasized surveillance to ensure regulatory compliance. However, in 1998, the FAA established the Air Transportation Oversight System (ATOS), a systems safety approach to air carrier oversight. The ATOS program was initially deployed at the 10 largest U.S. air carriers. The benefits of the ATOS program's system safety approach to air carrier oversight, compared with the oversight conducted as part of the National Work Program Guidelines,[34] include a more integrated approach to oversight that better identifies risks to system safety and a more effective allocation of oversight resources to problem areas.[35]

The Safety Board has previously expressed concerns about the ATOS program. In its March 12, 2001, letter to the FAA about Safety Recommendation A-98-51,[36] the Board stated its concern that the FAA had not addressed how the ATOS program would ensure that systemic problems were identified and corrected before they resulted in an accident. As a result, the Board classified Safety Recommendation A-98-51 "Open—Unacceptable Response." Also, in its report

[33] In November 2005, ICAO asked Member States to provide the organization with information about the development of SMS programs. During 2006, ICAO published a safety management manual that addressed concepts and processes required to implement an SMS program.

[34] The National Work Program Guidelines are part of a traditional inspection program to ensure that airlines comply with safety regulations. The guidelines have been in effect since 1985.

[35] To apply some benefits of the system safety approach used in the ATOS program to those air carriers that were not covered by ATOS, the FAA deployed the Surveillance and Evaluation Program during 2002 to augment the oversight conducted as part of the National Work Program Guidelines.

[36] This recommendation, which was issued as a result of the Safety Board's investigation of the August 7, 1997, Fine Airlines flight 101 accident, can be found on the Board's Web site at <http://www.ntsb.gov>.

on the Alaska Airlines accident, the Board addressed its concerns about ATOS implementation and the program's ability to detect problem areas.[37]

Other concerns about the FAA's implementation of ATOS have been noted. For example, according to a Government Accountability Office (GAO) report,[38] the FAA's ATOS transition plan, dated March 1, 2004, did not set dates beyond fiscal year 2005 for moving additional air carriers to the ATOS program, and, as of September 2005, 15 air carriers were under the ATOS program. Also, the GAO testified in November 2005 that the National Work Program Guidelines were still being used at those passenger airlines that were not covered under ATOS.[39]

The FAA acknowledged that staffing and budgetary resources were affecting ATOS deployment. During October 2005, the FAA initiated its System Approach for Safety Oversight CFR Part 121 Pilot Project. The objectives of the project are to revise ATOS so that the program can handle all Part 121 air carriers; provide new policies, processes, and tools for measuring safety; and roll out the latest version of the ATOS program to all Part 121 air carriers by December 31, 2007.[40] The FAA stated that preparations were underway to keep this transition on schedule. Even if this project is completed according to its intended timetable, it will still take time to determine whether ATOS is an effective oversight method.

The Safety Board is concerned about the delay in deploying ATOS to additional Part 121 air carriers because they are not receiving the benefits of a system safety approach to oversight.[41] Although the ATOS and SMS programs are complementary and are designed to work in an integrated manner, an air carrier does not need to be under ATOS oversight to effectively develop its own SMS program. The FAA's initial guidance in AC 120-92 should facilitate the process of developing and implementing an SMS program. Existing voluntary system safety tools, such as the FOQA, ASAP, and LOSA programs, have demonstrated their effectiveness in monitoring flight operations and are considered integral safety assurance components to an SMS program, but these programs do not have universal application in the aviation industry. The Safety Board concludes that all air carriers would benefit from SMS programs because they would require the carriers to incorporate formal system safety methods into the carriers' internal oversight programs. Therefore, the Safety Board believes that the FAA should require that all 14 CFR Part 121 operators establish SMS programs.

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[37] National Transportation Safety Board, *Loss of Control and Impact With Pacific Ocean, Alaska Airlines Flight 261, McDonnell Douglas MD-83, N963AS, About 2.7 Miles North of Anacapa Island, California, January 31, 2000*, Aircraft Accident Report NTSB/AAR-02/01 (Washington, DC: NTSB, 2002).

[38] Government Accountability Office, *Aviation Safety: System Safety Approach Needs Further Integration Into FAA's Oversight of Airlines*, GAO-05-726 (Washington, DC: GAO, 2005).

[39] Government Accountability Office, *Aviation Safety: FAA's Safety Oversight System Is Effective but Could Benefit From Better Evaluation of Its Programs' Performance*, GAO-06-266T (Washington, DC: GAO, 2005).

[40] For more information, see System Approach for Safety Oversight Program Update, dated July 7, 2006, at <http://www.faa.gov/safety/programs_initiatives/oversight/saso/update>. Also, in December 2006, the FAA stated that 46 air carriers operating under Part 121 were under the ATOS program.

[41] The Safety Board notes that some air carriers that are not covered under ATOS, including Pinnacle Airlines, have begun using ATOS job aids and inspection guidelines generated for FAA inspectors in their own internal audit programs.

The Safety Board acknowledges that it may take time for the FAA to complete SMS rulemaking and for air carrier SMS programs to become fully operational. In its review of air carriers with FOQA programs at the end of 2006, the Board found that, besides Pinnacle Airlines, only one other regional air carrier had a FOQA program. (The Board is aware of at least one other regional air carrier that is working toward implementing a FOQA program.) Although system safety tools such as FOQA and ASAP have demonstrated safety benefits, the Board is concerned that these programs are not used more widely by regional air carriers. Because of the limited number of regional air carriers in the lists of approved ASAP and FOQA programs, the Safety Board concludes that the establishment of an ASAP and a FOQA program at regional air carriers would provide the carriers with a means to evaluate the quality of their operations. Therefore, the Safety Board believes that the FAA should strongly encourage and assist all regional air carriers operating under 14 CFR Part 121 to implement an approved ASAP and an approved FOQA program.

Quality of Flight Data Recorder Data for Regional Jet Airplanes

On May 16, 2003, the Safety Board issued Safety Recommendation A-03-15 to the FAA because of problems with the quality of FDR data recorded by several regional jet airplanes. Safety Recommendation A-03-15 asked the FAA to do the following:

> Require that all Embraer 145, Embraer 135, Canadair CL-600 RJ, Canadair Challenger CL-600, and Fairchild Dornier 328-300 airplanes[42] be modified with a digital flight data recorder system that meets the sampling rate, range, and accuracy requirements specified in 14 *Code of Federal Regulations* Part 121.344, Appendix M.

On June 9, 2005, the FAA stated that Embraer had released a service bulletin (SB) to correct known FDR anomalies on the Embraer 145 and 135 and that the Brazilian Department of Civil Aviation issued an airworthiness directive (AD) that required incorporation of the Embraer SB within 18 months. The FAA also stated that it planned to release a corresponding AD. In addition, the FAA stated that it was working with Transport Canada to get expeditious action from Bombardier regarding the problem of low update rates on the normal acceleration and pitch attitude parameters for Canadair CL-600-2B19 (CRJ-100, -200, and -440) and CL-600-2B16 (Challenger 604) airplanes. On September 28, 2005, the Safety Board stated that, pending the FAA's issuance of ADs that mandated correction to the Embraer 145 and 135 and CRJ-100, -200, and -440 and Challenger 604 FDR systems, Safety Recommendation A-03-15 was classified "Open—Acceptable Response."

Since the time of the Pinnacle Airlines accident, the Safety Board has downloaded FDR data from seven events involving CL-600-2B19 airplanes—the most recent of which occurred on August 27, 2006.[43] All of these downloads showed that the FDRs recorded the vertical

[42] On September 28, 2005, the Safety Board stated that no problems existed with the FDR parameters on the Fairchild Dornier 328-300 airplane.

[43] This FDR was installed aboard the Comair Airlines flight 5191 accident airplane, which crashed in Lexington, Kentucky, after the pilots attempted to take off from the wrong runway. For information about this accident, see DCA06MA064 at the Safety Board's Web site <http://www.ntsb.gov>.

acceleration and pitch parameters from sources that did not meet the recording intervals required by 14 CFR 121.344, Appendix M, as was the case with the FDR installed on the Pinnacle Airlines accident airplane.

In November 2006, Bombardier told the Safety Board that production of Challenger 604 airplanes had ceased and that the Challenger 605 model had replaced the Challenger 604 model. Bombardier also stated that the sampling rate problem had been corrected in the FDRs installed on Challenger 605 airplanes. However, the Board notes that Challenger 604 airplanes that are currently in service will still have FDRs with sampling rate problems.

Bombardier further stated that, for FDRs installed on CRJ-100, -200, and -440 airplanes, the sampling rate problem would be corrected during the next applicable digital control unit update, which was scheduled for the second or third quarter of 2007, and that airplanes would be retrofitted within the 18 months that followed. Thus, if this schedule were maintained, the sampling rate problem would not be fixed on all CL-600-2B19 airplanes until late 2008 or early 2009. Also, as of December 1, 2006, the FAA had not issued an AD to correct FDR anomalies on Embraer 145 and 135 airplanes. The Safety Board concludes that the parameter quality problems with the FDR systems installed on Canadair CL-600-2B19, Challenger 604, and Embraer 145 and 135 airplanes need to be corrected so that future investigations involving these airplane models are not hindered by inaccurate or incomplete data. Therefore, the Safety Board reiterates Safety Recommendation A-03-15. Further, the Board classifies Safety Recommendation A-03-15 “Open—Unacceptable Response.”

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

> Work with members of the aviation industry to enhance the training syllabuses for pilots conducting high altitude operations in regional jet airplanes. The syllabuses should include methods to ensure that these pilots possess a thorough understanding of the airplanes’ performance capabilities, limitations, and high altitude aerodynamics. (A-07-1)
>
> Determine whether the changes to be made to the high altitude training syllabuses for regional jet airplanes, as requested in Safety Recommendation A-07-1, would also enhance the high altitude training syllabuses for all other transport-category jet airplanes and, if so, require that these changes be incorporated into the syllabuses for those airplanes. (A-07-2)
>
> Require that air carriers provide their pilots with opportunities to practice high altitude stall recovery techniques in the simulator during which time the pilots demonstrate their ability to identify and execute the appropriate recovery technique. (A-07-3)

Convene a multidisciplinary panel of operational, training, and human factors specialists to study and submit a report on methods to improve flight crew familiarity with and response to stick pusher systems and, if warranted, establish training requirements for stick pusher-equipped airplanes based on the findings of this panel. (A-07-4)

Verify that all Canadair regional jet operators incorporate guidance in their double engine failure checklist that clearly states the airspeeds required during the procedure and require the operators to provide pilots with simulator training on executing this checklist. (A-07-5)

Require regional air carriers operating under 14 *Code of Federal Regulations* Part 121 to provide specific guidance on expectations for professional conduct to pilots who operate nonrevenue flights. (A-07-6)

For those regional air carriers operating under 14 *Code of Federal Regulations* Part 121 that have the capability to review flight data recorder (FDR) data, require that the air carriers review FDR data from nonrevenue flights to verify that the flights are being conducted according to standard operating procedures. (A-07-7)

Work with pilot associations to develop a specific program of education for air carrier pilots that addresses professional standards and their role in ensuring safety of flight. The program should include associated guidance information and references to recent accidents involving pilots acting unprofessionally or not following standard operating procedures. (A-07-8)

Require that all 14 *Code of Federal Regulations* Part 121 operators incorporate into their oversight programs periodic Line Operations Safety Audit observations and methods to address and correct findings resulting from these observations. (A-07-9)

Require that all 14 *Code of Federal Regulations* Part 121 operators establish Safety Management System programs. (A-07-10)

Strongly encourage and assist all regional air carriers operating under 14 *Code of Federal Regulations* Part 121 to implement an approved Aviation Safety Action Program and an approved Flight Operational Quality Assurance program. (A-07-11)

In addition, the following previously issued recommendation (previously classified "Open—Acceptable Response") is reiterated and classified "Open—Unacceptable Response":

> Require that all Embraer 145, Embraer 135, Canadair CL-600 RJ, Canadair Challenger CL-600, and Fairchild Dornier 328-300 airplanes be modified with a digital flight data recorder system that meets the sampling rate, range, and accuracy requirements specified in 14 *Code of Federal Regulations* Part 121.344, Appendix M. (A-03-15)

Chairman ROSENKER, Vice Chairman SUMWALT, and Members HERSMAN, HIGGINS, and CHEALANDER concurred with these recommendations.

[*Original Signed*]

By: Mark V. Rosenker
Chairman