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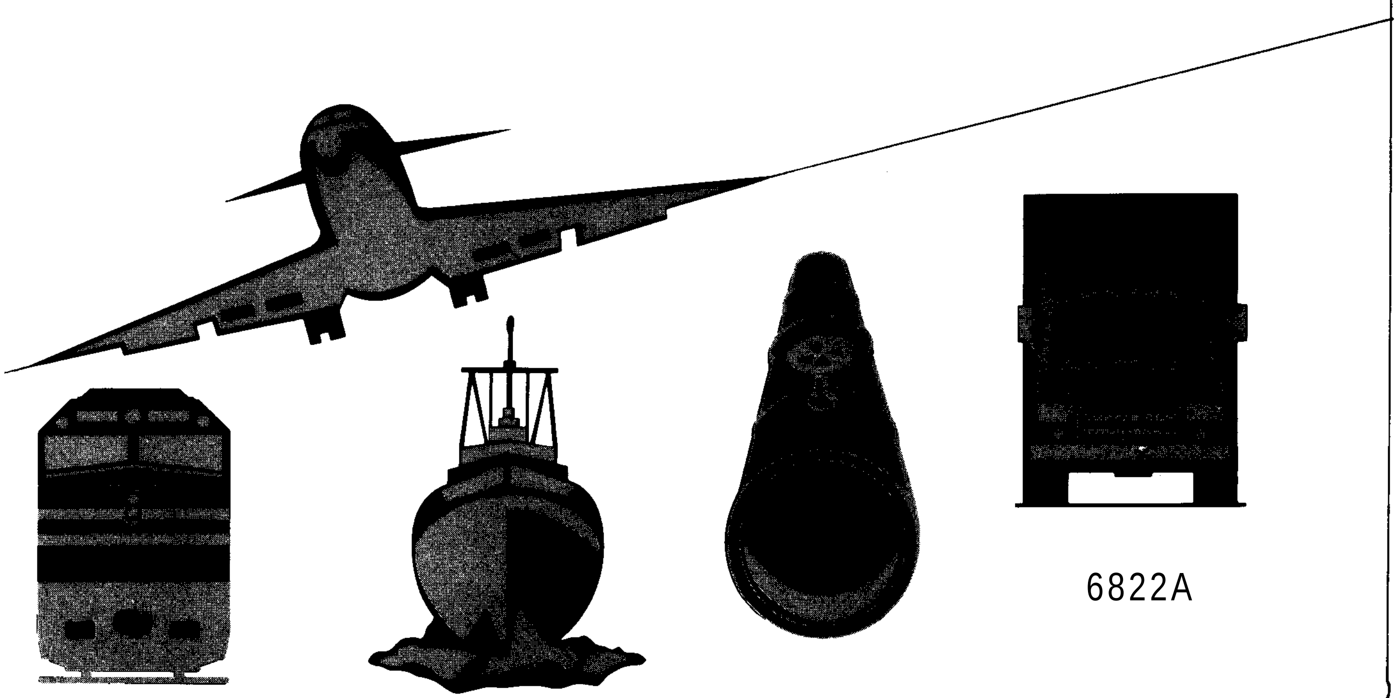
NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT REPORT

UNCONTROLLED FLIGHT INTO TERRAIN
ABX AIR (AIRBORNE EXPRESS)
DOUGLAS DC-8-63, N827AX
NARROWS, VIRGINIA
DECEMBER 22, 1996



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DECEMBER 22, 1996

Adopted: July 15,1997
Notation 6822A

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CONTENTS

EXECUTIVE SUMMARY

On December 22, 1996, at 1810 eastern standard time, a Douglas DC-8-63, N827AX, operated by ABX Air Inc. (Airborne Express) impacted mountainous terrain in the vicinity of Narrows, Virginia, while on a post-modification functional evaluation flight. The three flightcrew members and three maintenance/avionics technicians on board were fatally injured. The airplane was destroyed by the impact and a postcrash fire. The functional evaluation flight, which originated from Piedmont Triad International Airport, Greensboro, North Carolina, was conducted on an instrument flight rules flight plan and operated under Title 14 Code of Federal Regulations Part 91.

The National Transportation Safety Board determines that the probable causes of this accident were the inappropriate control inputs applied by the flying pilot during a stall recovery attempt, the failure of the nonflying pilot-in-command to recognize, address, and correct these inappropriate control inputs, and the failure of ABX to establish a formal functional evaluation flight program that included adequate program guidelines, requirements and pilot training for performance of these flights. Contributing to the causes of the accident were the inoperative stick shaker stall warning system and the ABX DC-8 flight training simulator's inadequate fidelity in reproducing the airplane's stall characteristics.

Safety issues discussed in this report include airplane stall recovery procedures for functional evaluation flights, stall warning systems, fidelity of the ABX DC-8 flight training simulator, guidelines and limitations for conducting functional evaluation flights, and Federal Aviation Administration surveillance of air carrier functional evaluation flight programs. Recommendations concerning these issues were made to the Federal Aviation Administration.

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1. FACTUAL INFORMATION

1.1 History of Flight

On December 22, 1996, at 1810 eastern standard time,[1] a Douglas DC-8-63, N827AX, operated by ABX Air Inc. (Airborne Express) impacted mountainous terrain in the vicinity of Narrows, Virginia, while on a post-modification functional evaluation flight (FEF).[2] The three flightcrew members and three maintenance/avionics technicians on board were fatally injured.[3] The airplane was destroyed by the impact and a postcrash fire. The FEF, which originated from Piedmont Triad International Airport, Greensboro, North Carolina (GSO), was conducted on an instrument flight rules (IFR) flight plan and operated under Title 14 Code of Federal Regulations (CFR) Part 91.

The airplane had received major modifications at Triad International Maintenance Corporation (TIMCO), a Federal Aviation Administration (FAA)-certified repair station located at GSO, including a "D" check (major airplane overhaul),[4] modification and standardization of cockpit, avionics and airplane systems, installation of a cargo handling system and engine modifications to achieve Stage III noise level requirements.[5] A partial FEF was conducted on December 21, 1996, but was terminated when the airplane developed a hydraulic system anomaly (low fluid quantity indication). On the day of the accident, the crew had originally scheduled a 1320 departure. However, the airplane departed GSO at 1740, following maintenance delays.

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[1]Unless otherwise indicated, all times are eastern standard time, based on a 24-hour clock.
[2]Title 14 Code of Federal Regulations (CFR) Part 91.407, "Operation after maintenance, preventive maintenance, rebuilding, or alteration," requires that an operation check (an FEF) be conducted following maintenance "that may have appreciably changed [the airplane's] flight characteristics or substantially affected its operation in flight.…" The post-modification FEF was the most extensive conducted by ABX. Air carriers routinely conduct less-exhaustive FEFs, or acceptance flights, following less extensive repairs.
[3]The three technicians were aboard to assist the flightcrew with the resolution of aircraft systems questions and problems during the FEF. A review of ABX FEF records indicated that this was a routine practice.
[4]According to Subpart L of Part 121, airlines are required to create and maintain an FAA-approved continuing maintenance program. As part of such a program, maintenance tasks are divided into categories based on the level of maintenance checks required, beginning with "A" checks through "E" checks. The major focus of the work scope provided by ABX to TIMCO was to perform an all-phases "C" check, which was equivalent to a "D" check.
[5]Stage III regulations establish maximum allowable noise levels for airplanes based on airplane weight and number of engines and affect all airplanes being operated in the United States. The first phase implementation deadline went into effect on January 1, 1997. Full (Stage III) implementation for all airplanes will be required by January 1, 2000.

Following takeoff and climb out, air traffic control (ATC) assigned the flight a block altitude of 13,000 feet to 15,000 feet mean sea level (msl). The flight received a "round-robin" IFR clearance to GSO with a planned route of flight from GSO northwest to Pulaski (PSK) very high frequency omnidirectional radio range (VOR), to Beckley, West Virginia, and points in Kentucky and Virginia before returning to GSO after a planned flight duration of about 2 hours. Scattered clouds at 8,000 feet and a broken ceiling at 25,000 feet were reported at GSO when the airplane departed.

FAA National Track Analysis Program (NTAP)[6] data indicate that the airplane climbed through 9,000 feet at 1743:08. The airplane was level at 14,100 feet at 1745:50 and remained within 300 feet of that altitude until 1808:18, just before it entered a steep descent, according to NTAP data. Upper air temperature and dew point data indicated that cloud tops were just below 14,000 feet along the airplane's route of flight. Flightcrew comments recorded on the cockpit voice recorder (CVR)[7] indicated that the airplane flew briefly in and out of the clouds and that ice buildup was observed after they reached their assigned block altitude. At 1748:34, the pilot flying (PF) in the left seat stated, "We're gettin' a little bit of ice here," followed by "…probably get out of this" three seconds later at 1748:37. At 1752:19, the PF said, "We just flew out of it, let's stay here for a second."

At 1805:37, after performing several landing gear, hydraulic and engine system checks, the flight engineer told the other flightcrew members that the "next thing is our stall series,"[8] according to the CVR.

The evaluation flight profile form that the flightcrew was using for the FEF required that the flightcrew identify and record the speed at which the stick shaker activated and the speed of the stall indication. At 1805:56, the pilot not flying (PNF) said, "one eighty four [1.5 V_s, the reference for the crew to stop trimming the airplane][9], and…we should get uh, stall at uh, one twenty two. I'm going to set that in my, interior bug." At 1806:10, the flight engineer stated, "shaker at one twenty eight [5 percent faster than calculated stall speed] if you just … call out your numbers, I'll record them." At 1806:14, the PF asked "that's shaker and the stall?" and the flight engineer replied, "yeah, shaker and stall both." The crew then commenced to slow the airplane about 1 knot per second toward the stall.

At 1806:18, the PNF told the PF that "the only trick to this is just don't unspool [to allow the engine rpm to decay to near flight idle]." At 1807:21, the PF, referring to the engine power settings, asked, "are you saying you don't want to pull all the way back to it [the stall] and

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[6]The NTAP system provides analog flight tracking information based on digital ATC radar computer data.

[7]A transcript of the CVR is included in appendix B.

[8]According to ABX, the purpose of this part of the FEF was to verify the airplane's flight characteristics following the removal, installation and rigging of flight control surfaces (flaps and ailerons) and to check the operation of the stall warning and stick shaker systems. Federal regulations in place at the time the airplane was manufactured stated that an airplane "shall be considered stalled when, at an angle of attack [the angle of the wing to the relative wind] measurably greater than that of maximum lift, the inherent flight characteristics give clear indication to the pilot that the airplane is stalled." The regulations added, "A nose-down pitch or a roll which cannot be readily arrested are typical indications that the airplane is stalled."

[9]V_s is the stalling speed or minimum steady flight speed at which the airplane is controllable.

then spool back or just wait?" The PNF responded, "Aw you can do that, just when you get close to the stall you don't want to be unspooled." The PF replied, "Unspool and then I'll respool."

At 1807:51 the PF said, "Yeah, I'm going to spool now." The PNF replied, "All right," and, at 1807:55, the CVR recorded sounds similar to the engines increasing in rpm.

At 1808:06, the PF announced "some buffet" (at 151 knots), and the PNF noted "yeah, that's pretty early." At 1808:09, the sound of rattling was heard on the CVR and, at 1808:11, the flight engineer said "that's a stall right there… ain't no [stick] shaker" (at 145 knots). The PF then called "set max power" at 1808:13. Seven seconds later popping sounds began and continued for nine seconds until 1808:29. At 1808:30, the PNF said, "You can take a little altitude down. Take it down." At 1808:42, the PNF added, "Start bringing the nose back up."

At 1809:10, ATC asked the crew if they were in an emergency descent and the PNF replied "yes sir." ATC then asked the crew "can you hold seven thousand?" There was no reply, and there were no further radio communications from the accident airplane with ATC. At 1809:29, the PNF told the PF to apply left rudder and the PF replied "left rudder's buried" 1 second later. Two seconds later, the PNF added "OK, easy, don't. OK now, easy bring it back." Three seconds later the aural warning ("terrain, terrain, whoop, whoop, pull up") of the ground-proximity warning system (GPWS) activated. The sound of impact was recorded on the CVR at 1809:38, 3 seconds after the GPWS aural warning.

Three ground witnesses told accident investigators that the airplane was generating loud "skipping or missing" noises. Two of the witnesses reported seeing the airplane descending out of the clouds at a steep angle, with bright lights shining downward. The witnesses described weather conditions at the time of the accident as cloudy with precipitation that was freezing at the surface.

The airplane struck mountainous terrain in a 52-degree, left wing low and 26-degree, nose-down attitude about 3,400 feet msl, 1 minute and 32 seconds after the PF called "some buffet." According to satellite-based global positioning system (GPS) data, the accident site was located at 37 degrees, 19.30' north latitude and 80 degrees 53.06' west longitude. The accident occurred during the hours of darkness.

1.2 Injuries to Persons

Injuries	Flightcrew	Cabin Crew	Passengers	Other[10]	Total
Fatal	3	0	0	3	6
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	3	0	0	3	6

1.3 Damage to Airplane

The airplane was destroyed by impact forces and a postcrash fire. The estimated value of the airplane, including modifications performed by TIMCO, was about $21 million.

1.4 Other Damage

There was extensive impact and fire damage to trees and foliage at and near the accident site, and fuel soaking of the ground in some areas.

1.5 Personnel Information

The flightcrew consisted of two DC-8-qualified captains and a flight engineer. Three maintenance technicians (two ABX and one TIMCO employee) were on board to assist in the post-modification FEF.

1.5.1 The Pilot Not Flying (PNF)

The PNF, age 48, was hired by ABX in March 1988 as a DC-8 first officer. He later was promoted to DC-8 simulator instructor and, in 1990, to DC-9 flight standards pilot. After a brief period as a DC-9 line captain, he was promoted in 1994 to DC-8 flight standards manager and to B-767 flight manager in July 1996, in anticipation of the planned delivery of Boeing B-767 airplanes to the ABX fleet. He was also an FAA-designated DC-8 examiner. He held an airline transport pilot certificate (ATP) with an airplane multiengine land rating and type ratings in the Cessna CE-500, DC-8 and DC-9, along with commercial privileges, single-engine land. He was issued a flight engineer certificate, turbojet powered rating, in 1979. His most recent FAA first-class medical certificate was issued on September 13, 1996, with no limitations. His most recent proficiency check was July 12, 1996, and his most recent line check was on September 5, 1996. He had logged a total of 8,087 hours of flying, of which 869 hours were in the DC-8. He had logged 463 hours as a captain in the DC-8. The PNF had flown 1.1 hours (logged for the December 21 flight) within the last 24 hours before the accident. In the 30, 60 and 90 days before the accident, he had flown 13.1, 25.8 and 34.4 hours, respectively. He had accumulated a total of 114.5 hours, all in the DC-8, in the 365 days before the accident.

[10]See section 1.5.

Before being hired by ABX, the PNF was employed as a B-727/DC-8 flight engineer at Braniff International Airways from 1978 through 1980; as a DC-9/MD-80 captain at Transtar/Muse Air from 1983 to 1987; and as a DC-9 pilot at several small carriers. He began his aviation career in the U.S. Air Force, serving as a C-141 pilot and instructor pilot, and he later continued flying in the U.S. Navy Reserve.

The PNF's personnel records at ABX contained complimentary performance evaluations. A June 1991 company evaluation noted that the PNF was a "little laid back…may want to do his own thing, doesn't want to upset or rock boat." There was no ABX company record of disciplinary actions, and a search of the National Driver Register found no history of driver's license revocation or suspension.

1.5.2 The Pilot Flying (PF)

The PF, age 37, held an ATP certificate with an airplane multi-engine land rating and type ratings in the DC-8, British Aerospace Jetstream 31, and Saab 340. He also held a commercial certificate, airplane single-engine land, a flight engineer certificate, turbojet powered rating, and an airframe and powerplant (A&P) certificate. His FAA first-class medical certificate was issued on October 18, 1996, with the limitation, "Holder shall wear corrective lenses." Company records indicated that he wore corrective lenses for distant vision.

He was hired by ABX in April 1991 as a DC-8 first officer and completed his initial operating experience (IOE) that June. In August 1993, he was promoted to DC-8 equipment chief pilot and was assigned as a DC-8 standards pilot in May 1996. He was promoted to manager of DC-8 flight standards in June 1996, replacing the accident PNF in that position. He had also been selected to become an FAA-designated DC-8 examiner. His most recent proficiency check was on July 11, 1996, and his most recent line check was on December 5, 1995. He had logged a total of 8,426 hours of flying, with 1,509 hours of pilot time in the DC-8, of which 434 were as a DC-8 pilot-in-command (PIC). He had flown a total of 1.1 hours (logged as PF on the December 21 flight) in the 24 hours before the accident. In the 30, 60 and 90 days before the accident, he had flown 7.5 hours, 10 hours and 31.5 hours, respectively. He had flown a total of 89.1 hours, all in the DC-8, in the 365 days before the accident.

The PF had a general aviation and regional airline background before being hired by Trans World Airlines in 1988, where he served as a B-727 flight engineer and DC-9/MD-80 first officer. ABX performance evaluations were complimentary. There was no record of company disciplinary actions, and a search of the National Driver Register revealed no history of driver's license revocation or suspension.

1.5.3 Flight Engineer

The flight engineer, age 52, was hired by ABX as a DC-8 flight engineer in February 1988 and was promoted to DC-8 flight standards flight engineer in May 1991. He held a flight engineer certificate, turbojet-powered rating, issued in March 1987 and an A&P certificate issued in May 1987. He was also an FAA-designated DC-8 examiner. His FAA second-class medical certificate was issued in June 1996 with the limitation, "Holder shall wear corrective lenses." His most recent proficiency check was on February 6, 1996, and his most recent line check was on July 17, 1996. He had logged a total of 7,928 hours of flying (all as a flight engineer), of which 2,576 hours were in the DC-8. He had flown 1.1 hours in the 24 hours before the accident. In the 30, 60 and 90 days before the accident, he had logged 9.4 hours, 27.6 hours and 34.2 hours, respectively. He had flown a total of 110 hours in the 365 days before the accident.

From 1970 through 1974, the flight engineer was a crew chief on B-52 airplanes in the U. S. Air Force. He was an instructor flight engineer on C-141 airplanes from 1974 through 1978. From 1978 through 1981, he was one of the first U.S. Air Force flight engineers qualified on the E-4B, a modified B-747 airborne command post, and he instructed all flight engineers in differences training for qualification on the airplane. He was with the E-4B unit when he retired from the Air Force in 1986, after 26 years of service. At the time he was hired by ABX, the flight engineer had logged 2,665 hours in B-747s and 2,687 hours in C-141s.

The flight engineer's company performance evaluations were unremarkable and complimentary, and there was no record of disciplinary actions. A search of the National Driver Register revealed no history of driver's license revocation or suspension.

1.5.4 FEF Experience of the Accident Pilots

According to ABX records, the PNF on the accident flight had a total of 1.1 hours of flying experience as PIC (logged the previous day) of a DC-8 post-modification FEF. The PNF had 12.6 hours of experience as a nonflying second-in-command (SIC) on post-modification DC-8 FEFs and had conducted other, less-extensive FEFs in the DC-8 that did not involve a stall series. Between 1991 and 1993, the accident PNF had flown 15 FEFs as PIC in DC-9s, according to ABX records. Some of these DC-9 flights may have involved approach to stall. The accident flight PF had no experience as a pilot on a DC-8 post-modification FEF before the abbreviated December 21 FEF.

1.5.5 Flightcrew's 72-hour History Before the Accident

The flight engineer had arrived on December 9 to begin preparations for the FEF that was originally scheduled for December 16. The accident flight PNF and PF arrived in GSO on December 15. After the December 16 flight was delayed, the accident PNF returned home to Dayton, Ohio, on December 17 and returned to GSO on the morning of December 19. The flightcrew had dinner together on December 19, according to family members. TIMCO employees said the flightcrew performed an initial preflight inspection on N827AX on the evening of December 20. The flightcrew completed another preflight inspection of the airplane between 1000 and 1200 on December 21. The FEF was scheduled for 1200, and the flightcrew performed engine run-up tests, then departed GSO at 1315. After returning from the abbreviated FEF on December 21 at 1419, the flightcrew went to dinner in GSO. On December 22, the flightcrew arrived at the airport between 1000 and 1200 and performed preflight duties. The airplane was released to the flightcrew between 1630 and 1700. Relatives told Safety Board investigators that the flightcrew members typically went to bed at 2300 and awoke at 0700 when at home, and that the timing of daily phone calls indicated that they kept that schedule in GSO.

1.6 Airplane Information

N827AX, a Douglas DC-8-63, serial number 45901, was manufactured on July 15, 1967. It was previously registered to Emery Airplane Leasing as N929R and to KLM Royal Dutch Airlines as PH-DEB. It was equipped with four Pratt & Whitney JT3D-7 turbofan engines. As of December 12, 1996, the airframe had accumulated a total of 62,800.9 hours and a total of 24,234 landings, or cycles, since new (CSN).

1.6.1 N827AX Overhaul and Modification Maintenance Work

The airplane was purchased by ABX from Aerolease International Inc., Miami, Florida on June 17, 1996, and subsequently underwent modifications at TIMCO. At the time of the accident, it had not yet been placed in service by ABX. Before the accident flight, TIMCO had performed a comprehensive maintenance work package, including completion of an all-phases “C” check overhaul. (The “C” check for ABX is divided into four phases, and each phase includes applicable task requirements of a “D” check. All “D” check tasks are incorporated into these four phases.)

In addition to the extensive overhaul work, ABX ordered many equipment modifications to standardize N827AX with 14 other company DC-8s. Many avionics, cockpit and airplane systems were modified, including the flight directors, color radar, air data instruments, communications and navigation receivers and transmitters. A new cargo handling installation and a dual electronic flight instrument system (EFIS) were also part of ABX’s order. Nineteen supplemental type certificates (STCs) were incorporated on N827AX during modification at TIMCO.

All four JT3D-7 Pratt & Whitney turbofan engines were removed. Two engines were overhauled (by another contractor), and two engines were replaced with JT3D-7 engines supplied by ABX. Stage III (hush kit) noise attenuation modifications were performed by TIMCO on the four engines and pylons.

Because the TIMCO inspection discovered a greater amount of corrosion than anticipated, especially on the underside of the airplane, a scheduled 4-month project extended into a 6-month work period, according to TIMCO records examined by the Safety Board. TIMCO’s original estimated delivery date of the airplane was October 31, 1996. Delays caused by the replacement of seven fuselage “belly skins” because of corrosion moved that date forward to November 24, 1996. The late arrival of parts and kits further delayed the estimated delivery date to December 15, 1996.

1.6.2 Stall Warning System Checks

The airplane's electrically powered (115-volt AC, 28-volt DC) stall warning system consists of a lift transducer, lift computer, control column shaker, test relay, test switch and circuit breaker protection.[11] The lift transducer, located in the right wing leading edge, is the sensing mechanism for the stall warning system. During a final engine run-up check on December 20, 1996, the stall warning system and pitot heaters were checked, according to ABX records. Operation of the lift computer and stick shaker is tested on the ground during preflight by placing the STALL WARN TEST switch in the TEST position. This electrically simulates a stall warning in the computer, which activates the shaker. Cockpit checks do not test operation of the lift transducer. A maintenance check of the airplane's stall warning system, including the operation of the lift transducer, was performed on December 5, 1996, and records indicate that the system was operational. According to Douglas records, the airplane's stall warning system functioned in accordance with its design specifications when it was delivered in 1967.

The lift transducer heater is on whenever the "Anti-icing and Meter Sel" switch is in any position except "off." The heater can be checked for proper operation by noting the indication on the anti-icing (Pitot Amp) ammeter. A "Heater Inop" light monitors several anti-icing heaters through a current sensing detector. If the stall warning heater current drops below 1.2 amperes, or increases above 2.9 amperes, a relay contact within the detector will close, illuminating the monitor light.

1.6.3 Maintenance Discrepancies Listed on the First FEF

The first FEF conducted on December 21, 1996, was terminated because of an indication of hydraulic quantity loss. No major leak was found, but a minor leak was located at the nose landing gear actuator. TIMCO maintenance personnel said they suspected that trapped air in the lines may have caused the low hydraulic quantity indication. The nose gear actuator was replaced, and the system was reserviced after the arrival of replacement parts at 1630 on December 22. The airplane had no open maintenance items before the second FEF.

1.6.4 Weight and Balance

The airplane's weight and balance report was computed as part of the ABX-scheduled maintenance on December 11, 1996. The operating empty weight (OEW) was computed to be 145,273 pounds. According to ABX records, 81,000 pounds of fuel was on board the airplane when it departed on the first FEF. The flight returned with 65,600 pounds of fuel, after a flight duration of 1 hour and 4 minutes. No fuel was added for the accident flight. Parts of some pages relating to the airplane's weight and balance logs were discovered at the accident site, but records for the accident flight were not recovered. Fuel weight for the accident flight's takeoff was estimated by Safety Board investigators by adjusting fuel remaining on board

[11] Airflow around the leading edge of the right wing is sensed by the lift sensor, and when the airspeed is about 1.05 V_s (stalling speed) both control columns will shake, indicating that the airplane is approaching a stall. The lift sensor is protected against ice by heaters. The system is operative in flight and on the ground when electric power is applied. Unless the anti-ice heater and selector switch is in the OFF position, the pitot tubes, the static ports, the outside air temperature probe and the lift transducer are heated.

for an estimated 1,000-pound taxi-out fuel burn. The airplane's weight at the time of the accident was adjusted for an estimated 9,000-pound additional fuel burn. The airplane's gross weight at takeoff was estimated at 209,783 pounds and 200,783 pounds at the time of the accident.[12] The approved zero fuel weight (145,783 pounds) center of gravity (CG) range at takeoff and accident weight was 14.0 percent to 32.0 percent mean aerodynamic chord (MAC). The estimated CG location at takeoff was 21.67 percent MAC. The estimated CG location at the time of the accident was 21.23 percent MAC.

1.6.5 Airplane Performance Calculations

Records of the flightcrew's performance calculations were not recovered, and they were not required to be filed as part of the Part 91 dispatch process they followed. Based on weight and balance estimates performed by the Safety Board, assuming an estimated 5-degree Celsius surface temperature at GSO and a flap 18 [takeoff] setting, the following performance parameters were calculated for the takeoff weight: takeoff EPR [engine pressure ratio] =1.81; V_1=108 knots; V_R=120 knots; and V_2=138 knots.[13]

1.6.6 Operating Authority to Conduct the Accident Flight

The FAA principal operations inspector (POI) assigned to ABX and ABX managers stated that N827AX was authorized to operate the accident flight under Part 91 because (1) an FAA-designated airworthiness representative employed by ABX had issued an airworthiness certificate, (2) the airplane was being maintained in accordance with ABX's Part 121 maintenance program, and (3) airworthiness conformity inspection records were partially complete pending conclusion of the FEF. Further, in a February 11, 1997, memorandum, ABX's FAA-designated airworthiness representative stated that N827AX met the requirements of ABX's Part 121 maintenance program, upon completion of the planned inspections and modifications, and he described the FEF as the final step in the maintenance process. The memorandum said that "a letter is then sent to the [FAA] certificate holding office stating that the airplane meets the requirements for 121 operation." The letter "was not signed pending completion of the functional test flight." Also, the accident airplane was added to ABX's Operating Certificate airplane list on November 4, 1996 (6 weeks before the accident FEF).

According to an April 2, 1997, memorandum from the FAA's Flight Standards Service to the Safety Board, ABX would have required a letter of deviation authority under Part 125.3 to operate under Part 91, unless the airplane had been added to the ABX aircraft list. There was disagreement among FAA personnel about whether it was appropriate to include the airplane on the ABX aircraft list prior to the completion of all airworthiness certification activities, including the FEF.

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[12]ABX procedures approved by the local FAA Flight Standards District Office (FSDO) included computations for ballast fuel. However, ballast fuel procedures do not appear in the FAA-approved airplane flight manual.

[13]V_1 is takeoff decision speed; V_R is rotation speed; and V_2 is takeoff safety speed.

1.7 Meteorological Information

Weather observations at GSO and Winston-Salem, North Carolina, (INT) indicated visual conditions in the area at the time of the accident flight's departure. GSO reported scattered clouds at 8,000 feet and a broken ceiling at 25,000 feet. INT reported a broken ceiling estimated at 15,000 feet. The 1900 Surface Analysis chart of the National Weather Service (NWS) showed a ridge of high pressure located along the east coast of the United States and a northeast-southwest stationary front extending from Michigan to Missouri. The chart indicated overcast clouds, scattered precipitation and light-to-moderate southerly surface winds over western Virginia, West Virginia, and Ohio.

Digital radar data from the Roanoke, Virginia, Weather Surveillance Radar Doppler (WSR-88D) facility at the time of the accident showed a scattered area of light rain along N827AX's flightpath and a cross-section of the radar data indicated radar tops in the area were about 13,100 feet to 13,500 feet. Radiative temperature data obtained by infrared satellite imagery indicated that corresponding cloud tops were in the vicinity of 14,000 feet. A radiosonde[14] launched at Blacksburg, Virginia, at 1815 showed the top of the moist layer to be between 13,600 feet and 13,700 feet. The upper freezing level in the accident area was about 7,600 feet.

Two pilots (a corporate pilot and a regional airline pilot), who landed at Bluefield, West Virginia, 16 nautical miles west of the accident site, about the time of the accident, told Safety Board investigators that they were on top of the cloud deck at 13,000 feet and 15,000 feet, respectively, on flights from Hilton Head, South Carolina, and Charlotte, North Carolina. The pilots said that they did not encounter any icing or turbulence during their descents into Bluefield. A surface weather observation at Bluefield shortly before the accident reported light rain, 1,500 feet overcast and visibility 2 miles.

Astrological data for the accident location were calculated using a Safety Board computer program. Sunset was calculated to be 1721 with the end of twilight at 1750. The altitude of the Moon in relation to the airplane was about 27 degrees, with a magnetic bearing to the airplane of 90 degrees. The Moon's illumination was calculated at 96 percent (or nearly full). Infrared satellite imagery also indicated the presence of cirrus clouds above the cloud deck in the area.

1.8 Aids to Navigation

There were no reported problems with navigational aids.

1.9 Communications

No external communications difficulties were reported.

[14]A radiosonde is a balloon-borne instrument for the simultaneous measurement and transmission of meteorological data.

1.10 Airport Information

GSO has two asphalt surface runways. Runway 14-32 is 6,380 feet long and 150 feet wide. Runway 5-23 is 10,000 feet long and 150 feet wide. The field elevation is 926 feet. It is equipped for instrument landing system (ILS), VOR, nondirectional beacon (NDB), airport surveillance radar (ASR), global positioning system (GPS) and area navigation (RNAV) approaches. The accident airplane departed from runway 23.

1.11 Flight Recorders

The airplane was equipped with a CVR and a flight data recorder (FDR).[15] They were recovered from the accident site on the morning following the accident and sent to the Safety Board's laboratory in Washington, D.C., for readout and evaluation.

The FDR was a Fairchild model F1000 that recorded 11 parameters, including time, indicated airspeed, pressure altitude, control column position, engine pressure ratios (EPRs),[16] heading, longitudinal acceleration, vertical acceleration, pitch angle, roll angle and very high frequency (VHF) radio keying. Although the recorder sustained extensive impact damage, the memory module (the recording medium) did not sustain any impact or thermal damage and was in good condition. A complete recovery of the data was accomplished.

The FDR is installed in the aft cabin ceiling. According to ABX's DC-8 operations manual, it derives static pressure information from the alternate static ports; magnetic heading data from the first officer's compass indicator; vertical accelerations from the acceleration sensor; keying information from high frequency (HF) and VHF keying lines, and pitot pressure from the tail pitot tube.

The CVR was a Fairchild model A-100A, SN56935. The recording consisted of four channels of good quality audio information: the cockpit area microphone, and channels for the captain, first officer and flight engineer.[17] The recording began at 1739:08, with the crew reading the final items of the before-takeoff checklist, and continued until 1809:39, when electrical power to the unit ceased on impact with terrain. The interior of the memory module showed moderate impact damage, but the tape sustained no thermal or impact damage. A transcript was prepared of the 30:31-minute recording (see appendix B).

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[15]Excerpts from the FDR are included in appendix C.

[16]Engine pressure ratio is a measure of engine thrust, comparing total turbine discharge pressure to the total pressure of the air entering the compressor.

[17]The Safety Board uses the following criteria to assess the quality of a CVR recording: a "poor recording is one in which a transcription is nearly impossible because a large portion of the recording is unintelligible; a "fair" recording is one in which a transcription is possible, but the recording is difficult to understand; a "good" recording is one in which few words are unintelligible; and an "excellent" recording is very clear and easily transcribed.

1.11.1 FDR Data During Stall Entry and Subsequent Loss of Control

FDR data indicated that the EPRs on all engines were at or near idle power as the airplane slowed to stall speed for the stall test maneuver and EPRs were increased by about 0.05 about 11 seconds before the pre-stall buffet was called. FDR data showed that at the time of impact, engine EPR levels were at or near idle. The full range of motion of the airplane's control column position (CCP) was about 37 degrees (5 degrees forward of neutral and 32 degrees aft of neutral). During the last 2 minutes of flight, the CCP peaked, at times, at 32 degrees aft, according to FDR data. A Safety Board performance study based on FDR data indicated that the pre-stall buffet began at 149 knots and that the stall occurred at 126 knots.

FDR data indicated that immediately after the PF commanded and applied power to recover from the stall (at 1808:13), all four engines accelerated, although the No. 2 engine accelerated to a slightly lower EPR than the other engines during the power increase. The engines had stabilized at maximum EPR by 1808:18. At 1808:20, the airspeed was decaying from 130 knots and the CVR recorded sounds similar to engine compressor surges (popping sounds) that continued for 9 seconds. During the period of engine compressor surges (at 1808:25), the FDR recorded EPR reductions. The power was subsequently increased two additional times before the airplane impacted terrain, but the CVR recorded no further sounds linked to engine compressor surges.

According to FDR data, at 1807:40, just before entering the stall sequence, the airplane's airspeed was diminishing from 180 knots. The airspeed had decreased to 126 knots at 1808:11. Between that time and 1809:20, the indicated airspeed fluctuated rapidly and significantly, consistent with erratic airspeed indications.[18] The airplane impacted terrain at more than 240 knots.

FDR data indicated that for about 14 seconds after the flight engineer noted the stall indication (at 1808:11) and through the time that the first roll excursion began at 1808:25, the airplane remained pitched nose up between 7 degrees and 14 degrees. CCP values ranged from about 5 degrees aft when the stall was noted to 20 degrees aft at 1808:25. During this period, the airplane's airspeed decayed from 145 knots to about 120 knots (the FDR was providing erratic airspeed indications below 126 knots, and was indicating about 90 knots). FDR data indicated that the airplane's pitch attitude then decreased from about 11 degrees above the horizon at 1808:25 to 12 degrees below the horizon at 1808:35. Thirteen seconds after the stall was called, vertical acceleration forces began to increase and remained (with minor fluctuations) consistently more than 1 G (with a maximum of 1.5 G) until impact.

The airplane experienced four roll reversals between 1808:25 and impact at 1809:38. Ten seconds before impact, at 18:09:28, the airplane was 52 degrees nose down, in a 113-degree right roll (the largest roll angle recorded on the FDR). At 18:09:31, the airplane was

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[18]The FDR recorded erratic airspeed indications below 126 knots. The erratic indications were most likely caused by disruption of airflow around the tail-mounted pitot tube from the effects of a high angle of attack and a sideslip as the airplane entered the stall.

67 degrees nose down, the maximum pitch value recorded, and in a 79-degree right roll. At impact, the airplane was in a 26-degree-nose-down, 52-degree-left-wing-down-attitude.

1.12 Wreckage and Impact Information

The airplane wreckage was found on the southeast side of a 4,200-foot mountain at the 3,400-foot level in a 700-foot-long wreckage path. The airplane systems displayed heavy impact damage and fire damage consistent with a postcrash ground fire. Examination of the wreckage area and vicinity revealed no evidence of a preimpact fire or in-flight separation of components. The majority of the airplane's system components were located in the main debris field. An examination of the initial tree breaks indicated that the airplane impacted trees in a left-wing-down attitude. The airplane's flightpath angle from initial tree impact to ground impact was about 35 degrees. The location of the ground scars and separated airframe and engine components indicated that the left wing tip made initial ground contact, and the ground impact crater became deeper and wider as the left wing continued to penetrate the ground. The impact of the No. 1 engine followed. All four engines were found at the accident site, similarly damaged and broken into three or four sections. There was no evidence of uncontained rotating parts failures, case ruptures or in-flight fires on the engines.

The alignment of the impact craters for the outboard left wing, the No. 1 engine and the aft fuselage is consistent with FDR data showing high vertical G forces and a steep left bank angle at the time of ground impact. The initial ground impact scar was 65 feet long and oriented along a magnetic heading of 045 degrees. The distance between the initial tree impacts and the first ground impact was about 75 feet. Several pieces of leading edge structure were found in the area between the tree impacts and the initial ground impact. A section of the vertical stabilizer (the lower 19 feet) was found on its left side in a third ground scar area along with the tail cone. Fuselage pieces were scattered throughout a debris field that expanded in a fan-shaped pattern beyond the empennage area. Parts of the cockpit were found in this debris field, and several small pieces of wing skin were found well beyond the empennage and down the hill to the right of the main wreckage area.

The airplane's flight controls were destroyed in the crash sequence. One of the airplane's two horizontal stabilizer trim jack screws was found separated from the drive system and broken from the stabilizer. The threads were measured from the top of the threads to the top of the rotating bezel. Extension of the jack screw corresponded to a horizontal stabilizer position of 8 degrees airplane nose up (ANU).[19] The rudder system components were found in the debris field. The rudder was found torn from its attachment points and not fully recovered. The rudder power unit was damaged, and the hydraulic and electrical lines were torn from their attachment points. No evidence of preimpact hydraulic leaks was found in the area surrounding the power unit.

[19]According to the DC-8 operations manual, the horizontal stabilizer is adjustable to provide longitudinal trim in a range from 1 degree nose down to 10 degrees nose up from the neutral position. The stabilizer is actuated by two jack screws, which are driven by a primary hydraulic actuator, or by an alternate electric actuator. The motor is actuated by dual trim handles located on the left side of the cockpit control pedestal or by dual switches on the outboard horn of each control wheel.

1.13 Medical and Pathological Information

Both pilots and the flight engineer tested negative for a wide range of drugs, including major drugs of abuse.[20] Ethanol was detected in the tissue samples of the PF and the flight engineer. According to the FAA's Civil Aeromedical Institute toxicological analysis, the ethanol found "may be the result of post-mortem ethanol production."

1.14 Fire

A fuel-fed fire erupted on impact.

1.15 Survival Aspects

The accident was not survivable.

1.16 Tests and Research

Safety Board investigators evaluated flight characteristics of ABX's DC-8 flight training simulator[21] in Wilmington, Ohio, in January 1997. A clean stall (landing gear and wing flaps retracted, wing slots closed) was performed using the approximate accident airplane CG and weight (200,000 pounds) and environmental conditions of the accident flight. The stick shaker activated at 140 knots, followed by the stall buffet. As the airspeed continued to decrease and the simulator was flown farther into the stall, the buffet ceased and the simulator developed a sink rate in a nose-high, wings-level attitude. There was no uncommanded nose-down pitch or lateral rolloff at the stall, regardless of how deeply the simulator was stalled, the rate of entry (deceleration) into the stall, or the vertical G loading leading up to the stall. After slowing well below stall speed, the simulator entered a mode in which airspeed did not continue to decrease.

1.16.1 Douglas DC-8 Certification and Simulation Data

According to Douglas DC-8-63 performance certification data, an aerodynamic stall is typically preceded by aerodynamic buffet about 15 knots above stall speed. Based on the flightcrew's calculation of 122 knots for the stall speed, the expected buffet airspeed would be 137 knots. Douglas data also indicated that the stall warning (stick shaker) activation point had a tolerance band of plus or minus 5 knots.

In addition, simulations and calculations conducted by Douglas based on the accident airplane's weight and CG location indicated that an 8-degree ANU trim resulted in a trim speed of about 175 knots.

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[20]The five drugs of abuse tested in postaccident analysis are marijuana, cocaine, opiates, phencyclidine and amphetamines.

[21]ABX's flight training simulator was certified on April 3, 1990, by the FAA's National Simulator Evaluation Team. It was rated a Level B simulator on October 30, 1990, and its last recertification before the accident was on October 2, 1996. Flight training simulators (levels A through D) are approved by the FAA based on the capabilities of their aerodynamic programming, motion systems and visual systems.

1.17 Organizational and Management Information

ABX Air Inc., was listed in its company fact sheet as the air carrier division and wholly-owned subsidiary of Airborne Freight Corporation of Seattle, Washington. ABX and Airborne Freight did business as Airborne Express. The company provides door-to-door pickup services in all U.S. metropolitan areas and in 200 countries. ABX employs more than 6,900 persons, of which about 750 were flightcrew members operating a fleet of 35 DC-8s, 65 DC-9s and 9 twin-turboprop YS-11s. The air carrier's operational and package sorting hub was located at Airborne Air Park, a privately owned airport near Wilmington, Ohio. All flightcrew members were domiciled in Wilmington. Line maintenance, overhaul and repair shops were also located in Wilmington. DC-8 heavy maintenance checks and modifications were contracted out. TIMCO accomplished most of the DC-8 fleet modernization modifications for ABX. Contracts were monitored by an ABX maintenance representative based at GSO. ABX's air carrier certificate was issued on November 28, 1979, by the FAA's Great Lakes regional office. Operations specifications issued by the FAA to ABX authorized the air carrier to conduct supplemental, cargo-only operations under Part 121 rules.

ABX was organized into five major departments: administration, airplane maintenance, air park services, flight operations and ground operations. The ABX flight operations department was organized into six divisions. The "flight training/standards" and "crew operations/system chief pilot" divisions reported independently to the senior vice president of flight operations, who also served as director of operations. The flight training and standards/check airman functions were managed by a captain who supervised flight managers for each airplane type. The DC-8 flight standards manager, for example, was responsible for all training and checking in the DC-8 fleet, and he supervised a staff of DC-8 flight standards pilots and line check airmen who conducted the training and checks. The DC-8 flight standards manager also supervised the DC-8 flight standards second officer, formerly known as the DC-8 flight standards flight engineer. The pilot flying the accident airplane was serving as the DC-8 flight standards manager, having taken over the job from the accident flight PNF 6 months before. The flight engineer on the accident flight was the DC-8 flight standards manager - second officers, who reported to the PF at the time of the accident. The ABX FEF program was managed by the director of flight technical programs, who reported to the senior vice president of flight operations. (See Figure 1).

1.17.1 Selection and Workload of Management Pilots

A Safety Board review of the employment histories of the two accident pilots and other ABX management pilots indicated that ABX selected many of its management pilots from a pool of flight officer employees recently hired by the company. Some of the new flight officers had previous experience as captains, check airmen or managers at other carriers. Many of these pilots had initially qualified as captains at ABX when they were selected as management pilots. Thus, they had not accumulated extensive experience as pilots-in-command at ABX in the airplane types that they were assigned to manage. ABX senior operational managers told Safety Board investigators that this selection system was designed to obtain the best managers possible, noting that seniority was not necessarily indicative of the best management skills.

ABX AIR, INC.
FLIGHT OPERATIONS ORGANIZATIONAL CHART

SR. VICE PRESIDENT, FLIGHT OPERATIONS

DIRECTOR, FLIGHT CONTROL & SYSTEM CONTINGENCY
- Flight Dispatchers
- Apprentice Dispatchers
- Flight Tracking Specialist
- Flight Control Training and Standards Supervisor
  - Flight Control Instructor/Check Airman
- Contingency Coordinators
- Flight Control Facilitator

SR. DIRECTOR, CREW OPS & SYSTEM CHIEF PILOT
- Equipment Chief Pilot -DC-8
  - DC-8 Pilots
- Equipment Chief Pilot - DC-9
- Assistant Chief Pilots - DC-9
  - DC-9 Pilots
- Equipment Chief Pilot - YS-I I
  - YS- I I Pilots
- Manager, Crew Scheduling
  - Supervisor, Crew Utilization
  - Senior Crew Schedulers
  - Crew Scheduler
  - Flight Ops Analyst
  - Crew Operations Specialist

DIRECTOR FLIGHT TECHNICAL PROGRAMS
- Supervisor, Aircraft Training Instruction
  - Senior Aircraft Training Instructor
  - Aircraft Training Instructors
- Manager, Flight Technical Services
  - Aircraft Performance Specialist
  - Aircraft Performance Engineer
  - Flight Control Coordinator

MANAGER, COMPLIANCE & PUBLICATIONS
- Flight Standards Coordinator
- Records Specialist

DIRECTOR, FLIGHT TRAINING/STANDARDS
- Flight Standards Manager - DC-8
  - Flight Standards Pilots
  - Line Check Airmen
  - Flight Standards Manager - Second Officers
    - Flight Standards Second Officers
    - Line Check Airmen - Second Officers
- Flight Standards Manager- DC-9
  - Standards Pilots
  - Line Check Airmen
- Flight Standards Manager - YS- I I
  - Standards Pilots
  - Line Check Airmen
- Manager. Simulator
  - Simulator Engineer
  - Simulator Technicians

SUPERVISOR FLIGHT ADMINISTRATION
- Senior Secretary
- Secretary
  - Assistant

Figure 1.—ABX Air Inc., Organizational Chart.

The FAA POI assigned to ABX said he had spoken to ABX senior management about his concern that check airmen were not scheduling sufficient time to fly the line and maintain proficiency. He told Safety Board investigators that this remained a problem at ABX. The POI said that the accident flight PF had spent much of his recent time working on administrative duties in the chief pilot's office, while the PNF had focused on training and simulation requirements for the new B-767 acquisition.

1.17.2 Crew Resource Management (CRM) Program

ABX maintained a CRM training program under the direction of the DC-9 equipment chief pilot. As of October 1996, 266 of ABX's 733 pilots had not yet received the 2-day training course. A review of ABX records indicated that neither the manager of flight training/standards nor the director of flight technical programs had received CRM training. The accident flight PNF had been scheduled to take the course, but had not received it before the accident. The PF had been a CRM course instructor. The flight engineer on the accident airplane had not yet taken the course. ABX had not established a program of recurrent CRM training in either the classroom or the simulator. The company had established a recurrent operations-oriented simulation training (ROOST) program that included some elements of CRM in a real-time, line-oriented simulation, according to ABX managers. The flight standards department was in charge of the ROOST program and the chief pilot's department ran the CRM course.

1.17.3 ABX's FEF Program

Flightcrews for FEF missions were primarily selected from the flight standards department, where these pilots were normally responsible for the training and flight checks in their respective airplane fleet. The director of flight technical programs, who managed the FEF program, created a written profile for conducting FEFs that specified the maneuvers to be performed (see appendix E). It provided spaces to record flight parameters and results.[22] The flight technical programs director said he did not use Douglas evaluation flight guidelines because of differences between production test flight objectives for a new airplane and those for an airplane coming out of maintenance. He said that he had compiled an FEF checklist from a variety of sources, including those used by other carriers. The profile stated that the flightcrew should allow 2.5 hours for preflight checks, 45 minutes from first engine start to takeoff, and 5 hours and 40 minutes from the start of the preflight inspection to final engine shutdown.

The director of flight technical programs told Safety Board investigators that there were no specific in-flight weather restrictions for FEFs, although he said he preferred that they be conducted in clear air. There was no prohibition against conducting the tests at night, although the director said he preferred to conduct the flights during the day. He added that he preferred that the stall series not be performed in instrument meteorological conditions (IMC). There was no written record of these preferences. ABX's flight training/standards manager said that the

[22]The ABX "Flight Test Report" included accepted tolerances for some evaluation items, such as duration of flap extension, but it did not provide acceptable tolerances for the stall and stick shaker speeds or further explanation of the maneuver (items 17-19 on the "Flight Test Report").

only takeoff and landing restrictions for conducting the evaluation flights were ceiling and visibility minimums of 800 feet and 2 miles.

The flight technical programs director said he briefed pilots on how to conduct evaluation flights during a review of the evaluation flight profile in an office environment. He said that the purpose of the briefing was to ensure that pilots understood each maneuver and the reason for performing it. The ground briefing also addressed the sequence in which the maneuvers should be performed and flightcrew roles and responsibilities. The flight technical programs director said that the flight engineer controlled the evaluation sequence because he had the profile forms and the right seat pilot coordinated with the flight engineer. The left seat pilot was expected to be the PF commanding configuration changes. The director said that crew coordination was stressed in the ground orientation, and that flightcrews were cautioned about not becoming so absorbed in the evaluation process that they became distracted from their flying duties. Altitude restrictions and potential hazards were also discussed, he said. The director stated that evaluation flights consisted of maneuvers that line pilots would be expected to perform. He said that a previous upset incident in 1991 involving a DC-8 on an FEF was also addressed (see Section 1.18.1 and appendix E). Procedures used to train and designate ABX pilots as qualified to conduct FEFs were not documented, nor were they required to be documented, in company records.

The accident flight PNF was trained to conduct DC-8 evaluation flights by the flight technical programs director about 2 years before the accident. The director said the training primarily consisted of the accident flight PNF, in the right seat, acting as second in command (SIC) and observing the director flying the evaluation profiles. The director said that he had not personally trained the accident flight PF, but he was aware that the PF had received simulator instruction from the accident flight PNF. The director said that he had originally planned to conduct the evaluation flight of N827AX with the accident flight PF, but was unavailable because he was ferrying another airplane back from Japan. He said the accident flight PF was assigned to the flight because he was replacing the PNF as DC-8 flight standards manager and that it was appropriate that he should gain evaluation flight experience.

According to the director of flight technical programs, he was the FEF PIC for most of the DC-8s that had earlier undergone major modification. From 1991 through 1994, the DC-8 flight standards manager was PIC for nine of these DC-8 post-modification FEFs, while the director of flight technical programs performed two of them. Beginning in October 1994, the director of flight technical programs instructed the accident PNF in FEF procedures on several flights during which the accident PNF served as SIC and nonflying pilot. The director of flight technical programs also told Safety Board investigators that he had provided the accident PNF with a simulator training session in which stall recoveries and unusual attitude recoveries were practiced. The manager said that the stall recovery procedure he taught the accident PNF was identical to the procedure taught to line pilots for their proficiency checks.

1.17.4 ABX Management Communication with the Accident Flightcrew

The ABX director of flight training and standards said that he spoke to the accident flight PNF by telephone before the flight. He said that they discussed weather minimums and the higher minimums (1,000 feet and 3 miles) of another carrier for similar evaluation flights. The director of flight training and standards said he told the accident PNF, “don’t do anything you’re uncomfortable with…what’s another day?” The flightcrew’s desire to complete the flights before the Christmas holidays was also discussed, according to the manager, who added that there was no company pressure to complete the flights before the holidays.

1.17.5 ABX Scheduling Requirements and Plans for the Accident Airplane

The accident airplane had originally been scheduled as available for revenue service by late October or November 1996, before that date slipped to December 15, and then December 22. ABX’s freight business experienced an annual peak load from Thanksgiving through Christmas, according to company managers. Airplane maintenance and flightcrew training were generally not scheduled during this period to allow the maximum number of flightcrews and airplanes for revenue operations. ABX also operated a series of charter flights carrying U.S. mail during the day from mid-December to December 25. These postal charter flights required DC-8s equipped with cargo doors. During this contract period, eight airplanes equipped with cargo doors were available for revenue service, not including N827AX, which was also equipped with a cargo door. Seven of these airplanes were required to operate daily to fulfill the postal contract.

In addition, ABX had contracted to operate a freight charter between the United States and Honduras using the eighth airplane equipped with a cargo door. In mid-December, with N827AX facing additional delays, ABX notified the customer that ABX would be unable to fly the charters on a consistent basis and that flights would be canceled if an airplane involved in the postal charters developed a mechanical problem. ABX canceled one Honduras charter flight during this period. ABX’s marketing manager told Safety Board investigators that the company was bidding for a 3-week series of domestic charter flights in January and that the accident airplane was to be scheduled for these charters.

1.17.6 Department of Defense Inspection of ABX

The Department of Defense’s (DOD’s) Air Carrier Survey and Analysis team conducted a survey of ABX’s operation near Wilmington, Ohio, in November 1996.[23] As a result of this survey, ABX was approved for continued participation in the DOD Air Transportation Program. The survey report ranked ABX as “excellent, above average or average” in all categories examined, which ranged from overall management to flight operations, training, hiring, operational controls, charter procedures and maintenance quality assurance. The report concluded that ABX management was “committed to dedicating the resources necessary to ensure a safe, quality operation.” The report added that flightcrews were “well trained, qualified and suitably compensated” and that the flightcrew work force was “stable and turnover is nil.”

[23]DOD surveys of air carriers are part of a routine approval process for participation in the air transportation program.

1.17.7 FAA Oversight of ABX Operations

The FAA conducted a regularly scheduled National Aviation Safety Inspection Program (NASIP) audit at ABX in November 1991.[24] According to the executive summary of the NASIP report, the NASIP team found that ABX was in compliance with Federal Aviation Regulations (FARs), but determined that its day-to-day operations were "outstripping [its] own written policy and procedures guidance." The NASIP team found that many company tasks were "being performed without written guidance." In some cases, the NASIP team found, new guidelines were "issued in the form of bulletins" and were "several generations past the manual policies." In addition, the NASIP team concluded that ABX's instructor/check airman training outlines and records were inadequate, noting that the company "does not have formal lesson plans detailing the subjects, elements and events that will take place in the training." ABX's FAA-approved flight training program also did not contain the flight maneuver "go-around with horizontal stabilizer out of trim," the NASIP report said. The NASIP team's findings were provided to ABX, and the specific issues were cited in the report and later resolved in conjunction with the POI assigned to ABX.

ABX's certificate was managed by the FAA's Flight Standards District Office (FSDO) in Detroit, Michigan. The FAA POI, who was assigned to ABX in 1989, described the company as an "extremely compliant" operator that was attempting to operate in accordance with the Federal regulations and that needed only occasional guidance. At the time of the accident, ABX was the only certificate for which he was responsible. The POI said he did not conduct surveillance of the FEF program because there was no requirement to do so. He said that he assumed that these flights would not be conducted at night or in IMC.

1.17.8 ABX Safety Program

A safety program was in place at ABX at the time of the accident under the direction of a corporate director for operational safety and planning. This manager reported directly to ABX's president. The safety officer, as part of his corporate planning responsibilities, also participated in labor negotiations with the pilot group as a representative of ABX management. He said that his goal was to improve safety-related communication with the pilots through cooperative arrangements with their labor union. At the time of the accident, ABX had not established a formal safety partnership program with its pilots' union or the FAA. Before the accident, pilots submitted safety reports directly to the chief pilots. The safety officer told Safety Board investigators that the reports were now routed to him. He said that he was not familiar with ABX's FEF procedures, but was aware that there had been a loss-of-control incident in 1991 involving an ABX DC-8 on an FEF (see Section 1.18.1). He said that he did not know if ABX's FEF procedures had been changed following that incident.

[24]NASIP inspections are part of the FAA's normal air carrier inspection process.

1.18 Additional Information

1.18.1 Previous DC-8 Loss of Control Incident at ABX

FAA records indicate that a DC-8-63F operated by ABX experienced an in-flight loss of control incident during an FEF on May 16, 1991, while recovering from a stall in the landing configuration (landing gear and flaps down). The stall was being conducted as part of the FEF profile and involved engine compressor surges in the No. 1 and No. 2 engines during application of power in the stall recovery. The maneuver was begun at 13,000 feet msl, and the flightcrew recovered control of the airplane at 7,000 feet msl. The PIC of the incident flight was the DC-8 flight standards manager at the time, and the PF in the right seat was the DC-8 equipment chief pilot.

The flight engineer on the 1991 incident flight, now a DC-8 first officer, told Safety Board investigators that the flightcrew calculated the stall speed and stick shaker speed, configured the airplane for the landing stall, and slowed to stall speed. He said that the flightcrew was surprised when the stick shaker activation and buffet occurred simultaneously.[25] The PF called for maximum power and the flight engineer advanced the throttles. The flight engineer said that he then heard popping noises on the left side of the airplane and noticed that the EPR gauges for the No. 1 and No. 2 engines showed no acceleration. The throttles were retarded to idle and advanced again by the flight engineer. The airplane then yawed to the left, rolled right and began a rapid, spiral descent. The PIC took the controls and reversed all four engines. The crew said they experienced a 1 ½-turn spin.

After the recovery from the stall/spin incident, the FEF was continued for nearly 3 hours until the FEF checklist was completed. FAA records indicate that the FAA Winston/Salem FSDO processed an enforcement action because of the flightcrew's failure to terminate the flight after the incident, and the pilots' check airmen status was temporarily suspended.

As a follow-up to the incident, the POI assigned to ABX wrote in a June 7, 1991, letter to the Winston/Salem FSDO that he had met with ABX personnel and they agreed that the following changes would be made to the FEF profile: flightcrews would fly the FEF profile in the simulator before the actual evaluation flight; airborne maneuvers would be executed in an ATC-assigned altitude block depth ranging from 3,000 feet to 5,000 feet (see appendix D). Recovery was to be accomplished with pitch (lowering the nose), and power then slowly advanced to complete the recovery (and fly out of the buffet). "The stall maneuver will no longer use power [first] for recovery," the POI wrote in the June letter. He added in the letter, "In the simulator, lowering the nose three to four degrees results in an instant recovery. Power can then be slowly advanced to complete the recovery. All of this is being incorporated in their acceptance flight profile."[26]

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[25]According to ABX's director of flight technical programs, FEF flightcrews were also told that they should be prepared for the stick shaker not to activate before the stall during the clean stall maneuver.

[26]ABX maintains that it did not receive a copy of this letter. The POI told Safety Board investigators that he could not recall whether he sent a copy of the letter to ABX, but he added that ABX managers were aware of its contents.

Pilots reported using the new procedure on subsequent FEF flights. The PIC of the incident flight said that in performing stall series during subsequent evaluation flights he reduced pitch attitude more positively and "let the altitude go." He said that the airplane typically lost about 200 feet to 500 feet using this (modified) stall recovery procedure (compared to little or no altitude loss using the former power-recovery procedure). The flight engineer on the incident flight told Safety Board investigators that he was aware that the FEF stall recovery procedure had been changed following the incident. "The biggest change was to use a pitch recovery technique rather than a power recovery technique."

ABX's director of flight technical programs, who had been on sick leave and then returned to flight status primarily flying DC-9 airplanes, told Safety Board investigators that he did not use the revised FEF stall recovery procedures when he subsequently flew several DC-8 post-modification FEFs. He added that he believed that if the engines were spooled up properly during the approach to stall, the resulting power recovery maneuver would be "okay."

The POI said that he recalled having a disagreement with the director of flight technical programs about the stall procedures, arguing that ABX had been "performing the stall series in level flight like it was a precision [FAA-recommended stall recovery] maneuver." He said that he told ABX personnel, "Let's apply some common sense here." The POI said he told ABX managers and pilots that it was not necessary to hold altitude in such FEF scenarios.

1.18.2 Survey of Evaluation Flight Procedures

Guidance on the requirements for conducting FEFs is contained in a brief section entitled "Test Flights" in ABX's flight operations manual (FOM). The FOM stated, in part, that:

> night test flights may be conducted only when the reported ceiling is 800 feet or above and the reported visibility is 2 miles or greater, and the weather forecast indicates that the ceiling and visibility will remain at or above those limits for the duration of the flight. Night test flights flown by flight supervisory personnel may be operated with lower minimums when circumstances warrant.

The Safety Board also collected documentation from other operators on FEF procedures. The American Airlines flight manual stated, in part, that:

> every effort will be made to conduct … [FEFs] during VFR conditions. If the functional evaluation program warrants, an FCF may be made in IFR conditions. (The captain may stipulate higher than regular minima.) Flight Department management permission must be obtained for FCFs to be accomplished when the departure or landing airport is forecast to be less than 800/2.

The Boeing Commercial Airplane Group's flight test operations manual for new airplanes noted that "production flights are normally flown in daylight hours." It added, in part, that:

> the following maneuvers should only be flown during daylight hours: engine relights, stick shaker tests and tests requiring visual confirmation by occupants of wing or engine status. First flights are made during daylight only.

Referring to production flight test policies (including extensively modified airplanes), the Boeing manual stated:

> Night flying shall be kept to an absolute minimum. If a flight cannot depart in time to be completed by nightfall, then it should be rescheduled for the next morning.

For stall warning checks, the manual specifies that airspeed should be reduced slowly at about 1 knot per second "while maintaining altitude until stick shaker actuates. Maintain as close to 1-G flight during the maneuver as possible." The B-757 flight evaluation profile, for example, stated that if the stick shaker has not actuated 5 knots below the computed value, the evaluation flight should be terminated and the airplane returned to base for additional maintenance.

The Douglas Aircraft Company's production flight check minimums for first flights stated that weather conditions at takeoff must be at least 600 feet and 1 ½ miles visibility "with cloud tops below 5,000 feet. Final landing will be accomplished no later than one hour before official sunset." The Douglas manual specified takeoff minimums on subsequent evaluation flights of 200 feet and ½ miles visibility "provided that all Category I[27] equipment is fully operational, including radios, flight instruments and related systems." United Parcel Service's (UPS's) procedures for DC-8 condition flight checks note that stall warning tests "shall be accomplished in VFR conditions and an altitude of at least 10,000 feet agl [above ground level], where recovery can be made without reference to the attitude indicator. If stick shaker functions in the clean configuration, then no further testing is required."

1.18.3 Survey of Stall Recovery Procedures

The Safety Board examined stall recovery procedures outlined in ABX's DC-8 operations manual and those recommended by the airplane's manufacturer. According to the introductory section (page 4) of ABX's DC-8 operations manual, dated December 31, 1988, stall recovery is to be accomplished "sufficiently smooth to avoid sustained secondary indication of approach to stall while minimizing altitude loss."

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[27]Category I instrument landing system (ILS) approaches have minimums of 200 feet decision height (DH) and runway visual range (RVR) 2,400 feet.

The ABX DC-8 operations manual prescribes stall recovery practice procedures to be accomplished between 10,000 feet and 15,000 feet agl. For zero flap clean stalls, the manual describes the sequence of operations as follows: an initial entry speed of 200 knots, straight and level, slow deceleration by reduction of power to "minimum 'spool up' rpm, maintaining heading and altitude. Maintain altitude by increasing pitch, maintaining the rate of climb indicator at zero rate of climb." It said to discontinue trimming below 1.5 V_s. The manual described the recovery as follows:

> At 'stick shaker' or initial buffet, apply and call out 'Set Max Power.' Simultaneously reduce back pressure sufficiently to stop the stick shaker. Fly the airplane out of the buffet. There should be very little, if any, altitude loss. The PF should observe the trim changes as the engines accelerate.

> The 1988 ABX manual (section 00, pages 54-55) further stated:

> The primary purpose of stall practice is to enable the pilot to avert a dangerous stall condition by early stall recognition, followed by immediate corrective action. It should be remembered that a stall recovery is accomplished by reducing the angle of attack at which the airplane is flying. This may be accomplished by a number of ways, but basically by (1) lowering the pitch attitude, (2) acceleration produced by adding thrust and/or (3) by leveling the wings, if in a bank.

> All stall approaches should be made only to the 'stick shaker' or initial buffet, whichever occurs first. Points to be stressed are a smooth entry, striving for a zero rate of climb, and a prompt, well coordinated recovery without inducing a secondary stall. The altitude lost in stall recovery depends on the promptness and smoothness of applying the recovery technique, i.e., lowering the pitch attitude, applying power and leveling the airplane.

The manual added, "Particular care should be exercised to ensure that the buffet has ceased before the airplane is rotated nose up for recovery. Additionally, the controls should be moved smoothly to preclude inducing acceleration loads which could cause secondary stall indications."

According to a draft of a new ABX operating manual, dated October 15, 1996, and written by the accident PF, the DC-8 was "designed to have good stall characteristics. Longitudinal stability is positive below the stall, and there is a strong pitch down tendency after the stall. Light buffet may be felt prior to the stall, although artificial stall warning from the stick shaker will occur about 10 percent above the 1 G stall speed." The manual, which had not been approved at the time of the accident, stated that the initial buffet on the DC-8 "occurs very close to actual stall speeds."

Referring to stall recovery techniques, the draft manual stated:

> Points to be stressed are a smooth entry, striving for a zero rate of climb, and a prompt, well-coordinated recovery without inducing an accelerated secondary stall. Minimal loss of altitude in stall recovery depends upon the prompt and smooth application of the recovery technique, i.e., lowering the pitch attitude, applying power and leveling the wings. During approaches to stalls, there should be no trimming below the minimum maneuvering speed for the given flap configuration.
>
> Since a heavy jet airplane will not easily accelerate from a stalled or near stalled condition without decreasing the angle of attack, some altitude loss should be expected. The amount varies depending upon the method of entry, power application, timing, smoothness and delicacy with which altitude changes are made on recovery.

The manual also noted that because of the DC-8's "underslung engine configuration, the airplane has a strong pitch-up moment as thrust is increased."

A 1970 Douglas DC-8 flight study guide describes a clean stall in the following way:

> At 'stick shaker' or initial buffet, apply in-flight takeoff thrust and call for 'FLAPS 25 (degrees)' [Flaps to 23 degrees for DC-8 models 62 and 63]. Simultaneously lower the nose toward the horizon and fly the airplane out of the buffet. There should be very little, if any, altitude loss. The student should observe the trim change as slots open, flaps extend and engines accelerate."[28]
>
> …the minimum altitude for accomplishing stall checks is 18,000 feet msl and at least 10,000 feet above the terrain. Stall checks will be accomplished only in VFR conditions, and when a natural horizon is visible. Stall checks will not be accomplished in turbulent air conditions. Delay check until air conditions are more suitable.

In November 1984, Douglas issued new procedures for "inadvertent approach to stall" based on increasing knowledge of and concern about windshear and downdrafts. The procedures were first issued for DC-9/MD-80 and DC-10 airplanes, but Douglas noted that the "procedure for the DC-8 is similar to these, and reflects our current thinking and recommendations." The following is the 1984 recovery procedure for DC-8s:

[28]Recovery procedures with flaps were in effect before windshear avoidance maneuvers (with no configuration changes) were instituted in the mid-1980s.

RECOVERY FROM APPROACH TO STALL

> At first indication of approach to stall, simultaneously apply maximum available thrust, level the wings and adjust pitch as required to minimize altitude loss. In an emergency situation (i.e., encountering a downdraft or decreased performance windshear condition), positive climb performance and limited maneuver margins still exist at or near stick shaker actuation speed. High pitch attitudes are to be expected; however, pitch attitude should not be increased so rapidly that airspeed decreases below stick shaker actuation speed.
>
> First indication of approach to stall may be one or any combination of the following:
>
> Rapid decrease of airspeed below bug setting.
>
> Rapid decrease of climb rate during takeoff or go-around.
>
> Rapid increase of sink rate during approach.
>
> Stick shaker or initial stall buffet.
>
> If ground contact is imminent, apply maximum available thrust (up to throttle mechanical stops) for the time required to recover from the situation.
>
> NOTE: After a maximum thrust application (overboost), those engine parameters that exceeded the limits and the duration will require a log entry.
>
> At first indication of a stall with the autopilot engaged, immediately disconnect the autopilot and initiate stall recovery. Be alert to counteract excessive nose-up trim condition.

1.18.4 Previous Nonroutine Operation DC-8 Accident

On February 16, 1995, a DC-8-63 operated by Air Transport International (ATI) was destroyed by ground impact and fire during an attempted three-engine takeoff at Kansas City International Airport in Kansas City, Kansas. Following an investigation of this accident, the Safety Board determined that the probable causes of the accident included "the flightcrew's lack of understanding of the three-engine takeoff procedures" …and "the failure of the company to ensure that the flightcrew had adequate experience, training and rest to conduct the non-routine flight."[29]

[29]See Aircraft Accident Report—"Uncontrolled Collision with Terrain, Air Transport International, Douglas DC-8-63, N782AL, Kansas City International Airport, Kansas City, Missouri, February 16, 1995" (NTSB/AAR-95/06).

As a result of its investigation, the Safety Board issued the following safety recommendation to the FAA:

> A-95-39
> Limit operations of engine-out ferry flights to training, flight test or standardization flightcrews that have been specifically trained in engine-out procedures.

In response, on July 18, 1995, the FAA issued flight standards information bulletin 95-16A, “Flightcrew Training and Qualifications for One-engine Inoperative Ferry Flights.” The bulletin directed POIs to inform their respective operators to take additional measures to ensure:

1. That aircraft manual requirements for engine-out ferry flights are clear and unambiguous.
2. That flightcrew training segments are clearly outlined for engine-out operations.
3. That flightcrew members who conduct engine-out ferry flights have satisfactorily completed an approved qualification and training program specific to the aircraft type within the previous 12 months.
4. That flightcrew members who conduct engine-out ferry flights are recommended by the chief pilot and approved by the POI through a letter of authorization.

The Safety Board determined that the bulletin satisfied the intent of the recommendation and, on November 14, 1995, classified A-95-39 “Closed—Acceptable Action.”

1.18.5 Previous Safety Board Recommendation on Angle of Attack Indicators

Following a December 20, 1995, fatal accident involving an American Airlines (AAL) B-757 near Buga, Colombia, the Safety Board recommended that the FAA:

> A-96-94
> Require that all transport-category aircraft present pilots with angle of attack[30] information in a visual format, and that all air carriers train their pilots to use the information to obtain maximum possible climb performance.

AAL flight 965 struck trees and crashed into the side of a mountain in night visual meteorological conditions (VMC) on approach to Cali, Colombia. The airplane was destroyed, and all but four of the 163 passengers and crew on board were killed. In an October 16, 1996, recommendation letter to the FAA, the Safety Board noted the following:

[30]Angle of attack is the angle of the airplane wing to the relative wind. The stick shaker does not provide information about the degree to which the angle of attack exceeds a critical level, only that it has. However, knowledge that the angle of attack has approached or exceeded the level necessary for the wings to create lift effectively is important. In the absence of a stick shaker, the angle of attack can only be estimated indirectly by such cues as airplane handling characteristics, buffet or the relationship between pitch attitude, airspeed and G-loading.

> Data revealed that the first officer promptly initiated a nose-up elevator input after the GPWS warning activated, and continued the nose-up inputs until the stick shaker activated. Next, he immediately reduced the pitch attitude until the stick shaker stopped. He then increased the pitch attitude until the stick shaker again activated, and continued to increase the pitch attitude to the stall angle of attack. Had the stick shaker activation angle been steadily maintained during the escape maneuver, the airplane may have climbed above the initial impact point. The evidence from this accident demonstrates that inadequacies in the use of the stick shaker as a primary indicator for angle of attack limited the first officer's ability to obtain the maximum climb performance possible from the airplane when it was most needed. Although the stick shaker presents effective tactile and aural indications of the angle of attack needed to achieve maximum performance of the airplane, angle of attack information should be presented in a visual and more readily interpretable format. Military aircraft have been equipped with angle of attack indicators for many years; however, these indicators are not required on civil air transport aircraft.
>
> Presentation of angle of attack information can enhance pilot control of the airplane during takeoffs and climbs, and during maneuvers, such as engine-out procedures, holding, maximum range, GPWS encounters, windshear and approach and missed approach procedures. The visual presentation of angle of attack information in transport-category aircraft, combined with pilot training in using this information to achieve maximum airplane climb performance, would enhance the ability of pilots to extract maximum performance from an airplane.…

In a December 31, 1996, response to the Safety Board's letter, the FAA said that it had "initiated an evaluation to assess the operational requirements for an angle of attack indicator to obtain maximum airplane climb performance. This evaluation will include implementation and training requirements, the complexity and cost of the system, and other functions as well as indicating the angle of attack for maximum rate of climb. If it is determined that angle of attack indicators are warranted, the FAA will take appropriate regulatory action." Pending the Safety Board's evaluation of the FAA's completed action, on April 11, 1997, the Safety Board classified Safety Recommendation A-96-94 "Open—Acceptable Response."

1.18.6 Safety Board Recommendations on Unusual Attitude Recovery Training

The Safety Board has addressed the need for training in the recognition of and recovery from unusual attitudes for nearly 30 years, culminating in the following safety recommendation to the FAA:

A-96-120
Require 14 CFR Part 121 and 135 operators to provide training to flightcrews in the recognition of and recovery from unusual attitudes and upset maneuvers, including upsets that occur while the aircraft is being controlled by automatic flight control systems, and unusual attitudes that result from flight control malfunctions and uncommanded flight control surface movements.

The October 18, 1996, safety recommendation letter to the FAA that included Safety Recommendation A-96-120 stated that the Safety Board was “convinced that unusual attitude training programs would improve the safety of air transport-category aircraft.” It noted that several airlines had instituted such “advanced maneuver training” or “selected event training” and that these programs “have been enthusiastically accepted by flightcrews.”

The FAA replied to the Safety Board, in a letter dated January 16, 1997, that it agreed with Safety Recommendation A-96-120 and that it was considering a Notice of Proposed Rule Making to require that air carriers conduct training that will emphasize recognition, prevention, and recovery from aircraft attitudes normally not associated with air carrier operations.

In its review of the FAA response, the Safety Board noted again that while many operators are providing training on the recognition, prevention and recovery from attitudes not normally associated with air carrier operations, it was not aware of “any training in which the unusual attitude was the result of a control system failure” or because “some flight controls would not be available for, or would be counterproductive to, the recovery.” The Safety Board added, “The Safety Board trusts that the full intent of this recommendation will be addressed in the FAA’s final action on this recommendation.” Pending further correspondence with the FAA, on July 15, 1997, the Safety Board classified Safety Recommendation A-96-120 “Open—Acceptable Response.”

2. ANALYSIS

2.1 General

The three-member flightcrew was properly certificated and qualified in accordance with applicable Federal regulations and company requirements. There was no evidence that any medical, behavioral, or physiological factor affected the flightcrew on the day of the accident. Both pilots were qualified in accordance with Federal regulations and company requirements to act as DC-8 PICs and to fulfill the duties of the roles they were assigned, although neither the FAA nor ABX had established any additional experience requirements or qualifications for flightcrew members to perform FEFs (see section 2.5.3 for a discussion of this issue).

The airplane was properly certificated, equipped and maintained in accordance with Federal regulations and approved procedures. There were no open or deferred maintenance items listed on the airplane before the accident flight, and there was no evidence that failures of the airplane structures, flight control systems or engines contributed to the accident. Other than the failure of the stall warning system stick shaker to activate (which is addressed in section 2.3.1), there was no evidence of mechanical malfunctions. All records for airplane systems indicated proper maintenance and normal operation. Airplane logs indicated that all four engines had received approved overhaul and noise attenuation modifications. There were no open or deferred maintenance items involving the engines and all inspections were conducted within required intervals.

The Safety Board's analysis of the accident focused on flightcrew performance during the accident sequence, and whether the cues presented to the flightcrew, their prior experience, the fidelity of the ABX DC-8 flight training simulator, the organizational structure and function of ABX, or oversight by the FAA may have affected the flightcrew's performance.

2.2 Flightcrew Performance During the Accident Sequence

2.2.1 Execution of the Stall Recovery

The purposes of the FEF stall series were to verify that the airspeeds at which the airplane experienced stick shaker activation and stall indication were in accordance with precalculated values for the DC-8-63 and to determine whether maintenance performed had changed any of the airplane's flight characteristics. A comparison between the CVR transcript and the ABX procedures for executing a clean stall (see section 1.18.3) indicates that the flightcrew prepared for the stall maneuver generally in accordance with ABX procedures, with the exception of their use of pitch trim, which is discussed in section 2.2.3. The PF reduced the airspeed into the stall region at approximately the desired rate of 1 knot per second, and he increased engine EPR (spooled up the engines) prior to the onset of buffet to provide adequate engine acceleration during the recovery.

By 1808:13, 2 seconds after the flight engineer stated, "That's the stall right there * ain't no shaker," significant engine thrust had been applied, and the PF had stated, "Set max power." The flightcrew had recognized the incipient stall and initiated the stall recovery in accordance with ABX's procedures. Based on the thrust application and the "Set max power" statement of the PF, the Safety Board concludes that the PF made a timely decision to terminate the clean stall and begin the stall recovery.

For 8 seconds following the initiation of the stall recovery, from 1808:13 through 1808:21, the PF maintained the airplane's pitch attitude at between 10 degrees and 14 degrees ANU. During this 8-second period, the airspeed continued to decrease and the airplane entered a fully developed stall.

The failure of the airplane to recover before entering the full stall resulted from the control column inputs the PF was making to maintain pitch attitude. The control column was moved aft by the PF, from 5 degrees aft (at 1808:11, just prior to initiating the recovery) to 20 degrees aft (14 seconds later). An increasingly downward flightpath angle coupled with a relatively constant pitch angle resulted in an increasing angle of attack. The increase in angle of attack, which placed the airplane farther into the stalled condition, may not have been perceived by the flightcrew unless they were closely monitoring the airspeed indicator. In addition, the vertical speed indicator and altimeter should have provided evidence of a developing sink rate and stall.

Thereafter, the airplane began a series of roll reversals, and the airplane remained in an aerodynamic stall condition because the PF held significant back pressure on the control column all the way to impact. Each time the airplane developed a large nose-down pitch rate (combined with reductions in airspeed at 1808:25 and 1809:22), the PF responded with additional back pressure, according to FDR data on control column movement. In contrast, the appropriate pilot response to an uncommanded decrease in pitch attitude (which is, itself, an indication that the airplane is in a stall) would have been forward movement of the control column.[31]

ABX's stall recovery procedures, established in accordance with FAA standards, were used to train line flightcrews to recognize an impending stall and perform a recovery with a minimum loss of altitude. The training procedures call for the airplane to be slowly decelerated at a constant altitude until stall recognition; i.e., the onset of a pre-stall buffet or activation of the stick shaker. Recovery is executed by adding power, reducing pitch attitude slightly (until the stick shaker stops) and maintaining heading. Evaluation criteria for the performance of this maneuver by line flightcrews during proficiency checks include minimum altitude loss and avoidance of a secondary stall (which can be recognized by reactivation of the stick shaker or aerodynamic buffet).

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[31]FDR data on control column position indicated that the elevator controls were not jammed during the loss of control sequence. There was forward and aft movement of the column, but the column was moved forward of the 10-degree nose-up position only once, momentarily.

The flightcrew had initiated the clean stall maneuver at 13,500 feet, within a block altitude range of 13,000 feet to 15,000 feet. Their use of the lowest 500 feet of the block altitude indicated that the flightcrew anticipated recovering from the stall with a minimum altitude loss, just as they were accustomed to performing and instructing the standard ABX stall maneuvers in the simulator. Further, their execution of the clean stall only slightly above the cloud tops suggests that the flightcrew did not anticipate the possibility of greater altitude loss.

Pilots control airplanes, including in stall recoveries, by first establishing appropriate pitch attitudes and power settings, then monitoring the effects of pitch and power on the performance instruments, such as the airspeed and vertical speed indicators. Although the PF attempted to establish his desired pitch attitude and power setting, he failed to recognize that these initial pitch and power inputs were inadequate for the stall recovery he was executing, and he failed to take further action to correct for the decreasing airspeed and developing sink rate. Allowing the control column to move forward would have stopped the airspeed loss, and the airplane would have recovered from the stall. However, he failed to do so. The Safety Board concludes that the PF applied inappropriate control column back pressure during the stall recovery attempt in an inadequate performance of the stall recovery procedure established in ABX's operations manual, and these control inputs were causal to the accident.

Further, although the stall recovery procedure established by ABX cautioned pilots to relax enough control column back pressure to avoid secondary stalls during the recovery, the Safety Board notes that the objective of a minimum altitude loss procedure, including the ABX procedure, is to use the minimum reduction in pitch attitude required to recover from the stall. As such, the minimum altitude loss stall recovery procedure places the airplane at a more critical angle of attack and drag configuration during the initial recovery from the stall, compared to an alternative procedure that uses a greater pitch reduction and trades a greater altitude loss for a more rapid reduction in angle of attack and increase in airspeed. ABX's role in specifying the type of stall recovery procedure to be used during FEFs is discussed in section 2.5.1.

2.2.2 Buffet Onset and Stall Speeds

Prior to executing the clean stall maneuver, the flightcrew calculated the airspeed values at which the stall warning stick shaker should activate and the airplane should stall, based on their estimates of the airplane's weight at the time the maneuvers began. According to ABX procedures, the flightcrew would have used a table to look up the value for 1.5 V_s (1.5 times the stall speed in the clean configuration based on the airplane's weight), the airspeed below which, according to ABX procedures, the flightcrew should not apply additional nose-up pitch trim; then the flightcrew would have divided this value by 1.5 to calculate the expected stall speed. They would have then calculated the expected stick shaker activation speed, according to ABX procedures, by multiplying the stall speed by 1.05.

According to the CVR, at 1805:56 the PNF said, "one eighty four [1.5 V_s], and… we should get uh, stall at uh, one twenty two." Based on this stall speed calculation, the flightcrew would have expected the stick shaker to activate at 128 knots.

The flightcrew noted “some buffet” at 1808:06 and appeared surprised that the buffet had begun at the existing airspeed of 149 knots (the PNF stated, “That’s pretty early”). DC-8-63 performance certification test data provided by Douglas indicate that an aerodynamic stall is typically preceded by aerodynamic buffet about 15 knots above the stall speed. Therefore, the nominal airspeed for the buffet to have begun on the accident flight would have been 137 knots; based on these data, the buffet apparently began about 12 knots early.

Because the pre-stall buffet began at an airspeed greater than the flightcrew expected, the Safety Board evaluated three factors that could have affected the airspeeds for both pre-stall buffet and stall during the accident flight: the weight of the airplane, airframe icing, and flight control surface rigging.[32]

The aircraft log page for December 22, 1996, which would have included the flightcrew’s entries for aircraft weight and the amount of fuel aboard at departure, was not recovered in the wreckage. However, based on the stall speed stated by the flightcrew on the CVR (122 knots), the crew believed the weight of the aircraft to have been approximately 200,000 pounds at the time they began the stall maneuver. FDR data on the performance of the airplane during its takeoff on the accident flight were consistent with the flightcrew’s calculations of the airplane’s weight and stall speed. Therefore, the Safety Board concludes that aircraft weight and balance were not a factor in the greater-than-expected buffet onset speed. Further, based on the Safety Board’s estimates of weight and balance for the accident flight, which were developed using ABX records of the basic operating weight of N827AX and the fuel weight remaining after the December 21 FEF, the Safety Board concludes that the airplane was loaded within its approved weight and balance limits during the accident flight.

The flight had been operating at least intermittently in the cloud tops and below-freezing air temperatures, where weather conditions were conducive to light-to-moderate icing for a brief period before the attempted stall maneuver. The flightcrew’s statements on the CVR, at 1748:34, indicate that the airplane was accumulating airframe ice. Recorded comments of the flightcrew further indicated that the airplane departed from the icing conditions shortly thereafter. The Safety Board was unable to determine the amount of airframe ice that the airplane would have accumulated during this period. However, airframe icing could have caused the airplane to buffet at a greater airspeed than the flightcrew expected.

The buffet and stall speeds also could have been affected by the rigging of the airplane’s flap and aileron control surfaces. These control surfaces had been re-rigged prior to the FEFs of December 21 and 22, 1996, as a routine part of the overhaul of N827AX. One of the purposes of performing the stall series during the post-modification FEF was to verify that control surface rigging was proper by comparing calculated stick shaker activation and stall speeds to the airspeeds at which the airplane actually encountered these events.

[32]Stall speed is an increasing function of an airplane’s weight. An accumulation of ice on the lift-producing surfaces of an airplane can increase the stall speed by altering the shape of these surfaces. A control surface that is rigged at or beyond the forward (retracted) tolerance limit decreases the airplane’s wing area and the camber (curvature) of the wing, increasing the stall speed. Also possibly affecting the stall speed are load factor (vertical G), aileron deflection, spoiler deflection, sideslip, and smoothness of the wing leading edge.

Consequently, like airframe icing, variations in flap and aileron rigging could have caused the airplane to buffet at a greater airspeed than expected. The Safety Board was unable to determine the extent to which these possible conditions individually contributed to the early onset of buffet, but concludes that some combination of airframe icing, flight control rigging, or other factors resulted in the greater-than-expected buffet onset speed.

However, the Safety Board's analysis of FDR parameters indicated that the actual stall occurred at 126 knots, only four knots greater than the stall speed calculated by the flightcrew.[33] Therefore, despite the early onset of aerodynamic buffet, the Safety Board concludes that any effects of airframe icing or flight control rigging upon the stall speed of the accident airplane were minimal, and did not contribute to the accident.

2.2.3 Flightcrew's Mis-trim of the Airplane

At 1807:43, when the FDR data indicated the airspeed was decreasing through 173 knots, the PF stated, "Guess I better not trim below * two *."[34] However, ABX procedures for the clean stall maneuver required that he stop trimming the airplane's nose up at 1.5 V_s (184 knots for the accident flight).

Based on the measured position of a horizontal stabilizer trim jackscrew found at the accident site, the stabilizer was trimmed to the 8-degree ANU position. Simulations and calculations conducted by Douglas based on the accident airplane's weight and CG location show that an 8-degree ANU trim would result in a trim speed of about 175 knots.

The effect on the stall recovery of trimming the airplane to a slower airspeed than desired would have been to require more forward control column movement to achieve the desired nose-down pitch rate and recover from the stall. However, because the airplane's 175-knot trim speed was significantly greater than the 126 knot stall speed, additional control column back pressure was required from the PF to slow the airplane to the stall speed, and the airplane would have rapidly recovered from the stall if the PF had relaxed his back pressure on the control column. Therefore, the Safety Board concludes that although the PF trimmed the airplane below the recommended minimum trim speed for the clean stall, this action did not contribute to the accident.

2.2.4 Monitoring and Challenging by the PNF

Because both pilots were qualified to act as a DC-8 captain at ABX, the Safety Board evaluated flight records, the flightcrew's previous experience with check flights and flightcrew statements on the CVR to determine whether the PNF was serving as the pilot-in-command of the accident flight and instructing the PF from the right seat.

The ABX aircraft log page for the FEF of December 21, during which the two pilots had flown in the same seating positions as on the accident flight, had the PF's name

[33]According to FDR data, an aerodynamic stall occurred between 18:08:21 and 18:08:22.
[34]When transcribing CVR recordings, the Safety Board uses an asterisk to signify an unintelligible word.

entered in the "Captain" block. However, that log page was ambiguous as to who had been the PIC of the December 21 flight because the PNF signed for the airplane in the "Captain's signature" block. The aircraft log page for the accident flight was not recovered.

The PNF had previous experience as the SIC of several DC-8 post-modification FEFs, while the FEFs of December 21 and 22 were the first exposure of the PF to post-modification FEF procedures. Although it is typical for the left seat pilot to fulfill the role of the PIC, flight instruction can be conducted from the right seat, and the flight instructor usually serves as the PIC.

Flightcrew comments recorded on the CVR during the set-up for the clean stall maneuver and the unpowered controls V_{mc}[35] check that preceded it, revealed that the PNF directed the PF, while the PF expressed uncertainty and asked questions. Further, several of the communications from the PNF to the PF were instructional in nature. Based on these communications and the PF's lack of any prior experience with a complete DC-8 post-modification FEF, the Safety Board concludes that the PNF, in the right seat, was serving as the pilot-in-command of the accident flight and was conducting instruction in FEF procedures; and that the PF, in the left seat, was serving as the second-in-command and was receiving instruction in FEF maneuvers, including the clean stall maneuver.

During the attempted stall recovery, there were several indications of the PF's excessive aft control column inputs that should have suggested to the PNF that, as the PIC, he needed to correct the control inputs and recover from the stall. These included the position of the control column, which was, at times, being held in the full aft position by the PF; continued aerodynamic buffet; the extreme pitch down moments (stall breaks) accompanied by roll-off into steep bank attitudes; engine compressor surges; and the instrument indications of low airspeed and high rate of descent. The Safety Board evaluated why, despite these cues, the PNF did not take control of the airplane or otherwise intervene effectively as the PF held the airplane in a stalled condition all the way to impact.

The reduced effectiveness of the monitoring and challenging of one crew member by another when each is qualified as captain has been recognized in previous accidents investigated by the Safety Board.[36] In this accident, both pilots were captains, both were managers, and both had similar backgrounds at ABX. In this kind of crew pairing, it may be difficult for one captain to challenge the actions of the other because of a lack of overt command authority.

The PNF's role as an instructor pilot during the FEF maneuvers should have clarified the roles and responsibilities of the two pilots. As the instructor, his pilot-in-command authority should have been enhanced, and it should not have been difficult for him to exercise direct control to ensure the safety of the flight. However, the PNF's instructional role, like his

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[35]V_{mc} is defined as minimum controllable airspeed with critical engine inoperative.

[36]For example, see Aircraft Accident Report—"Midwest Express Airline, Inc., DC-9-14, N100ME, General Billy Mitchell Field, Milwaukee, Wisconsin, September 8, 1985" (NTSB/AAR-87/-1); and Aircraft Accident/Incident Summary Report—"Controlled Flight into Terrain, GP Express Airlines, Inc., N115GP, Beechcraft C99, Shelton, Nebraska, April 28, 1993" (NTSB/AAR-94/01/SUM).

command role, was informal on this flight. Therefore, his command and instructional authority may have remained unclear.

Further, instructors often prefer to “talk” a student through a recovery, rather than take over the controls. This milder, verbal intervention can be carried too far if instructors are overconfident about their students’ or their own ability to recover at the last moment, or if they lose their awareness of impending danger.

In this accident sequence, early in the recovery attempt at 1808:30, the PNF made a helpful comment to the PF, “You can take a little altitude down, take it down [that is, give up altitude to facilitate the stall recovery].” However, when the PF did not respond adequately, the PNF did not escalate his verbal interventions or take over the controls. During the uncontrolled descent, the PNF continued to provide suggested control inputs to the PF, but the PNF never told the PF to move the control column forward.

It is possible that the PNF’s priorities changed after the extreme rolling moments developed. The PNF may have become less concerned about angle of attack, and the reduction of pitch attitude may have become a secondary priority to roll attitude control. Throughout the recovery sequence, the PNF made several statements to the PF to help direct him out of the roll situation (but not out of the stall condition), and he remained in an instructional role up to the time of impact. During this period, the PNF also took time to respond to a query from ATC pertaining to the airplane’s rapid descent below its assigned block altitude floor. Based on the PNF’s lack of urgency in correcting the PF’s control inputs and the PNF’s radio transmissions with ATC, he apparently lost awareness of the flight’s descent rate and proximity to the ground. The Safety Board concludes that the PNF’s failure, as the pilot-in-command, to recognize, address and correct the PF’s inappropriate control inputs were causal to this accident.

2.3 Cues Presented to the Flightcrew

The Safety Board evaluated the adequacy of the cues that were presented to the flightcrew and the role of distraction as possible contributors to the flightcrew’s failure to recover from the stall. The Board examined the cues that were presented to the flightcrew by the airplane’s flight deck instrumentation and engines, and the flightcrew’s visual references to the natural horizon based on the existing weather and light conditions.

2.3.1 Stall Warning System

The stall warning system stick shaker failed to activate during the accident sequence at the appropriate margin above the stall and during the full stall that followed. According to Douglas, DC-8 models up to the -61 series provided an adequate margin between the buffet and stall in the clean configuration, so they did not require the artificial stall warning of the stick shaker. However, the stick shaker was needed to fulfill the certification requirements for adequate pre-stall warning on subsequent DC-8 models, including the accident airplane (a DC-8-63).

Despite these requirements, ABX FEF pilots told Safety Board investigators that the stick shaker activated inconsistently relative to the onset of pre-stall buffet during the clean stall maneuver, sometimes activating prior to buffet, but in some cases activating simultaneously with buffet or after the buffet had begun. According to the ABX director of flight technical programs, FEF flightcrews were told that they should be prepared for the stick shaker not to activate before the stall during the clean stall maneuver. Further, the CVR transcript indicates that the flightcrew had clearly identified a stall buffet and that they initiated a recovery in a timely manner. Consequently, the Safety Board concludes that the absence of the stick shaker prior to the stall did not affect the flightcrew's recognition of the initial entry into the stall.

However, the Safety Board is concerned that the stick shaker failed to activate at any time during the full stall that followed. Given the extreme angles of attack that were eventually attained prior to impact, the stall warning system clearly was inoperative.

The Safety Board attempted to determine why the airplane's stick shaker stall warning system did not activate. Douglas records indicated that the airplane's stall warning system functioned in accordance with its design specifications when it was delivered in 1967. Preflight cockpit checks before the accident flight indicated that the airplane's stall warning system was operational; however, the preflight check of this system (using the test switch located on the flight deck overhead panel) does not test the stall warning system's wing-mounted angle of attack sensor and transducer. According to TIMCO records of the maintenance work performed on N827AX, a test was performed on the sensor and transducer by TIMCO on December 5, 1996; this test was more extensive than the preflight check, but it did not include verification of the stall warning system transducer's calibration with a measured-force applicator or a functional check of the lift computer. Because stall warning components found at the accident site were destroyed, the recovered components provided no evidence about the system's status and function. Consequently, the Safety Board was unable to identify the failure mode of the stall warning system.

Although it did not hamper the initial identification of the stall, the absence of a stick shaker warning may have been confusing for the flightcrew. The pilots' training and experience would have made them expect a stick shaker cue during the period the airplane was in a stalled condition. They were trained to respond to the stick shaker by adding power and reducing control column back pressure until the stick shaker ceased.

During the first moments of the recovery attempt, an operative stick shaker would have provided the flightcrew with cues about the ineffectiveness of the PF's recovery efforts which could have alerted the pilots that the angle of attack needed to be further reduced. Similarly, if the flightcrew had received the expected cues from the stick shaker as the airplane subsequently was flown farther into the stall, the PF may have responded with more aggressive stall recovery actions, and the PNF would have received a stronger signal to intervene.

It is even possible that, in the absence of the stick shaker warning, the flightcrew may have gradually lost the perception that the airplane was stalled (especially in the latter stages of the accident sequence when the airplane was descending in an accelerated stall condition at high airspeed and positive G load) and may have been attempting to perform a high airspeed, nose-low unusual attitude recovery. The unusual attitude recovery procedure calls for engine thrust to be reduced to idle and primary attention to be focused on leveling the wings; FDR engine thrust parameters and the flightcrew's statements about lateral control recorded by the CVR were consistent with this procedure. The Safety Board concludes that the inoperative stall warning system contributed to the accident by failing to reinforce to the flightcrew the indications that the airplane was in a full stall during the recovery attempt. Further, based on the circumstances of this accident, the Board is concerned that existing air carrier maintenance programs may not ensure that stall warning systems are adequately checked during scheduled maintenance. Therefore, the Safety Board believes that the FAA should require Douglas Aircraft Company to review and amend the stall warning test procedures in the DC-8 maintenance manual and maintenance planning document to include regular calibration and functional checks of the complete stall warning system.

2.3.2 Angle of Attack Instrumentation

A flight deck display of angle of attack would have maintained the flightcrew's awareness of the stall condition, and it would have provided a direct indication of the pitch attitudes required for recovery throughout the attempted stall recovery sequence in this accident. The Safety Board recognizes that, in response to Safety Recommendation A-96-94 (see section 1.18.5), the FAA is currently evaluating the operational requirements for angle of attack instrumentation on transport-category aircraft. However, the Safety Board concludes that this accident might have been prevented if the flightcrew had been provided a clear, direct indication of the airplane's angle of attack. Therefore, the Safety Board reiterates Safety Recommendation A-96-94.

2.3.3 Engine Compressor Surges

Distraction may have also played a role in the flightcrew's failure to recover from the stall. The engine compressor surges that began at 1808:20 (as a result of the disruption of air flow though the No. 2 engine at the prevailing high angle of attack)[37] were loud and potentially distracting during this critical period (the airplane stalled 1 second later, according to FDR data). The flightcrew responded to the surges by reducing power on all four engines, but to differing degrees: at 18:08:27, EPR levels on the No. 1 and No. 2 engines decreased to 1.39 and 1.04, respectively. EPR levels on the No. 3 and No. 4 engines were reduced to 1.66 and 1.73,

[37]EPR data recorded on the FDR for the period when the PF advanced power to spool up the engines just prior to buffet onset indicate a very slight power increase at that time for all four engines. However, the EPR readings were split, with the No. 2 engine 0.17 EPR less than the No. 4 engine, and 0.14 and 0.12 EPR less than the Nos. 1 and 3 engines, respectively. An engine that is inadequately spooled may be more subject to engine compressor surges and may accelerate more slowly when power is advanced, resulting in yawing and rolling moments. Although the EPR split prior to buffet onset might have indicated that the No. 2 engine (which subsequently experienced engine compressor surges) was inadequately spooled for the stall recovery, the FDR data for the No. 2 engine EPR displayed inconsistencies throughout the accident flight and the preceding FEF. At times it matched the EPR of the other engines, but at other times it stabilized both above and below them. The Safety Board was unable to determine whether the slightly lower EPR on the No. 2 engine at spool-up represented an instrumentation error or a difference in the spooling of the engine.

respectively, with resultant asymmetrical thrust. At this time, the airspeed had dropped below the stall speed of 126 knots with the airplane still in a 10-degree nose-up attitude.

During the roll reversals that began at 1808:30 and that continued until impact, and with the airplane rolling at angles from -70 degrees to +115 degrees, the flightcrew's attention was most likely focused on their inability to control the airplane's roll attitude. It is possible that the pilots perceived the roll reversals to be caused by pilot-induced oscillations from rudder inputs out-of-phase with the airplane's roll/yaw moments. If so, the PF may have been devoting a great deal of attention to the increasing mismatch between his rudder control inputs and the airplane's roll attitude.

The Safety Board was unable to assess the precise role of asymmetric power in generating the rolling moments. The airplane's lateral stability would have been reduced, and its sensitivity to rudder-induced sideslip would have been increased. In the stall condition that prevailed on the accident flight; both of these factors (engine surges and rudder inputs) could also have been responsible for the rolling moments. However, the Safety Board concludes that the engine compressor surges in the No. 2 engine (caused by airflow disruption) may have distracted the flightcrew during the critical early period of the stall recovery, when sufficient lateral control was available for the recovery.

2.3.4 Ambient Lighting, Visibility, and Cloud Clearance

Although IMC prevailed for parts of the night flight, the accident airplane was in VMC above a cloud layer when the flightcrew began the stall series. However, based on weather satellite data and almanac information, the Safety Board concludes that the flightcrew did not have a clearly visible natural horizon because of darkness and clouds above and below the airplane, and that the airplane most likely encountered IMC soon after descending through 13,500 feet and remained in IMC until just before impacting terrain.

As a result of their initiating the maneuver with minimum clearance from clouds, the flightcrew was immediately forced to rely on instrument references for the stall recovery when the airplane entered a full stall and started a steep descent. The Safety Board recognizes that the artificial horizon on the electronic flight instrument system (EFIS) display facilitates precise attitude control and orientation in extreme pitch and roll attitudes. However, the natural horizon may have provided a more rapid orientation for the flightcrew in the range of +10/-20 degrees pitch and +/-70 degrees roll, which the airplane experienced during the early stages of the loss of control, because a natural horizon would have been visible through the airplane's windshield in this range of pitch and roll attitudes. Other air carriers and manufacturers require that a natural horizon be visible during approach to stall or stall characteristics checks. The Safety Board concludes that by conducting these maneuvers without a visible natural horizon, the flightcrew was deprived of an important flight attitude reference that would have aided in their recovery from a full stall. The role of ABX in regard to this issue is discussed in section 2.5.2.

2.4 Simulator Fidelity and Training for Stall Recovery Procedures

The Safety Board's evaluation of the ABX DC-8 simulator indicated that the simulator did not reproduce the stall characteristics of the DC-8 with fidelity. For example, when slowed to below the airspeed of stick shaker activation, the simulator developed a stable, nose-high, wings-level descent, with no tendency to pitch down in a stall break (abrupt nose-down pitch or roll). In contrast, according to Douglas and ABX manuals and the FDR data from the accident flight, the actual DC-8 airplane's stall characteristics include a pronounced stall break. Further, after slowing well below stall speed, the simulator entered a mode in which the aerodynamic buffet stopped and the airspeed did not continue to decrease.

The simulator's benign flight characteristics when flown more into the stall provided the flightcrew with a misleading expectation of the handling characteristics of the actual airplane. The PF's initial target pitch attitudes during the attempted stall recovery (from 10 degrees to 14 degrees) may have resulted in a successful recovery during his practice and teaching in the simulator. Further, because their experience with stalls in the DC-8 was obtained in a simulator without a stall break, the PF and PNF could not practice the nose-down control inputs required to recover a stalled airplane that is pitching down or at a nose-low attitude. Moreover, because the PF and PNF were exposed during extensive simulator experience to what they presumed was the stall behavior of the DC-8, the stall break that occurred in the airplane most likely surprised them. The Safety Board concludes that the flightcrew's exposure to a low fidelity reproduction of the DC-8's stall characteristics in the ABX DC-8 flight training simulator was a factor in the PF holding aft (stall-inducing) control column inputs when the airplane began to pitch down and roll, which contributed to the accident.

The Safety Board has previously expressed concerns about the inadequate fidelity of air carrier pilot training simulators and their deficiencies in reproducing handling characteristics of an airplane during specific maneuvers.[38] The FAA does not require air carrier flightcrews, for example, to be trained in full or deep stall maneuvers, and simulators are not required to be programmed to provide fidelity farther into the stall than the initial buffet or stick shaker.[39] Consistent with FAA requirements, simulator manufacturers do not routinely obtain accurate data about airplane stall characteristics from airplane manufacturers.[40]

However, the Safety Board is aware that for many airplane types (including the DC-8), data obtained from stall maneuvers performed during the certification process could be used to improve the fidelity of stall characteristics in air carrier flight simulators. Further, the stall phase of the flight envelope is one that has received increasing attention in air carrier pilot training through the advent of "advanced maneuver" or "selected event" training programs.[41]

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[38]See Aircraft Accident Report—"Runway Departure During Attempted Takeoff, Tower Air flight 41, Boeing 747-136, N605FF, JFK International Airport, New York, December 20, 1995" (NTSB/AAR-96/04); and Aircraft Accident Report—"Uncontrolled Collision with Terrain, Air Transport International, Douglas DC-8-63, N782AL, Kansas City International Airport, Kansas City, Missouri, February 16, 1995" (NTSB/AAR-95/06).
[39]See FAA Advisory Circular 120-40B, "Airplane Simulator Qualification."
[40]However, regardless of the level of simulator approval, a flight training simulator is required to provide "stall buffet to, but not necessarily beyond the FAA certified stall speed, V_s."
[41]See section 1.18.6.

Improved simulator fidelity may therefore benefit all pilots and passengers. The Safety Board believes that the FAA should evaluate the data available on the stall characteristics of airplanes used in air carrier service and, if appropriate, require the manufacturers and operators of flight simulators used in air carrier pilot training to improve the fidelity of these simulators in reproducing the stall characteristics of the airplanes they represent to the maximum extent that is practical; then add training in recovery from stalls with pitch attitudes at or below the horizon to the special events training programs of air carriers.

2.5 ABX Organizational Structure and Function

2.5.1 Failure of ABX to Use Revised FEF Stall Recovery Procedures

According to the POI, a revision to the FEF stall recovery procedure was agreed upon by ABX and the FAA promptly following a 1991 loss-of-control incident during an ABX DC-8 post-modification FEF. The revised FEF stall recovery procedure stressed a positive reduction of pitch attitude to rapidly decrease the angle of attack below the critical stall angle before the application of engine power. In calling for a more positive reduction of pitch attitude, the revised procedure eliminated the emphasis of the standard ABX stall recovery procedure on minimum altitude loss.

The POI stated that the revision was accepted on behalf of ABX by the pilot who was the DC-8 flight standards manager in 1991, who had also been the PIC of the incident flight. The POI said that the director of flight technical programs had little involvement in the DC-8 FEF program at that time.[42] The POI described the revision to the ABX FEF stall recovery procedures in a letter to an FAA inspector at the Winston-Salem FSDO. He told Safety Board investigators that he could not recall whether he had sent a copy of this letter to ABX, although he was certain that the revised procedures had been covered during meetings and simulator sessions with ABX. He stated that he believed the revised FEF stall recovery procedures to have been a permanent change.

The DC-8 flight standards manager (who held the position in 1991) told Safety Board investigators that he had immediately begun using the revised FEF stall recovery procedures after the 1991 incident. This use was confirmed in interviews with flightcrew members who had served as second-in-command and flight engineer on many of his flights. According to ABX records, the DC-8 flight standards manager performed most of the DC-8 post-modification FEFs (which involved stalls) from 1991 through 1994, while the director of flight technical programs performed a limited number during that period.

The POI recalled that at some time following the 1991 incident (he did not remember precisely when) the director of flight technical programs had voiced disagreement about the need to change the FEF stall recovery procedures. The POI said that he was not

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[42]ABX records indicate that the director of flight technical programs was on extended sick leave for some periods in 1989 and 1990, and he did not log flight time at ABX between February 19, 1990, and February 14, 1991. From March 1991 to August 1992, he was extensively involved in the ABX DC-9 FEF program. He returned to DC-8 flying in August 1992, and conducted two post-modification FEFs in the DC-8 through 1994.

concerned about this disagreement because, at that time, the director of flight technical programs had a limited role in the DC-8 FEF program.

The director of flight technical programs also confirmed to Safety Board investigators his belief that the stall recovery procedures contained in ABX's operations manual were adequate for FEFs if performed with sufficient attention to engine spooling. He had continued to use these stall recovery procedures when he flew FEFs. After the DC-8 flight standards manager, who had adopted the revised FEF procedure, returned to line flying in 1994 and was replaced by the accident PNF, the director of flight technical programs trained the accident PNF using the original stall recovery procedure. The accident PNF, in turn, trained the accident PF.

The Safety Board notes that some provisions of the revised procedure were implemented and used during the accident flight, although the manner in which they were used confirmed that the flightcrew was attempting the original, minimum altitude loss stall recovery. For example, the flightcrew used the block altitude clearance designed to provide sufficient altitude for stall recoveries involving greater altitude loss. However, they only obtained a 2,000-foot block, rather than the 3,000-foot to 5,000-foot block specified in the revised procedure. In addition, they conducted the stall 500 feet above the bottom of the altitude block and only slightly above the clouds. The flightcrew also referred to engine spooling. Further, although both pilots received simulator training during their informal qualification as FEF pilots, ABX did not implement a simulator session prior to each FEF, which was also specified by the POI.

Despite its partial implementation of the revised procedure, the statements of the director of flight technical programs and the actions of the accident flightcrew show that ABX ultimately did not institutionalize the technique of exchanging altitude for a more rapid stall recovery, and thus failed to take advantage of the valid lessons of the 1991 DC-8 FEF loss-of-control incident. The revised FEF stall recovery procedure (temporarily adopted by the DC-8 flight standards manager) was designed to provide an immediate stall recovery and prevent the occurrence of engine compressor surges (which occurred in the 1991 loss-of-control incident and on the accident flight). In contrast, the minimum altitude loss stall recovery procedure contained in ABX's DC-8 operations manual re-instituted by the director of flight technical programs extended the airplane's operation at a critical angle of attack and added significant exposure to the distracting and destabilizing effects of engine compressor surges.

The Safety Board concludes that the accident could have been prevented if ABX had institutionalized and the flightcrew had used the revised FEF stall recovery procedure agreed upon by ABX in 1991. The Safety Board believes that the FAA should ensure that ABX explicitly incorporates the revised FEF stall recovery procedure (that was agreed upon in 1991 by ABX and the FAA), or an equivalent procedure, in its DC-8 FEF program.

2.5.2 FEF Conditions and Limitations Guidance

ABX had no specific prohibition against conducting an FEF at night. In addition, the pilots' direct supervisor, the director of training and standards, stated that he had conducted

FEFs at night and that he would have approved the operation of the accident flight at night had he been asked by the flightcrew. ABX's director of flight technical programs also stated that he had conducted several FEFs at night, although he said that he preferred to conduct the flights during the day. In contrast to this practice at ABX, procedures established by a major U.S. airplane manufacturer for the first flight[43] after a major modification stated, "If a flight cannot depart on time to be completed by nightfall, then it should be rescheduled for the next morning."

Although ABX had set weather minimums for FEF takeoffs, no weather minimums were established by ABX for maneuvers performed at higher altitudes and beyond the vicinity of an airport, such as a stall series. Further, the guidance provided by ABX to flightcrews for the performance of the clean stall maneuver specified a minimum altitude of 10,000 feet agl; a maximum altitude of 15,000 feet msl was also specified. However, no requirements were established by ABX for ambient lighting conditions, visual references, or distance from cloud tops. (The director of flight technical programs told Safety Board investigators that he preferred the stall series not to be performed in IMC.)

In contrast, manuals of two airplane manufacturers reviewed by the Safety Board limited the stall maneuver to daylight hours. The Douglas Aircraft Company production flight minimums further specified maximum cloud tops of 5,000 feet msl, with at least 5,000 feet clearance from clouds for performance of the stall series. In addition, the Douglas manual stated that the stall series should be performed in VMC with a visible natural horizon. This restriction to a stall recovery using visual references was echoed in the manuals of two of the three air carriers reviewed by the Safety Board.

Further, according to Douglas, the approved tolerance for DC-8 stick shaker activation was within 5 knots of the calculated stick shaker activation speed. Similarly, a major manufacturer's flight evaluation profile stated that an evaluation flight should be terminated if the stick shaker has not actuated 5 knots below the computed value. Although the ABX "Flight Test Report" provided acceptable tolerances for some evaluation items, it did not provide the acceptable tolerances for the stick shaker and stall tests or a further explanation of the maneuver. The establishment of those tolerances would have helped the crew of the accident flight to identify an inoperative stick shaker and possibly preclude entry into a full stall.

The Safety Board concludes that ABX's failure to require completion of an FEF by sundown or to establish adequate limitations on ambient lighting and weather conditions led the flightcrew to attempt the stall series in the absence of a natural horizon, and contributed to the accident. Further, based on its review of the provisions of selected air carrier and manufacturer manuals, the Safety Board concludes that there is a lack of consistency across the industry in the conditions and limitations for conducting FEFs and associated approach to stall maneuvers. Consequently, the Safety Board believes that the FAA should develop an advisory circular (AC)[44] that provides guidance to air carriers on the appropriate conditions, limitations and

[43]Because the functional check flight on December 21, 1996, was terminated prematurely because of mechanical problems and the flight control tests (including the stall series) were not completed, the Safety Board considers the accident flight to be the continuation of the "first flight" following major modification.
[44]An FAA advisory circular provides nonregulatory guidance to certificate holders for a means, but not necessarily the only means, of complying with Federal Aviation Regulations.

tolerances for the performance of FEFs and the specific maneuvers performed during these flights, including approaches to stall.

2.5.3 Training of Flightcrews for Nonroutine Operations

Although the pilots of the accident flight had less PIC experience in the DC-8 and less recent flying experience than many other pilots who did not have management responsibilities, the Safety Board was unable to identify any link between these measures of experience and the flightcrew's performance during the accident flight. As a result of their instruction and check airman duties, both pilots were well-acquainted with ABX procedures for conducting a stall in the clean configuration. However, an analysis of the accident pilots' recent flight experience showed that the PF had no experience as a pilot on a post-modification DC-8 FEF before the first evaluation flight on December 21, 1996. Although the PNF, who was the PIC on the accident flight, had been trained to conduct post-modification DC-8 FEFs by the director of flight technical programs 2 years before the accident, he had never served as PIC on a post-modification DC-8 FEF prior to December 21. In addition, the director of flight technical programs had operated the controls during most of the maneuvers in previous evaluation flights, while the accident PNF had occupied the right seat. The clean stall maneuver was performed by ABX pilots in the airplane only during post-modification FEFs. Therefore, neither pilot involved in the accident had performed the clean stall maneuver in a DC-8 airplane before the accident flight.

The ABX director of flight technical programs developed the flight evaluation profile for the DC-8 fleet specifying the maneuvers to be performed during FEFs. The form describing this profile, however, consisted only of a list of maneuvers with space provided for entering evaluation data during the flight. Limited guidance on the performance of FEF maneuvers was included on the form or in any other ABX publication. Training for FEFs was informal and undocumented, and ABX had established no specific training or proficiency requirements for pilots conducting FEFs.

The informality of its FEF training program led ABX to fail to recognize that a post-modification FEF was a non-routine operation with special characteristics, including further entry into the stall than was provided in regular line pilot training and for which the simulator did not provide adequate fidelity. In contrast, if ABX had been required to develop a formal curriculum for training FEF procedures, the air carrier may have recognized that simulator training for FEF stall recoveries (which comprised the PF's training for FEFs) was inadequate, and that the additional training received by the PNF (which was limited to observing the director of flight technical programs performing the stall series during several FEFs), also was inadequate. Both pilots should have been given the opportunity to perform the stall in the airplane, under the supervision of a check pilot who had previous experience with the maneuver. The Safety Board concludes that the informality of the ABX FEF training program contributed to the accident by permitting the inappropriate pairing of two pilots for an FEF, neither of whom had handled the flight controls during an actual stall in the DC-8.

Beyond providing the opportunity for ABX to have better identified the training needs of its FEF pilots, a requirement for a formal training program in FEF procedures would have also facilitated the review, approval, and surveillance of the air carrier's FEF program by the FAA. This would have increased the likelihood that the deficiencies of the program would have been identified and corrected prior to the accident.

In its investigation of a February 16, 1995, DC-8 accident at Kansas City International Airport,[45] the Safety Board also found evidence of inadequate flightcrew training and qualification for a nonroutine, special operation (a three-engine ferry operation). In both the Kansas City accident and this accident, the lack of explicit procedures and formal training for conducting nonroutine operations exposed the flights to unnecessary risks. The Safety Board concludes that the occurrence of fatal accidents during two different nonroutine operations (an FEF and a three-engine ferry) by air carriers indicates a need to identify other nonroutine operations conducted by air carriers that may require additional procedural definition and training measures. Consequently, the Safety Board believes that the FAA should identify the set of operations conducted by air carriers that require special consideration, including FEFs and other nonroutine operations that have similar needs for training and operational guidance; then amend air carrier operations specifications to include appropriate guidelines and limitations for these nonroutine operations and amend Subpart N of Title 14 CFR Part 121 to require air carriers to establish appropriate flightcrew training and qualification requirements in their training manuals.

2.5.4 Potential Pressures on the Flightcrew

Although performing a post-modification FEF at night was an accepted practice at ABX, according to the flightcrew's supervisors, it was preferable to conduct the FEF stall series during the day. The prospect of conducting the stall series at night should have at least prompted the flightcrew to consider whether additional risks were involved, both prior to departure and while preparing to perform the stall maneuver. The Safety Board evaluated whether the flightcrew's decision to undertake the FEF at night was prompted by supervisory or self-imposed pressure.

Completion of modifications to N827AX had been delayed for several months. Although ABX operational and maintenance managers said that the company had made no specific plans to use the airplane in revenue service, ABX marketing managers indicated that the delayed availability of the airplane had caused the company to inform a freight charter customer that its charters were subject to cancellation on short notice (because N827AX would not be available in case another airplane needed repairs) and subsequently to cancel one of these charters. In addition, the loss of the airplane in the accident caused ABX to lose another charter opportunity.

The Safety Board was unable to identify the accident flightcrew's state of awareness of these specific plans for N827AX; however, according to ABX's director of flight training and standards, the accident PNF was aware of the company's desire to place the airplane

[45] NTSB/AAR-95/06. <u>op. cit.</u>

in revenue service. The flightcrew, as ABX managers, would most likely have responded to the urgency to place the airplane in service with a strong effort to get the job done.

However, there was no evidence of direct pressure on the flightcrew from higher level ABX managers to complete the flight. Further, on the day of the accident, the flightcrew had experienced a succession of delays as maintenance was completed on the airplane. The crew must have only gradually become aware, as the delays extended, that the planned evaluation flight could not be completed in daylight conditions. For the flight's originally scheduled 1320 departure time and for several of the subsequent estimated departure times, the flightcrew would have assessed that they could complete the flight in daylight; after having made these initial assessments, it may have been more difficult for them to reverse their decision to perform the flight. The Safety Board concludes that the flightcrew's decision to conduct the flight at night was influenced by the succession of delays they had experienced earlier in the day.

2.6 FAA Oversight

2.6.1 FAA Surveillance of ABX

The FAA's 1991 NASIP inspection found evidence that ABX had problems ensuring that company manuals and other documentation of operations procedures kept pace with the company's growth. There were no requirements for the FAA to provide surveillance of the FEF program, and there was no documentation on the FEF program in the NASIP report. However, this accident has indicated that the ABX FEF program was also functioning with inadequately defined and documented guidelines for conducting evaluation flights, and inadequate flightcrew training and qualification standards for FEFs. Therefore, the FEF program deficiencies were consistent with the general problems identified by the 1991 FAA inspection.

Subsequent action by ABX and the FAA to resolve these general deficiencies focused on the specific operational areas identified by the NASIP inspection. The Safety Board concludes that the deficiencies of the ABX FEF program remained latent after general organizational problems were identified by the NASIP in the other company functions. To ensure that inadequacies in the FEF program are corrected at ABX and, if necessary, at other air carriers, the Safety Board believes that the FAA should undertake an appropriate level of surveillance of the FEF programs of all air carriers, following implementation of the Board's suggested changes to FEF and other nonroutine operations (see section 2.5.3).

The Safety Board notes that the FAA POI assigned to ABX successfully identified the safety issues raised in the 1991 DC-8 loss of control incident, as shown by his efforts to cause ABX to revise its FEF stall recovery procedures and the air carrier's implementation of this revision. The response of the FAA principal operations inspector to the 1991 ABX DC-8 loss-of-control incident was timely and appropriate, but it was not formally incorporated into ABX procedures.

2.6.2 Operating Authority to Conduct the Accident Flight

ABX maintenance department managers asserted that ABX was authorized to conduct the functional test flight of N827AX under the regulations of 14 CFR Part 91. The FAA POI concurred with the procedures being used by ABX. However, the Safety Board identified confusion among FAA personnel regarding whether it was appropriate to operate the flight without a letter of deviation authority under 14 CFR Part 125.3, and whether it was appropriate to have added the accident airplane to the ABX aircraft list prior to the completion of all airworthiness certification activities, including the FEF and a final conformity inspection that was to follow the FEF. TIMCO, in a letter to the Safety Board, expressed its desire for the FAA to clarify this issue.

Based on the apparent confusion within the FAA and among the air carrier operations and maintenance communities about regulatory requirements for operating an FEF, the Safety Board concludes that the currently established FAA airworthiness and operating procedural requirements for conducting FEFs on large transport aircraft provide inadequate guidance to air carrier operators, maintenance repair stations, FAA principal operations and maintenance inspectors, and other affected parties. Consequently, the Safety Board believes that the FAA should modify the operating and airworthiness regulations of Title 14 CFR or issue appropriate guidance material to clarify airworthiness and operational procedural requirements for conducting FEFs in transport-category aircraft.

3. CONCLUSIONS

3.1 Findings

1. The pilot flying made a timely decision to terminate the clean stall and begin the stall recovery.

2. The pilot flying applied inappropriate control column back pressure during the stall recovery attempt in an inadequate performance of the stall recovery procedure established in ABX's operations manual.

3. Aircraft weight and balance were not a factor in the greater-than-expected buffet onset speed; and the airplane was loaded within its approved weight and balance limits during the accident flight.

4. Some combination of airframe icing, flight control rigging, or other factors resulted in the greater-than-expected buffet onset speed; however, any effects of airframe icing or flight control rigging upon the stall speed of the accident airplane were minimal.

5. Although the pilot flying trimmed the airplane below the recommended minimum trim speed for the clean stall, this action did not contribute to the accident.

6. The pilot not flying, in the right seat, was serving as the pilot-in-command of the accident flight and was conducting instruction in functional evaluation flight procedures; and the pilot flying, in the left seat, was serving as the second-in-command and was receiving instruction in functional evaluation flight maneuvers, including the clean stall maneuver.

7. The pilot not flying, as the pilot-in-command, failed to recognize, address and correct the pilot flying's inappropriate control inputs.

8. The absence of the stick shaker prior to the stall did not affect the flightcrew's recognition of the initial entry into the stall.

9. The inoperative stall warning system failed to reinforce to the flightcrew the indications that the airplane was in a full stall during the recovery attempt.

10. This accident might have been prevented if the flightcrew had been provided a clear, direct indication of the airplane's angle of attack.

11. The engine compressor surges in the No. 2 engine (caused by airflow disruption) may have distracted the flightcrew during the critical early period of the stall recovery, when sufficient lateral control was available for the recovery.

12. The flightcrew did not have a clearly visible natural horizon because of darkness and clouds above and below the airplane, and the airplane most likely encountered instrument meteorological conditions soon after descending through 13,500 feet and remained in instrument meteorological conditions until just before impacting terrain.

13. By conducting these maneuvers without a visible natural horizon, the flightcrew was deprived of an important flight attitude reference that would have aided in their recovery from a full stall.

14. The flightcrew's exposure to a low fidelity reproduction of the DC-8's stall characteristics in the ABX DC-8 flight training simulator was a factor in the pilot flying holding aft (stall-inducing) control column inputs when the airplane began to pitch down and roll.

15. The accident could have been prevented if ABX had institutionalized and the flightcrew had used the revised functional evaluation flight stall recovery procedure agreed upon by ABX in 1991.

16. ABX's failure to require completion of a functional evaluation flight by sundown or to establish adequate limitations on ambient lighting and weather conditions led the flightcrew to attempt the stall series in the absence of a natural horizon.

17. There is a lack of consistency across the industry in the conditions and limitations for conducting functional evaluation flights and associated approach to stall maneuvers.

18. The informality of the ABX functional evaluation flight training program permitted the inappropriate pairing of two pilots for a functional evaluation flight, neither of whom had handled the flight controls during an actual stall in the DC-8.

19. The occurrence of fatal accidents during two different nonroutine operations (a functional evaluation flight and a three-engine ferry) by air carriers indicates a need to identify other nonroutine operations conducted by air carriers that may require additional procedural definition and training measures.

20. The flightcrew's decision to conduct the flight at night was influenced by the succession of delays they had experienced earlier in the day.

21. The deficiencies of the ABX functional evaluation flight program remained latent after general organizational problems were identified by the 1991 National Aviation Safety Inspection Program in the other company functions.

22. The response of the FAA principal operations inspector to the 1991 ABX DC-8 loss-of-control incident was timely and appropriate, but it was not formally incorporated into ABX procedures.

23. The currently established FAA airworthiness and operating procedural requirements for conducting functional evaluation flights on large transport aircraft provide inadequate guidance to air carrier operators, maintenance repair stations, FAA principal operations and maintenance inspectors, and other affected parties.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable causes of this accident were the inappropriate control inputs applied by the flying pilot during a stall recovery attempt, the failure of the nonflying pilot-in-command to recognize, address, and correct these inappropriate control inputs, and the failure of ABX to establish a formal functional evaluation flight program that included adequate program guidelines, requirements and pilot training for performance of these flights. Contributing to the causes of the accident were the inoperative stick shaker stall warning system and the ABX DC-8 flight training simulator's inadequate fidelity in reproducing the airplane's stall characteristics.

4. RECOMMENDATIONS

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

--to the Federal Aviation Administration:

Require Douglas Aircraft Company to review and amend the stall warning test procedures in the DC-8 maintenance manual and maintenance planning document to include regular calibration and functional checks of the complete stall warning system. (A-97-46)

Evaluate the data available on the stall characteristics of airplanes used in air carrier service and, if appropriate, require the manufacturers and operators of flight simulators used in air carrier pilot training to improve the fidelity of these simulators in reproducing the stall characteristics of the airplanes they represent to the maximum extent that is practical; then add training in recovery from stalls with pitch attitudes at or below the horizon to the special events training programs of air carriers. (A-97-47)

Ensure that ABX explicitly incorporates the revised functional evaluation flight stall recovery procedure (that was agreed upon in 1991 by ABX and the FAA), or an equivalent procedure, in its DC-8 functional evaluation flight program. (A-97-48)

Develop an advisory circular that provides guidance to air carriers on the appropriate conditions, limitations and tolerances for the performance of functional evaluation flights and the specific maneuvers performed during these flights, including approaches to stall. (A-97-49)

Identify the set of operations conducted by air carriers that require special consideration, including functional evaluation flights and other nonroutine operations that have similar needs for training and operational guidance; then amend air carrier operations specifications to include appropriate guidelines and limitations for these nonroutine operations and amend Subpart N of Title 14 Code of Federal Regulations Part 121 to require air carriers to establish appropriate flightcrew training and qualification requirements in their training manuals. (A-97-50)

Undertake an appropriate level of surveillance of the functional evaluation flight programs of all air carriers, following implementation of the Board's suggested changes to functional evaluation flight and other nonroutine operations.
(A-97-51)

> Modify the operating and airworthiness regulations of Title 14 Code of Federal Regulations or issue appropriate guidance material to clarify airworthiness and operational procedural requirements for conducting functional evaluation flights in transport-category aircraft. (A-97-52)

In addition, the Safety Board reiterates Safety Recommendation A-96-94 to the FAA:

> Require that all transport-category aircraft present pilots with angle of attack information in a visual format, and that all air carriers train their pilots to use the information to obtain maximum possible climb performance.

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

James E. Hall
Chairman

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Vice Chairman

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Member

July 15, 1997

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5. APPENDIXES

APPENDIX A—INVESTIGATION AND HEARING

1. Investigation

The National Transportation Safety Board was notified of this accident about 1900 on December 22, 1996. A go-team dispatched from Washington, D. C., shortly thereafter, arrived in Bluefield, West Virginia, and proceeded to the scene. Investigative specialists for meteorology, operations, powerplants, structures, systems and maintenance gathered evidence at the scene for about 1 week. Investigative groups for the cockpit voice recorder, flight data recorder and airplane performance were also formed in Washington, D. C. A Safety Board Member did not travel to the scene.

Parties to the investigation were the Federal Aviation Administration, Douglas Aircraft Company, ABX Air Inc. (Airborne Express), United Technologies Pratt & Whitney, and Triad International Maintenance Corporation (TIMCO).

2. Public Hearing

No public hearing was held in connection with this accident investigation.

APPENDIX B—COCKPIT VOICE RECORDER TRANSCRIPT

LEGEND

RDO	Radio transmission from accident aircraft
CAM	Cockpit area microphone voice or sound source
TWR	Radio transmission from Greensboro control tower
DEP	Radio transmission from Greensboro departure control
CTR	Radio transmission from Atlanta center
UNK	Radio transmission received from unidentified aircraft
-1	Voice identified as Co-Pilot
-2	Voice identified as Pilot-in-Command (PIC)
-3	Voice identified as flight engineer
-4	Voice identified as first ACM
-5	Voice identified as second ACM
-6	Voice identified as third ACM
-7	Aircraft mechanical voice
-?	Voice unidentified
*****	Unintelligible word
@	Non pertinent word
#	Expletive
- - -	Break in continuity
( )	Questionable insertion
[ ]	Editorial insertion
.....	Pause

Note 1: Times are expressed in central standard time (CST).

Note 2: Words shown with excess vowels, letters, or drawn out syllables are a phonetic representation of the words as spoken.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**

START of RECORDING

START of TRANSCRIPT

1739:08 **CAM-2**	* checked.		
1739:09 **CAM-1**	clear left.		
1739:11 **CAM-3**	reverse hydraulic pump?		
1739:13 **CAM-2**	on. pressure checked.		
1739:15 **CAM-3**	ignition?		
1739:16 **CAM-2**	on both.		
1739:16 **CAM-3**	transponder?		
1739:17 **CAM-2**	on. three five six zero.		
1739:20 **CAM-3**	freon, CTC recirc fans set, fuel management set standby rudder pump on, before takeoff checklist complete.		
1739:27 **CAM**	[sound similar to engines increasing in RPM]		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1739:42 **CAM-1**	eighty percent, rolling.		
1739:44 **CAM-3**	jet pump off.		
1739:46 **CAM**	[sound of further increase in RPM similar to takeoff power being applied]		
1739:52 **CAM**	[sound of click]		
1739:52 **CAM-1**	set max power.		
1739:55 **CAM**	[sound of sliding click similar to auto-spoiler system re-setting]		
1739:57 **CAM-3**	max power set.		
1740:01 **CAM-2**	one hundred knots.		
1740:02 **CAM-1**	checked.		
1740:03 **CAM-2**	V one.		
1740:05 **CAM-2**	rotate.		
1740:10 **CAM-2**	V two.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1740:12 **CAM-1**	positive rate, gear up.		
1740:13 **CAM-2**	positive rate.		
1740:14 **CAM**	[sound similar to landing gear warning horn starts]		
1740:16 **CAM-2**	* *.		
1740:18 **CAM**	[sound similar to landing gear warning horn stops]		
		1740:21 **TWR**	ABX eight twenty seven heavy, contact departure.
		1740:23 **RDO-2**	eight twenty seven heavy roger.
1740:24 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1740:32 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1740:35 **CAM-2**	one thousand feet.		
1740:36 **CAM-1**	roger.		
		1740:37 **RDO-2**	*, ABX eight twenty seven is two thousand five hundred for five thousand.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1740:41 **DEP**	ABX eight twenty seven Greensboro departure, radar contact, turn right heading uh, I'll tell ya, turn right direct to BOTTM climb and maintain one two thousand.
1740:43 **CAM-1**	flaps zero set MCT.		
1740:44 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
		1740:50 **RDO-2**	BOTTM one two thousand, ABX eight two seven heavy.
1740:54 **CAM-1**	right direct BOTTM, cleared to one two thousand.		
1740:57 **CAM-2**	roger.		
1741:00 **CAM-2**	you did say flaps zero, right?		
1741:01 **CAM-1**	yes.		
1741:03 **CAM-2**	did you say MCT? I didn't hear you.		
1741:05 **CAM-1**	yes I did say that.		
1741:06 **CAM-3**	MCT.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1741:13 **CAM-2**	three thousand feet.		
1741:14 **CAM-3**	MCT set, ignition off.		
1741:18 **CAM**	[sound of unintelligible conversation in background]		
1741:20 **CAM-?**	** nose gear **.		
1741:22 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1741:30 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1741:24 **CAM-?**	** nose gear extension *.		
1741:42 **CAM-2**	let's do an up-latch check just for the hell of it.		
1742:08 **CAM-2**	we climb up you wanna cycle the gear once to see if we get that horn again?		
1742:11 **CAM-1**	yeah, I don't know why, what we got there.		
1742:14 **CAM-?**	OK.		
1742:14 **CAM-1**	well anyway, gear down.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1742:15 **CAM**	[sound similar to landing gear being extended]		
1742:31 **CAM-1**	that's good.		
1742:33 **CAM-1**	gear up.		
1742:34 **CAM**	[sound of click and sound similar to landing gear being retracted]		
1742:39 **CAM-2**	better that time.		
1742:54 **CAM-4**	when we get to a point, maybe try the flaps back down.		
1742:56 **CAM-1**	yeah that's what I was going to say w ** ya.		
1742:59 **CAM-2**	you're OK on speed, you want flaps?		
1743:00 **CAM-1**	yeah, let's go flaps twelve.		
		1743:04 **DEP**	ABX eight two seven heavy, contact Atlanta center one two eight point eight, good day.
		1743:09 **RDO-2**	two eight eight, ABX eight two seven heavy.
1743:20 **CAM-2**	flaps twelve set.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1743:22 **RDO-2**	Atlanta, ABX eight two seven heavy is uh, one zero thousand for one two thousand.
		1743:28 **CTR**	ABX eight twenty seven heavy, Atlanta center roger good evening, climb and maintain one five thousand. and when you leave one three thousand, you're cleared direct Pulaski. rest of * route unchanged.
		1743:38 **RDO-2**	* and ABX eight two seven uh, we're on a maintenance check uh, any chance we can get a block of one zero to one two thousand for a few minutes?
		1743:46 **CTR**	OK, could you take a block of uh, thirteen to fifteen, would that uh, work for you?
		1743:50 **RDO-2**	we can do that.
		1743:51 **CTR**	ABX eight twenty seven roger uh, climb and maintain block altitude of uh, one three thousand through one five thousand.
		1744:00 **RDO-2**	roger ABX eight two seven uh, block one three through one five thousand.
		1744:04 **CTR**	do you eventually gonna want to go up to flight level three five zero ABX uh, eight twenty seven?

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1744:04 **CAM-1**	block of one three to one five.		
		1744:08 **RDO-2**	yeah we'll need that eventually, probably about half an hour at this uh, altitude.
		1744:12 **CTR**	ABX uh, eight twenty seven OK, I'm gonna show that for your uh, final for now. when you need higher, just let the next controller now. I know you're going to be actually gonna be on that routing there uh, Pulaski up to Beckley uh, and the rest of that.
		1744:24 **RDO-2**	uh, yeah that'd be fine.
		1744:25 **CTR**	ABX eight twenty seven roger.
1744:30 **CAM-2**	thousand from the block. I don't know ***.		
1744:31 **CAM-1**	let's just go to fourteen then.		
1744:33 **CAM-2**	all right, we'll try the gear with flaps.		
1744:35 **CAM-1**	gear down.		
1744:36 **CAM-?**	*.		
1744:37 **CAM**	[sound similar to landing gear warning horn starts]		

INTRA-COCKPIT COMMUNICATION | **AIR-GROUND COMMUNICATION**

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1744:41 **CAM**	[sound similar to landing gear being extended]		
1744:41 **CAM-2**	little weird.		
1744:45 **CAM**	[sound similar to landing gear warning horn stops]		
		1744:48 **CTR**	and ABX eight twenty seven, ** confirm I heard that uh, the altitude's back right uh, it's thirteen uh, block fifteen.
		1744:53 **RDO-2**	that's affirmative, one three to one five.
		1744:55 CTR	*.
1744:57 **CAM-2**	you want to try it up *.		
1744:58 **CAM-1**	yeah, gear up.		
1744:59 **CAM**	[sound similar to altitude alert signal]		
1745:03 **CAM**	[sound similar to landing gear warning horn]		
1745:05 **CAM-1**	well I guess we'll try the engine anti-ice there, engine anti-ice scoop heat on.		

INTRA-COCKPIT COMMUNICATION | AIR-GROUND COMMUNICATION

INTRA-COCKPIT TIME & SOURCE	INTRA-COCKPIT CONTENT	AIR-GROUND TIME & SOURCE	AIR-GROUND CONTENT
1745:09 **CAM-2**	OK. two and three.		
1745:13 **CAM**	[sound of click]		
1745:14 **CAM-2**	on.		
1745:15 **CAM-3**	checked.		
1745:16 **CAM-2**	one and four.		
1745:18 **CAM**	[sound of click]		
1745:18 **CAM-2**	on.		
1745:19 **CAM-3**	checked.		
1745:20 **CAM-2**	scoops...		
1745:22 **CAM**	[sound of click]		
1745:22 **CAM-2**	on.		
1745:25 **CAM-3**	didn't get a left one, try it again.		
1745:26 **CAM-2**	all right. scoops.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1745:28 **CAM-2**	off.		
1745:30 **CAM**	[sound of clicks]		
1745:32 **CAM-3**	checked on the right one, and I'm not gettin' **.		
1745:34 **CAM-2**	OK scoops... on.		
1745:40 **CAM**	[sound similar to engines decreasing in RPM]		
1745:42 **CAM-3**	couldn't tell, let's do it again. put the power back up to about **.		
1745:45 **CAM-1**	all right. sorry, let's try it again.		
1745:48 **CAM-2**	scoops...		
1745:50 **CAM**	[sound of click]		
1745:50 **CAM-2**	off.		
1745:54 **CAM-3**	OK let's let's let's try and leave 'em on for a second and I'll watch 'em.		
1745:57 **CAM-1**	OK.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1745:58 **CAM-3**	I'm ready here.		
1745:59 **CAM-2**	OK, scoops... on.		
		1746:03 **CTR**	ABX eight twenty seven uh, is cleared direct Pulaski, rest of the route unchanged.
		1746:07 **RDO-2**	eight twenty seven direct Pulaski, ABX eight two seven heavy.
1746:10 **CAM-1**	* cleared direct Pulaski.		
1746:11 **CAM-3**	left one ain't working.		
1746:11 **CAM-?**	* there.		
1746:13 **CAM-3**	the left's not working. lets check the right one.		
		1746:15 **CTR**	ABX eight twenty seven, are you gonna be operating at a reduced airspeed or uh, you gonna be normal speed.
		1746:20 **RDO-2**	uh yes sir, we'll be reduced airspeed about a hundred and sixty knots for a little while here.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1746:25 CTR	**.
		1746:28 **CAM-1**	direct Pulaski, direct Pulaski LRN's, one and two and uh, also on nav * and uh, I got it set on my side on the LRN.
1746:36 **CAM-2**	all right, it's in nav one and two.		
		1746:50 **CTR**	ABX eight twenty seven, turn right heading of uh, three six zero vectors for traffic.
		1746:55 **RDO-2**	ABX eight two seven uh, right three six zero.
1746:57 **CAM-1**	right three six zero.		
1746:59 **CAM-2**	roger.		
1747:01 **CAM-1**	flaps zero. I don't know if we need them up or down there any more, we know where the problem is **.		
1747:04 **CAM-2**	OK, ready?		
1747:05 **CAM-2**	flaps *.		
1747:06 **CAM**	sound of click.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1747:08 **CAM-2**	yeah. and then we're gonna do our uhhh, manual drop...		
1747:12 **CAM-3**	yeah.		
1747:12 **CAM-1**	go ahead.		
1747:16 **CAM-1**	OK uh.		
1747:17 **CAM-2**	you ready to start? ... ready for hydraulics to come off Keith?		
1747:24 **CAM-1**	yeah, go right ahead.		
1747:25 **CAM-2**	go ahead Terry.		
1747:26 **CAM-3**	OK, gear free fall one point five Vs zero.		
1747:29 **CAM-?**	*.		
1747:30 **CAM-3**	gear up power lever off.		
1747:31 **CAM-2**	accelerate to two hundred.		
1747:33 **CAM-3**	both engine hydraulic pumps bypass.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1747:34 **CAM-1**	yeah you wanna be at uh		
1747:36 **CAM-2**	one uh, one point five Vs zero.		
1747:37 **CAM-1**	OK one eighty eight.		
1747:38 **CAM-?**	OK.		
1747:39 **CAM-3**	OK, whenever you're ready.		
1747:41 **CAM-1**	try to get up to speed here.		
1747:56 **CAM-2**	OK, you ready?		
1748:01 **CAM-1**	yeah, I'm ready, gear down.		
1748:03 **CAM**	[sound similar to landing gear being extended]		
1748:16 **CAM-2**	down three green		
1748:17 **CAM-3**	got it.		
1748:24 **CAM-3**	are you ready to bring it up on the aux pump want me turn on the aux pump to get pressure?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1748:27 **CAM-3**	***.		
1748:34 **CAM-1**	we're gettin' a little bit of ice here, we ...		
1748:36 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1748:37 **CAM-1**	...* probably get out of this.		
1748:54 **CAM-3**	let's go ahead and try it now.		
1748:55 **CAM-2**	OK, ready *.		
1748:57 **CAM-3**	* * pumps, yeah.		
1749:10 **CAM-3**	well we have eighty seconds on this.		
1749:12 **CAM-2**	all right?		
1749:15 **CAM-1**	there's that vibration again.		
1749:18 **CAM-3**	yeah, that was just...		
		1749:18 **CTR**	ABX uh, eight twenty seven heavy is now cleared again direct Pulaski. rest of the route unchanged.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1749:22 **CAM-3**	.. I guess just.		
1749:25 **CAM-1**	direct Pulaski. direct Pulaski LRN one and two.		
1749:34 **CAM-3**	forty seconds have went by so we still got forty more.		
1749:53 **CAM-1**	OK **.		
1749:55 **CAM-3**	it's up.		
1749:55 **CAM-2**	sorry.		
1749:56 **CAM-3**	OK, here we go. cycle gear two hundred thirty knots. extend and retract aileron power lever on... both engine hydraulic pumps on.		
1750:05 **CAM-2**	all right.		
1750:10 **CAM-3**	turn aux hydraulic pump off.		
1750:18 **CAM-3**	let me know when you're ready.		
1750:20 **CAM-1**	roger.		
1750:34 **CAM-1**	there's two hundred and thirty knots.... gear down.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1750:37 **CAM-2**	gear down.		
1750:39 **CAM**	[sound similar to landing gear being extended]		
1750:46 **CAM-1**	* get * some (lights) off here.		
1750:54 **CAM-2**	down three green.		
1750:56 **CAM-3**	OK ready to bring 'em up.		
1750:58 **CAM-1**	gear up.		
1750:59 **CAM**	[sound similar to landing gear being retracted]		
1751:06 **CAM-?**	** sound like ***.		
1751:16 **CAM-2**	red light.		
1751:19 **CAM-2**	OK, that's out.		
1751:21 **CAM-3**	* that was kinda slow but.		
1751:25 **CAM-3**	coming back. * pull the circuit breaker here....		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1751:42 **CAM-3**	**...**. K, I got the landing gear warning horn interlock circuit breaker pulled...		
1751:45 **CAM-?**	*.		
1751:46 **CAM-3**	... so we're not gonna have any lights on the landing gear.		
1751:47 **CAM-2**	all right **.		
1751:49 **CAM-3**	OK, the next thing is at two hundred knots. flaps zero extend wings to fifty while slowing to one point three.		
		1751:55 **CTR**	ABX eight twenty seven, contact Atlanta center one three two point niner.
		1751:59 **RDO-2**	thirty two nine, ABX eight two seven heavy.
1752:10 **CAM-1**	Garth if we could get up to fifteen, I think we could get out of this stuff.		
1752:13 **CAM-2**	OK you can go on up there. we're we got that block.		
1752:15 **CAM-1**	I mean as far as doing uh, let's let's just do that * I'll go on up *. if we need a, need a block up there.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1752:18 **CAM-2**	yeah.		
1752:19 **CAM-1**	* we just flew out of it. let's stay here for a second.		
		1752:30 **RDO-2**	Atlanta, ABX eight two seven heavy is in a block of one three to one five thousand.
1752:52 **CAM-3**	I'm not ready to do... I wanta * ... at two hundred knots flaps zero. extend flaps to fifty. while slowing to one point three Vs fifty. which is.....		
1753:03 **CAM-2**	we need to get that speed.		
1753:05 **CTR**	* six eight two seven Zulu, Atlanta center roger. climb and maintain flight level two one zero.		
1753:07 **CAM-3**	let me get it here for you.		
		1753:08 **RDO-2**	and ABX eight two seven uh, any chance we can stay in the block here one three to one five for uh, probably thirty minutes?
		1753:16 **CTR**	ABX eight twenty seven uh, I was talking to another air-craft. main, maintain your altitude or block right now and I'll check it out.
		1753:23 **RDO-2**	all right, thank you.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1753:25 **CTR**	there is a uh, eight two seven Zulu on the frequency.
1753:33 **CAM-?**	uh, let's see.		
		1753:33 **CTR**	ABX eight twenty seven there's another frequency and he's uh, the call sign is November six eight two seven Zulu.
		1753:41 **RDO-2**	roger, ABX eight two seven.
1753:43 **CAM-2**	about one thirty is close enough.		
1753:44 **CAM-1**	one, one thirty is it.		
1753:46 **CAM-?**	one thirty *.		
1753:47 **CAM-1**	I gotta get reconfigured here.		
1753:51 **CAM-?**	OK.		
1753:52 **CAM-3**	OK so aux hydraulic pump is on. both engine hydraulic pumps are bypassed.		
1754:00 **CAM-1**	OK.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1754:02 **CAM-3**	we're going from flaps zero to flaps fifty whenever you're ready.		
1754:05 **CAM-1**	best way to do it is just to pull the power back and accelerate you're gonna go straight to flaps fifty or...		
1754:09 **CAM-2**	you're * go straight to flaps fifty just pull your power back a little bit so you....		
1754:13 **CAM-1**	OK.		
1754:14 **CAM-2**	... as you do it. you ready?		
1754:14 **CAM-1**	yep. I'm ready.		
1754:15 **CAM-2**	here they go.		
1754:29 **CAM-1**	this a time check or?		
1754:31 **CAM-2**	slot light's still on.		
1754:34 **CAM-3**	why * we just go on the old aux pumps.		
1754:36 **CAM-2**	there it goes, it's off now.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1754:38 **CAM-2**	there we're moving. ***.		
1754:50 **CAM-1**	where we at on ...		
1754:51 **CAM-2**	that's probably all she wrote.		
1754:52 **CAM-3**	OK.		
1754:54 **CAM-3**	OK retract flaps to accelerate to one point five Vs zero. * aux pump is on. both engine hydraulic pumps are bypassed.		
1755:02 **CAM-2**	OK.		
1755:02 **CAM-3**	let me know when you're ready.		
1755:07 **CAM-1**	I'm ready.		
1755:08 **CAM-2**	OK, here we go.		
1755:09 **CAM-2**	flaps zero.		
1755:10 **CAM**	[sound of two clicks]		
1755:11 **CAM-3**	accelerate to one point five Vs zero.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1755:13 **CAM-1**	roger.		
1755:16 **CAM-2**	yeah, probably need a little more power, I think.		
1755:41 **CAM-2**	flaps zero.		
1755:42 **CAM-2**	got a master warning.		
1755:46 **CAM-3**	OK, I got a number two manifold over temp.		
1755:48 **CAM-1**	got it.		
1755:49 **CAM-3**	it's not indicating but I'm gonna go ahead and and uh,		
1755:58 **CAM-3**	I'm gettin' manifold over temp but it's not indicating up in the uh, temp gauge.		
1756:02 **CAM-?**	***.		
1756:03 **CAM**	[sound of rustling pages]		
1756:17 **CAM-3**	see, here's the next check. at two hundred knots, flaps zero, extend flaps to fifty, while slowing to one point three, Vs fifty.		
1756:25 **CAM-1**	thought we just did that.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1756:27 **CAM-3**	nope. aux pump off, one engine hydraulic pump bypass.		
1756:30 **CAM-1**	all right. ready, flaps fifty.		
1756:33 **CAM-3**	hang on, I'm not configured.		
1756:34 **CAM-2**	OK.		
1756:36 **CAM-3**	aux pump is off, one hydraulic pump is bypassed...... OK, I'm ready.		
1756:45 **CAM-1**	flaps fifty.		
1756:46 **CAM-2**	here we go. now.		
1756:52 **CAM**	[sound of rumble]		
1757:01 **CAM-2**	Beckley, seventeen seven and uh, nav one, there they are.		
1757:06 **CAM-3**	OK.		
1757:12 **CAM-3**	OK, trim change at flap extension.		
1757:16 **CAM-2**	gotta feel.. didn't have any trim change, did ya?		

INTRA-COCKPIT COMMUNICATION | AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1757:18 **CAM-1**	no.		
1757:19 **CAM-3**	none?		
1757:19 **CAM-?**	OK.		
1757:20 **CAM-1**	nope, I didn't change it.		
1757:22 **CAM-3**	OK.... flaps fifty at one point three Vs zero, to flaps twenty three while accelerating to one point five, Vs twenty three. it should be both engine hydraulic pumps on to give me a chance to get configured.		
1757:36 **CAM-2**	to about one sixty... * seventy or somewhere in there...		
1757:39 **CAM-1**	I'll use that first bug... so accelerate to the first bug.		
1757:44 **CAM-3**	yep. flaps twenty three.		
1757:45 **CAM-1**	OK. flaps twenty three.		
1757:46 **CAM-2**	you all set Terry?		
1757:47 **CAM-3**	yeah, I'm ready.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1757:48 **CAM-2**	you ready Keith? ... now..... they're set, they're a little high but..		
1758:04 **CAM-1**	there's a little, there's a little.		
1758:06 **CAM-2**	.. they're reading about twenty eight.. well they're kinda... there's a master warning.		
1758:10 **CAM-3**	OK, got number two manifold over temp again.		
1758:16 **CAM-2**	they're reading uh, I'd say they're readin' about twenty seven.		
1758:21 **CAM-3**	OK, we have thirteen seconds on that ***.		
1758:23 **CAM-1**	there's one sixty.		
1758:25 **CAM-2**	OK, wanna try it again?		
1758:27 **CAM-3**	yeah, let's go uh... back to fifty.		
1758:33 **CAM-1**	OK, they're up to twenty three.		
1758:34 **CAM-2**	back to fifty and slow...		
1758:35			

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
CAM	[sound of click]		
1758:36 **CAM-2**	.. * fifty.		
1758:53 **CAM-3**	whenever you're ready, I'm ready.		
1758:55 **CAM-2**	ready?		
1758:56 **CAM-1**	yeah.		
1758:56 **CAM-2**	now.		
1758:57 **CAM**	[sound of two clicks]		
1759:05 **CAM-2**	OK they're there. that's as far as they're gonna go.		
1759:06 **CAM-1**	OK, that's that's better that's pretty good.		
1759:08 **CAM-2**	that flaps gauge is still readin' what do you read about twenty seven?		
1759:12 **CAM-?**	*.		
1759:13 **CAM-2**	from your angle?		
1759:15 **CAM-1**	yeah.... set at twenty three?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1759:20 **CAM-3**	OK, we have flaps twenty three * flaps up. both engine hydraulic pumps on whenever you're ready.		
1759:26 **CAM-2**	OK... ready Keith.		
1759:27 **CAM-1**	ready. flaps zero.		
1759:29 **CAM-2**	goin'.		
1759:48 **CAM-2**	flaps zero set.		
1759:49 **CAM-3**	OK.		
1759:51 **CAM-2**	OK.		
1759:55 **CAM-?**	reset the circuit breaker.		
1800:01 **CAM-4**	if we're gonna have normal indications at twenty seven twenty three then **.		
1800:05 **CAM-3**	pardon?		
1800:06 **CAM-4**	it's an abnormal *... you have twenty three set, twenty seven indicated?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1800:10 **CAM-2**	yeah.... but I was pointin' to this CDI, it's really, it's done that on two frequencies so far it's really, jumpin' around *.		
1800:19 **CAM-4**	no on the flaps.		
1800:20 **CAM-2**	yeah. flaps, when I had 'em set for twenty three they were readin' twenty seven.		
1800:24 **CAM-4**	right.		
1800:25 **CAM-2**	on the way up.		
1800:27 **CAM-1**	what was hel.., was there anything, what was on at that point, hydraulic pressure wise?		
1800:31 **CAM-2**	uuh, one pump.		
1800:35 **CAM-1**	(doubt that it blowed) up there all right.		
1800:37 **CAM-2**	yeah.		
1800:43 **CAM-4**	what, what airspeed were we roughly?		
1800:45 **CAM-2**	uuuuuh, one sixty.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1800:48 **CAM-1**	yeah, right about one sixty.		
1800:54 **CAM-3**	OK, next thing. standby rudder pump operation. aileron power lever (on). both engine hydraulic pumps bypassed. standby rudder pump on.... aileron power lever, ready for it to come off?		
1801:08 **CAM-1**	go ahead.		
1801:13 **CAM-3**	aileron power lever off, both engine hydraulic pumps are by-passed, standby rudder pump is on.... go around EPR's one point, nine two..... now the next thing is, rudder travel and two engine Vmc, takeoff flaps.		
1801:39 **CAM-1**	flaps eighteen.		
1801:40 **CAM**	[sound of three clicks]		
1801:51 **CAM-2**	(and for) this you'll pull two to idle and two to MCT and, wanna slow to about one fifty five.		
1801:59 **CAM-1**	OK ***.		
1802:00 **CAM-2**	may have to climb a little bit ***.		
1802:03 **CAM-1**	do we have uh, hydraulics at all now?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1802:06 **CAM-2**	no.		
1802:06 **CAM-3**	standby rudder pump.		
1802:08 **CAM-1**	are we supposed to be a flaps setting at eighteen?		
1802:09 **CAM-2**	oh, oh. yeah we're gonna, I'm gonna put the flaps back up.		
1802:10 **CAM-1**	I'm gonna put an aux pump on.		
1802:14 **CAM-2**	you ready?		
1802:15 **CAM-?**	***.		
1802:16 **CAM-?**	OK.		
1802:19 **CAM-2**	flaps comin to eighteen.		
1802:20 **CAM**	[sound of four clicks]		
1802:27 **CAM-2**	flaps eighteen set.		
1802:30 **CAM-1**	all right, OK two to idle, two ta. two to MCT.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1802:36 **CAM-2**	yep, we can bring yeah, bring which ever two to idle or I'll.do it for you.		
1802:39 **CAM**	[sound similar to landing gear warning horn]		
1802:42 **CAM**	[sound of rumble]		
1802:44 **CAM-1**	OK, you've got one and two to idle.		
1802:46 **CAM-2**	OK. slowing to one fifty five.		
1802:57 **CAM-2**	and then we go to MCT on the other two and see if you can hold heading.		
1803:01 **CAM-1**	OK.		
1803:06 **CAM-2**	master warning.		
1803:07 **CAM-3**	OK, just a low flow on the CTC.		
1803:10 **CAM-1**	OK.		
1803:26 **CAM-2**	OK, slowly do you want me to bring 'em in.		
1803:28 **CAM-1**	go ahead, bring 'em on in.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1803:29 **CAM-2**	here they come. slowly comin' slowly comin' in.		
1803:36 **CAM**	[sound of rumble]		
1803:37 **CAM-1**	MCT.		
1803:42 **CAM-2**	let me know when you're ready to swap.		
1803:45 **CAM-1**	what's, what's the speed showing. I'm gonna ...		
1803:47 **CAM-2**	eeh, one sixty, that's close enough.		
1803:49 **CAM-1**	yep, OK go ahead and swap.		
1803:50 **CAM-2**	***.		
1803:52 **CAM-2**	left's comin' in. right's comin' back.		
1803:55 **CAM-1**	OK.		
1804:06 **CAM**	[sound similar to landing gear warning horn]		
1804:14 **CAM-2**	MCT.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1804:20 **CAM-1**	slow up (here a little bit).		
1804:21 **CAM-2**	OK, OK, climb a little bit **.		
1804:45 **CAM-2**	altitude's fourteen two going up to...		
1804:47 **CAM-1**	we're climbing to fifteen.		
1804:48 **CAM-2**	yeah we got a block of thirteen to fifteen **.		
1804:51 **CAM-1**	just losing airspeed is what I'm doing here.		
1804:52 **CAM**	[sound similar altitude alert signal]		
1804:53 **CAM-1**	there's one fifty five and's holding headings.		
1804:55 **CAM-2**	OK.		
1804:56 **CAM-2**	I'm gonna bring the others two in and bring the first two back.		
1805:00 **CAM-1**	OK.		
1805:01 **CAM-3**	OK, that checks, huh?		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1805:02 **CAM-2**	yep.		
1805:06 **CAM-?**	OK.		
1805:08 **CAM-2**	we're getting back to normal here.		
1805:10 **CAM-1**	OK.		
1805:11 **CAM-?**	**.		
1805:16 **CAM-3**	your aileron power, ready for that to come back on Keith?		
1805:19 **CAM-1**	yeah, go ahead.		
1805:23 **CAM-3**	OK.		
1805:34 **CAM-1**	flaps zero.		
1805:37 **CAM-3**	next thing is our stall series.		
1805:40 **CAM-1**	..K.		
1805:47 **CAM-?**	** stall.		
1805:49 **CAM-2**	**. that's uuuuuh.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1805:51 **CAM-1**	we got two oh. what's our uh... one eighty eight or one eighty four.		
1805:56 **CAM-2**	one eighty four, and..... we should get uh, stall at uh, one twenty two. I'm gonna set that in my, interior bug.		
1806:07 **CAM-1**	mine's set *.		
1806:08 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1806:10 **CAM-3**	shaker one twenty eight if you just hall out call out your numbers, I'll record 'em.		
1806:14 **CAM-1**	that's shaker and the stall?		
1806:15 **CAM-3**	yeah, shaker and stall both.		
1806:17 **CAM-1**	all right.		
1806:18 **CAM-2**	the only trick to this is just don't unspool.		
1806:25 **CAM-2**	I just swapped the igniters. I'll leave 'em on the for the stall.		
1806:34 **CAM-3**	standby rudder pump back on.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1806:36 **CAM-1**	OK.		
1807:08 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1807:21 **CAM-1**	looks like, are you saying you don't want to pull all the way back to it and then spool back or just wait.		
1807:23 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1807:25 **CAM-2**	aw you can do that, just when you get close to the stall you don't want to be unspooled.		
1807:28 **CAM-1**	unspool and then I'll respool.		
1807:29 **CAM-2**	that's fine.		
1807:31 **CAM-1**	speed it up.		
1807:41 **CAM**	[sound similar to stabilizer-in-motion warning horn]		
1807:43 **CAM-1**	guess I better not trim below * two *		
1807:51 **CAM-1**	yeah, I'm gonna spool now.		
1807:52 **CAM-2**	all right.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1807:55 **CAM**	[sound similar to engine increasing in RPM]		
1808:06 **CAM-1**	some buffet.		
1808:07 **CAM-2**	yeah, that's pretty early. *.		
1808:09 **CAM**	[sound of rattling]		
1808:11 **CAM-3**	that's a stall right there. * ain't no shaker.		
1808:13 **CAM**	[sound similar to increase in engine RPM]		
1808:13 **CAM-1**	set max power.		
1808:14 **CAM-2**	one thirty three.		
1808:17 **CAM-3**	* power.		
1808:19 **CAM-1**	one forty's about where I'm at.		
1808:20 **CAM**	[sound of irregular popping similar to engine compressor stall starts]		
1808:23 **CAM-2**	that's number two engine.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1808:25 **CAM**	[sound similar altitude alert signal]		
1808:25 **CAM-3**	** pull her back.		
1808:26 **CAM-2**	you got it.		
1808:29 **CAM**	[sound of irregular popping similar to engine compressor stall stops]		
1808:30 **CAM-2**	you can take a little altitude down. take it down.		
1808:32 **CAM-1**	** control. [spoken with buffeting voice]		
1808:36 **CAM**	[sound similar to engine decreasing in RPM]		
1808:38 **CAM-2**	a little rudder.		
1808:39 **CAM-1**	all right.		
1808:40 **CAM-2**	OK.		
1808:42 **CAM-2**	start bringing the nose back up.		
1808:43 **CAM-1**	got it.		

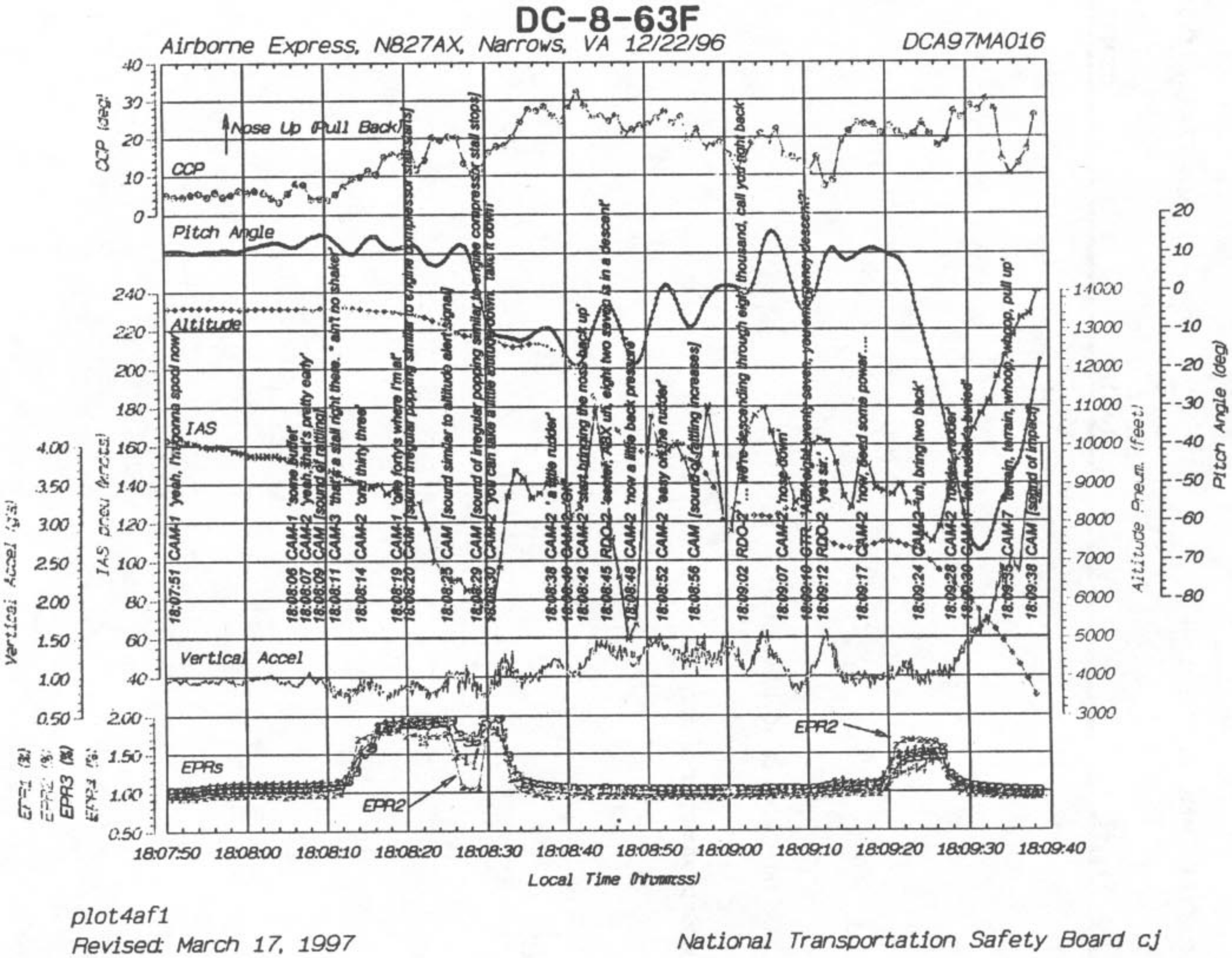
INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1808:45 **RDO-2**	center, ABX uh, eight two seven is in a descent.
1808:48 **CAM-2**	now a little back pressure.		
1808:49 **CAM-1**	got it.		
		1808:50 **CTR**	... X eight two seven change to Indianapolis one two eight point four.
1808:52 **CAM-2**	easy on the rudder.		
1808:53 **CAM-1**	yaw damper on?		
1808:54 **CAM-2**	yaw damper's on.		
1808:56 **CAM**	[sound of rattling increases]		
		1808:58 **CTR**	ABX eight twenty seven, Indianapolis one two eight point four.
		1809:02 **RDO-2**	ABX eight two seven we're going to stay on this frequency a minute, we're descending through eight thousand call you right back.
1809:07 **CAM-2**	nose down.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1809:08 **CAM-2**	* power in, your gonna get *....		
1809:10 **CAM-?**	*.		
		1809:10 **CTR**	ABX eight twenty seven, you emergency descent?
		1809:12 **RDO-2**	yes sir.
		1809:14 **CTR**	OK uh, can you hold seven thousand?
1809:17 **CAM-2**	now, need some power in, 'n you can use just your outboards if number two is giving you some problems.		
1809:19 **CAM**	[sound similar to engine increasing in RPM]		
1809:22 **CAM-1**	OK.		
1809:24 **CAM-2**	uh, bring two back.		
1809:26 **CAM**	[sound of click]		
1809:27 **CAM**	[sound similar to engine decreasing in RPM]		
1809:28 **CAM-2**	rudder, rudder.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1809:28 **CAM-1**	I got it.		
1809:29 **CAM-2**	left rudder.		
1809:30 **CAM-1**	left rudder's buried.		
1809:32 **CAM-2**	OK, easy, don't. OK now, easy bring it back.		
1809:35 **CAM-7**	terrain, terrain, whoop, whoop, pull up.		
1809:36 **CAM-?**	(really, really)		
1809:38 **CAM**	[sound of impact]		
1809:39 **END of RECORDING**			

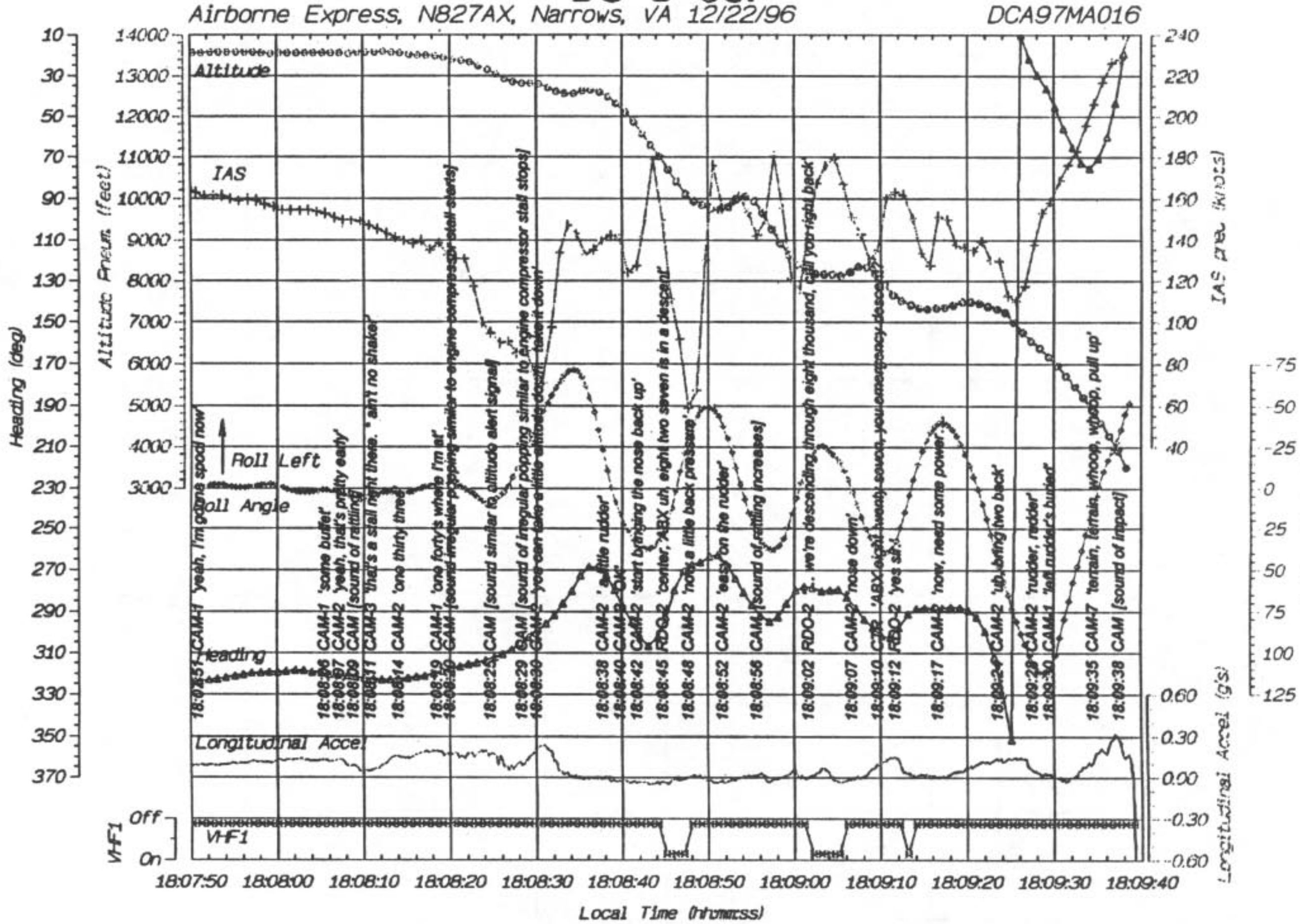
END of TRANSCRIPT

APPENDIX C—EXCERPTS FROM THE FLIGHT DATA RECORDER



DC-8-63F

Airborne Express, N827AX, Narrows, VA 12/22/96 DCA97MA016



plot4bf1
Revised: February 04, 1997

National Transportation Safety Board cj

DC-8-63F, Airborne Express, N827AX, Narrows, VA 12/22/96, DCA97MA016
Last Two Minutes of the Accident Flight, Revised: February 04, 1997, NTSB

Local Time (hh:mm:ss)	IAS pneu (knots)	Altitude Pneum. (feet)	CCP (deg)	EPR1 (%)	EPR2 (%)	EPR3 (%)	EPR4 (%)	Heading (deg)	Longitudinal Accel (g's)	Pitch Angle (deg)	Roll Angle (deg)	Vertical Accel (g's)	VHF1
18:07:54	160.03	13585.30	5.45	1.03	0.95	1.03	1.07	322.01	0.09 0.09 0.10 0.10	10.19 10.26 10.34 10.42	-1.26 -0.62	0.91 0.92 0.92 0.94 0.94 0.94 0.95 0.96	Not Keye
18:07:55	159.08	13579.72	4.54	1.05	0.96	1.04	1.08	321.24	0.10 0.10 0.10 0.10	10.49 10.49 10.42 10.42	-0.28 -0.22	0.96 0.95 0.94 0.93 0.95 0.95 0.96 0.95	Not Keye
18:07:56	159.46	13579.72	5.90	1.06	0.96	1.05	1.09	320.36	0.11 0.10 0.10 0.11	10.42 10.42 10.49 10.64	-0.45 -0.91	0.94 0.93 0.93 0.94 0.92 0.94 0.95 0.96	Not Keye
18:07:57	159.08	13582.51	4.49	1.07	0.95	1.05	1.09	319.80	0.12 0.12 0.11 0.11	10.80 10.87 10.87 10.80	-1.32 -1.79	0.99 1.00 0.98 0.97 0.97 0.97 0.94 0.95	Not Keye
18:07:58	157.17	13560.19	5.13	1.08	0.96	1.06	1.10	319.69	0.11 0.11 0.11 0.11	10.72 10.64 10.57 10.57	-2.27 -2.63	0.93 0.94 0.95 0.96 0.93 0.90 0.90 0.91	Not Keye
18:07:59	156.20	13557.39	6.30	1.08	0.96	1.06	1.10	319.58	0.11 0.10 0.11 0.12	10.57 10.64 10.80 10.95	-2.45 -1.97	0.92 0.91 0.91 0.89 0.91 0.94 0.97 0.97	Not Keye
18:08:00	154.84	13562.97	5.64	1.08	0.97	1.06	1.10	319.36	0.13 0.13 0.12 -0.12	11.18 11.41 11.57 11.65	-1.32 -0.39	0.98 0.97 0.97 0.97 0.97 0.96 0.96 0.97	Not Keye
18:08:01	154.64	13560.19	6.14	1.08	0.96	1.06	1.10	319.13	0.13 0.13 0.13 0.13	11.80 11.88 12.04 12.20	0.74 1.61	0.98 1.00 0.99 0.98 0.98 0.99 1.00 1.00	Not Keye
18:08:02	154.64	13565.76	5.76	1.08	0.96	1.06	1.10	318.80	0.13 0.13 0.13 0.13	12.28 12.36 12.51 12.59	2.21 2.57	1.00 0.99 0.99 0.99 1.00 1.00 1.01 1.01	Not Keye
18:08:03	154.84	13562.97	4.32	1.08	0.95	1.06	1.11	318.80	0.13 0.13 0.13 0.12	12.75 12.83 12.83 12.83	2.57 2.33	1.02 1.02 1.02 0.98 0.99 0.99 0.98 0.95	Not Keye
18:08:04	154.05	13562.97	3.23	1.08	0.94	1.06	1.11	319.36	0.12 0.12 0.12 0.12	12.83 12.75 12.51 12.36	2.09 1.67	0.94 0.92 0.93 0.95 0.93 0.94 0.91 0.93	Not Keye
18:08:05	152.87	13565.76	5.44	1.08	0.95	1.06	1.11	319.91	0.13 0.13 0.13 0.12	12.12 11.96 11.80 11.80	1.14 0.97	0.93 0.94 0.95 0.94 0.91 0.91 0.89 0.89	Not Keye
18:08:06	151.07	13560.19	7.89	1.08	0.97	1.06	1.11	320.47	0.11 0.12 0.12 0.13	11.80 11.88 12.12 12.36	1.37 2.27	0.87 0.88 0.87 0.88 0.91 0.92 0.93 0.93	Not Keye
18:08:07	150.06	13571.34	7.70	1.08	0.97	1.07	1.11	320.80	0.13 0.13 0.13 0.11	12.67 13.08 13.48 13.81	3.19 3.94	0.96 0.97 0.99 1.00 1.01 1.02 1.05 1.06	Not Keye

DC-8-63F, Airborne Express, N827AX, Narrows, VA 12/22/96, DCA97MA016
Last Two Minutes of the Accident Flight, Revised: February 04, 1997, NTSB

Local Time (hh:mm:ss)	IAS pneu (knots)	Altitude Pneum. (feet)	CCP (deg)	EPR1 (%)	EPR2 (%)	EPR3 (%)	EPR4 (%)	Heading (deg)	Longitudinal Accel (g's)	Pitch Angle (deg)	Roll Angle (deg)	Vertical Accel (g's)	VHF1
18:08:08	150.06	13557.39	4.09	1.09	0.97	1.07	1.12	321.24	0.09 0.08 0.08 0.09	14.05 14.30 14.47 14.63	4.58 5.17	0.99 0.99 0.96 0.99 0.96 0.92 0.97 0.95	Not Keye
18:08:09	149.25	13579.72	4.25	1.09	0.96	1.07	1.12	321.79	0.09 0.07 0.04 0.04	14.72 14.88 14.88 14.97	5.57 5.37	0.99 0.98 0.98 0.97 0.91 0.98 0.85 0.95	Not Keye
18:08:10	147.20	13579.72	3.80	1.10	0.97	1.08	1.14	322.35	0.05 0.05 0.04 0.05	14.80 14.55 14.22 13.72	4.78 3.94	0.94 0.85 0.98 0.82 0.81 0.86 0.74 0.88	Not Keye
18:08:11	145.53	13593.68	5.39	1.12	0.99	1.10	1.17	322.89	0.05 0.06 0.07 0.07	13.24 12.75 12.28 11.65	3.19 2.82	0.74 0.83 0.83 0.81 0.75 0.84 0.75 0.81	Not Keye
18:08:12	143.22	13599.26	7.37	1.18	1.20	1.15	1.33	323.22	0.09 0.09 0.10 0.12	11.18 10.64 10.26 10.04	2.45 2.33	0.79 0.74 0.80 0.79 0.76 0.86 0.66 0.84	Not Keye
18:08:13	141.51	13588.09	8.96	1.36	1.69	1.27	1.51	323.22	0.13 0.15 0.15 0.16	9.96 9.89 10.04 10.49	2.57 2.75	0.79 0.77 0.85 0.78 0.86 0.76 0.80 0.87	Not Keye
18:08:14	139.77	13568.55	9.76	1.56	1.74	1.51	1.58	322.89	0.15 0.14 0.15 0.14	11.18 11.88 12.59 13.08	3.00 2.94	0.81 1.00 0.83 0.93 0.81 0.98 0.93 0.86	Not Keye
18:08:15	138.46	13537.87	11.51	1.64	1.77	1.59	1.76	322.24	0.14 0.14 0.15 0.16	13.56 13.97 14.30 14.38	2.51 2.03	0.90 0.94 0.83 0.89 0.98 0.90 0.91 0.83	Not Keye
18:08:16	139.77	13515.58	10.22	1.86	1.79	1.85	1.83	321.57	0.17 0.17 0.18 0.18	14.47 14.30 13.89 13.16	1.14 -0.17	0.84 0.92 0.84 0.86 0.75 0.89 0.83 0.81	Not Keye
18:08:17	135.11	13510.00	14.93	1.91	1.79	1.86	1.84	321.13	0.19 0.19 0.19 0.19	12.51 12.04 11.65 11.49	-1.08 -1.79	0.80 0.70 0.77 0.69 0.77 0.76 0.73 0.82	Not Keye
18:08:18	138.24	13498.87	15.64	1.93	1.81	1.89	1.90	320.24	0.19 0.19 0.19 0.19	11.34 11.26 11.18 11.34	-2.51 -3.06	0.73 0.74 0.76 0.77 0.84 0.80 0.77 0.81	Not Keye
18:08:19	132.37	13465.48	15.15	1.95	1.74	1.90	1.91	319.13	0.19 0.15 0.17 0.17	11.49 11.57 11.65 11.65	-3.19 -3.00	0.86 0.81 0.89 0.84 0.86 0.87 0.88 0.89	Not Keye
18:08:20	130.75	13409.90	18.82	1.93	1.77	1.90	1.91	318.02	0.18 0.17 0.18 0.18	11.73 11.80 12.04 12.12	-2.45 -1.73	0.76 0.89 0.87 0.81 0.95 0.76 0.96 0.85	Not Keye
18:08:21	130.51	13379.38	11.68	1.93	1.72	1.90	1.65	316.79	0.14 0.16 0.14 0.14	12.12 11.73 11.18 10.42	-0.68 0.68	0.89 0.93 0.93 0.88 0.84 0.90 0.83 0.83	Not Keye

DC-8-63F, Airborne Express, N827AX, Narrows, VA 12/22/96, DCA97MA016
Last Two Minutes of the Accident Flight, Revised: February 04, 1997, NTSB

Local Time (hh:mm:ss)	IAS pneu (knots)	Altitude Pneum. (feet)	CCP (deg)	EPR1 (%)	EPR2 (%)	EPR3 (%)	EPR4 (%)	Heading (deg)	Longitudinal Accel (g's)	Pitch Angle (deg)	Roll Angle (deg)	Vertical Accel (g's)	VHF1
18:08:22	117.16	13337.80	14.23	1.92	1.74	1.89	1.91	315.78	0.17 0.18 0.18 0.15	9.59 8.71 7.99 7.42	2.03 3.88	0.87 0.81 0.86 0.72 0.84 0.71 0.73 0.80	Not Keye
18:08:23	99.88	13257.59	20.20	1.92	1.74	1.91	1.94	315.00	0.18 0.18 0.19 0.19	7.14 6.93 6.86 6.86	6.11 8.20	0.80 0.78 0.81 0.78 0.82 0.74 0.82 0.84	Not Keye
18:08:24	94.82	13163.80	19.41	1.94	1.76	1.92	1.95	313.88	0.19 0.19 0.15 0.18	7.00 7.28 7.63 8.20	9.22 8.42	0.84 0.85 0.86 0.80 0.86 0.94 0.86 1.05	Not Keye
18:08:25	89.80	13048.33	20.25	1.82	1.46	1.94	1.72	312.43	0.17 0.18 0.08 0.16	8.93 9.66 10.34 11.03	6.86 4.97	0.79 1.00 1.09 1.00 1.04 1.04 1.03 0.97	Not Keye
18:08:26	90.49	12941.49	20.13	1.50	1.07	1.74	1.72	310.76	0.12 0.08 0.08 0.06	11.49 11.96 12.20 12.28	2.39 -1.43	1.00 1.08 1.05 0.80 1.05 1.02 1.06 0.90	Not Keye
18:08:27	85.21	12873.21	13.26	1.43	1.04	1.66	1.74	308.54	0.09 0.06 0.07 0.10	12.04 11.73 10.80 9.44	-6.72 -12.20	1.01 1.08 0.85 1.16 1.05 1.06 0.92 1.02	Not Keye
18:08:28	86.29	12832.30	10.15	1.37	1.06	1.67	1.66	305.79	0.11 0.08 0.09 0.13	7.56 5.44 3.37 1.43	-17.90 -23.86	1.04 0.82 1.05 0.86 0.84 0.72 0.93 0.80	Not Keye
18:08:29	76.01	12826.85	11.73	1.79	1.71	1.93	1.94	302.77	0.12 0.17 0.16 0.19	-0.74 -2.69 -4.58 -6.31	-29.81 -35.79	0.78 0.90 0.73 0.77 0.72 0.82 0.79 0.73	Not Keye
18:08:30	70.51	12805.06	16.03	1.89	1.79	1.97	1.98	299.60	0.21 0.22 0.23 0.23	-7.84 -9.07 -10.04 -10.72	-41.31 -46.45	0.70 0.83 0.78 0.87 0.96 0.82 0.86 0.84	Not Keye
18:08:31	97.38	12709.91	17.63	1.80	1.71	1.99	1.77	296.13	0.24 0.20 0.19 0.19	-11.26 -11.57 -11.73 -11.80	-51.68 -56.48	1.08 0.96 0.86 1.18 0.89 1.14 1.18 1.26	Not Keye
18:08:32	133.75	12620.46	18.00	1.55	1.17	1.46	1.29	291.84	0.12 0.12 0.05 0.05	-11.96 -11.96 -11.96 -12.04	-60.92 -64.87	1.09 1.01 1.30 1.00 1.22 1.16 1.00 1.07	Not Keye
18:08:33	147.40	12563.67	20.06	1.21	1.03	1.20	1.20	285.90	0.03 0.02 0.03 0.02	-12.20 -12.36 -12.51 -12.67	-68.44 -70.84	1.05 1.32 0.97 1.08 1.08 0.92 1.12 1.02	Not Keye
18:08:34	143.22	12577.18	24.23	1.14	0.98	1.12	1.12	280.11	0.01 0.00 0.01 0.00	-12.75 -12.75 -12.67 -12.43	-71.74 -70.48	1.03 0.96 0.83 0.99 0.97 0.92 1.03 0.98	Not Keye
18:08:35	132.37	12647.54	27.53	1.10	0.97	1.09	1.09	272.69	-0.01 -0.01 -0.01 0.00	-12.28 -11.96 -11.65 -11.26	-67.30 -62.15	0.97 0.97 0.91 1.04 0.93 0.96 1.00 0.98	Not Keye

APPENDIX D—FAA LETTER DETAILING REVISIONS TO ABX STALL RECOVERY PROCEDURES

US Department of Transportation
Federal Aviation Administration

DETROIT FLIGHT STANDARDS DISTRICT OFFICE
Willow Run Airport - East Side
8800 Beck Road
Belleville, Michigan 48111

June 7, 1991

JUN 1991

Inspector Ed Murnane
Winston/Salem FSDO
8025 N. Point Blvd.
Suite 250
Winston Salem, NC 27106

Dear Mr. Murnane:

As a result of the incident that occurred on May 15, 1991, I conducted a complete proficiency check on all three airmen. The checkride was conducted at ABX'S request. As part of a proficiency checkride oral, the following observations were made. The actual entrance to the maneuver, the maneuver, the recovery, and ways to prevent any reoccurrence of this incident were discussed.

The maneuver is required in the ABX Flight Test Guide, it requires the crew to calculate speeds for the stick shaker and initial buffet. Power is set at 80% N2. As the aircraft approached stick shaker, speed #1 N2 was noted as below 80%. The crew was attempting the adjust #1 as the aircraft went through stick shaker to buffet. At buffet, the crew executed the normal stall recovery: Max power. Numbers 1 and 2 engine compressor stalled and failed to accelerate. The adverse yaw aggravated the stall and caused the aircraft to enter what the crew described as a 1 1/2 turn spin.

The aircraft was recovered with a loss of about 7,000 feet. The aircraft was at 13,000 feet when it entered the stall and at 6,000 feet when controlled flight resumed. The crew set the transponder on 7700 and notified ATC of their problem.

After the stall/spin, the crew performed the remainder of the acceptance flight. Captain Blum stated that he wanted to be very sure that his aircraft was airworthy prior to returning to a populated area for landing. The entire crew stated that they could have returned and landed sooner; however, "It felt so good to do something normal". In retrospect, they wish they had landed sooner.

When asked why the logbook did not reflect exceeding aircraft limitations, I was given a copy of the Maintenance Discrepancy Log. This was completed by an ABX mechanic who was on the flight. This is the only maintenance record of the incident and corrective action.

After this, the group discussed ways to prevent any possible reoccurrence of this incident. Several suggestions were made.

1. Prior to any further test flights, the crew will review and fly the profile in the simulator. (They only do about two of these flight a year)

2. The airborne maneuvers will be accomplished in an ATC assigned altitude block of 3 to 5 thousand feet.

3. The stall maneuver will no longer use power for recovery. Recovery will be accomplished with pitch. (In the simulator, lowering the nose 3 to 4-degrees results in an instant recovery. Power can then be slowly advanced to complete the recovery.

All of this is being incorporated in their acceptance flight profile.

Crew performance during the simulator checkride was superior. In addition to normal items, both pilots were given engine failures during takeoff (VI Cuts), go arounds, steep turns and stalls. None of these engine failures gave the crew any problems. We also flew the suggested stall recovery profile, and found it to be a very easy and gentle maneuver.

I ran a current detail record of both pilots and the flight engineer, and found all crewmembers have no record of violations or incidents. As a result of these checkrides, the crew was returned. to line flight status. Check airman status was removed pending conclusion of FAA investigation.

The crew was extremely cooperative during this discussion. Their goal was safety and to prevent any reoccurrence. Their check airman pay will be suspended until they return to status. I have every confidence in these gentlemen, and my only desire is for a rapid conclusion.

Sincerely,

Ted E. Innes

Ted E. Innes
Principal Operations Inspector

Enclosures
1. Aircraft logs 03703 and 03704
2. Maintenance discrepancy by J-0955
3. Captains Irregularity Report
4. Copy of Airborne Express Flight Test Report
5. FAA 8020-5 competed by ABX
6. Copy of letter suspending check airman status
7. Copies of 3 Proficiency Checks
8. C.A.I.S. information all 3 Crewmembers

APPENDIX E-ABX FEF FLIGHT TEST REPORT DC-8-61/62/63 (EXCERPTS)

AIRBORNE EXPRESS.

PAGE: 16
REV. NO.: ORIG.
DATE: 04-2696

FLIGHT TEST REPORT DC-8-61 /62 /63

9. AT 200 KTS, FLAPS 0° EXTEND FLAPS TO 50° WHILE SLOWING TO 1.3Vs / 50°
(Aux pump off, one eng hyd pump bypassed.) (12-25 sec) .... (sec) ______

10. TRIM CHANGE AT FLAP EXTENSION (Unit change ail. and rud) .... A ______ R ______

11. FLAP 50° AT 1.3Vs / 50 TO 25 / 23° (While accelerating to 1.5 Vs / 25 / 23o)
(Both eng hyd pumps on) (6-10 sec) .... (sec) ______

12. FLAPS AT 25/23° 1.5 Vs / 25 / 23°) TO UP
(Both engine hyd pumps on) (11-25 sec) .... (sec) ______

13. RESET LANDING GEAR WARN & INTERLOCK C/B .... ______

14. STANDBY RUDDER PUMP OPERATION (All pwr lever off, both eng hyd pumps bypassed, –
standby rudder pump on) .... ______

15. GO AROUND EPR .... ______

16. RUDDER TRAVEL AT 2 ENG Vmc L / R (TAKEOFF FLAPS) .... ______

STALL

GW ______ LBS, CG ______ % MAC, ZFW CG ______ %, FUEL ______

17. CALC 1G STALL & SHAKER (Flaps 0° GR UP / Flaps 35°. GR DN)

1.5Vs/0	1.3 Vs/35
STICK SHAKER ______	STICK SHAKER ______
STAU ______	STAU ______
(1.5 Vs / O Speed divided by 1.5 = stall)	1.3 Vs/35 divided by 1.3 = stall)
(Stall x 1.05 = shaker)	(Stall x 1.05= shaker)

	FLAPS O GEAR UP CAPT	FLAPS O GEAR UP F/O	FLAPS 35 GEAR DN CAPT	FLAPS 35 GEAR DN F/O
18. STICK SHAKER (IAS)	______	______	______	______
19. ACTUAL STAU (IAS)	______	______	______	______

20. FOUR-ENGINE SYMMETRICAL ACCELERATION (Idle to GA power) .... ____ / ____ / ____ / ____

ACCOMPLISH AFTER TAKEOFF CHECKLIST

21. UPLATCH CHECK AT 2.0 G (60° BANK) .... ______

22. FLIGHT SPOILER RIGGING CHECK .... ______
(Gear up, spoiler pump override and rotate control wheel sufficient enough to deploy flight spoilers; verify flight spoilers do not deploy.)

23. POWERED AILERON AT 260 KT(1 to 2 units) .... ______ (Units)

24. MANUAL AILERON AT 280 KT .... ______ (Units)
(Ail power lever off. ± 1 unit change from powered.)

25. POWERED RUDDER AT 260 KT (1 to 2 units) .... ______ (Units)