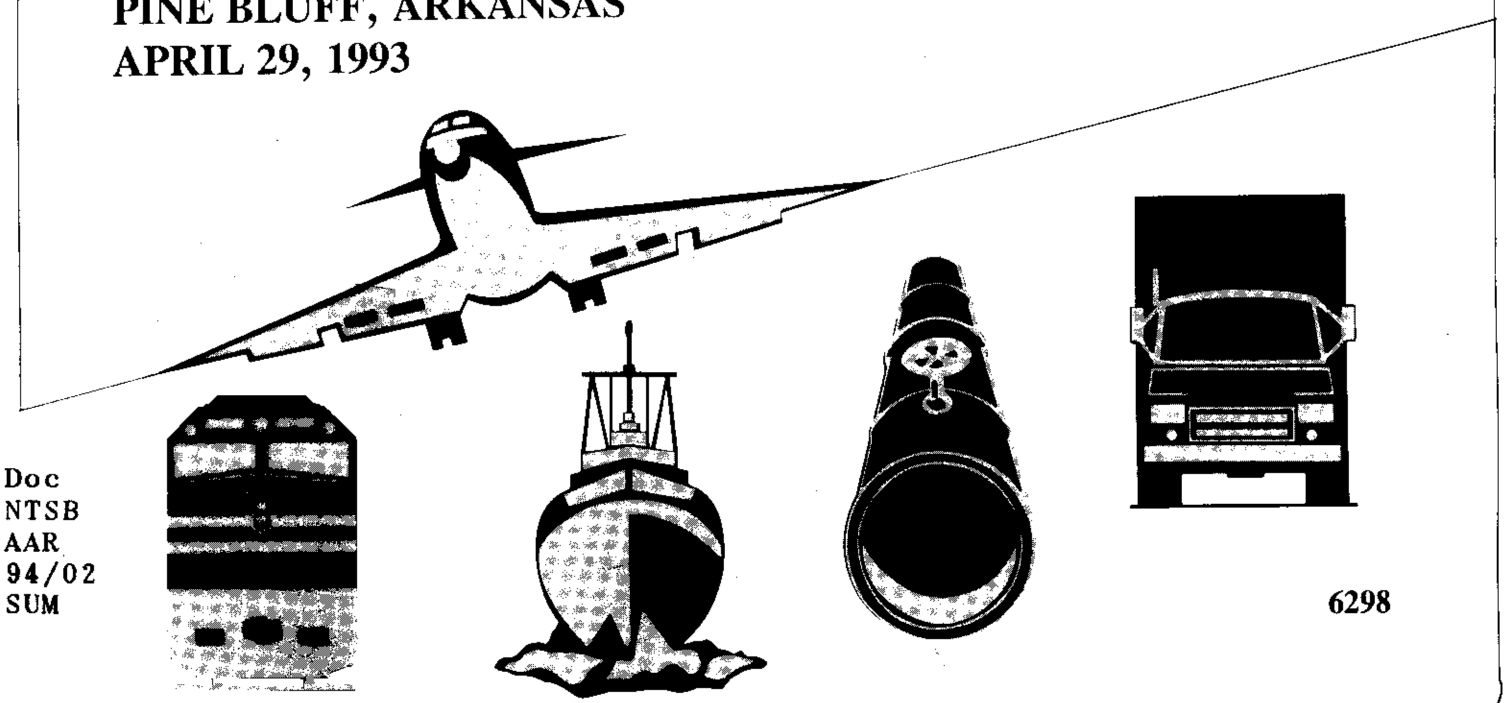
PB94-910404
NTSB/AAR-94/02/SUM

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C. 20594

AIRCRAFT ACCIDENT/INCIDENT SUMMARY REPORT

IN-FLIGHT LOSS OF CONTROL, LEADING TO FORCED LANDING AND RUNWAY OVERRUN CONTINENTAL EXPRESS, INC., N24706 EMBRAER EMB-120 RT PINE BLUFF, ARKANSAS APRIL 29, 1993



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Adopted: March 15, 1994
Notation 6298

Abstract: This report explains the in-flight loss of control of N24706, leading to a forced landing and runway overrun at Pine Bluff, Arkansas, on April 29, 1993. The safety issues discussed in the report are flightcrew professionalism, inattentiveness, and fatigue. A recommendation concerning fatigue was made to the Federal Aviation Administration.

✓ Cockpit resource mgt./discipline
✓ fatigue
✓ icing
✓ stall

National Transportation Safety Board
Washington, D.C. 20594

AIRCRAFT ACCIDENT/INCIDENT SUMMARY

Accident No:	FTW93-M-A143
Airplane Owner/Operator:	Continental Express, Inc.
Airplane Type and Registration:	Embraer EMB-120 RT, N24706
Location:	Pine Bluff, Arkansas
Date and Time:	April 29, 1993, 1555 cdt[1]
Injuries:	13 Minor
Type of Occurrence:	Stall, Loss of Control, and Landing Overrun

1. THE FLIGHT

On April 29, 1993, at 1555 central daylight time, an Embraer EMB-120 RT, Brasilia, N24706, was substantially damaged when it collided with rough terrain during an overrun following a forced landing on runway 17 at the Grider Field Airport (PBF) in Pine Bluff, Arkansas. The forced landing was executed after the airplane stalled and went out of control at approximately 17,000 feet during the climb to cruise altitude. The flightcrew regained control of the airplane after losing about 12,000 feet of altitude. However, after regaining control, the flightcrew noted that the left engine nacelle was extensively damaged, three of the four propeller blades were missing, and the airplane was unable to maintain level flight.

The airplane, owned by Continental Airlines, Inc., was operated by Continental Express, Inc., as Jet Link flight 2733. It was being flown by two airline transport pilot (ATP)-rated pilots under the provisions of Title 14 Code of Federal Regulations (CFR) Part 135 on a scheduled passenger flight from Adams Field Airport (LIT), Little Rock, Arkansas, to Intercontinental Airport (IAH), Houston, Texas. An instrument flight rules (IFR) flight plan had been filed and visual meteorological conditions prevailed at the accident site. The loss of control, descent, and recovery of control occurred while the flight was in instrument meteorological conditions (IMC). Of the three crewmembers and 27 passengers aboard the airplane, the flight attendant and 12 passengers received minor injuries, while the two flightcrew members and remaining 15 passengers were not injured.

[1] All times in this report are central daylight time.

The flight had departed LIT en route to IAH at 1516:00. Upon contacting the Memphis Air Route Traffic Control Center (ARTCC), the crew reported climbing through 7,500 feet and was instructed to climb to and maintain flight level (FL) 220 (22,000 feet). The cockpit voice recorder (CVR) then recorded a conversation between the captain and the first officer in which they discussed the performance data for a climb to FL260. It was noted on the recording that the captain said "I don't care" in response to a question from the first officer regarding what final altitude the captain wanted for cruise. During this exchange, while the airplane was passing through about 8,000 feet, the CVR recorded the voice of the flight attendant saying "Hi" at 1522:54. Nonpertinent conversation between the pilots followed for about 1 minute. At 1526:26, Memphis Center instructed the flight to continue the climb and gave a final cruise altitude of FL230. The first officer, who was handling the radios, requested and was given FL220 as a final altitude. That was the last radio contact between the flight and air traffic control (ATC) before the loss of control.

At 1528:49, the flight attendant and the captain began conversing and continued to do so until the time of the loss of control at 1533:16, 4 minutes and 27 seconds later. The first officer later said that he had been making log book entries and eating his crew meal during this period. The flight attendant and captain discussed using the windshield wipers to remove something from the windscreen. They later stated that they were referring to insects on the windscreen. At 1530:52, the flight attendant requested that the captain "climb faster" as she wanted to begin cabin service, and she would have trouble moving the beverage cart "uphill" during the climb. The captain agreed and subsequently said, "Okay, we'll try to get up a little more," and "yeah we're almost there, another 6 thousand feet another 6 minutes." This exchange was followed by more nonpertinent conversation between the captain and the flight attendant, during which the first officer commented that the airplane was not climbing very fast. The captain replied, "heavy really heavy" and continued with the conversation. At 1533:11, the captain interrupted the conversation with the flight attendant and said to the first officer, "Frank, hang on something ain't right." This was followed by the sound of the autoflight system disconnect at 1533:16.3, and stick shaker activation at 1533:16.8. At 1533:18, the aural stall warning activated, and the captain said, "airspeed." The stick shaker and aural stall warning continued until the end of the CVR recording. At 1533:22.7, the captain again said "hang on," and at 1533:24.6, the first officer said, "power up power's." This was followed by increasing engine noise at 1533:25.6 and the beginning of vibrations through the airframe at 1533:34.7. At 1533:39.7, the engine noise decreased and was then no longer audible on the CVR. The CVR recording ended 12 seconds later at 1533:46.7.[2] At 1534:50, following recovery of control, flight 2733 contacted Memphis Center and declared an emergency, stating that they had "lost an engine and needed to put her down." The flight data recorder (FDR) data showed that the airplane had regained stabilized flight at about 5,500 feet when the emergency was declared.

The flightcrew indicated that the autoflight system was engaged in the "heading" and "pitch hold" (attitude hold) modes during the climb and remained in these modes until the system disconnected. Further, the captain stated that immediately before the loss of control, he had noticed the ball in the turn-and-slip indicator slewed full left and the rudder trim wheel trimmed 10 units right to its full limit. Neither of the pilots recalled moving the trim wheel to this position.

The captain stated that he ordered the left engine shut down during the descent because he thought he had experienced an overspeed on that engine. Following the recovery, the captain noticed that the left engine was displaced in the mounts and was missing three of the four propeller blades and all of the upper cowlings. The pilots stated that the airplane would fly at an airspeed of about 125 knots before the stick shaker activated, and would maintain a rate of descent that varied from zero to 500 feet per minute (fpm) at that airspeed. The pilots further stated that they had difficulty turning the airplane to the right, with the left engine shut down and the left cowlings missing. They were also uncertain about the airplane's structural integrity.

During the initial contact with Memphis Center, in which they declared an emergency, the crew requested to go to Little Rock. They subsequently stated that they needed to land immediately and were losing altitude. The ARTCC controller

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[2]The CVR normally records continuously from before engine start until the last engine is stopped after the flight. The Federal Aviation Regulations (FARs) require a means of stopping the operation of the CVR within 10 minutes after a crash impact. In smaller commercial aircraft installations, most manufacturers have used a "G" sensing switch to remove electrical power to the CVR in the event of an impact. Approximately 30 seconds after the initial upset, the CVR stopped recording. The subsequent recovery and flight to the emergency landing were not recorded on the CVR. The Safety Board has experienced several inadvertent or premature stoppages of the CVR recording because of "G" switch activations and is currently considering evaluating means to address the problem.

then told them about H.L. Hopkins Municipal Airport (5M4), Fordyce, Arkansas, about 3 miles away. The crew was apparently assessing their situation, and again, said that they wanted to go to LIT. After deciding that LIT was too far away, they repeated their desire to land at the first available airport. The ARTCC controller again mentioned 5M4, and also PBF and Sheridan Municipal Airport, Sheridan, Arkansas. The pilot decided on 5M4, but reported that they had no approach plates for that airport. The ARTCC controller stated that there was no IFR approach at 5M4, but couldn't answer the pilot's question regarding weather at that airport. The ARTCC controller then reported the weather at PBF as a 4,500 foot broken ceiling, but later provided conflicting information that conditions were IMC. The pilot decided to land at PBF after reporting to the ARTCC controller that they needed an IFR approach if they could not land under visual flight rules (VFR) conditions. The pilot then requested the actual weather at PBF but never received it from the ARTCC controller. The ARTCC controller learned that men and equipment were on the runway and that only 5,000 feet of the 6,000 foot runway were available, but relayed only to the pilot, "five thousand feet of runway at Pine Bluff." The controller then told the pilot that he should be able to get into the airport visually, and to contact Little Rock Approach Control.

The approach controller issued weather information for PBF that included a 4,500 foot broken ceiling with a visibility of 5 miles. As the flight reported descending through 2,200 feet, 8 miles from the airport, the controller reported that the instrument landing system (ILS) was out of service. This was the first time that the pilot was given this information. Another advisory was then given that men and equipment were on the runway, but that the runway would be available. This was also the first time that the pilot was advised of this situation.

On the date of the accident, a notice to airmen (NOTAM) was effective for PBF informing pilots that the runway lighting system was undergoing upgrade construction, and the south 3,000 feet of runway 17, which measured 6,008 by 130 feet, was closed. When the Little Rock Approach Control controller notified the airport manager of the inbound emergency about 5 minutes before the airplane's arrival over the airport, the manager immediately took action to clear the runway of construction equipment. However, at the time of the landing, some personnel who had not been notified and one vehicle remained in the grass beyond the departure end of runway 17.

The airplane broke out of IMC about 1 mile from PBF. The captain stated that he overshot the right turn to final for runway 17 due to control problems. The investigation revealed that the airplane touched down with 1,880 feet of runway remaining. The captain further stated that he applied the brakes at touchdown and the airplane immediately began hydroplaning on the wet surface and went off the departure end onto wet rough sod, avoiding the vehicle and construction personnel that remained near the end. Both flightcrew members stated that braking action was nonexistent on the runway and that both braking and steering were nonexistent in the wet grass off the runway. Landing gear tire tracks were found on the runway consistent with those associated with hydroplaning.

As the airplane departed the pavement, the right main gear traveled over a 3-foot deep runway end lighting ditch.[3] The landing gear tracks then veered to the left away from the ILS equipment building. The building was mounted on a 3-foot-high shale pad. The right main landing gear track went up the 45° slope of the pad, while the nose gear traveled along the left edge of the pad and the left main gear track traversed level ground. In addition, evidence of slash marks from the right propeller were found forward of the gear imprint on the pad. After passing over the pad, the tracks entered a wet rice field. The ground scars were consistent with the airplane yawing nose right and eventually coming to rest on a heading of 220°, about 75 feet beyond the building and 687 feet beyond the departure end of runway 17 (see Figure 1). The crew and passengers immediately evacuated the airplane uneventfully. The right engine gas generator could not be shut down by the crew or aircraft rescue and fire fighting personnel and continued to run in a pool of Jet A fuel for about 15 minutes.[4] Figure 2 shows the flightpath of the airplane during the approach to PBF obtained from ATC radar data.

Several of the passengers commented on the smoothness and lack of turbulence on the flight before the loss of control. Two specifically noted that they did not observe any lightning or hear thunder. A few characterized the onset of the loss of control as a shudder through the airframe and associated it with turbulence. The passenger seated in the front row, seat 1B, stated that during the climb, she observed the captain put his seat back, unbuckle his seatbelt, and put

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[3]The ditch was dug to contain electrical conduit for the runway end lighting. It was not filled in because construction was ongoing.

[4]In this engine/propeller arrangement, the propeller shaft is not directly attached to the compressor shaft. Because of this, the propeller was stopped during ground impact, but the gas generator portion of the engine continued to run.

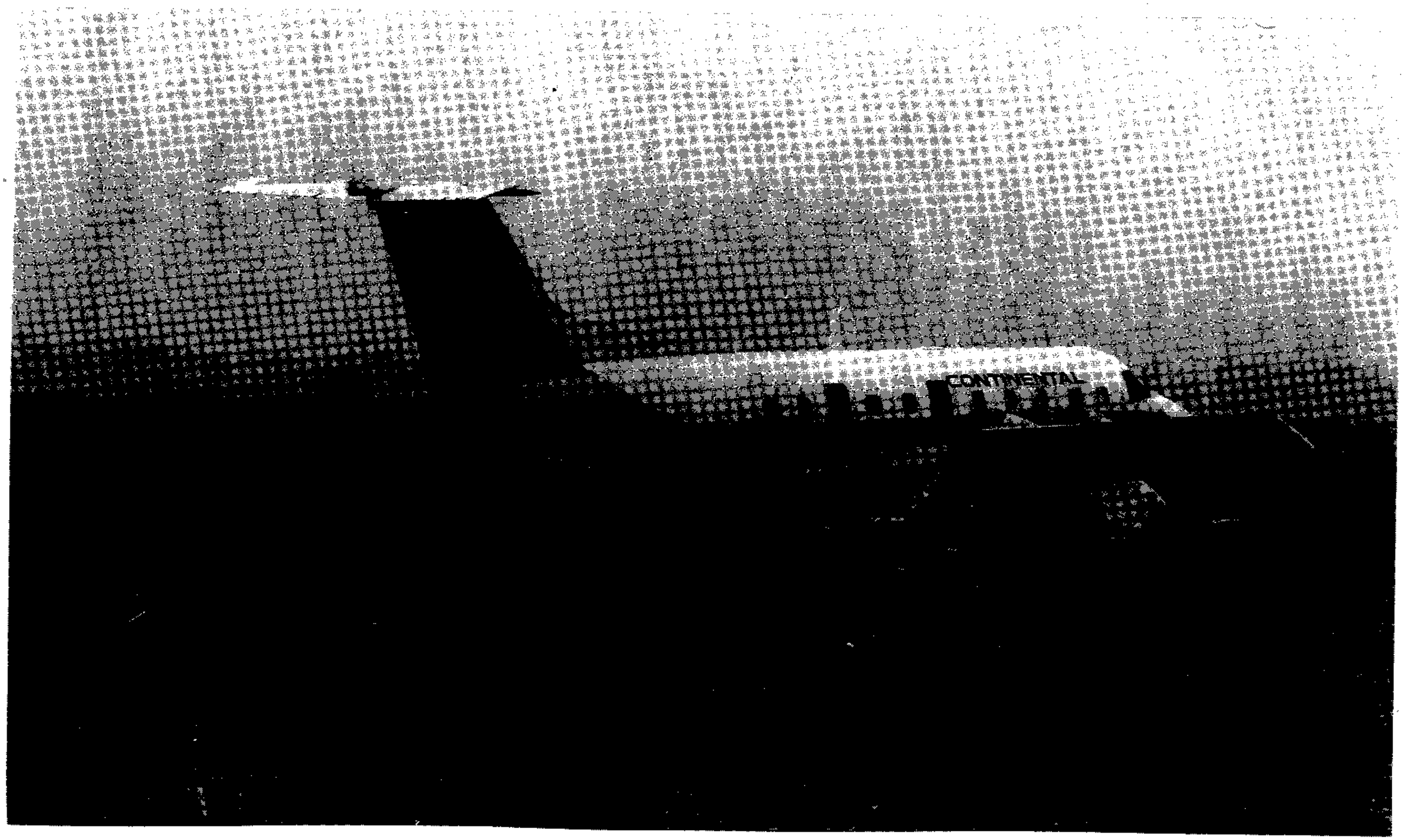

Figure 1.--The airplane off the runway following the overrun.

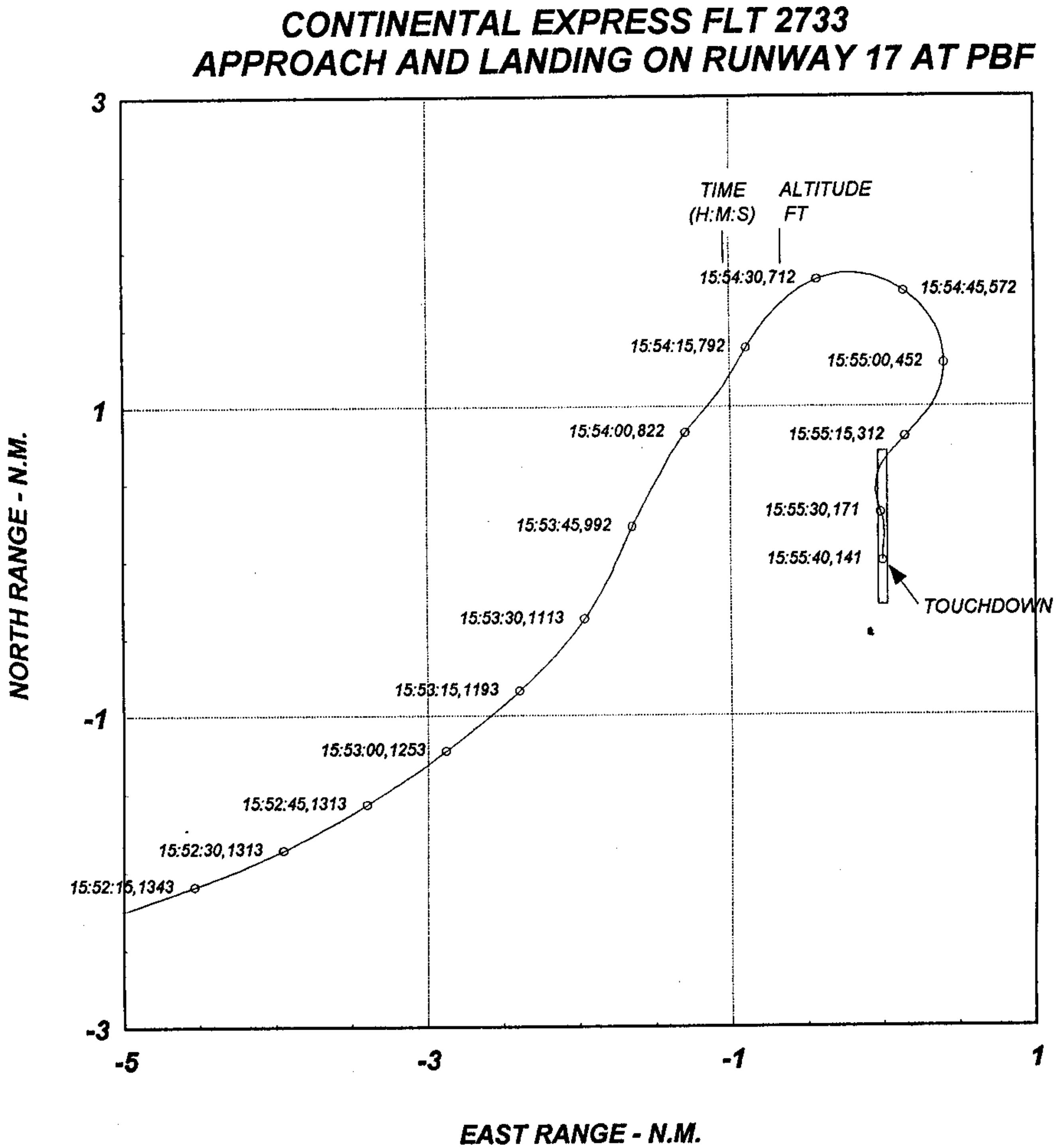

Figure 2.--Flightpath of the airplane during the approach to PBF

his foot up on the console. An interview with the captain revealed that he had removed his shoulder harness, but his seatbelt remained fastened. The passenger further said, "I watched the pilot (captain) turning a wheel, which I think made us turn to the right. He kept turning a knob it looked like for balance." A majority of the passengers recalled the flight attendant's pretakeoff emergency procedure briefing and remembered that she had pointed out the locations of the emergency exits. They also recalled her instructions to assume the impact position several times during the descent, her instructions about the locations of the exits, and her statement that the landing would be "hard and fast." The flight attendant was thrown out of the cockpit during the loss of control, but managed to get back to her crew station during the recovery.

2. FLIGHTCREW INFORMATION

Both pilot crewmembers were properly certificated, qualified, and current for the operation being conducted. They had received initial and recurrent training in accordance with the Federal Aviation Administration (FAA)-approved Continental Express training program. None of the crew had reported any physical or psychological problems that would have interfered with their ability to perform their duties. Samples for toxicological testing were obtained from all three crewmembers at about 2300 on April 29, 1993, under a company drug testing program. For all three crewmembers, the blood sample tested negative for alcohol, and the urine sample tested negative for other major drugs of abuse.

Company records indicated that the three crewmembers had flown together during the preceding month and that the pilots had flown together for the preceding 2 months. The crew said that they socialized together during off-duty time when on their scheduled trips and had socialized as a group most of the day before the accident.

The Captain

The captain, the flying pilot, held an ATP rating with airplane, single-engine, and multiengine land privileges. In addition, he held a Class I medical certificate, issued on November 16, 1992, with a limitation for the use of corrective lenses. He passed his current 14 CFR Part 135 and instrument recurrent proficiency check ride in the EMB-120 on February 12, 1993. He was hired by Continental Express, Inc., on September 11, 1989, and had qualified as a captain in the EMB-120, on September 13, 1990. Company records indicated that at the time of the accident, he had accumulated a total of 3,600 flight hours, of which 2,600 hours were in the same make and model as the accident airplane. The records indicated that the captain had flown 130 hours actual instrument time and 40 hours simulated instrument time. During the 90 and 30 days before the accident, he had flown 204 and 77 hours respectively, all in airplanes of the same make and model as the accident airplane.

A review of the captain's training records indicated that he had failed his initial qualification simulator check during his transition to the Embraer EMB-120. He passed the second check, with the FAA assistant Principal Operations Inspector (POI) in attendance, after receiving additional training in the deficient area in accordance with company training procedures. The director of training and the domicile chief pilot indicated that a failure was not abnormal with a pilot making the transition to a more sophisticated aircraft. The captain also failed a simulator proficiency check in February 1991, but subsequently passed after receiving additional training. The training records retained by the operator did not describe the deficiencies evident in either check. The captain had been given two line checks by the FAA during his tenure with the company. Both were successfully accomplished.

It was the carrier's policy to give an individual up to two additional training periods after a failure. The pilot would then be reexamined by a different check airman, and if a second failure occurred, the pilot would be terminated. The company's policy was also to track a pilot after a failure and follow up with an additional line check within 90 days of the training. This procedure was followed in the case of the captain.

According to the operator's domicile chief pilot, the captain's greatest strength as a pilot was his ability to establish an open cockpit environment with first officers. According to the accident first officer, the captain was easy to get along with and not intimidating. Two first officers who had flown previously with the captain agreed and indicated that he set up a "relaxed" cockpit climate.

A review of the captain's schedule revealed that before he reported for the 3-day trip that culminated in the accident, he had 2 days off. On the first day of the trip, he reported at 1328 for a 1428 departure and went off duty at 2246 at Jackson, Mississippi. The captain indicated that he fell asleep about midnight and awoke the next day about 0615. He departed Jackson at 0735 and went off duty at Shreveport, Louisiana, at about 1130. He spent the rest of the day with the other crewmembers in routine activities that included lounging by the pool, sightseeing, and dinner. There was no evidence of unusual activity that would have adverse effects on performance. The captain said he got to bed between midnight and 0030 and awoke about 0500 for a departure at 0630. The captain stated that he felt well rested before departing the day of the accident. The accident flight occurred during the seventh and last flight of the day.

The First Officer

The first officer, the nonflying pilot, held an ATP rating with airplane, single-engine, and multiengine land privileges. He was hired by the company on June 25, 1990, and qualified as a first officer on the EMB-120 on October 15, 1991, after having served as a captain for the company on different equipment at a different domicile. He held a Class II medical certificate, issued without limitations on June 12, 1992. He had completed his current 14 CFR Part 135 and instrument check in the EMB-120 on November 10, 1992. Company records indicated that the first officer had accumulated a total of 3,300 flight hours, of which 700 were in airplanes of the same model as the accident airplane. These included 310 hours in actual instrument conditions and 60 hours in simulated instrument conditions. During the 90 and 60 days preceding the accident, he had flown 199 and 68 hours respectively, all in airplanes of the same model as the accident airplane. It was revealed during the crew interviews that the first officer was an aerobatics pilot and flew in aerobatics competition during his off-duty time.

The first officer's training records and employment background were unremarkable. The domicile chief pilot stated that the first officer's greatest strength as a pilot was his ability to give input and demonstrate the principles of crew resource management (CRM) and assertiveness. The captain of the accident flight stated that the first officer's greatest attribute as a pilot was vigilance and attention to detail in the cockpit. He described the first officer as a "good pilot who loved aviation" and who had taught him a lot.

The first officer's flight, duty, and crew rest schedule was the same as that of the captain's for the 3-day trip sequence. The first officer indicated that he had gone to bed between 0030 and 0100 on the first night of the trip and awoke about 0530 the next morning. The first night of the trip involved a reduced rest layover, and the first officer indicated that he normally felt tired in the morning after such a schedule. On the second night, the first officer said that he had gotten to bed between 2300 and midnight, awoke about 0430, and felt rested the next day.

The Flight Attendant

The flight attendant was hired by Continental Express, Inc., on December 18, 1992, following her successful completion of initial training on December 14, 1992. She was flying the same trip sequence and rest periods as the flightcrew during the 3 days before the accident.

Crew Resource Management Training

Both pilots indicated that they had received initial training in CRM, termed cockpit crew coordination by Continental Express, during their initial ground school training, even though it was not required for 14 CFR Part 135 operators. In addition, the carrier's director of flight operations and director of in-flight services indicated that flightcrews and flight attendants trained together on CRM during recurrent training in a program that had been in place for about 2 years.

3. METEOROLOGICAL INFORMATION

The 1550 record observation taken at Pine Bluff reported the weather as the following: estimated ceiling 4,500 feet broken, 10,000 feet overcast, visibility 5 miles in light drizzle and fog, temperature 68°F, dew point 62°F, winds from 100° at 3 knots, and an altimeter setting 30.00 inches of Hg, with a note that the drizzle was intermittent. A special observation, taken at 1556, immediately after the accident, reported that the wind had changed to 080° at 3 knots, and the altimeter to 29.99 inches of Hg.

The upper air data taken at LIT indicated that the freezing level was at about 11,500 feet, and the temperature at 17,400 feet was about minus 11°C. A Meteorological Impact Statement issued by the Memphis ARTCC Weather Service Unit called for occasional moderate icing in clouds and precipitation between 12,000 and 20,000 feet.

During the investigation, it was found that seven aircraft were operating in the same ATC sector as the accident airplane at approximately the same time.

Five of the seven captains were interviewed regarding their recollections of the weather conditions they had encountered, especially icing conditions. Two of the captains recalled encountering icing conditions--the captain of a Boeing 727 operating as United Airlines flight 421 recalled encountering light-to-moderate icing conditions, and the captain of an Arkansas Power and Light shuttle flight, flying a Beech 1900, recalled encountering a trace of light icing while flying at 15,000 feet en route from Little Rock to New Orleans, Louisiana.

The accident flightcrew members did not recall seeing evidence of icing before the loss of control. The captain stated that he recalled last looking for ice as the flight passed through about 12,000 feet. Only one of the passengers recalled seeing any evidence of ice. The passenger stated that about 10 minutes after takeoff, the flight attendant commented to other passengers about the snow on the pilot's windshield. He further stated that he looked and saw a "whitish" substance that appeared to be snow about 8 to 10 inches above the windshield wipers. The wiper blades were mounted vertically. However, when questioned after the accident, the flight attendant did not recall making any statement about snow. There was no significant turbulence.

4. AIRCRAFT INFORMATION

The airplane was properly certificated in the transport category and maintained under an FAA-approved continuous airworthiness inspection program. It was equipped with two Pratt and Whitney Canada PW118 engines and two Hamilton Standard 14RF-9 propellers. A review of the airplane's maintenance records indicated that there were no outstanding discrepancies that would have affected its airworthiness, and all of the applicable airworthiness directives (ADs) and service bulletins had been complied with in accordance with the operator's maintenance management procedures. The airplane was dispatched from LIT on the accident flight in accordance with FAA and company procedures and was within prescribed limits for weight and center of gravity.

No evidence of primary or trim flight control system malfunction or failure was found. The FDR data, coupled with the crewmembers' statements, indicated that the controls were functioning normally before, during, and after the loss of control. Cable continuity, tensions, and routing were found to be in accordance with maintenance manual specifications. All of the airplane's lift-enhancing devices remained attached during the accident. The components and functions of the stall warning system, including the sensor heating elements, were tested and found to have been operating within normal specifications. Functional testing of the rudder power control unit revealed no anomalies that would have prevented it from operating normally. It was also determined that the rudder trim system on the EMB-120 does not interface with any other aircraft flight control or autoflight system.

The cockpit area microphone channel of the CVR was inoperative during the flight. According to the flightcrew, they had checked the CVR operation when they boarded the airplane that morning and had not noted any discrepancies. The normal self-test of the CVR, as outlined in the company and manufacturer's aircraft operations and maintenance manuals, only checks the recorder unit itself and does not check the continuity of any of the signals to the recorder. During the postaccident investigation, a broken wire was found between the area microphone and the recorder.

To enhance the preflight testing of CVRs, the Safety Board issued Safety Recommendation A-90-70 on May 30, 1990. The recommendation asked that all air carriers establish procedures requiring the use of a headset to further verify that the area microphone is functioning properly. In its August 28, 1991, response, the FAA stated that it had issued guidelines to all of its POIs requiring them to ensure that all aircrew training programs include procedures to properly check the CVR and to verify its operation by using a headset.

The Safety Board replied on January 16, 1992, stating its concern over an October 16, 1991, runway collision between a Continental Airlines B-737 and an American Airlines MD-80 at the Newark International Airport. The CVR from the B-737 contained no recorded information from the accident. Evidence indicated that the CVR from the B-737 was inoperative at the time of the accident, and had not been working for at least 10 flight legs. This is the type of problem that should have been detected had appropriate CVR preflight procedures been used. This CVR failure occurred 4 months after the issuance of FAA Handbook Bulletin 91-27. Thus the Board is concerned that the FAA's action has failed to remedy the problem. As of the date of this report, Safety Recommendation A-90-70 remains in an "Open--Acceptable Response" status awaiting further response from the FAA.

5. AUTOFLIGHT SYSTEM DESCRIPTION AND OPERATION

The airplane was equipped with a multimode autoflight system whose functions were controlled by the autoflight panel. The system's lateral capabilities included roll, heading, navigation, approach, back course, and go-around modes. The vertical functions included pitch hold (the default mode), altitude hold, indicated airspeed, vertical speed, altitude preselect, descent, and climb modes. The operations manual stated that with one of the lateral navigation modes selected and no vertical mode selected, the electronic attitude direction indicator command bars would be in view and display roll commands appropriate to the selected lateral mode and pitch commands to maintain the pitch attitude present at the time of mode selection.

The system description for the "climb" mode stated that upon engagement, the autoflight system would initiate a gradual climb, stabilizing at an indicated airspeed defined by the climb profile. The climb profile is controlled by the air data computer and maintains a constant 155 knots up to 20,000 feet after which the airspeed will decrease about 2 knots for each 1,000 feet of altitude, to about 135 knots at 32,000 feet. If the "climb" mode was selected at a speed below the climb profile speed, the autoflight system would decrease the rate of climb to 50 fpm until the climb profile speed was attained. With the proper power settings selected, the "climb" mode afforded a stall speed margin throughout the climb envelope, whereas, the "pitch hold" mode offered no such speed guarantee.

A review of the Continental Express Aircraft Operations Manual, the training syllabus, and discussions with the chief pilot indicated that crews were instructed to climb in either the "climb" or "indicated airspeed" modes. Contrary to this guidance, the captain stated that he had selected the "heading" and the "pitch hold" modes during the flight. He further stated during the interview that he thought the "pitch hold" mode would give him the best climb performance. This was in direct contradiction to the airplane operations manual, which clearly states that the "climb" mode would provide the best performance. The "pitch hold" mode maintained a constant airplane attitude regardless of airspeed and would not prevent the airplane from flying into a stall situation. By contrast, both the "climb" and "indicated airspeed" modes allowed the autoflight system to monitor airspeed and provide stall protection.

No failures were noted in either the pilot's or copilot's autoflight systems when a ground test mode check was performed at the accident site, and no anomalies were noted during subsequent off-site testing. In particular, both systems were found to be capable of engaging in any mode selected without any tendency to switch modes in an uncommanded fashion.

6. STALL WARNING SYSTEM

According to Embraer, the stall warning system consists of two identical subsystems that function independently and redundantly to drive two control column shakers, two pusher servos, and the aural warning system. The warning of an impending stall develops in a sequence, first with the vibration of the control column and the sound of the stick shaker (at 10° body angle of attack), and finally by sounding the stall warning tones (at 12.5° body angle of attack) and pushing the stick forward. Stick shaker actuation also disengages the autopilot system. The stick pusher maintains a forward pressure until the airplane reaches a normal acceleration of 1/2 G, pitch attitude is reduced, or the pilot disconnects the system. The mechanical clutch allows the pilot to override pusher actuation with a force of 88 pounds, plus or minus 20 pounds. Control wheel switches are provided to temporarily deactivate the stick pushers. Aft panel switches are provided to permanently dump one or both of the stall warning systems should a malfunction occur.

7. LEFT ENGINE NACELLE DAMAGE

On the left nacelle, the forward and aft inboard and outboard cowling doors were separated in flight and not recovered. The forward upper edge of the skin was bent and torn, and matched similar type damage on the aft edge of the propeller spinner. There was a transverse buckled area in the skin of the lower nacelle structure that extended completely around the bottom of the structure from the outboard cowling door sill to the inboard cowling door sill. The outboard side was buckled and crushed in compression, and the inboard was torn and separated. The structure forward of this buckled area was displaced downward and outboard. The rear half frames were buckled, and the aft engine mount brackets were separated from them by fastener failure. The brackets remained attached to the engine mount pads by the vibration isolators.

8. PROPELLER DESIGN AND BLADE SEPARATION

The Hamilton Standard Model 14RF-9 propeller assembly consists of four blades inserted into a hub as shown in Figure 3. During normal operation, the blades are retained in the hub by high centrifugal loads holding the blade outward against the bearing, and any bending loads are overcome by the high centrifugal loads. When there are no centrifugal loads on the propeller assembly, the retaining rings will retain the blades statically from dropping into the hub.

The three propeller blades that separated from the left hub following the loss of control were never found. The fourth blade remained loose in the hub. Its pitch change pin and roller were pinched in the actuator yoke by a bent yoke arm. The FDR, flight data acquisition unit (FDAU), and CVR data indicated that the blade separation sequence probably started about 35 seconds after the onset of the loss of control. Postaccident examination of remnants of the left propeller system indicated that the hub was intact, and the individual blade deice leads were attached at the time of separation.

The hubs installed on the accident airplane were equipped with composite material (Rynite) retaining rings for each blade. The evidence indicated that the composite blade retaining rings fractured and led to the blade loss. During departure from normal flight attitudes, the roll and yaw oscillations cause significant angle-of-attack changes on the blades, which produce increasingly severe propeller cyclic loads. Damage signatures observed in the left propeller hub were consistent with the blade departing the hub by rocking in the plane of rotation. The rocking motion of the blades would load the retaining rings so as to produce a fracture.

Following earlier blade loss events on other Hamilton Standard Model 14 propellers installed on other types of airplanes, the FAA issued AD 88-20-08 requiring the replacement of composite material blade retaining rings on those propellers with aluminum blade retaining rings. The 14RF-9 submodel, installed on the EMB-120, and the 14RF-21 submodel, installed on the CASA CN-235, were excepted from this AD. When AD 88-20-08 was created, it was thought that because the 14RF-9 and 14RF-21 models were turned by lower power engines, their blade retaining rings did not need to be made of aluminum. Following this

UNITED TECHNOLOGIES HAMILTON STANDARD

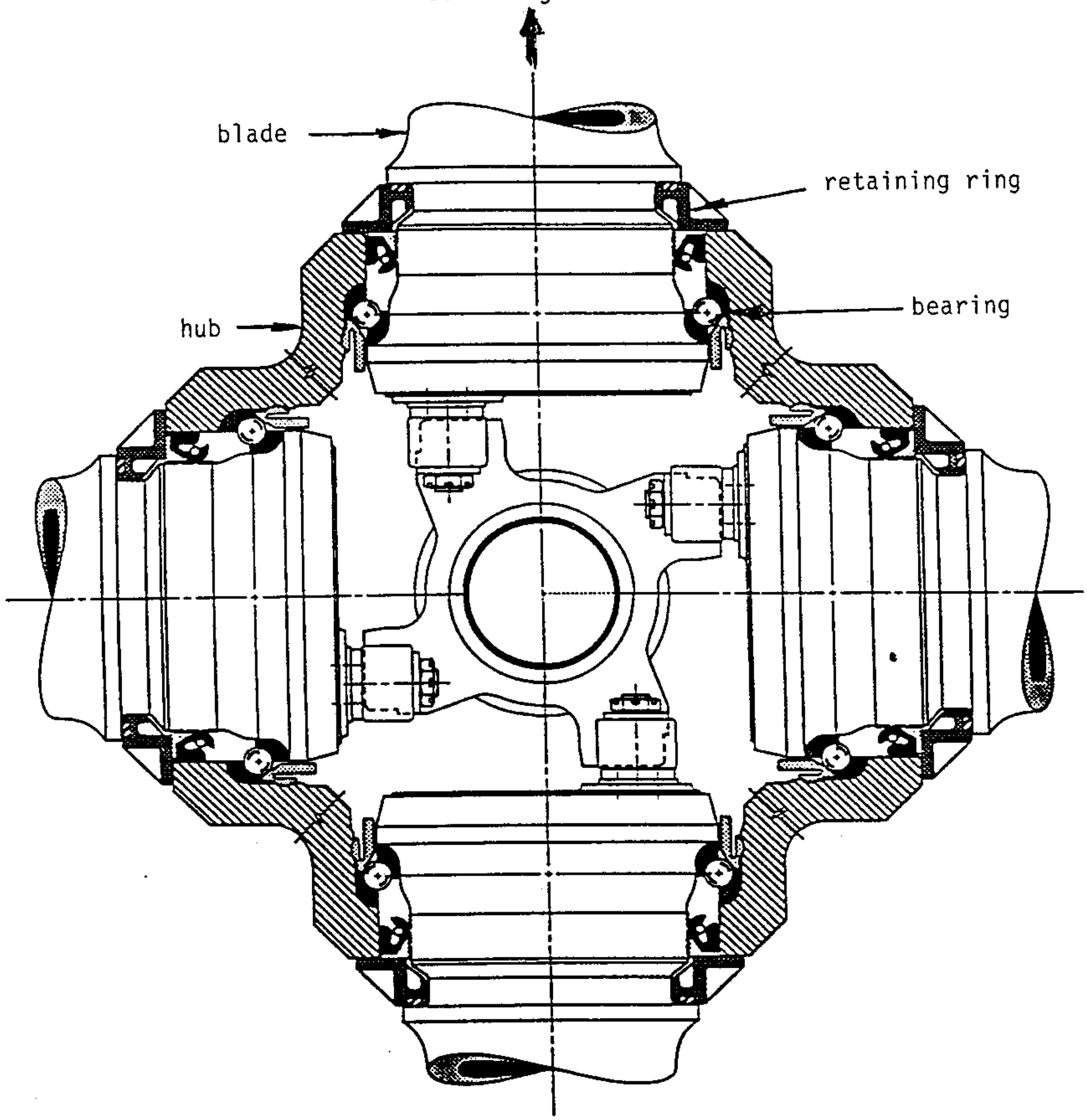

Figure 3.--Hamilton Standard 14RF-9 Propeller Assembly

accident, however, the FAA issued a notice of proposed rulemaking[5] to propose an AD that would require the submodels 14RF-9 and 14RF-21 to also have aluminum retaining rings. The final rule has not been issued as of the date of this report.

9. COMPANY PROCEDURES

Continental Express operations and maintenance procedures were reviewed during the course of the investigation, specifically, those areas pertinent to the conduct of the accident flight. The procedures and practices reviewed were found to be logical, clearly presented, and in accordance with the FARs. In many instances, the operator's procedures and requirements exceeded the minimum standards set by the FAA.

Continental Express' policy regarding the use of boom microphones was in accordance with 14 CFR 135.151(d) and stated that the boom headsets would be used at all times below 18,000 feet on aircraft equipped with a CVR. On the accident flight, the crew elected not to wear the headsets. The captain stated that the headsets "get bothersome at the end of the day with the heat of the day and it would have been uncomfortable to put them on."

The sterile cockpit procedures used by the operator were standard and complied with 14 CFR 135.100. The procedures were covered in crew training and were contained in both the operations manual for the flightcrew and the in-flight manual for the flight attendants. The flight attendant's brief, nonpertinent conversation with the flightcrew as the airplane passed through 8,000 feet during the climb was not in compliance with those procedures. When questioned, company officials stated that it would not have been unusual for a flight attendant to visit the cockpit for periods of 5 minutes or more during the nonsterile periods, if the visit was associated with the conduct of the flight.

The Continental Express EMB-120 RT Aircraft Operations Manual normal procedures section called for the pilot flying to accomplish the following recovery procedures at the first indication of a stall: "Simultaneously a) apply maximum power, b) level wings, c) hold a pitch attitude to stop deceleration and minimize

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[5]Federal docket number 93-ANE-73, *Federal Register* Vol. 58, No. 249, December 30, 1993.

sink, d) call for flaps 15 degrees." The procedure also stated that the "non-flying pilot must position or leave the flaps at 15 degrees."

The FAA POI for Continental Express, interviewed as part of the investigation, stated that he had observed no gross problems in operations during the surveillance conducted by himself and his assistants. In addition to the three operations inspectors assigned to Continental Express out of the Houston Flight Standards District Office, various geographical inspectors surveilled the carrier throughout its area of operation. The POI stated that he had not observed performance to be a systemic problem throughout the Continental Express operation. The POI also stated that he thought the surveillance program was more than adequate. A review of the surveillance reports for the 6 months before the accident indicated no major deficiencies or trends.

10. ANALYSIS

FDR Data Associated with Loss of Control

The Safety Board used recorded radar data, weather data, CVR data, and FDR information to develop a time history on the flight parameters of flight 2733. Correlation of the data indicated that the airplane's performance during takeoff, initial climb, and the steady climb to altitude was normal with a power reduction to 90 percent (climb power) accomplished at about 12,400 feet.

At 1530:52, the flight attendant inquired about climbing faster. The airplane was climbing through 15,800 feet about 420 fpm and at 180 knots indicated airspeed (KIAS). The pitch angle was about 3.2°. At 1531:09, the pitch angle increased to about 5.2°, and the altitude was 16,100 feet. The rate of climb increased to about 900 fpm as the airspeed slowed from 173 KIAS to 166 KIAS within the next 20 seconds. The pitch angle further increased to about 6.4° at 1531:55, while the airspeed was about 160 KIAS. The altitude was about 16,700, and the rate of climb increased very little, to 1,000 fpm within the next 10 seconds. Within an additional 10 seconds, at 1532:15, the climb rate decreased to 900 fpm while the airspeed decreased to 152 KIAS. Within the next 45 seconds, at 1533:00, the climb rate decreased to zero, and the airspeed decreased to 143 KIAS. The stick shaker activated at 1533:17 at an airspeed of 141 KIAS, and the roll angles started to develop 1 second later at 1533:18. Within 7 seconds after the stick shaker onset, the airplane developed a high rate of descent that reached in excess of 17,000 fpm during which the roll oscillations continued. The FDR recorded a change in heading to the left for about 270° coincident with a roll angle of about 110° at the onset of the descent. Roll oscillations as high as 90° in each direction and pitch attitudes as low as 67° airplane nose down were recorded during the descent. Coincident with the roll oscillations, the airspeed reached about 210 KIAS, and the airplane, while remaining near a stall condition, developed a positive load factor between 2 and 3 Gs.

The FDR indicated control wheel movements left and right initially out of phase with the airplane's roll oscillations. The control column was moved aft to command airplane nose up throughout the descent. According to the flightcrew, the recovery was initiated soon after the first officer lowered the landing gear. However, the FDR showed that the control column and wheel were returned to near neutral about the same time. FDR data show that the minimum altitude during the loss of control was approximately 5,600 feet. The airplane then climbed rapidly and briefly entered a second stall at about 6,700 feet and ultimately returned to controlled flight at 5,500 feet. The loss of control, descent, and recovery all occurred in IMC.

Comparison of Theoretical and Actual Airplane Performance

The crew stated that the autoflight system was configured in the pitch and heading hold modes throughout the climb. A review of the manufacturer's performance data for the gross weight and atmospheric conditions that existed indicated that for an international standard atmosphere (ISA) +0° day, at an altitude of 17,000 feet, climb speed should have been 155 KIAS, which would have resulted in a climb rate of 1,333 fpm. In ISA +10° conditions, the target climb speed would have remained the same, and the rate of climb would have been 800 fpm. The performance data also indicated that for the conditions present, the stick shaker should have activated at 127 KIAS, and the airplane would have stalled at 117 KIAS. The stick shaker on the accident airplane activated at 141 knots, or 14 knots higher than expected. The theoretical angle of attack at which the stick shaker activates is 10°. Although angle of attack is not recorded directly on the FDR, a comparison of recorded pitch attitude and computed flightpath angle confirmed that the actual angle of attack was about 10° when the stick shaker activated.

Although the deceleration of the airplane below the normal climb speed was a direct result of the captain's selection of a higher-than-normal pitch attitude, the activation of the stick shaker and the loss of lateral control at airspeeds 14 and 22 knots higher than the theoretical speeds for those events indicated that the aerodynamic performance of the airplane was affected by still other factors. Two of these factors were examined on the EMB-120 engineering simulator: drag due to sideslip and ice accretion.

Drag due to Sideslip

The captain's observation that the ball in the turn-and-slip indicator was slewed full left and that the rudder trim wheel was trimmed 10 units right immediately before the loss of control indicated that the airplane was in a left sideslip as it approached the stall. The FDR lateral acceleration and control wheel position parameters show that a left sideslip developed about 20 seconds before the autopilot disconnect.

However, as the airplane slowed during the climb, right rudder trim would have been required to balance the normal left turning forces produced by propeller effects at high angles of attack. At 140 KIAS, the airplane would have required about four units of nose-right rudder trim. Thus, the sideslip resulting from full nose-right trim was less significant than it would have been at a higher climb speed. When examined in the engineering simulator, it was evident that the reduction in climb performance resulting from the sideslip drag was less than that encountered on the accident flight. Furthermore, because of the short time of the sideslip condition, the Safety Board believes that the out-of-trim condition was not a factor in the loss of control.

Effect of Ice Accretion

The meteorological data and the observation of other pilots indicate that the conditions present at the time of the accident were conducive to the accretion of ice on the airplane's aerodynamic surfaces, which would have affected performance. The airplane was in clouds as it climbed above the freezing level at 11,500 feet and was exposed to freezing temperatures and visible moisture for over 7 minutes before the loss of control occurred. While the effect of ice on aerodynamic performance is well known, the ability to quantify the effect in terms of the lift decrease and drag increase associated with specific amounts of ice is limited. Embraer had aerodynamic performance data available for a wing having an inch or more of rough rime ice on the leading edge. When these data were examined in the simulator, the noted degradation in the airplane's climb performance was far greater than the degradation evident for flight 2733.

Although the captain and first officer both stated that they had not observed ice on the wings, there is no evidence that they looked for ice at any time during the climb above freezing level. The passenger's observation of a whitish substance on the windshield, which appeared to be snow, would be consistent with some amount of ice accretion.

The Safety Board believes that an accretion of ice on the wing is the only reasonable explanation for the occurrence of stick shaker activation and loss of roll control at higher-than-expected airspeeds. The Safety Board believes that only a small amount of ice on the wing's leading edge could have had a significant effect on the aerodynamic performance under the circumstances of this flight. If the airplane accumulated ice during the climb above 11,500 feet while at a relatively low angle of attack, the ice would have formed at the stagnation point[6] associated with that angle of attack. As the airplane slowed, the corresponding increase in angle of attack would have resulted in a movement of the stagnation point lower on the leading edge. Thus, the ice that had formed at the higher speed would be above the new stagnation point and produce a greater disruption of the air flow over the wing upper surface leading to premature boundary layer[7] separation. The result would be a progressive reduction in the lift produced by the wing and a stall at a lower angle of attack. In past aviation accident investigations, the Safety Board has determined that almost imperceptible amounts of ice, 1/4 of an inch or less, on the wing leading edge has significantly increased the stall speed and lateral control capability of the airplane.

Thus, the Safety Board believes that ice accumulated during the climb and resulted in a stall at higher-than-normal speed. While it is likely that the accretion of ice alone would not have led to a stall had the captain attempted to maintain a

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[6]The stagnation point is the point on the leading edge of the airfoil where the relative airflow diverges to pass above and below the wing so that the local airflow velocity is zero.

[7]The boundary layer is the airflow immediately adjacent to the wing surface.

target airspeed instead of a target pitch attitude, the Safety Board cites the captain's inattention to ice accretion as a factor in the accident.

Propeller Failure

Evaluation of the FDR, FDAU, and CVR data revealed that operation of the engines and propellers was normal until after the loss of control occurred. This information corresponded with the crew's statements. Evidence obtained after the accident from the left engine indicated that at some point the engine had been operated under extremely high vibratory loads at low engine speeds. The FDR revealed that the right engine and propeller continued to operate within normal parameters until the collision with the terrain as the airplane departed the runway during the landing.

The Safety Board considered and could not conclusively discard the possibility that the nacelle damage was caused by the maneuvering and air loads imposed on the structure during the out-of-control descent. If this were the case, the distortion of the nacelle and engine mounts could have moved the propeller control linkage to feather, which in turn would have resulted in a loss of blade centrifugal loads, which permitted the blades to separate. The Safety Board believes that it is more probable that the loss of the propeller blades was initiated when the crew attempted to feather the left engine in the belief that an engine overspeed had occurred. The loss of centrifugal loads on the blades as the propeller rotational speed slowed, combined with the severe cyclic loads imposed on the blades during the departure from stabilized flight, would have allowed the blades to rock in the hub with consequent failure of the blade retaining rings, release of the bearings, and blade separation. The Safety Board believes that the imbalance of the propeller assembly as the blades separated imposed the high vibratory loads to the engine shaft, which produced the nacelle damage.

Thus, the Safety Board believes that while the propeller blade separation was a result of the loss of control, it contributed to the severity of the accident, in that the effective loss of one engine and the nacelle damage resulted in a performance degradation that limited the captain's ability to control the airplane and maintain altitude. The limited control led to a long landing touchdown and subsequent overrun.

Flightcrew Performance

Selection of Improper Autoflight Mode

The Safety Board believes that the guidance provided in Continental Express' manuals and training programs is clear in the description of the autoflight system operating modes. These materials specifically state that climbs should be conducted in either the "climb" or "airspeed" modes to ensure that an adequate airspeed margin above stall is maintained. Contrary to that guidance, the captain chose to use the "pitch hold" mode. Moreover, the captain increased the pitch attitude to increase the rate of climb apparently without reference or concern about the performance capability of the airplane to maintain a safe airspeed. Consequently, the airspeed decreased, and as a result of increased drag, the rate of climb decreased. That the captain's action to select the "pitch hold" mode was intentional is evident from his postaccident statements and his attempt to increase the pitch attitude in response to the flight attendant's request to enhance the rate of climb.

The Safety Board is particularly concerned that an experienced pilot with over 2,500 hours in the airplane type would fail to recognize the loss of efficiency as well as the potential danger in selecting a constant pitch attitude climb. The Safety Board believes that the captain's action was not only contrary to company procedures, but contrary to the principles of basic airmanship. Of equal concern is the inaction of the first officer to question the captain or monitor the autoflight system selection.

The Safety Board concludes that the captain's inappropriate selection of the "pitch hold" mode combined with the flightcrew's subsequent failure to maintain a safe airspeed was the primary cause of this accident.

Flightcrew Inattentiveness

The recorded cockpit conversation between the captain, first officer, and flight attendant was consistent with a complacent and lax atmosphere throughout the flight. Having selected the "pitch hold" mode for the climb, it was particularly important that the flightcrew monitor the essential flight instruments continually to maintain a safe airspeed and positive rate of climb. Instead, the captain permitted the flight attendant to enter the cockpit and then engaged in casual conversation for over 4 minutes before the loss of control occurred. Meanwhile, the first officer was making entries into the airplane's log book, which diverted his attention from the flight instruments.

It was in response to the flight attendant's request that the captain selected an increased pitch attitude. Subsequently, he continued to talk to the flight attendant and was not attentive to his flight instruments. The Safety Board believes it likely that the captain began to dial in nose-right rudder trim as a normal action during climb and, without observing the turn-and-slip indicator, continued to do so until full trim was reached. A passenger observed the captain "turning a knob" that was located in the approximate position of the rudder trim knob. The investigation determined that there were no autoflight or trim system malfunctions that could have resulted in full nose-right rudder trim.

Further, neither of the flightcrew remembered observing the wing leading edges or propeller spinners to check for ice accretion even though they were flying through visible moisture and freezing temperatures. The Safety Board believes that the flightcrew's inattention to the flight led directly to their failure to maintain a safe airspeed.

It is probable that, during their last sequence of flights together, all three crewmembers became too relaxed with each other and, consequently, less professional in their relationship during flight. For instance, the open cockpit door and the non-use of headsets by the flightcrew encouraged and certainly allowed the flight attendant to distract the pilots for several minutes while a critical, unsafe flight situation developed. The crewmembers were apparently comfortable enough together to allow themselves to become extremely complacent, and the lax cockpit atmosphere set by the captain was accepted by the other crewmembers. All three individuals should have done more to prevent the accident situation from developing, and good crew coordination and resource management principles certainly would have assisted them.

Stall Recovery

The procedures for stall recovery are delineated in the Continental Express Operations Manual, and pilots are required to demonstrate their knowledge of these procedures repeatedly during training. However, the Safety Board believes that the pilot training for stall recovery is directed toward low altitude encounters where minimum altitude loss is critical. Further, during training, the pilot is expected to respond immediately to the first activation of the stick shaker where sufficient margin from full stall or loss of control exists and aggressive action to reduce pitch attitude is unnecessary and in fact would not be consistent with a minimum altitude loss recovery. Therefore, while the operations manual also states that it may be necessary to lower pitch attitude to trade altitude for airspeed if an impending stall is encountered at cruising altitude, and while this procedure is stressed in the most basic pilot training courses, it might not be an immediate or reflexive response to stick shaker onset.

Also, the approach to stall demonstrations during training are conducted with an airplane or simulator having normal aerodynamic performance characteristics, that is, there is no consideration given to the performance degradation or the effect on stall warning system margin that result from ice accretion on the wing leading edge.

During this accident, ice accretion on the wing significantly reduced the margin between the stick shaker onset and the loss of control. The FDR and CVR correlation show that within 2 seconds of stick shaker onset and autopilot disconnect, the airplane entered a sudden and uncontrollable roll oscillation. The data then show that instead of relaxing control column force, the captain increased back force to hold the control column aft and introduced roll commands through the control wheel that were initially out of phase with the proper corrective deflections. Thus, the captain's initial control deflections following the stick shaker onset and the almost immediate loss of control aggravated, rather than corrected, the out-of-control maneuvers.

The FDR data indicated that the airplane was capable of developing a positive load factor throughout the uncontrolled decent. Thus, the Safety Board believes that recovery could have been accomplished with minimum altitude loss at the time of the stick shaker activation or earlier in the descent had the captain relaxed control column force. Had he done so, the angle of attack would have been reduced and aileron effectiveness restored permitting the airplane to regain wings-level flight. The Safety Board acknowledges, however, that any crew, regardless of their training in the recovery from unusual attitudes, may have had difficulty responding to a situation such as that confronting this crew after the lateral control loss--that is, high lateral and vertical acceleration loads that combined with a lack of visual reference and the rapidly changing attitude instruments with corresponding changes in altimeter and airspeed readings would have produced disorientation. It appears to the Safety Board that the basic stability of the airplane when the control column was finally returned to neutral and perhaps the lowering of the landing gear were the only factors that prevented an uncontrolled descent into the terrain.

The Safety Board believes that this accident illustrates the need to emphasize to pilots the aerodynamic fundamentals of a stall-induced loss of control and the need to move the control column to reduce the angle of attack to recover from such a loss of control.

Flightcrew Fatigue

The accident flight came at the end of the crew's 3-day flight schedule. The first day of the schedule was demanding and culminated in a reduced rest period. The second day was short, with the crew going off duty about 1130 and not having to report back until 0530 the next day. The last day was perceived by the crew as being the most demanding because it was the end of the trip, and as the first officer said, "one is just ready to go home and see the family." The captain stated that the workload was slightly heavier on the last day due to having seven legs to fly in IMC.

The crew rest periods scheduled for the trip were within company guidelines and FARs. The crewmembers had sufficient opportunity on the second day of their flight schedule to get adequate rest; however, they did not take advantage of this opportunity. For the two nights before the accident, the pilots averaged only about 5 to 5 1/2 hours of sleep per night. The accident occurred after a long and relatively difficult day of flying and on the last leg when the crew anticipated getting home. Further, the accident occurred in the late afternoon when the human body normally reaches a physiological low level of performance and alertness. The Safety Board believes that the combined effects of cumulatively limited sleep, a demanding day of flying, and a time of day associated with fatigue had an effect on crew performance.

The Safety Board recently examined the 37 major air carrier accidents from 1978 through 1990 for which human performance issues were cited in the probable cause determination ("A Review of Flightcrew-Involved, Major Accidents of U.S. Carriers, 1978 through 1990." Safety Study NTSB/SS-94/01). Many human performance background variables were compared to the types of errors observed in the accident sequence in an effort to identify factors that might be useful in accident prevention. Several fatigue-related variables were examined--time since awakening, time of day, time zone crossings, and changing work schedules. It was found that the time since awakening for each pilot related to significant differences in performance, in terms of the number and types of errors made by pilots.

As a result of this safety study, the Safety Board recommended on February 4, 1994, that the FAA require U.S. air carriers operating under 14 CFR Part 121 to include, as part of pilot training, a program to educate pilots about the detrimental effects of fatigue, and strategies for avoiding fatigue and countering its effects (A-94-5). The FAA has not yet responded to this recommendation.

Such a training program might have assisted the pilots in the present accident to better recognize their own symptoms of fatigue and to develop personal strategies to help lower its effects in their demanding work schedules.

Air Traffic Control Procedures

A review of the ATC communications transcript revealed that the flightcrew did not describe the full nature of their difficulties to the controller until very late in the accident's sequence of events. In addition, the flightcrew were apparently analyzing their best options and thus did not clearly state to the air traffic controllers where they wanted to land the airplane.

When the flightcrew stated their intention to land at PBF, the air traffic controller should have informed the pilot that men and equipment were working on the runway. Additionally, the information concerning the ILS outage should have been issued to the pilot sooner than it was. This information was carried on a NOTAM that was not available to the ARTCC controller, but was available to the approach controller. Another controller on the ARTCC sector controlling the aircraft was aware that navigational aids (navaids) were not available at PBF, but the information never reached the pilot. Therefore, the Safety Board believes that the coordination and passing of information from approach control to the ARTCC was insufficient.

Additionally, had the ARTCC controller attempted to change control of the flight to Little Rock Approach Control sooner, the pilot would have received more timely information concerning the status of navaids. And again, had the flightcrew been more definitive about their intentions, and reached a more timely decision as to where they wanted to land, the air traffic handling would have been undoubtedly much improved. In spite of these anomalies, the Board believes that the failure to pass on information about the ILS outage and about men and equipment on the runway did not contribute to the accident sequence of events. The weather in the Pine Bluff local area was VFR, and by the time that the aircraft had landed, the full length of the runway was available.

11. CONCLUSIONS

1. The airplane was properly certificated, equipped, and maintained in accordance with FAA regulations and approved Continental Express procedures.

2. The airplane was dispatched in accordance with FAA regulations and operator procedures and was within the prescribed limits for weight and center of gravity.

3. The Continental Express operations and maintenance procedures pertinent to the conduct of the accident flight were found to be logical, clearly presented, and in accordance with the FARs. In many instances, the operator's procedures and requirements exceeded the minimum standards set by the FAA.

4. Both crewmembers were properly certificated, qualified, and current for the operation being conducted.

5. All of the flight control, autoflight, stall warning, and flight instrument systems were operating normally up to the time of the loss of control. No evidence of primary or trim flight control system malfunction was found.

6. The freezing level was near 11,500 feet and the potential for icing existed up through 19,000 feet. The airplane was in clouds with zero visibility, and the tops of the clouds extended above 21,000 feet.

7. The entire crew violated the sterile cockpit rule as the airplane was passing through 8,000 feet. In addition, the flight attendant was present in the cockpit as the airplane climbed above 10,000 feet, engaging in nonpertinent conversation with the captain, for 4 minutes and 27 seconds up to and during the loss of the control.

8. The captain and the first officer failed to adequately monitor the progress of the flight during the climb, and the first officer failed to adequately monitor the captain's actions.

9. The captain engaged the autoflight system in the "heading" and "pitch hold" modes during the climb, obviating the stall and speed protection afforded by the other vertical modes. This autoflight system configuration was contrary to the company's training and procedures.

10. During the climb, the pitch was increased by the captain, using the autoflight "pitch hold" mode, in the minutes before the loss of control.

11. The increase in pitch, and subsequent loss of airspeed, resulted in an aerodynamic stall. The stall and loss of control at a higher-than-expected airspeed was caused by aerodynamic performance degradation due to wing ice contamination.

12. The captain did not respond immediately to the stick shaker warning, which was followed within 2 seconds by a loss of lateral control. Thereafter, the continued exertion of back force on the control column was inappropriate.

13. The airplane recovered from the out-of-control descent when control forces were relaxed and the landing gear was lowered.

14. The operation of the engines and propellers was normal until after the loss of control. The captain shut down the left engine and feathered the propellers, mistakenly believing that there was an engine overspeed. Three of the four left propeller blades and the cowlings separated after the beginning of the event, during the post-stall gyration.

15. Following recovery, due to asymmetric aerodynamic drag caused by the damaged engine, propeller, and cowl, the airplane was unable to maintain level flight, and precise airplane control was not possible.

16. Because of the inability to precisely control the airplane after the recovery, the flightcrew landed long. This, and the fact that the runway was wet, precipitated the overrun landing roll, subsequent airplane damage, and injuries.

17. The crew rest periods scheduled for the trip sequence were within company guidelines and FARs. However, the crew did not take advantage of the rest periods, and the combined effects of cumulatively limited sleep, a demanding day of flying, and a time of day associated with fatigue were factors in the crew's inadequate judgment and performance.

18. Although coordination between Little Rock Approach Control and Memphis ARTCC could have been much improved, it did not contribute to the accident.

12. PROBABLE CAUSE

The National Transportation Safety Board determines that the probable causes of this accident were the captain's failure to maintain professional cockpit discipline, his consequent inattention to flight instruments and ice accretion, and his selection of an improper autoflight vertical mode, all of which led to an aerodynamic stall, loss of control, and a forced landing. Factors contributing to the accident were poor crew discipline, including flightcrew coordination before the stall and the flightcrew's inappropriate actions to recover from the loss of control. Also contributing to the accident was fatigue induced by the flightcrew's failure to properly manage provided rest periods.

13. RECOMMENDATIONS

As a result of its investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require that 14 CFR Part 135 air carriers provide aircrews, as part of their initial and recurrent training, information on fatigue countermeasures relevant to the duty/rest schedules being flown by the company. (Class II, Priority Action) (A-94-73)

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

Carl W. Vogt
Chairman

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Member

John A. Hammerschmidt
Member

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Member

March 15, 1994

APPENDIX A

COCKPIT VOICE RECORDER TRANSCRIPT

Transcript of a Fairchild Model A-100A cockpit voice recorder, S/N 53971, removed from a Continental Express Airlines Inc., Embraer EMB-120 RT, N24706, which was involved in an in-flight accident on April 29, 1993, near Pine Bluff, Arkansas.

RDO	Radio transmission from accident aircraft
CAM	Cockpit Area sounds picked up the two boom microphones
-1	Voice identified as Captain
-2	Voice identified as First Officer
-3	Voice identified as Flight Attendant
-?	Voice unidentified
TWR	Little Rock Local Controller (tower)
DEP	Little Rock Departure Controller
CTR	Memphis Center Controller
COMP	Continental Express Company Operations (Little Rock)
UNK	Unknown source
*	Unintelligible word
@	Nonpertinent word
#	Expletive deleted
%	Break in continuity
()	Questionable text
(())	Editorial insertion
-	Pause
Notes:	All times were derived from the LIT local and departure ATC recording. Only radio transmissions involving the accident aircraft were transcribed.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1502:07	start of recording.		
1515:25	start of transcript.		
		1516:01 TWR	Jet Link twenty seven thirty three cleared for takeoff two two right turn left heading one eight zero.
		1516:06 RDO-2	turn left one eight zero cleared to go two two right twenty seven thirty three.
1516:14 CAM	((sound of increasing engine noise))		
1516:26 CAM-2	* set.		
1516:32 CAM-2	eighty.		
1516:38 CAM-2	vee one.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1516:39 CAM-2	vee two.		
1516:43 CAM-2	positive rate.		
1516:44 CAM-1	gear.		
1516:45 CAM	((sound similar to landing gear handle being moved))		
1517:07 CAM-2	acceleration.		
1517:08 CAM-1	okay -- * flaps *.		
		1517:23 TWR	Jet Link twenty seven thirty three contact departure.
		1517:26 RDO-2	twenty seven thirty three so long.
1517:28 CAM	((sound of radio frequency change tone))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1517:30 RDO-2	departure Jet Link twenty seven thirty three's with you one point three four thousand one eight zero heading.
		1517:35 DEP	Jet Link twenty seven thirty three departure radar contact join J-180 climb and maintain one zero thousand.
1517:40 CAM-3	*.		
		1517:42 RDO-2	J-180 one zero thousand twenty seven thirty three.
1518:29 CAM-2	*.		

INTRA-COCKPIT COMMUNICATION

TIME & SOURCE	CONTENT
1521:12 CAM-1	what do you think your doin'.
1521:14 CAM-2	I don't know.

AIR-GROUND COMMUNICATION

TIME & SOURCE	CONTENT
1518:33 RDO-2	Little Rock twenty seven thirty three.
1518:37 COM	and twenty seven thirty three this is Little Rock go ahead.
1518:39 RDO-2	Yes sir we'll give you on time and sixteen you have a good day.
1518:46 COM	copy on time and sixteen thanks sorry about the mix-up there guys.
1518:50 RDO-2	no problem see ya.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1522:09 DEP	Jet Link twenty seven thirty three Memphis center now one three five point eight so long
		1522:21 RDO-2	and that was thirty five eight for twenty seven thirty three, see ya.
		1522:26 DEP	Jet Link twenty seven thirty three Memphis center one three five point eight that is correct.
		1522:30 RDO-2	have a good day.
1522:32 CAM	((sound of radio frequency change tone))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1522:33 RDO-2	center Jet Link twenty seven thirty three is seven and a half one zero thousand.
		1522:37 CTR	Jet Link twenty seven thirty three Memphis center climb and maintain flight level two two zero.
		1522:41 RDO-2	up to two two zero twenty seven thirty three.
1522:45 CAM-2	I'm gunna' go ahead and run a weight for two six oh right.		
1522:48 CAM-1	I don't I don't care.		
1522:51 CAM-1	I don't know what the winds are like up there.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1522:54 CAM-3	Hi.		
1522:56 CAM-1	* difference huh.		
1523:12 CAM-2	at eighteen its ah two ninety at twenty six at two four its twenty six at thirty three.		
1523:21 CAM-1	It really don't make a big difference.		
1523:25 CAM-2	the higher you go.		
1523:27 CAM-1	the more it turns into a head wind any way.		
1523:29 CAM-2	yeah *.		
1523:36 CAM-2	what do you want to go for a final? you want to go *.		
1523:38 CAM-1	I don't care.		
1523:41 CAM-1	*.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1523:42 CAM-2	*.		
1523:45 CAM-1	* no no thanks.		
1523:51 CAM-1	do guys really want to eat somethin' that bad.		
1523:54 CAM-2	That girl's got you all screwed up. *.		
1524:00 CAM-2	it look's like * concentrate.		
1524:04 CAM-1	man I just couldn't help it I was tryin' I was tryin to change the conversation all right.		
1524:08 CAM-2	yeah.		
		1526:26 CTR	Jet Link twenty seven thirty three climb and maintain flight level two three zero.

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
		1526:30 RDO-2	two three zero twenty seven thirty three requesting two two zero for a final.
		1526:35 CTR	Jet Link twenty seven thirty three roger maintain flight level two two zero.
		1526:38 RDO-2	two two zero thanks.
1526:45 CAM-1	* when I go back to eighty five.		
1526:51 CAM-2	eight five -.		
1527:06 CAM-?	*.		
1528:28 CAM-?	*.		
1528:42 CAM-?	*.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1528:43 CAM-1	* final.		
1528:49 CAM	((unintelligible conversation between the flight attendant and the captain))		
1530:29 CAM-?	you got the * on?		
1530:33 CAM-3	oh do the windshield wipers that'll wipe it off.		
1530:35 CAM-1	naw I can't naw I can't do it 'cause we're goin' too fast.		
1530:40 CAM-3	* that'd be funny that'd be funny that'd crack me up that'll make my day.		
1530:47 CAM-1	* off.		
1530:48 CAM-3	do it do it do it.		
1530:48 CAM-1	okay *.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1530:52 CAM-3	can't we climb any faster.		
1530:54 CAM-1	why do you want to get up *.		
1531:08 CAM-3	* - - I can't pull it uphill.		
1531:09 CAM-1	okay.		
1531:10 CAM-3	the last time I had to pull it up the hill.		
1531:11 CAM-1	okay we'll try to get up a little more.		
1531:14 CAM-3	we'll try to get up there.		
1531:15 CAM-1	yeah we're almost there another six thousand feet another six minutes *.		
1531:26 CAM-3	*.		
1531:38 CAM-1	gimee gimee gimee.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1531:41 CAM-3	climb gimee gimee gimee.		
1531:45 CAM-1	you're right better to receive than to give.		
1531:48 CAM-3	what.		
1531:49 CAM-1	ah like I said better to receive than to give.		
1531:55 CAM-3	I don't know.		
1531:56 CAM-1	live by that.		
1531:59	((5 seconds of non-pertinent conversation between the Captain and the flight attendant))		
1532:05 CAM-2	*.		
1532:06 CAM-1	that was * for us.		
1532:08 CAM-2	did you set it for *.		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1532:11 CAM-3	I threw up.		
1532:28 CAM-2	we're not climbin' very fast.		
1532:29 CAM-1	heavy really heavy.		
1532:32 CAM-3	I know * no ** walk like walk a straight line not sway all over it.		
1532:51 CAM-1	(sound of laugh)		
1532:52 CAM-3	(sound of laugh)		
1532:57 CAM-3	so that's what you meant by *.		
1533:11 CAM-1	(Frank/hang on) somethin' ain't right.		
1533:16.3 CAM	((sound of auto-pilot disconnect warning))		
1533:16.8 CAM	((sound of stick shaker starts and continue until end of recording))		

INTRA-COCKPIT COMMUNICATION		AIR-GROUND COMMUNICATION	
TIME & SOURCE	**CONTENT**	**TIME & SOURCE**	**CONTENT**
1533:16.8 CAM-1	airspeed.		
1533:18.0 CAM	((aural stall warning tones start and continue until the end of the recording))		
1533:22.7 CAM-1	hang on.		
1533:23.4 CAM-1	hang on.		
1533:24.6 CAM-2	power up power's *.		
1533:25.6 CAM	((sound of increasing engine noise))		
1533:27 CAM-1	*.		
1533:34 CAM-1	up.		
1533:34.7 CAM	((sound of vibration starts and continues until end of recording))		
1533:36 CAM-1	up.		

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

TIME & SOURCE	CONTENT	TIME & SOURCE	CONTENT
1533:37.2 CAM-2	airspeed * airspeed.		
1533:39.7 CAM	((sound of engine noise decreases and no longer is heard))		
1533:41.6 CAM-1	* overspeed.		
1533:44.2 CAM-1	it's an overspeed.		
1533:46.7	(end of recording)		

As part of the Safety Board's accident investigation process, the surviving cockpit flightcrew and cabin flight attendant were invited to review the CVR group's transcript and suggest corrections or additions. The flight attendant declined the invitation. The captain and first officer reviewed the CVR recording and the transcript on May 23, 1993, and suggested the following changes:

Page 35
 Add the word "up" after gear at 1516:44.
Page 36
 Change * at 1518:29 to "going to ops."
Page 40
 Add the words "Not much" to the beginning of statement at 1522:56.
Page 41
 Add word "you" between words "do" and "guys" to statement at 1523:51.
Page 44
 Change * in statement at 1530:54 to "so fast?"
Page 45
 Change word "I" to "you" in statement at 1531:49.
Page 46
 Change CAM-2 to CAM-1 at statement at 1532:28.
 Change first word "heavy" in beginning of statement at 1532:29 to "yeah we're."
 Change * in statement at 1532:57 to "weight problem."
 Change word "somethin'" in statement at 1533:11 to "this."
Page 47
 Change CAM-2 to CAM-1 at statement at 1533:24.
Page 48
 Change * in statement at 1533:37.2 to "kay."
 Change * in statement at 1533:41.6 to " I think it's an."

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*U.S. G.P.O.:1994-300-644:80025