National Transportation Safety Board

Washington, D.C. 20594

Aircraft Accident Brief

Accident No.:	DCA00MA052
Operator or Flight Number:	Executive Airlines
Aircraft and Registration:	British Aerospace J-3101, N16EJ
Location:	Bear Creek Township, Pennsylvania
Date:	May 21, 2000

HISTORY OF FLIGHT

On May 21, 2000, about 1128 eastern daylight time (EDT),[1] a British Aerospace Jetstream 3101, N16EJ, operated by East Coast Aviation Services (doing business as Executive Airlines) crashed about 11 miles south of Wilkes-Barre/Scranton International Airport (AVP), Wilkes-Barre, Pennsylvania. The airplane was destroyed by impact and a postcrash fire, and 17 passengers and two flight crewmembers were killed. The flight was being conducted under 14 *Code of Federal Regulations* (CFR) Part 135 as an on-demand charter flight for Caesar's Palace Casino in Atlantic City, New Jersey. An instrument flight rules (IFR) flight plan had been filed for the flight from Atlantic City International Airport (ACY) to AVP.

The captain checked in for duty about 0800 at Republic Airport (FRG) in Farmingdale, New York, on the day of the accident. The airplane was originally scheduled to depart FRG at 0900 for ACY and to remain in ACY until 1900, when it was scheduled to return to FRG. While the pilots were conducting preflight inspections, they received a telephone call from Executive Airlines' owner and chief executive officer (CEO) advising them that they had been assigned an additional flight from ACY to AVP with a return flight to ACY later in the day, instead of the scheduled break in ACY.

Fuel records at FRG indicated that 90 gallons of fuel were added to the accident airplane's tanks before departure to ACY. According to Federal Aviation Administration (FAA) air traffic control (ATC) records, the flight departed at 0921 (with 12 passengers on board) and arrived in ACY at 0949. According to passenger statements, the captain was the pilot flying from FRG to ACY.[2] After arrival in ACY, the flight crew checked the weather for AVP and filed an IFR flight plan. Fuel facility records at ACY indicated that no additional fuel was added. The

[1] Unless otherwise indicated, all times are EDT, based on a 24-hour clock. The accident time is approximate, based on air traffic control (ATC) information.

[2] According to company practices, pilots alternated pilot flying duties each flight leg. Representatives of Executive Airlines who were familiar with both pilots reviewed the ATC recordings from AVP approach and tower facilities and identified the captain as the pilot speaking with ATC in all radio transmissions. Based on company policy, it is likely that the first officer was the pilot flying on the flight to AVP.

accident flight to AVP, which departed ACY about 1030, had been chartered by Caesar's Palace. According to ATC records, the flight to AVP was never cleared to fly above 5,000 feet mean sea level (msl).[3]

According to ATC transcripts,[4] the pilots first contacted AVP approach controllers at 1057 and were vectored for an instrument landing system (ILS)[5] approach to runway 4. The flight was cleared for approach at 1102:07, and the approach controller advised the pilots that they were 5 nautical miles (nm) from Crystal Lake, which is the initial approach fix (IAF) for the ILS approach to runway 4.[6] The pilots were told to maintain 4,000 feet until established on the localizer. At 1104:16, the approach controller advised that a "previous landing…aircraft picked up the airport at minimums [decision altitude]."[7] The pilots were instructed to contact the AVP local (tower) controller at 1105:09, which they did 3 seconds later. The airplane then descended to about 2,200 feet, flew level at 2,200 feet for about 20 seconds, and began to climb again about 2.2 nm from the runway threshold when a missed approach was executed (see the Airplane Performance section for more information).

At 1107:26 the captain reported executing the missed approach but provided no explanation to air traffic controllers.[8] The tower controller informed the North Radar approach controllers of the missed approach and then instructed the accident flight crew to fly runway heading, climb to 4,000 feet, and contact approach control on frequency 124.5 (the procedure published on the approach chart). The pilots reestablished contact with the approach controllers at 1108:04 as they climbed through 3,500 feet to 4,000 feet and requested another ILS approach to runway 4. The flight was vectored for another ILS approach, and at 1110:07 the approach controller advised the pilots of traffic 2 nm miles away at 5,000 feet. The captain responded that they were in the clouds. At 1014:38, the controller directed the pilots to reduce speed to follow a Cessna 172 on approach to the airport, and the captain responded, "ok we're slowing." The flight was cleared for a second approach at 1120:45 and advised to maintain 4,000 feet until the airplane was established on the localizer.

At 1123:49 the captain transmitted, "for uh one six echo juliet we'd like to declare an emergency." At 1123:53, the approach controller asked the nature of the problem, and the captain responded, "engine failure." The approach controller acknowledged the information, informed the pilots that the airplane appeared to be south of the localizer (off course to the right), and asked if they wanted a vector back to the localizer course. The flight crew accepted, and at 1124:10 the controller directed a left turn to heading 010, which the captain acknowledged. At

[3] ATC radar indicated that the airplane approached AVP from the southeast at an initial altitude of 5,000 feet.

[4] No information was recorded on the cockpit voice recorder (CVR). ATC transcripts are the only record of pilot communication. See the CVR Maintenance section for information about the CVR's failure to record information.

[5] The ILS is a precision approach system that provides lateral alignment (localizer) and vertical guidance (glideslope) with the runway.

[6] The Crystal Lake non-directional beacon is located about 8.4 nm from the runway 4 threshold.

[7] Decision altitude (DA) is a specified altitude at which a missed approach must be executed if visual references have not been established. DA for the ILS runway 4 approach is 1,263 feet msl, or about 300 feet above the runway touchdown zone.

[8] The airplane was about 2.5 nm from the runway threshold when it began to climb on the missed approach.

1124:33, the controller asked for verification that the airplane was turning left. The captain responded, "we're trying six echo juliet." At 1124:38, the controller asked if a right turn would be better. The captain asked the controller to "stand by." At 1125:07, the controller advised the pilots that the minimum vectoring altitude (MVA) in the area was 3,300 feet. At 1125:12, the captain transmitted, "standby for six echo juliet tell them we lost both engines for six echo juliet." At that time, ATC radar data indicated that the airplane was descending through 3,000 feet.

The controller immediately issued the weather conditions in the vicinity of the airport and informed the flight crew about the location of nearby highways. At 1126:17, the captain asked, "how's the altitude look for where we're at." The controller responded that he was not showing an altitude readout from the airplane[9] and issued the visibility (2.5 miles) and altimeter setting. At 1126:43, the captain transmitted, "just give us a vector back to the airport please." The controller cleared the accident flight to fly heading 340, advised the flight crew that radar contact was lost, and asked the pilots to verify their altitude. The captain responded that they were "level at 2,000." At 1126:54, the controller again advised the flight crew of the 3,300-foot MVA and suggested a 330° heading to bring the airplane back to the localizer. At 1127:14 the controller asked, "do you have any engines," and the captain responded that they appeared to have gotten back "the left engine now." At 1127:23, the controller informed the pilots that he saw them on radar at 2,000 feet and that there was a ridgeline between them and the airport. The captain responded, "that's us" and "we're at 2,000 feet over the trees." The controller instructed the pilots to fly a 360° heading and advised them of high antennas about 2 nm west of their position.

At 1127:46, the captain transmitted, "we're losing both engines." Two seconds later the controller advised that the Pennsylvania Turnpike was right below the airplane and instructed the flight crew to "let me know if you can get your engines back." There was no further radio contact with the accident airplane. The ATC supervisor initiated emergency notification procedures. A Pennsylvania State Police helicopter located the wreckage about 1236, and emergency rescue units arrived at the accident site about 1306. The accident occurred in daylight instrument meteorological conditions (IMC). The location of the accident was 41° 9 minutes, 23 seconds north latitude, 75° 45 minutes, 53 seconds west longitude, about 11 miles south of the airport at an elevation of 1,755 feet msl.

Witness Statements

The Safety Board interviewed several witnesses who were along the accident airplane's flightpath and near the accident site at the time of the accident. One witness located near the crash site stated, "the aircraft was making a very loud sound as if overspeeding and slowing down at different times. A short time later, the engines stopped." The witness added, "the plane's engines sounded unusually loud to me as if they were being accelerated to the maximum. A few seconds later, the sound of the engines stopped. A few seconds after that, the sound of the

[9] The airplane had descended below the MVA of 3,300 feet and radar was unable to record its altitude because of terrain interference.

engines started a short distance away from the location I originally heard the airplane and soon thereafter, once again stopped."

A second witness in the vicinity of the crash site stated, "I heard the engines cut out but the turbines continued to whine…soon after that, I heard the whining of the turbines but definitely the engine was not running." Another witness, who was in the vicinity where the pilots radioed that they had lost an engine, stated that he heard an engine noise that was "very loud, irregular running, with a real rough grinding noise…the sound pitched up and down in cycles."

PERSONNEL INFORMATION

Both flight crewmembers were certificated under company and FAA certification requirements. A review of FAA records indicated that the flight crewmembers had no record of airplane accidents, incidents, or enforcement actions. In addition, the flight crewmembers held valid driver's licenses with no history of accidents or violations during the 3 years before the accident. A search of the National Driver Registry found no history of driver's license revocation or suspension for either flight crewmember.

The Captain

The captain, age 34, was hired by Executive Airlines in April 1998 as a part-time pilot. He was also a full-time pilot for Atlantic Coast Airlines (ACA), where he had started working in December 1992. At ACA, he was a captain on the Jetstream 3200 and the Jetstream 4100. He held an airline transport pilot (ATP) certificate, issued on May 17, 2000, and type ratings in the Jetstream 3100, Jetstream 4100, and Dornier D-328 jet. His most recent FAA first-class medical certificate was dated December 16, 1999, with no restrictions or limitations. At the time of the accident, the captain had accumulated about 8,500 flying hours, including about 1,874 hours as pilot-in-command in the Jetstream. According to the captain's wife, the captain had flown previously with the accident first officer and considered him to be a good pilot.

According to his family, the captain awoke about 0600 on the day of the accident. His wife spoke to him just after he awoke, and she stated that he seemed very happy. On the day before the accident, the captain awoke about 0845 and went to his son's little league game, which started at 0900. The captain took a nap on Saturday afternoon from 1300 to 1600. He went out to dinner that evening with his wife. He went to bed about 2200 because he had to get up for the early flight. His wife stated that when he was not working, the captain usually went to bed about 2300 and awoke between 0800 and 0900. There was no family recall of what the captain did on Friday, 2 days before the accident.

The First Officer

The first officer, age 38, was hired by Executive Airlines on November 9, 1998. He held a commercial pilot certificate issued on May 19, 1998. His most recent FAA first-class medical certificate was dated January 28, 2000, with no restrictions or limitations. According to

Executive Airlines records, he had accumulated about 1,282 total flying hours, of which about 742 hours were in the Jetstream 3101.

According to the first officer's fiancée, the first officer had received a job offer on the Friday before the accident to fly with a regional airline. She stated that the first officer was excited about the new position and that the captain had helped the first officer prepare for job interviews during down times in ACY.

The first officer's fiancée reported that on the day of the accident, the first officer arose at 0600. He showered and ate breakfast. En route to the airport, he stopped for coffee, a bagel, and orange juice. He met the captain at the airport around 0815.

The day before the accident, the first officer departed ACY about 0130 on a routine flight to FRG that arrived at 0200. His fiancée was on the flight. They had a 20-minute drive home and went to sleep. He slept late and spent the day around the house. They watched TV and went out for lunch about 1400 to 1500. He went to bed on Saturday night about 2200 to 2230.

Two days before the accident, the first officer went on duty about 1400 and flew a series of flights for a total flight time of 6 hours and 42 minutes. His fiancée saw him in ACY about 1930 when they got together and had dinner at the airport. She stated that his mood was good and that after dinner he went to the pilot lounge for a nap.

AIRPLANE INFORMATION

According to FAA and company records, the accident airplane, serial number 834, was manufactured in 1988 by British Aerospace. The cabin was configured for 19 passenger seats, with 7 single passenger seats on the left side of the airplane, and 6 double passenger seats (12 total) on the right side of the airplane. At the time of the accident, the airplane had accumulated about 13,972 flight hours and about 18,503 cycles since new (CSN).[10] FAA records indicated that the airplane was imported to the United States from the United Kingdom in 1988 and that it was assigned aircraft registration number N851JS. Executive Airlines purchased the airplane on October 28, 1996, from Fairchild Dornier of Sterling, Virginia. The accident airplane's registration was changed to N16EJ in September 1997. The airplane entered Executive's line service on December 19, 1997.

A review of FAA and Safety Board accident and incident files indicated that the accident airplane was substantially damaged when it veered off a runway and impacted terrain during an aborted takeoff in snow conditions on December 15, 1989. In addition, on February 19, 1991, during cruise flight, an engine fire warning bell sounded. The crew shut down the engine and landed safely. There were no other accident or incident reports.

[10] A cycle is one complete takeoff and landing sequence.

Airplane Engines and Propellers

The accident airplane was equipped with two Honeywell (formerly AlliedSignal) model TPE331-10UGR-514H turboprop engines. This model engine is a single-spool design consisting of a dual centrifugal compressor, reverse-flow annular combustor, and a 3-stage axial flow turbine. It is rated at 940 shaft horsepower for takeoff and has a maximum continuous rating of 900 shaft horsepower.

At the time of the accident, the No. 1 (left) engine, serial number P63344C, had accumulated 14,027.5 hours time since new (TSN), 18,602 CSN, and 469 hours since the last overhaul. The last engine inspection performed was a 150/300-hour inspection on March 15, 2000. The engine had 13,853.4 hours TSN and 18,361 CSN at the time of the last inspection.

The No. 2 (right) engine, serial number P63328C, had accumulated 5,939.5 hours TSN, 6,017 CSN, and 56.9 hours since last overhaul. The last engine overhaul before the accident was performed on April 25, 2000, and the last operational check, ground runs, and leak checks were performed on May 10, 2000, when the engine was installed on the accident airplane.

The accident airplane was equipped with two Dowty model R333/4-82-F/12 single-acting, full-feathering,[11] constant speed, 4-blade propellers, which rotate counter-clockwise as seen from the cockpit. The No. 1 propeller, serial number DRG/598/82, had accumulated 14,047.8 hours TSN and 945.0 hours since overhaul. The No. 2 propeller, serial number DRG/1747/88, had accumulated 14,446.8 hours TSN and 3,822.1 hours since overhaul.

The propeller governor supplies oil pressure to drive the propeller to a low-pitch position (small blade angle) while the feathering spring drives the propeller to high blade angles, including feather. To maintain a constant speed, the propeller governor uses mechanical flyweights to position a metering valve that supplies oil pressure to the propeller dome. Propeller speed is maintained by modulating the blade angles to increase or decrease the load on the propeller.

The propeller governor cannot drive the blades lower than the low-pitch stop. Governor oil flows through a set of holes in the beta tube and out to the propeller dome. As the blade angle changes, the position of the beta tube changes. The beta tube slides inside a bronze bushing that covers the oil supply holes in the beta tube as the blade angle approaches the low-pitch stop (so that less oil flows to the propeller dome). The supply holes are completely covered when the blades are at the low-pitch stop, preventing additional oil from flowing to the propeller dome and

[11] When an engine fails in flight, the windmilling propeller creates drag and causes the airplane to yaw. Feathering a propeller rotates the leading edges of the propeller blades into the slipstream, which minimizes or stops the rotation of the propeller blades and, thus, reduces drag caused by the propeller.

a further blade angle decrease into the beta range.[12] To move the propeller into the beta range, the engine power lever must be reduced, which mechanically repositions the bronze bushing on the beta tube and allows governor oil pressure to flow to the propeller dome again, further reducing the blade angle and driving the propeller into the beta range.

Airplane Fuel System

The Jetstream 3101 is equipped with one fuel tank in each wing (see figure 1), and each has a maximum usable capacity of 227 U.S. gallons.[13] Each tank is divided into five cells (cell No. 1 is the most inboard and cell No. 5 is the most outboard) with flapper valves installed between the cells to limit fuel sloshing. Six fuel probes are installed in each tank and are connected to the cockpit fuel quantity gauges. A booster pump is installed in each tank to supply each respective engine. Downstream of each booster pump is a line-mounted, one-way check valve to prevent fuel transfer between tanks during crossfeed operations. A two-position, electrically operated crossfeed valve connects the left and right engine fuel feed lines when open. Low pressure (LP) fuel valves are installed in each system to isolate the fuel system in the event of an engine fire. The respective LP fuel valve closes if the associated feather lever is selected.

Each wing tank contains an independent low fuel level system that illuminates small low fuel quantity annunciator light(s) in the cockpit if fuel levels fall below about 200 pounds in the respective tank. The low fuel quantity annunciator lights are located on the left center panel between the fuel quantity gauges. According to the Jetstream 31 Operating Manual, the low fuel quantity annunciator lights were not designed to be warning lights. The manual states that they are a means to confirm low fuel quantity. The airplane is also equipped with two independent fuel quantity gauges and two fuel flow/fuel used indicators, one for each engine. An analog point continuously displays each engine's fuel flow rate. The indicator also has a 4-digit numerical display that shows fuel used for each engine. A small toggle switch allows the flight crew to reset (to zero) the fuel used display. The fuel used display automatically resets to zero when airplane power is shut off.

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[12] According to the BAE Jetstream 31 Crew Manual, in the beta mode, or the propeller reverse mode, propeller blade angles are "directly related to the engine power lever setting between reverse and flight idle positions." The manual further states that the propeller "has a pitch range between reverse and feather." The propeller also operates in the propeller governing mode, when "blade angles are controlled to maintain the rpm set by the engine rpm lever…when the power lever is advanced above flight idle position." The beta, or reverse, mode is used to decelerate the airplane after landing.

[13] According to the Jetstream 31 manual, about 5 U.S. gallons (about 33 pounds) are unusable in each tank. The amount of unusable fuel varies depending on airplane configuration. During certification, the manufacturer tested the Jetstream 31 for usable fuel in five phases of flight. The unusable fuel quantity ranged from 7 pounds 15 ounces to 33 pounds depending on the phase of flight/airplane configuration. For example, the largest unusable fuel quantity, 33 pounds, was measured in a climb at 110 knots, flaps at 10°, in a 5° bank with the booster pump off. The minimum quantity, 7 pounds 15 ounces was measured in level flight at 230 knots, in a 5° bank with the booster pump off. Jetstream publishes the most conservative configuration, 33 pounds of unusable fuel in each tank in the Jetstream 31 flight manual. In addition, fuel volume in the fuel lines (between the respective tank and the engine) is about 1.5 gallons.

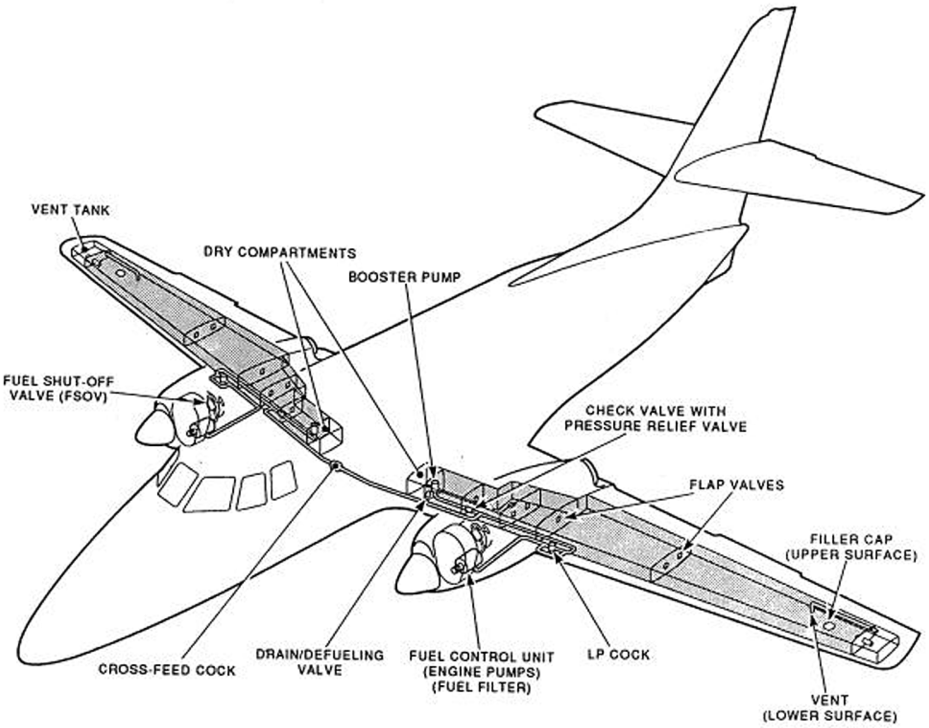

Figure 1. Diagram of the Jetstream Series 3100 fuel system (from the Jetstream Series 3100 Training Guide)

Cockpit Voice Recorder

The Fairchild cockpit voice recorder (CVR) was recovered from the accident scene and transported to the Safety Board's laboratory in Washington, DC, for examination. The CVR was damaged by impact forces but showed no evidence of fire damage. The impact damage was primarily confined to the connector plug, dust cover, and adjacent chassis. The magnetic tape was removed from the CVR and examined. The entire recording was monitored. No information pertaining to the accident flight or any other flight was found. A 400 hertz (Hz), 20 decibel tone, approximately 1.8 seconds in duration, was present on all four channels at the end of the recording. The remainder of the tape contained a signal consistent with a trace signal of bulk erase activation. (See the Maintenance section and the Tests and Research section later in this report for details about the accident airplane CVR and its maintenance history). The CVR impact inertia switch[14] was found in the "open" position when initially tested in the Safety Board's laboratory. Subsequent testing indicated that the switch was serviceable (that is, the switch would open when subjected to impact shock and could be reset to the closed position using the manual reset button).

No flight data recorder (FDR) was installed on the accident airplane, nor was one required.

[14] The impact switch interrupts the CVR power supply when subjected to a 4-G impact force. The switch can only be reset by manually depressing the reset button on the side of the switch.

Weight and Balance

Weight and balance calculations were performed using the accident airplane's records, the Executive Airlines operator's manual, and the manufacturer's flight manual. Calculations (which included 2,890 pounds assumed for 17 passengers) showed that the airplane could have contained as much as 2,192 pounds of fuel and remained within ramp and takeoff weight limitations when departing ACY.

METEOROLOGICAL INFORMATION

No significant surface weather features or upper air disturbances were present over the northeastern United States on the day of the accident. Radar and other data indicated widespread cloudiness and scattered light rain showers over the region.

The AVP surface weather observation current at the time that N16EJ executed its missed approach reported cloud layers at approximately 1,700 feet msl broken and 2,500 feet msl overcast.[15] In addition, a tower controller reported lower clouds on the approach end of the runway, and a previous landing airplane reported near minimum conditions on the approach.

Upper air, satellite, radar, and numerical model data indicated that the winds at and below 3,000 feet msl in the vicinity of AVP were likely from 220° to 250° at 5 to 10 knots. The temperature at 3,000 feet was about 7.5° Celsius (C) increasing to 11° C at the surface. The freezing level in the AVP area was about 9,300 feet msl.

The following official weather observation was current near the time of the accident airplane's second approach to AVP:

> Time—1123; type—SPECI; wind—260 degrees at 3 knots; visibility—2 1/2 miles; present weather—mist; sky condition—broken 500 feet agl broken 900 feet agl [above ground level] overcast 1,500 feet agl; temperature—11 degrees C; dew point—11 degrees C; altimeter setting—30.04 inches hg; remarks—rain began 1108 ended 1117

Regional weather observations and satellite imagery indicated overcast cloud layers over New Jersey and eastern Pennsylvania with cloud ceilings below 1,500 msl. Cloud tops of the lower layers varied between 5,000 feet and 9,000 feet msl. The en route winds between 4,000 feet and 5,000 feet msl were from 230° to 250° at 10 to 15 knots. The en route freezing level was about 10,000 feet msl.

AIRPORT INFORMATION

AVP, is at an elevation of 962 feet msl and is located about 5 miles southwest of Wilkes-Barre/Scranton. The active runway at the time of the accident was runway 4. Runway 4 is 7,501 feet long and equipped with an ILS, including high intensity runway lights, a medium

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[15] According to FAA data, N16EJ descended to 2,200 feet msl before declaring a missed approach at 1107:42.

intensity approach lighting system with runway alignment indicator lights, and a 3° precision approach path indicator located on the right side of the runway.

WRECKAGE INFORMATION AND IMPACT INFORMATION

The airplane wreckage was found on the top of a mountain on the east side of a pipeline clearway on state-owned property. Ground and tree impact marks indicated that the airplane impacted terrain at a steep angle and in an extreme bank angle. Witness marks on the attitude indicator, ground witness marks, airplane crushing, and other damage indicated that the airplane impacted the ground at a 60° nose low attitude and in a 135° left bank. Ground scars indicated that the airplane impacted the ground on a 40° heading. All of the airplane's primary structure was located at the accident site. All recovered primary and secondary flight control surfaces were found at the accident site. As shown in figure 2, fire damage was confined to the immediate impact area, with little fire damage to surrounding trees and foliage.

Figure 2. Photo of the accident site illustrating the lack of fire damage to the surrounding area.

The fuselage structure was found upright, in two major pieces, oriented on a 220° heading, with the right outboard wing folded up at a 90° angle. There was no evidence of in-flight fire, such as metal splattering, soot streaking, or heat damage along any horizontal plane. All heat damage and postcrash fire signatures were in the vertical direction.

The cockpit area was destroyed by impact and mostly consumed by the postcrash fire. The flight instruments, engine instruments and flight controls sustained severe fire damage. The cockpit roof switch panel was consumed by fire. The cockpit area had impact crushing damage from the rudder pedals through the instrument panel. All parts of the flight control system that were recovered were heat damaged and fragmented. Only small fragments of the aileron control handwheels were found, and the aileron longitudinal control shafts were found in multiple sections. All four rudder pedals were found separated. The elevator torque shaft was found in multiple segments. The aileron, rudder, and elevator trim cable drums were separated from their support structure and were severely heat damaged. The trim cables were not broken.

The flap selector was not found; the flap position indicator sustained severe heat damage and the position needle and stencil were consumed by the postcrash fire. All the switches and indicators aft of the power levers on the center pedestal were consumed by the postcrash fire. The empennage was found rotated 180° about its longitudinal axis. It was separated from the aft fuselage structure and inverted but remained attached to the remnants of the forward fuselage by cables and wire bundles. The empennage had minimal heat and soot damage. The lower outside empennage surface had light vertical sooting and some heat discoloration but no paint blistering.

The rudder was attached to the vertical stabilizer by its attach points. Teardown of the rudder trim mechanical screw jack revealed that it was extended approximately to the full airplane-nose-right position.[16] The rudder trim control cables remained attached to the empennage and rudder system but were stretched and twisted from the airplane's impact sequence. Because of this impact damage, the pre-impact rudder trim position could not be determined.

The left elevator was attached to the left horizontal stabilizer by its attach points. A tree trunk was lying on top (chordwise) of the elevator and horizontal lower surfaces with corresponding crushing damage to the lower skin. The right horizontal stabilizer with elevator attached was found about 32 feet north of the empennage structure. The right horizontal stabilizer had been torn from its spar attach points near the vertical stabilizer. A large indentation (crushing) was located on the leading edge of the stabilizer; the diameter of which matched a nearby tree. None of the elevator or rudder control cables that remained in the empennage exhibited any damage. The cable runs forward of the empennage were severely heat damaged due to the postcrash fire; however, all the cables were unbroken up to the cockpit area.

The left wing was found with extensive leading edge crushing. It had extensive heat damage and a portion of the upper skin was consumed by fire. The left inboard wing section between the engine nacelle and the fuselage was destroyed by fire. The left aileron had severe heat damage and was fractured just outboard of the inboard hinge. The inboard hinge was intact, but the outboard hinge point was separated. The inboard portion of the trim tab was intact and moved freely.

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[16] The airplane's rudder is controlled by a torsion bar mechanism and a combined trim/spring tab. Control inputs from the rudder pedals are transmitted by quadrants, cables, and pulleys to the rudder torsion bar, which twists against aerodynamic loads and drives the trim/spring tab to provide servo assistance. Rudder trim is controlled by rotating a trim control knob in the cockpit. The trim control knob is connected to the cable control system, which extends or retracts the trim screw jack output shaft. The screw jack, mounted on the top of the torsion bar, drives the torsion bar mechanism to deflect the trim/spring tab to relieve rudder forces.

The right wing was mostly separated from the fuselage but attached by cables and parts of the wing spars. The inboard wing structure was consumed by fire. The outboard wing section exhibited decreasing fire damage toward the wing tip. The bottom part of the bent wing structure had numerous tree impact marks and bark imbedded in the structure. The wing fuel tank was ruptured in several places consistent with impact damage. The right aileron was broken from its hinge points but was still in its approximate position on the wing. The trim tab was intact but could not be moved because of impact damage. The aileron system cables were unbroken but severely heat damaged in areas associated with the postcrash fire.

The majority of the left and right flap panels were broken and consumed in the postcrash fire. The flap actuator was found with the flap torque shaft attached. The flap actuator was found in its approximate position in the center fuselage area and was severely heat damaged. Examination of the flap actuator at the manufacturer determined that the position of the piston was consistent with a 20° flap setting.

The left and right main landing gear actuating cylinders were found in the extended position but were separated from their attach points and burned. The nose gear strut and wheels were found folded back along the fuselage and were not damaged by fire. The nose gear actuator was found separated from the nose gear strut cylinder and in the extended position. The cylinder and extension assembly were found in the extended position but were separated from the fuselage attach points.

The stick pusher[17] actuator was recovered in good condition with no heat damage. Examination determined that the actuator was operational.

Fuel System Wreckage

The left engine low pressure (LP) fuel valve actuator was found separated from its valve and the right engine LP fuel valve was found intact. The valve position indicators on both valves were in the open position, consistent with the observed valve positions. The left and right hydraulic LP cocks were also found in the open position. The crossfeed valve was found in a clump of melted aluminum. The melted aluminum was removed and the crossfeed valve position indicator was found in the closed position, consistent with the observed valve position. The LP fuel cock switches in the cockpit were consumed by the postimpact fire.

As previously noted, the low fuel quantity annunciator lights in the cockpit are located on the left center panel between the fuel quantity gauges. The main portion of the left center panel was found separated but approximately in its original location and with severe heat and impact damage. The lower third of the panel had been consumed and the fuel flow gauges and fuel quantity gauges had separated from the panel and were not identified. The low fuel quantity annunciator lights were consumed by the postcrash fire.

[17] The stick pusher is part of a stall prevention system. When triggered, the stick (control column) is forced forward, commanding the airplane to rotate from a climb to a shallow dive. About 80 pounds of force is required on the control wheel to override.

The right tank fuel booster pump was found separated in its approximate original position in the wreckage (most of the right inboard wing structure was consumed in the postcrash fire). The pump showed signs of surface deformation from extreme heat damage. The left booster pump was heavily sooted and was attached to the rib in fuel cell 1.

The fuel booster pumps were removed from the wreckage and examined at the manufacturer. Because of extensive fire damage, the pumps could not be bench tested. Both pumps were disassembled and examined. No rotational scoring was found on either armature.[18]

The left fuel filler cap was attached to its respective fuel port. The cap's inside face was deformed by heat damage and was covered with melted and resolidified aluminum. The right fuel filler cap was not attached to its respective fuel port and the cap was not found. The filler cap ports were removed from the airplane and sent to the Safety Board's materials laboratory for examination.

The right fuel port had a chordwise wrinkle mark that intersected the port and was consistent with the localized upward bending of the upper skin. Examination of the interior face of the port's lip revealed circumferential marks, consistent with normal rotation of the filler cap. In addition, the lip contained three areas of localized outward deformation.[19] A chordwise gouge mark was found on the interior surface of the lip in one of those areas. Metallurgical examination determined that the localized deformation and gouge mark were consistent with the right fuel filler cap being attached before impact.

The main fuel lines from each engine were recovered from the wreckage and sent to the Safety Board's materials laboratory for examination. A visual inspection determined that the lines were intact. No evidence consistent with kinking or blockage was found.

On-site Examination of Engines and Propellers

Both engines and their respective propellers were found at the crash site. After an initial on-site inspection, they were removed to a hangar at AVP for a detailed, preliminary inspection before being transported for extensive teardown inspections (see the Tests and Research section for details of the teardown inspections).

The No. 1 (left) engine was found partially attached to the left wing. There was no visible sign of any uncontained engine failure (that is, engine parts exiting the casing) or fire damage in the engine. The No. 1 engine was bent inboard toward the airplane's centerline, at a 35° angle, just forward of the wing spar, and was lying over on its right side. The rear engine mount was found intact, and the forward mounts, located at the 3, 6, and 9 o'clock positions, were broken

[18] The booster pumps do not operate continuously and are normally used for engine start, high altitude operations, fuel balancing, or abnormal or emergency situations.

[19] Each filler cap contains three tangs, or legs, spaced equally around the circumference, which are inserted into slots in the lip of the fuel port. The cap is then rotated clockwise to secure the cap.

out of the accessory gearbox. The 3rd-stage turbine blades, as viewed up the tailpipe, all appeared intact with no obvious signs of distress. The propeller remained attached to the engine.

Minimal external fire damage was found on the No. 1 engine, and all of its systems and accessories were generally intact with the exception of a broken starter/generator input shaft. Dirt and debris were found around the inlet circumference and on the 1st-stage compressor blades. The 1st-stage compressor blades were all intact with no signs of distress, and the rotating group was seized. The auto-ignition system was installed and intact. The aircraft electrical connector was still connected to the auto-relight pressure switch. The three negative torque system (NTS)[20] load arms were intact. The gearcase was cracked in two places from front to back.

Blade No. 1 of the No. 1 engine's propeller was found fractured 9 inches outboard from the hub flange. The tip of blade No. 1 was curled, and the blade had an "S" shape, bent in the direction opposite rotation. A 5-inch long impact/depression was centered 17.5 inches from the fracture surface that was closest to the hub. The counterweight was missing. Blade No. 2 had minor impact marks on the leading edge and the anti-ice boot was ripped. The No. 3 blade had a 1.5-inch depression on the leading edge that was centered 34 inches outboard from the hub. Blade No. 4 had a 5-inch leading edge dent/impact mark that was centered 40.5 inches outboard from the hub and was missing 2 inches of the blade tip. Blade No. 4 also had smaller impact marks along the leading edge, and its anti-ice boot was torn along the leading edge. The pressure side of blade No. 4 had scrape marks approximately 45° to the length of the blade. Blade No. 4 was the only blade that was able to rotate within the hub. Blades 2 and 4 were bent in the direction of rotation. Blade No. 3 was slightly bent opposite the direction of rotation. The hub was fractured at the No. 2 blade position; the crack extended axially and circumferentially through the hub from one of the No. 2 blade attachment bolt holes. The No. 1 engine's propeller governor[21] was recovered undamaged and contained residual oil. A bench test determined the propeller governor functioned within limits.

The No. 2 (right) engine was found partially attached to the right wing. The propeller assembly was attached to the engine. The engine was bent about 30° nose-down and 20° inboard. The outside of the engine was heavily fire damaged and the inlet case exhibited a burn-through. There were no visible signs of any uncontainments. The rear engine mount was intact and the forward engine mount, located at the 9 o'clock position, was fractured.

All the 1st-stage compressor blades were intact with no obvious signs of distress. The 3rd-stage turbine blades were all intact with no obvious signs of distress, and the rotating group was seized. The anti-ice system and its plumbing were intact. The propeller pitch control flange was partially separated from the gearbox. The inner contour of the inlet scoop was fractured

[20] Negative torque is a condition in which air loads on the propeller drive the engine. The NTS system is designed to sense this condition and modulate the propeller blade angles to prevent it from occurring.

[21] The propeller governor is a device that is used to control the speed of the propeller by using either governor oil pressure to drive the blades to a fine pitch or the force of the feathering spring to drive the blades to a course pitch. This blade angle change controls the propeller speed by either decreasing or increasing the load on the propeller. In the event of a loss of governor oil pressure, the feathering spring would drive the blades to the feathered position (failsafe mode) to minimize the drag on that side of the airplane. If necessary, the Jetstream 31's propellers can be unfeathered in flight.

circumferentially from about the 10 o'clock to the 2 o'clock position. The fuel control was severely fire damaged.

The No. 2 engine's propeller assembly had three blades intact and one blade fractured. Blade No. 2 was fractured 34 inches outboard from the hub. Blade No. 3 was bent in the direction of rotation. Blade No. 3 had a sharp bend, slightly less than 90°, located 17 inches outboard from the hub. Blades No. 1 and No. 4 were straight. Blade No. 2 was the only blade that could be rotated within the hub. With the exception of blade No. 2, none of the other three blades had any significant leading edge damage. All of the blade counterweights were in place.

The No. 2 engine's propeller governor drive spline was seized, consistent with the combined effects of impact forces, fire damage, and rust. The governor was disassembled and all components were found intact and without evidence of any internal failures.

SURVIVAL ASPECTS

The accident was not survivable because of high impact forces. Autopsies determined that the passengers and flight crew died of blunt force trauma.

MEDICAL AND PATHOLOGICAL INFORMATION

Tissue specimens from the captain and first officer were recovered and transported to the FAA's Civil Aerospace Medical Institute (CAMI) for toxicology analysis. The CAMI laboratory performed a routine analysis for major drugs of abuse[22] and prescription and over-the-counter medications, and the results were negative. The FAA's Final Forensic Toxicology Fatal Accident Report indicated that 15 milligrams per deciliter of ethanol was detected in a kidney sample from the first officer (a muscle sample tested negative). The report noted that the "ethanol found in this case may potentially be from postmortem ethanol formation and not from the ingestion of ethanol."

TESTS AND OTHER RESEARCH

Airplane Performance

The accident airplane's performance during the final 30 minutes of flight was calculated based on FAA three-dimensional radar data,[23] ATC communications, weather information, and aircraft aerodynamic performance data obtained from the manufacturer. The data were used to calculate performance parameters including airspeed, groundspeed, altitude, vertical speed, flightpath angle, pitch and roll angles, and magnetic heading. Upper wind data (wind direction, speed, and air temperature) were obtained from the FDR of a regional jet that had departed AVP about an hour before the accident.

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

[23] ATC airport surveillance radar at AVP and air route surveillance radar data were obtained from the FAA's New York Air Route Traffic Control Center.

Examination of the wreckage indicated that the airplane's flaps had been extended to 20° and that the landing gear was extended at impact. Aerodynamic information was obtained from British Aerospace for the airplane in several configurations, including flaps retracted, flaps extended to 20°, and with landing gear in the stowed and deployed position for the flap settings.

The performance study determined that during the first approach, the accident airplane descended to about 4,000 feet and turned to a 45° heading (the localizer heading) about 12.5 nm from the end of runway 4 (figure 3 shows the approach chart for the ILS runway 4 approach). The airplane intercepted the localizer at 4,000 feet (about 1104:50) and was descending between 900 feet and 1,000 feet per minute (fpm). The aircraft began to follow the glideslope about 9 nm from the runway. The airplane followed the center of the localizer and glideslope until it leveled off at 2,200 feet about 1106:50, about 3.7 nm from the runway threshold. The airplane was level at 2,200 feet for about 20 seconds and then began to climb while still following the center of the localizer. The airplane exited the localizer while at 2,900 feet, about 2.2 nm from the end of the runway.

After the missed approach was declared, the airplane began to climb at a rate of 2,000 fpm, reaching an altitude of 4,000 feet and an airspeed of 200 knots by 1108:30 (the climb was consistent with the airplane's expected twin-engine performance in such conditions). The airplane continued on the missed approach at 4,000 feet and 180 knots. After establishing a track to intercept the localizer, the airplane began reducing speed while continuing a right turn on the intercept course. At 1123:10 the airplane began descending at 300 fpm, and its airspeed continued to decrease (reaching about 128 knots during the following minute). The airplane was again on the localizer course when, at 1123:20, the accident airplane began to deviate to the right of the localizer track.

The accident airplane was at an altitude of 3,800 feet when the flight crew declared an emergency at 1123:51 (see figure 4). By this time, the airplane had deviated from the specified 45° approach course to about a 70° heading, had slowed to about 125 knots airspeed, and was about 12 nm from the runway threshold. The airplane continued to turn right. At 1124:14, when ATC instructed the flight crew to turn left, and a crewmember responded "we're trying," the airplane was on a 100° heading, or about 55° off of the desired heading and to the right of the specified approach course. About a minute later, when the crew radioed that it had lost both engines, the airplane was in a steeper descent, descending about 1,500 fpm at 130 knots airspeed. The airplane then turned to the left to a 90° heading and radar contact was temporarily lost. Airspeed increased to 140 knots as the airplane descended through 2,100 feet.

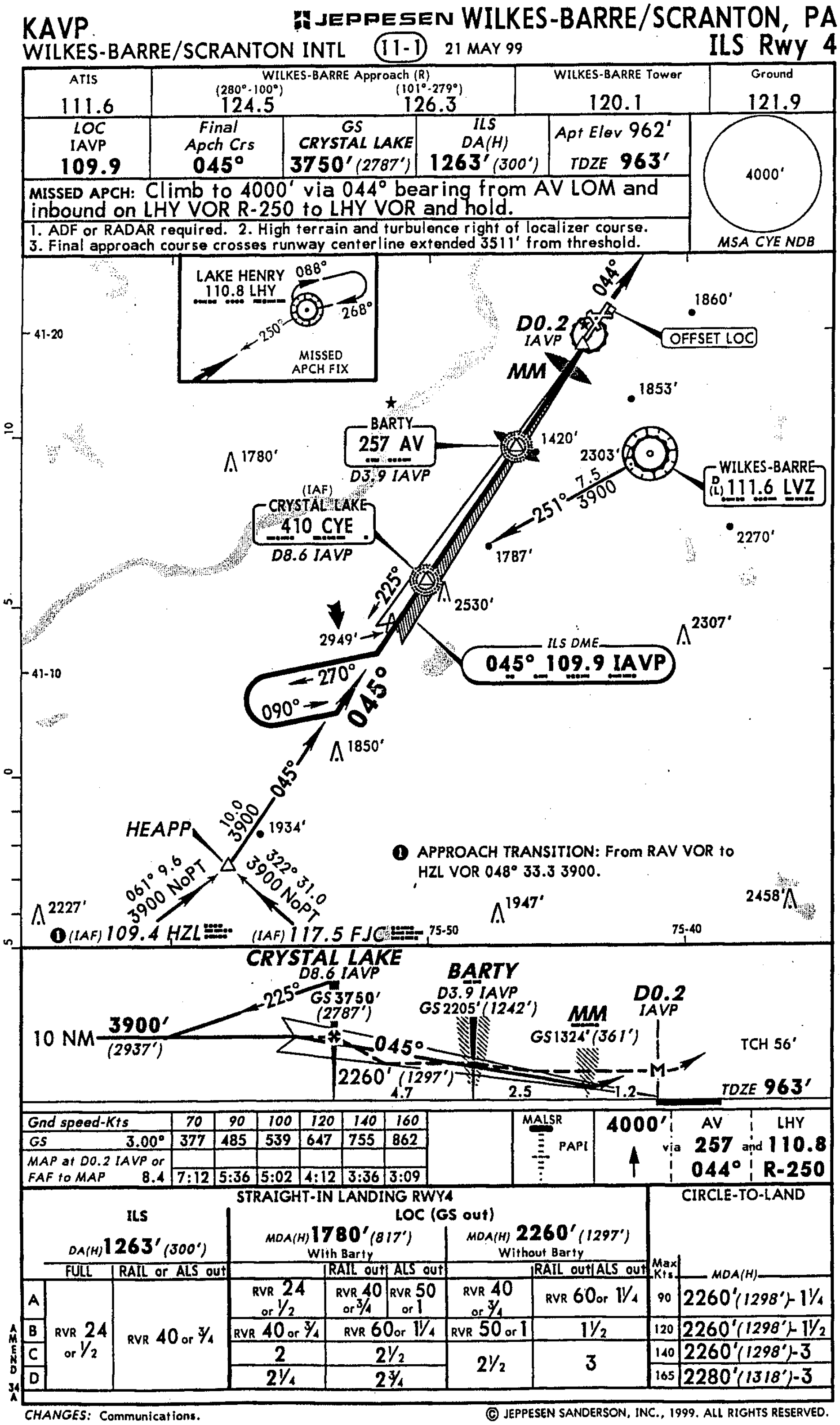

Figure 3. Approach chart for the ILS runway 4 approach at AVP.

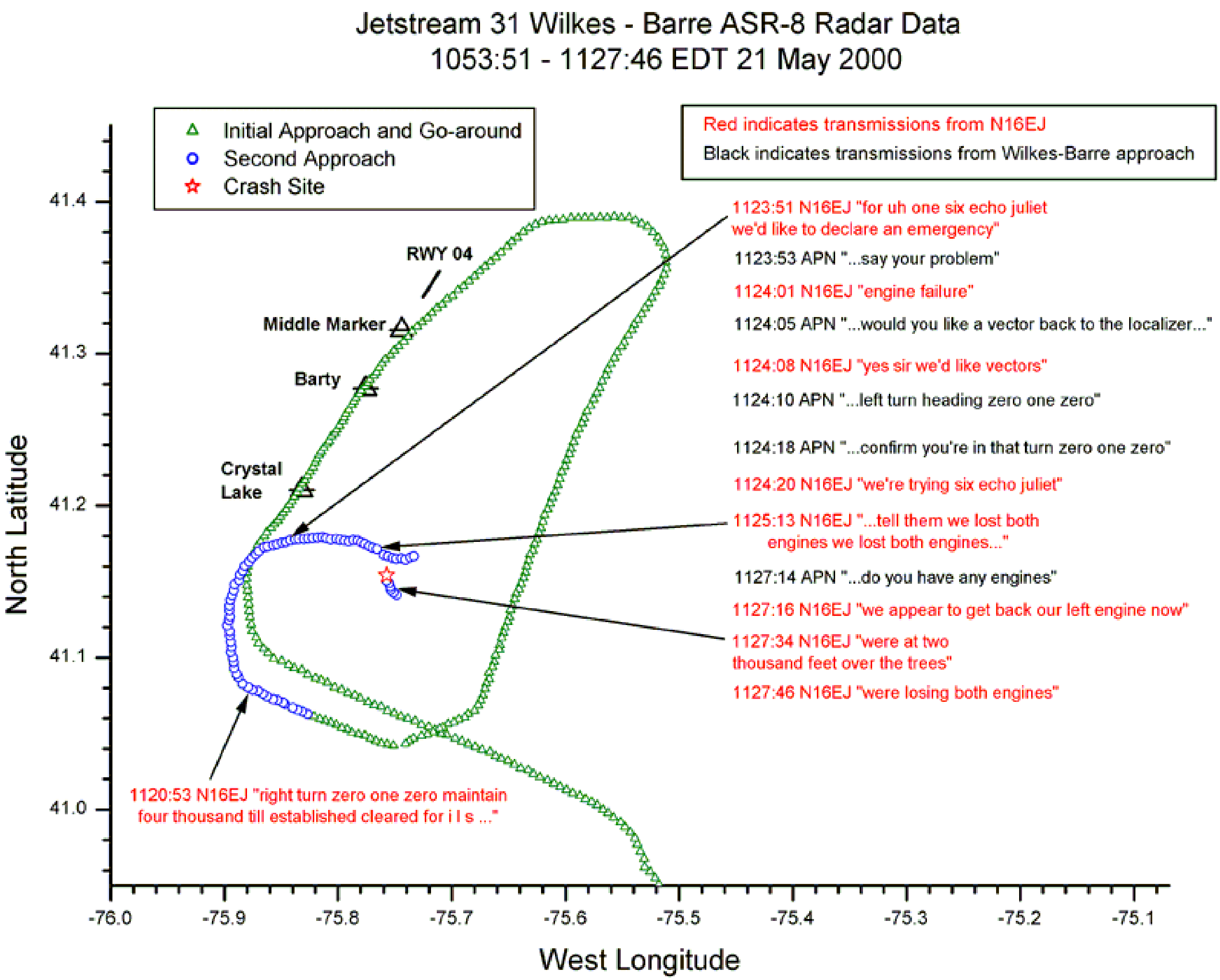

Figure 4. Plot of the accident airplane's initial and second approaches correlated with key ATC transmissions.

At 1127:16, when the pilots radioed that they had apparently regained power to the left engine, the airplane's heading would have been about 285°. The next radar return occurred at 1127:23. According to the performance calculations, the accident airplane would have had to execute a right turn while maintaining about 2,000 feet in a northwesterly direction to reach that radar return location. The final series of radar returns showed the airplane at 2,000 feet and an airspeed of 103 knots. The data indicated that the airplane continued to turn right at the same altitude and airspeed. The final radar return occurred at 1127:48, 2 seconds after the captain reported losing both engines. The crash site was about 0.22 nm north of the final radar return.

Fueling History and Fuel Burn

Safety Board investigators examined fueling records and interviewed company officials, fuelers that serviced the accident airplane, and passengers on the flight from FRG to ACY to determine the accident airplane's recent fueling history. Executive Airlines billing records, load manifests from some flights, and company records of the accident airplane's recent flights were also examined. The load manifest for the flight from ACY to AVP was not recovered from the wreckage.

Executive Airlines' owner and CEO stated that about 0100 on the day of the accident, he received a telephone call from a captain who had been originally assigned to ferry the accident airplane from FRG to ACY to pick up 17 passengers for AVP. That captain informed him that weather at ACY and AVP was marginal, that the airplane had only 1,200 pounds[24] of fuel on board, and that the fixed base operator (FBO) fueling operation at FRG was closed. The CEO stated that he decided to cancel the flight and told the captain to hangar the airplane. He stated that he then contacted Caesar's Palace and rescheduled the flight for 1030. As previously discussed, the pilots of the accident airplane were instructed when they arrived at FRG to add this leg to the day's flying schedule.

The CEO stated that he originally told the accident first officer to calculate the airplane's weight and balance based on nine passengers from ACY to AVP to determine if the airplane's fuel tanks could be topped off with fuel in FRG. He stated that the first officer told him that fuel tank measuring sticks[25] indicated that about 1,100 pounds of fuel were on board. The CEO stated that he learned that 17 passengers would be on board the flight from ACY to AVP and informed the first officer. He stated that the first officer informed him that 90 gallons (about 600 pounds) of fuel would be added to each tank and told him "we are going almost topped off." The CEO added that according to company procedure, pilots "would normally stick the tanks and then order the fuel."

The FBO fueler at FRG stated that the accident flight crew was at the airplane when he arrived in his fuel truck.[26] He stated that one pilot, whom he described as smaller than the other,[27] requested that the fuel tanks be topped off. The fueler stated that the larger pilot later requested 60 gallons of fuel, 30 gallons in each tank. He stated that he could not see the refueling meter while he was refueling and asked the larger pilot to monitor the meter. The fueler stated that, at one point, he stopped fueling and asked the pilot to tell him the meter indication and stated that he was told 4.5 (or 45 gallons). He stated that he asked the pilot if he wanted him to put 15 gallons in the other tank for a total of 60 gallons. The fueler stated that the larger pilot told him to put 45 gallons in the other tank for a total of 90 gallons. Fuel truck and billing records confirmed

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[24] Fuel quantity is also expressed in pounds. According to the Jetstream 31 weight and balance manual, one U.S. gallon is about 6.66 (the Safety Board used 6.7) pounds, based on the density of the kerosene-type fuel used.

[25] The fuel tank sticks are read by pulling them downward from built-in slot positions under the wings.

[26] The fueler stated that he had worked for the FBO for about 3 months and had refueled about 12 Jetstream airplanes before fueling the accident airplane.

[27] Company records indicated that the accident captain was 74 inches tall and weighed 210 pounds. The first officer was 71 inches tall and weighed 165 pounds.

the purchase of 90 gallons of fuel. The pilots did not receive a copy of the fuel receipt because Executive Airlines had a fueling contract with the FBO. The fueler stated that he "did not observe either pilot check the fuel drip sticks, climb up the fueler's ladder to check the fuel, or walk around the airplane."

The accident first officer's fiancée, who was a passenger on the first leg of the accident flight from FRG to ACY, stated that the first officer told her that one fuel gauge read 300 pounds and that the other read 900 pounds and that she subsequently saw these gauge readings herself. She stated that the 300-pound indication was "the right side." She stated that the first officer remarked, "I don't even know how to tell how much fuel we have on board." She stated that the pilots did not remain outside the airplane during fueling because it was raining. She stated that she did not know if either pilot had been involved with the fueling. She stated that she was aware of the decision, made during discussion with the operator's president, to top off the fuel tanks to avoid refueling in ACY. In a written statement, dated June 6, 2000, she stated that the captain "walked behind the aircraft to the right side to stick the tank" after learning of the added flight to AVP. She also stated, "the three of us remained in the aircraft during the fueling procedure…and the door of the airplane was closed." She also stated that she called the FBO in ACY[28] to confirm that the manifest listed 17 passengers flying to AVP. The line serviceman at ACY, who marshaled the airplane for departure on the accident flight, stated that he recalled looking at the plane and "did not see any fuel coming out of or off the wing at any time."

Fuel burn estimates for the accident airplane's flight legs between May 19, 2000, and May 21, 2000 were calculated. The estimates were based on approximate airplane weights from available weight manifests from the flights and fueling records. Altitudes used were based on information obtained from interviews with other Executive Airlines flight crews familiar with the flight legs. The taxi fuel burn was estimated at 6 pounds per minute, according to the Jetstream flight crew manual.

According to the airplane manufacturer, the maximum fuel load was 3,090 pounds. When fueling records indicated a fill-up of the fuel tanks, 3,090 pounds was used in the Safety Board's fuel calculations, which are presented in the following tables. During postaccident interviews, Executive flight crews indicated that it was a common practice to only put 2,900 pounds on the load manifest because flight crews assumed that the tanks were almost never filled to the top.

The Director of Operations of Executive Airlines, who was also an instructor and a check captain on the Jetstream 31, stated that Executive pilots normally used high-speed climb power for the climb to altitude and used high-speed cruise power during the cruise portion of the flight. However, Executive Airlines' owner and CEO stated that his pilots used long-range cruise power during cruise flight. Based on this information, the Safety Board calculated fuel burn for the nine previous flights and the accident flight using manufacturer performance information for high-speed cruise and long-range cruise power (presented in tables 1 and 2, respectively). Fuel burn calculations were based on flight times listed in the airplane logbook.

[28] The first officer's fiancée was employed at the FBO in ACY.

According to these calculations, if high-speed cruise power settings were used on the nine previous flights and accident flight, about 275 pounds of fuel would have remained at the time of the crash (of which 209 pounds would have been useable using a 66-pound estimate of unusable fuel), which is sufficient fuel for about 15 minutes of flight at high-speed cruise power settings. If long-range cruise power settings were used, the airplane would have had about 1,220 pounds remaining at the time of the crash, of which 1,154 pounds would have been useable. It should be noted that these fuel burn calculations did not take into account unknown factors that could have altered the amount of fuel burned on any flight. For example, altitude changes, temperature variations, the use of engine bleed air and airplane configuration variations (such as landing gear extended) can affect fuel burn.

Table 1. Estimated Fuel Remaining – High-Speed Cruise

Date	Flight	Fuel added lbs.	Estimated departure fuel amount	Departure fuel on load manifest	Flight time in minutes	Altitude	Fuel burn per flight	Taxi time in minutes	Taxi burn	Fuel remaining lbs.
5/19	GON-PHF	985	3090	2900	96	16000	1090	12	72	1928
5/19	PHF-FRG	None	1928	NA	72	17000	792	12	72	1064
5/20	FRG-ACY	800	1864	NA	30	4000	445	12	72	1347
5/20	ACY-FRG	None	1347	1400	30	5000	396	13	78	873
5/20	FRG-ACY	676	1549	NA	36	4000	483	15	90	976
5/20	ACY-AVP	1675	2651	NA	50	6000	662	13	78	1911
5/20	AVP-ACY	None	1911	2000	50	5000	677	15	90	1144
5/20	ACY-FRG	409	1553	1500	37	5000	498	9	54	1001
5/21	FRG-ACY	603	1604	2400	30	5000	401	13.5 est.[29]	81	1122
5/21	ACY-AVP	None	1122	NA	60	5000	847	6.5 est.[30]	48	275

Table 2. Estimated Fuel Remaining – Long-Range Cruise

Date	Flight	Fuel added lbs.	Estimated departure fuel amount	Departure fuel on load manifest	Flight time in minutes	Altitude	Fuel burn per flight	Taxi time in minutes	Taxi burn	Fuel remaining lbs.
5/19	GON-PHF	985	3090	2900	96	16000	941	12	72	2077
5/19	PHF-FRG	None	2077	NA	72	17000	655	12	72	1350
5/20	FRG-ACY	800	2150	NA	30	4000	341	12	72	1737
5/20	ACY-FRG	None	1737	1400	30	5000	329	13	78	1330
5/20	FRG-ACY	676	2006	NA	36	4000	402	15	90	1514
5/20	ACY-AVP	1675	3090	NA	50	6000	542	13	78	2470
5/20	AVP-ACY	None	2470	2000	50	5000	563	15	90	1817
5/20	ACY-FRG	409	2226	1500	37	5000	421	9	54	1751
5/21	FRG-ACY	603	2354	2400	30	4000	419	13.5 est.	81	1935
5/21	ACY-AVP	None	1935	NA	60	5000	676	6.5 est.	39	1220

[29] Because of the loss of the airplane log, which would have contained the taxi time for this flight, an average of the two previous fights that operated from FRG to ACY was used. The two previous flights used 12 minutes and 15 minutes of taxi time.

[30] Because of the loss of the airplane log, which would have contained the taxi time for this flight, the 13 minutes of taxi time for a previous flight from ACY to AVP was used. This time was then divided in half to estimate the taxi out.

Simulator Observations

Safety Board investigators conducted several Jetstream 31 simulator scenarios in June 2001 at Pan Am Flight Academy in Sterling, Virginia. The level C simulator was set to match as closely as possible the accident airplane's configuration when the engines were lost. The simulator was operated at a simulated airplane weight of 13,500 pounds, which is the estimated weight of the accident airplane when it crashed.

During the first simulated scenario, which was flown independently by two Safety Board pilots, a right engine failure was induced during an ILS approach, at an indicated airspeed of about 140 knots. A moderate amount of force on the rudder with rudder trim was sufficient to correct the resulting deviation. Any delay in flight control input led to heading deviations of 10° to 25° to the right of the ILS course. When deviations occurred, the airplane was easily controllable back to the ILS course. When the scenario was conducted with an airspeed of 110 knots, considerably more rudder and rudder trim inputs were required to correct the deviations, keep the airplane on course, and turn back to the ILS. However, the airplane remained controllable.

During the second simulator scenario, after a right engine failure was induced on an ILS approach (and after corrective rudder trim inputs were made), a left engine failure was induced. The simulated left engine failure was then allowed to operate as if the autolight system occasionally restored the engine briefly before failing again. In this scenario, the workload on the flying pilot was not considerably increased when the dual engine failure was induced. However, pilot workload increased considerably (the airplane was difficult to control and required constant flight control and trim inputs) when the left engine was intermittently lost and restored.

Before the simulator sessions, instructors briefed both pilots that the low fuel quantity annunciator lights would be activated during the session but did not indicate when. Neither pilot observed the lights when they first appeared, and both pilots continued to fly without observing the lights. It was observed that the left seat pilot's right hand blocked a view of the lights when his right hand was on the control wheel. It was also observed that at certain seat positions, a portion of the control wheel blocked a clear view of these lights. It was also observed that the digital "FUEL USED" indicator lights located immediately above the low fuel quantity lights were much brighter in intensity than the low fuel quantity annunciator lights during simulated daylight and nighttime conditions.

Engine and Propeller Teardown Examinations

The engines were shipped in June 2000 to Honeywell Engines & Systems in Phoenix, Arizona, for a teardown inspection and evaluation under Safety Board supervision. Propeller assemblies were shipped to Dowty Aerospace Propellers in Sterling, Virginia, and were disassembled and examined under Safety Board supervision during the same period.

The No. 1 engine showed rotational scoring between various rotating and static components, as well as metal spray on the turbine blades and vanes. The No. 2 engine was heavily fire damaged and exhibited no rotational scoring between rotating and static components. Static impact marks were observed on the compressor impeller shrouds, and neither the turbine blades nor vanes exhibited any signs of metal spray.

Disassembly of the left engine propeller hub revealed witness marks on the butts of three out of the four blades that were consistent with blade angles between 28° and 40°. The remaining blade revealed indications on the butts of two adjacent blades consistent with blade angles of approximately 80°. A feathered propeller is consistent with a minimum drag angle of 82°. The remaining two blades showed no discernible impact marks.

Examination of ATC Audio Tape of Cockpit Transmissions

The Safety Board's audio laboratory examined a copy of the ATC tape recording of approach control and tower communications with the accident flight crew to identify and document engine or propeller sounds during the radio transmissions. The Safety Board's examination assumed that the propeller normally rotates at a maximum speed of 1,591 rpm and that, at its maximum speed, the propeller would produce noise at the fundamental frequency of 106.06 Hz. The examination concluded that the low frequency response of the pilot's headsets, the aircraft's radios and the approach control's recording system were such that only the fundamental frequency of the rotating blades was recorded. The examination noted that none of the radio transmissions from the accident aircraft contained discrete frequency signatures that could be associated with the two rotating propellers. Several explanations could account for the lack of two sound signatures. Either both propellers were always operating at the same rpm, thus only producing one signature, or the recorded signature was being produced by only one of the two engines. However, the airplane is equipped with a system to closely match propeller rpm's. It was not possible to determine which of the aircraft's two engines was producing the noise that was observed on the recording or whether both engines were producing the noise. In addition, engine noise could not be conclusively identified in all radio transmissions.

CVR Testing and Evaluation

The CVR was examined at the manufacturer's facility in Sarasota, Florida. A standard bench check was conducted, and all components were found to be within the manufacturer's specifications. After installing a new tape, the recording capability of the CVR was tested, and it passed the standard bench check. The self-test and bulk-erase features were also tested and found to be within manufacturer's specifications. A bulk-erase trace signal was also identified on a second CVR of the same make and model after it was bulk erased, and the trace signals were identical. The presence of a bulk-erase trace signal was consistent with a CVR delivered from overhaul. There was no evidence of a 600 Hz self-test tone on the recording, which is recorded on the CVR tape when the self-test is activated in the cockpit as prescribed by the flight crew checklist. (See the CVR Maintenance section for details about the CVR operational test check.) After overhaul, the 600 Hz self-test tone is activated but is erased by the bulk-erase function.

COMPANY INFORMATION

Company History

East Coast Aviation Services was established in 1991. The company was previously known as Long Island Airlines and, prior to 1987, Montauk Caribbean Airways. Since 1991, the Part 135 on-demand charter operator has done business as Executive Airlines. The operation and all crews are based at FRG. At the time of the accident, Executive Airlines employed 10 pilots and operated 7 airplanes, 4 of which were Jetstream 31s. At the time of the accident, the director of operations had worked for the company for about 1 1/2 years, and the chief pilot had worked for the company for about 6 weeks.

Executive Airlines had a contract with Caesar's Palace from November 1998 to November 1999. When the contract expired, the airline continued to fly trips for the casino on an ad hoc basis and also operated ad hoc flights for other casinos in Atlantic City.

FAA records indicated that an Executive Airlines airplane was involved in an accident in 1991 when engine failure forced a Piper PA-31-350 to ditch into the ocean 6 miles from John F. Kennedy airport in New York. The aircraft sank, but all airplane occupants were rescued. In addition, another Executive Airlines Piper PA-31-350 was involved in an incident when it experienced engine trouble on takeoff and returned for landing.

MAINTENANCE

General

The FAA approved Executive Airlines' maintenance program under air carrier certificate number ECAA477A. The company was authorized to use a continuous airworthiness maintenance program (CAMP) for its Jetstream aircraft, including the accident airplane. Executive Airlines' CAMP manual, dated March 8, 2000, revision 5, provided for the following maintenance intervals:

- "Service Check"—Every 7 calendar days
- "A" Check—To be performed at a time in service not to exceed 200 hours or 4 months
- "B" Check—To be performed at a time in service not to exceed 400 hours or 8 months
- "C" Check—To be performed each 12 months
- "D" Check—To be performed each 24 months
- "E" Check—To be performed each 48 months

Executive Airlines documented its maintenance using a system of flight/maintenance log sheets and other records. According to the director of maintenance (DOM), logbook entries for each Jetstream were maintained in separate envelopes in the maintenance office.

According to the accident airplane's maintenance records, the right fuel quantity gauge was replaced in November 1999 after pilots reported that it fluctuated. The right fuel quantity gauge was replaced again in April 2000 after it was reported to have fluctuated. No unresolved discrepancies were noted for the engines, wings, fuel caps, or fuel tanks.

CVR Maintenance

According to the accident airplane's maintenance records, a Fairchild A100A CVR was installed on the airplane on May 31, 1991, when the airplane was owned and operated by a Part 135 operator in Ohio. On July 3, 1998, Executive Airlines removed this CVR and installed a "loaner" CVR into the accident airplane. The airplane's flight/maintenance log indicated that the "loaner" CVR was tested following installation. The log was marked with the statement, "Ops checked good." On July 16, 1998, the "loaner" CVR was removed and another CVR was reinstalled. The Discrepancy Correction sheet was marked with the following notation: "Ops Checked Good. No Defects Noted."

On June 29, 1999, an annual avionics inspection, which included the CVR, was performed by Duncan Avionics, an FAA-certified repair station. The aircraft's total time was about 13,462.3 hours. The CVR was also functionally checked during a "C" check in August 1999 and the following remark was noted on the operator's Discrepancy Correction Sheet: "Complied with 12 mo F/C of CVR No defects noted."

On February 29, 2000, after a pilot reported that the CVR was inoperative, the CVR was removed and replaced. The airplane's total time was 13,803.4 hours. The discrepancy for the removed CVR (serial number 58309) was described as "Battery Weak Requires Replacement."[31] The original CVR was sent to a repair station, which determined that it was defective.

The DOM indicated that on February 29, 2000, a serviceable CVR was installed in the accident airplane. This CVR was received after it was overhauled by a repair station. The accident airplane's maintenance log indicated that the CVR was operationally checked and that no defects were noted. According to the DOM, the operational check was in accordance with the Executive Airlines maintenance program.

The Safety Board reviewed all flight/maintenance logs between the date the accident CVR was installed in the airplane and May 20, 2000. (No maintenance logs were found dated May 21, 2000.) No evidence of CVR discrepancies or maintenance was noted for this period. The DOM stated that Executive Airlines maintained the CVR in accordance with the FAA-approved CAMP. Under this program, the CVR system was required to be maintained by performing checks at specific intervals. They included the following:

- CVR Operational Check. This is a flight crew checklist item and is to be accomplished using the flight crew "J31 Preliminary Check List." This check is to be performed by pressing the CVR's test button before the first flight of the day or whenever a crew

[31] The only battery associated with the CVR is part of the underwater locator beacon, and the battery has no effect on the CVR's operation.

change occurs. The crew then monitors a test signal on a meter on the CVR control unit next to the test button.

- Audio Interface Check. A complete audio interface testing procedure was described in the Fairchild installation manual, FAR02213189, and included plugging a headset into the control unit in the cockpit to test the system's recording capability. According to the DOM, Executive Airlines did not perform a complete system interface test following the February 29, 2000, installation of the accident CVR because the CAMP did not require it following unscheduled maintenance.[32]

- Overhaul. The CVR manufacturer called for an overhaul to be completed every 8,000 hours. Based on the accumulated hours on the accident CVR, it was not due to receive either a functional check or another overhaul. The DOM stated that CVR system repairs and functional checks were performed by contract avionics vendors. The DOM stated that Executive Airlines did not have a wiring diagram for the CVR system that was installed on the airplane. In addition, Executive Airlines did not have the FAA-approved Jetstream International Airlines, Inc., maintenance manual. According to the CVR installation documentation, the FAA required that the CVR system "be maintained in accordance with procedures contained in the FAA approved" Jetstream manual.

After the accident, L3 Communications, which acquired Fairchild, indicated that it would revise its CVR installation manual to add language specifying that a complete audio system interface test "must be completed during each annual inspection or specified maintenance period on the aircraft or rotorcraft <u>and</u> whenever unscheduled maintenance is performed on the aircraft or rotorcraft [that] may have affected the performance of the cockpit voice recorder system." Before the accident, the language did not provide specific guidance about complete audio interface check intervals or the kinds of unscheduled maintenance that might affect the CVR system.

Fuel Estimates Based on Fire Damage Evaluations

According to a May 6, 2002, letter to the Safety Board, a fire consultant was engaged by Executive Airlines, to "conduct a thorough analysis of the wreckage…in order to determine the quantity of fuel on board at the time of this accident." The consultant's report was submitted to the Safety Board on May 15, 2002. The report concluded that, "between a minimum of 41 gallons to a maximum of 163 gallons" of fuel caused the thermal damage to the wings and fuselage between the engine nacelles and that a "minimum of 1.6 gallons to a maximum of 10.7 gallons" of fuel caused the fire damage to the central region of the outboard left wing. The report added that "no account has been made of fuel lost during the crash kinematics or of how much fuel could be absorbed by the crash terrain. For these reasons…the amount of fuel released from the fuel cells during the crash would be more likely near the maximum quantities calculated by this analysis." The consultant's report noted that "some of the damage to the upper fuselage

[32] Following the accident, the operator's CAMP was amended to require a CVR interface check during its service check and to require audio interface checks whenever CVR system components are "installed or replaced."

area probably resulted from the burning of cabin upholstery during the fire" but added that the damage "would be limited to materials above floor level."

The consultant's report was reviewed by fire experts at the FAA Technical Center in Atlantic City, New Jersey. The FAA review of this report, which was submitted to the Safety Board, noted that the fuel estimates in the consultant's report rely "primarily on an approximately 10 square meter area between the engines" to reach conclusions about the amount of fuel on board the airplane at the time of the accident. The FAA report concluded that the 10 square meter area "used for the fuel quantity estimate should be reduced by half at a minimum to account for the contribution of cabin materials that make up 5 of the 10 square meter area. This would reduce the minimum estimate of fuel by half also, to 20.5 gallons." The FAA report added that the "contribution of burning cabin materials…is likely much more than 5 square meters considering the radiation and convection from the burning cabin materials forward and aft of that section. After the fuselage skin melts, the wing root area on both sides of the fuselage would be exposed to the heat of the burning cabin materials." The FAA report noted that other fuel sources, including hydraulic fluid and engine oil, were not considered in the consultant's report. The FAA report concluded that "by ignoring the contribution of burning cabin materials and other fuel sources, the quantity of fuel estimated to produce all of the thermal damage…is greatly overestimated."

ANALYSIS

GENERAL

The captain and first officer were properly certificated and qualified in accordance with applicable Federal regulations and company requirements. Their duty time, flight time, rest time, and off-duty activity patterns did not indicate any preexisting medical, behavioral, or physiological factors that might have affected their performance on the day of the accident.

Based on radar and AVP local and en route weather data, the accident airplane was in IMC during the entire flight from ACY to AVP and was in the clouds when the captain declared the missed approach at 1107:26. Weather data also indicate that the airplane remained in IMC (clouds and possibly occasional light rain) during the second approach (with intermittent ground visibility) until just before ground impact. Turbulence and/or airframe icing conditions were not factors in the accident.

The airplane was properly certificated and equipped in accordance with Federal regulations and approved procedures. Passengers and fuel were properly loaded in accordance with FAA-approved company weight and balance procedures. The airplane's weight and balance were within prescribed limits during all phases of the flight and were not factors in the accident.

There was no indication of preexisting maintenance discrepancies that could have contributed to the accident. There were no pre-impact failures of any flight control system component. There were no pre-impact failures of any fuel system component to either engine, and no evidence of pre-impact engine damage. There was no evidence of an in-flight fire.

A teardown examination of the No.1 (left) engine found rotational scoring and metal spray indicating that the engine was developing power at impact. An examination of the No. 2 (right) engine, which found static imprints and no evidence of rotational scoring or metal spray, determined that the engine was not running at impact.

All propeller blades were found at the crash site. The left engine's propeller blade angles were 28° to 40°, which is within the normal operating range, indicating that the engine was developing some power at impact. An examination of the right engine's propeller blades found angles of about 80°. This high blade angle is consistent with the right engine being in NTS and not developing power at impact. There was no evidence of any propeller anomalies. The fuel lines to each engine were intact and had no kinks or blockage that would have caused an interruption of fuel flow to the engines. The landing gear was extended at impact.

The CVR did not record information during the accident flight and, based on subsequent testing, the Safety Board concluded that although the CVR was capable of recording information, it likely never operated. Bench testing indicated that the recorder was functional if properly installed, and a cockpit functional check should have indicated to flight crews that the CVR was not operating. The Safety Board could not determine why the system did not operate. The Safety Board notes that the lack of CVR information hindered the investigation and emphasizes the

Board's position that functional onboard recording devices, including cockpit video recorders, are critical investigative tools.

According to ACY-bound passenger statements, the captain had flown the first flight of the day from FRG to ACY. According to company practice, pilots alternated as the flying pilot on each leg. Further, representatives of the airline identified the captain as the pilot speaking with ATC in all radio transmissions. Thus, it is likely that the first officer was the flying pilot for the accident flight and may have remained in control of the airplane throughout the accident sequence.

FLIGHT CREW ACTIONS

The Missed Approach

During the first ILS approach to runway 4 at AVP, the flight crew was advised by the AVP approach controller that a previous landing airplane had "picked up the airport at minimums." Radar data indicated that the accident airplane had intercepted the ILS course and glideslope and descended along the glideslope and localizer to an altitude of about 2,200 feet msl when the airplane began to climb and the pilots advised the AVP tower that they were executing a missed approach. Radar data indicated that the airplane was level at 2,200 feet (about 1,000 feet above the decision altitude) for about 20 seconds and followed the center of the localizer before climbing about 700 feet to 2,900 feet before the pilots initiated the missed approach when they were within 2.2 nm of the runway threshold.

Because the flight crew's cockpit conversation was not recorded and because the flight crew did not report the reason for the missed approach to controllers, the Safety Board could not conclusively determine why the missed approach was initiated. However, ATC tapes indicated no sense of urgency from the flight crew. Further, the flight crew accepted sequencing behind a slower airplane without advising the controller of a low fuel state or a desire to expedite the landing and flew a wide pattern to return to the localizer. Therefore, the Safety Board concludes that the flight crew was not aware of a potentially low fuel state or mechanical anomalies when the missed approach was executed.

Loss of Directional Control

ATC approach radar data indicated that the accident airplane deviated 55° in a right turn away from the localizer course during the second approach to AVP. Shortly after this deviation, the pilots informed the AVP controller that they were declaring an emergency because of engine failure. The deviation to the right was likely the result of asymmetrical thrust caused by stoppage of the right engine. Experiencing engine failure in IMC could cause pilots to fixate on instruments such as the attitude indicator and airspeed indicator and to allow the course heading to wander. However, during simulator tests, Safety Board investigators had minimal difficulty maintaining heading and controllability after a simulated right engine failure during approach to a landing.

The Safety Board notes that, based on the airplane's performance capabilities and simulator tests, the accident airplane was controllable after the initial engine stoppage and its subsequent deviation from the ILS approach course should have been sufficiently correctable to enable the flight crew to execute a single-engine ILS approach and landing. Further, the Safety Board notes that during simulator tests, when a left engine failure was induced along with a failed right engine on an ILS approach, the airplane remained controllable with minimal difficulty. However, the airplane was more difficult to control and required constant flight control and trim inputs when the left engine was intermittently failed and restored.[33] Because of impact damage to the empennage, and the stretching and twisting of the rudder trim control cables, an exact rudder trim position for the accident airplane could not be determined.

The Safety Board also considered the possibility of a propeller governor malfunction. However, postaccident examinations determined that both propeller governors were functional. Further, had an internal governor failure occurred (such as a seized drive shaft), the loss of oil to the propeller dome would have caused the feathering spring to drive the propeller into feather and would not have caused significant control problems.

Airplane Fuel Loading

Three witness accounts provided information about how much fuel was on board the airplane at FRG before fuel was added in preparation for the first flight leg of the day to ACY:

- The captain who cancelled the flight earlier in the day because of weather and because it was too late at FRG for the airplane to be refueled stated that the airplane had 1,200 pounds of fuel on board;
- The Executive Airlines owner and CEO stated that the accident first officer told him before departure that the fuel tank measuring sticks indicated that 1,100 pounds of fuel were on board; and
- The first officer's fiancée, who was a passenger to ACY, stated that the first officer indicated that 1,200 pounds of fuel were on board and told her that one fuel gauge read 300 pounds and that the other read 900 pounds. She stated that she believed that the 300-pound indication was for the right tank.

These reports are roughly consistent with Safety Board calculations, based on airplane log pages and flight crew records (between May 19 and before the accident airplane's fueling in FRG), which indicated that about 1,000 pounds of fuel were onboard the airplane before the 600 pounds (90 gallons) were added on the day of the accident.

[33] The left engine failure was allowed to operate as if the autolight system occasionally restored the engine briefly before failing again. The Safety Board pilots were briefed that the simulated engine failures would occur but did not know when.

Statements from the carrier's owner and the first officer's fiancée and information from the weight and balance form completed by the accident crew suggest that the flight crew planned to add a total of 180 gallons to the airplane. If the flight crew intended to load 180 gallons (about 1,200 pounds), it was common industry and company practice to ask for 90 gallons on each side. However, based on the evidence, it appears that a lack of clear communication between the pilots and the fueler resulted in only 90 gallons (about 600 pounds) of fuel being added, a total amount confirmed by the fuel order receipt. Further, it is likely that the flight crew did not confirm the amount of fuel loaded before departure because flight crews do not see the fuel receipts after fueling and because the pilots were not outside the airplane monitoring the fuel loading.

The accident flight crew completed a load manifest that stated that the airplane was loaded with 2,400 pounds of fuel when it departed from FRG, and it is probable that the accident flight crew planned to depart from FRG with 2,400 pounds. Based on the airplane's performance, 2,400 pounds of fuel would have been sufficient fuel to fly the two flights without adding fuel during the stop at ACY. This would have allowed a takeoff from ACY that was within normal weight and balance limits for the airplane with 17 passengers on board. There was no evidence that the flight crew asked for additional fuel to be added during the stop at ACY.

However, based on the Safety Board's calculations, it appears that the accident airplane departed FRG with about 1,600 pounds of fuel on board, which is 800 pounds less than listed on the load manifest. Therefore, the Safety Board concludes that the accident airplane departed FRG with less fuel than the pilots thought they had on board.

The accident pilots departed from FRG and ACY, completed two checklists (one for each of the flights) that included verification of fuel quantity,[34] completed both load manifests for each of these flights (which required an entry indicating the amount of fuel on the airplane), and flew both flights apparently without being aware of a low fuel state. It is possible that the pilots' belief that they had sufficient fuel on board for the flight to AVP caused them to be less vigilant in their monitoring of the airplane's fuel state and slower to consider a low fuel state as the cause of the initial engine failure. Although low fuel quantity annunciator lights for each tank illuminate on the forward instrument panel when the fuel quantity decreases below 200 pounds, Safety Board investigators determined in simulations that these annunciator lights were easily overlooked, even when illuminated. Flight crews are required to constantly monitor their airplane's fuel levels. If a pilot suspects that the fuel gauges are unreliable, fuel indicator sticks can be used to compare actual tank fuel levels to fuel gauge indications. Nevertheless, either pilot should have been able to determine a low fuel state by looking at the fuel gauges.[35] Although the first officer's fiancée stated that the first officer was concerned about the accuracy of the airplane's fuel gauges, her statements and those of the operator's CEO indicated that the tank levels had been measured before the airplane was fueled at FRG. It is possible that the pilots discounted the accuracy of the fuel gauges in flight because they had measured the tanks and believed that they added sufficient fuel (180 gallons) for the day's flights. Further, it is also possible that the pilots

[34] The "J31 Preliminary Checklist" contains a "Fuel Quantity" check item and a "low fuel caution system" test item. The "Before Takeoff Checklist," from the "J31 Normal Checklist," also has a fuel quantity check item.

[35] The pilot who flew the accident airplane the day before stated that the fuel gauges were operating normally.

trusted and monitored the LED display showing fuel used.[36] However, the Safety Board notes that this display's accuracy is dependent on pilot input of the correct fuel quantity at the beginning of the flight.

Engine Stoppage Scenarios

The accident airplane's estimated fuel burn was calculated using information provided by the airplane manufacturer, including the Jetstream 31 flight manual, and the operator. Fuel burn calculations were based on flight times entered into the airplane's logbook. Based on calculations for high-speed cruise power settings[37] (which included fuel load and fuel burn time estimates for taxi, climb, en route flight, and descent), the accident airplane could have had about 275 pounds of fuel on board when it crashed. If the airplane, in fact, had 275 pounds of fuel evenly distributed between the tanks at the time of the crash this would not explain the right engine stoppage and subsequent crash. However, several factors could affect the accuracy of the assumptions that were used in these calculations and, consequently, the reliability/accuracy of the 275-pound result.

Factors that can significantly change the amount of fuel burned on any flight include different (higher or lower) flight altitudes or airplane configurations, such as flaps and landing gear extended for long periods of time. Fuel burn is also increased during rapid, high-performance climbs, such as required for the execution of a missed approach.

It is also possible that fuel load information for the accident airplane documented in the days before the accident did not accurately represent the airplane's fuel load during this period. Carry-over errors in fuel load documents and differences in fuel calculations could result in assumptions of more fuel than was actually on board the airplane. For example, the Safety Board notes that its fuel calculations were based on the airplane being loaded to its maximum fuel load capacity, an amount that flight crews stated was rarely loaded. Using a 2,900-pound top-off fuel amount[38] instead of the maximum 3,090 pounds (as assumed in the fuel burn calculations) for these instances resulted in only 85 pounds of fuel remaining. Assuming that as much as 66 pounds were unusable, the remaining 19 pounds, or about 3 gallons, would have been enough for only about 1 to 4 minutes of flight. Therefore, assuming that these factors account for some or all of the fuel that would have remained under the conditions assumed for the high-speed cruise setting calculations and given the larger amount of fuel loaded in the left fuel tank, the right engine stoppage could be explained by fuel exhaustion.[39] However, the Safety Board notes that

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[36] In a postaccident interview, the owner and CEO of Executive Airlines stated that the airlines' pilots could determine current fuel loads by subtracting fuel burned from the known quantity at departure and that he believed that the fuel burned gauges are more reliable than the fuel quantity gauges.

[37] Although Executive's owner and CEO stated that flight crew used long range cruise settings, the Safety Board considered the airline's director of operations to be more credible based on his direct interaction with line pilots as their supervisor and as a Jetstream 31 check captain and instructor.

[38] As previously noted, Executive Airlines flight crews indicated that it was common practice to list 2,900 pounds on the load manifest because tanks are rarely filled to the top.

[39] Witness testimony indicated that the right tank contained less fuel when the airplane departed FRG. The airplane's fuel crossfeed valve was found in the closed position. However, it was not possible to determine whether this valve was open before the accident (as is required by the airplane checklist in the event of an engine failure).

both the 275-pound and 85-pound flight time estimates indicate a critically low fuel state, and a fuel state well below the reserve required by the IFR flight plan filed by the flight crew.

Further, the apparent difficulties with the left engine could be explained by unporting of whatever fuel remained in the left tank.[40] Conditions would have been conducive to unporting if, for example, the airplane was in a left bank and in a nose-right sideslip following the loss of the right engine, which is consistent with flying straight while attempting to turn to the left, as indicated by the pilot statement "we're trying" when the controller queried if the airplane was in a left turn. Assuming some usable fuel was in the left tank, it is probable that the flight crew's maneuvering after the right engine stoppage may have intermittently unported it, causing the sequential stoppage and restarting of the left engine. The Safety Board notes that the loss of the right engine occurred while the airplane was in relatively level flight and that the left engine stoppage occurred during attempts to maneuver back to the ILS course after the stoppage of the right engine. Further, the final loss of control may have been precipitated by momentary stopping or starting of the left engine when the airplane was at a reduced airspeed. Impact witness marks and airplane damage were consistent with a loss of control at low altitude.

Observations made during examination of the accident site and the surrounding area were consistent with only a small amount of fuel being on board at the time of the crash. Severe fire damage was limited to the area immediately surrounding the crash site, suggesting a lack of significant fuel splash from the ruptured tanks. The burn pattern also indicated that there was little fuel remaining on board at impact.

Fuel starvation to the engines caused by the failure of the LP fuel cock circuitry was also considered. However, no determination could be made because the LP fuel cock switches located in the cockpit were destroyed by impact and fire. The Safety Board notes that the right engine and left engine LP valves, which are controlled by the fuel cock circuitry, were found in the open position and that the hydraulic LP valves were found open.

Loss of fuel en route was also considered. However, witnesses who observed the airplane's departure from ACY saw no indication of leaking fuel from the wings or the fuel caps. Although the right tank fuel cap was not recovered, metallurgical evidence determined that it had been in place before impact. Further, the airplane's manufacturer indicated that, because of the outboard location of the fuel caps, spillage or suction from an open fuel tank filler in level flight would be minimal and unlikely.

Although the Safety Board's fuel calculations do not demonstrate that the accident airplane was completely out of fuel, the Safety Board considered a critically low fuel state to be the most likely scenario given the lack of evidence indicating mechanical failures. Federal regulations and company policy state that it is the pilot-in-command's responsibility to ensure before departure that the airplane has the correct amount of fuel onboard for the planned flight. The Safety Board concludes that because of miscommunication between the flight crew and the

[40] Banking and acceleration can cause fuel to flow away, or become unported from, the airplane's fuel pumps, which are located in the inboard section of the fuel tanks near the fuselage.

fueler about the amount of fuel to add at FRG and the flight crew's failure to ensure an adequate fuel supply, the airplane departed FRG with less fuel than the flight crewmembers stated on the load manifest and with less fuel than they believed they had. Further, the Safety Board concludes that the flight crewmembers failed to adequately monitor the airplane's fuel state en route and at ACY based on the expectation that they had sufficient fuel on board to complete both flights.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's failure to ensure an adequate fuel supply for the flight, which led to the stoppage of the right engine due to fuel exhaustion and the intermittent stoppage of the left engine due to fuel starvation. Contributing to the accident were the flight crew's failure to monitor the airplane's fuel state and the flight crew's failure to maintain directional control after the initial engine stoppage.

Adopted on August 26, 2002