National Transportation Safety Board
Aviation Accident Final Report

Location:	CLARKSVILLE, TN	**Accident Number:**	MIA98FA091
Date & Time:	03/05/1998, 0520 CST	**Registration:**	N840FE
Aircraft:	Cessna 208B	**Aircraft Damage:**	Destroyed
Defining Event:		**Injuries:**	1 Fatal
Flight Conducted Under:	Part 135: Air Taxi & Commuter - Non-scheduled		

Analysis

The flight was in radio contact with air traffic controllers at the FAA Memphis Air Route Traffic Control Center (ARTCC), and was level at 9,000 feet, when the pilot checked in on frequency. The last radio contact with the flight was at 0447. At 0520, radar contact was lost. The airplane impacted in rough terrain, at a steep angle of impact. Two other company pilots flying in trail of the accident aircraft said, they had radio contact with the pilot of N840FE about 5 minutes before the accident. They said he sounded fine and did not say anything about any problems. Radar data showing the flight's ground speed indicated that at 0512, the ground speed was 158 knots (182 mph). The ground speed then decreased to 153 (176 mph), 143 (165 mph), 138 (159 mph), and 132 (152 mph), until at 0519:40, when the ground speed of the flight was 125 knots (144 mph). After the radar read out at 0519:40, the next radar hit was coast (no information), and then the flight disappeared from the radar scope. The airplane's heading and altitude did not change during the decrease in ground speed. According to the NTSB Radar Data Study, calculated flight parameters indicated the airplane "...experienced a slow reduction of airspeed in the final 8 minutes of flight at altitude, and then abruptly exhibited a sharp nose down pitch attitude with a rapid increase in airspeed." About the time of the reduction in airspeed, pitch angle began to slowly increase also. When radar contact was lost, the calculated airspeed had reduced to less then 102 knots [118 mph], and calculated body angle of attack [AOA] had increased to 8.8 degrees. A large reduction in pitch angle, angle of attack, and flight path angle as the airspeed increases after peak AOA was reached. Examination of the engine Power Analyzer and Recorder (PAR) revealed that no exceedences were in progress at the time power was removed from the PAR. It was determined that no caution timing events were in progress. The PAR computer appeared to be operating correctly until power was removed at impact. Examination of the airplane's autopilot were not conclusive due to impact damage. Determination of whether the autopilot was engaged or not engaged at the time of the accident could not be determined. The NTSB Meteorological Factual Report revealed that at 0515, about 7 minutes before the flight was lost on radar, the radiative temperature in an area centered at Clarksville (4 kilometer resolution data), showed that the Mean Radiative Temperature was -6.26 degrees C (21F). The Minimum Radiative Temperature was -6.66 degrees C (19F). The Maximum Radiative Temperature was -6.06 degrees C (21F). According to the Archive Level II Doppler weather radar tape for a beginning

sweep time of 0508:10, showed that N840FE had tracked into a weather echo from 0510:34, to 0516:28. The Doppler Weather Radar data, revealed that N840FE, had entered a weak weather echo about the same time that the airspeed of the airplane started to decrease, at an altitude of about 9,000 feet, and the airplane was in the weak weather echo for a few minutes. Based on the weather data, it was determined that in-flight airplane icing conditions were encountered by N840FE. Cessna Aircraft Company Airworthiness Directive (AD) 96-09-15; Amendment 39-9591; Docket No. 96-CE-05-AD, applicable to this airplane and complied with by the company, on December 12, 1996, stated: "...to minimize the potential hazards associated with operating the airplane in severe icing conditions by providing more clearly defined procedures and limitations associated with such conditions...operators must initiate action to notify and ensure that flight crewmembers are apprised of this change...revise the FAA-approved Airplane Flight Manual (AFM) by incorporating the following into the Limitation Section of the AFM. This may be accomplished by inserting a copy of this AD in the AFM...." The airplane was equipped with leading edge deicing boots on the wings, elevators, struts, and had a cargo pod deicing capability. Lights were installed to illuminate the leading edge of the wings, to aid the pilot in detecting ice on the leading edges of the wings during night operations. The airplane was not equipped with an ice detection device.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: the pilot did not maintain control of the airplane due to undetected airframe ice, resulting in an inadvertent stall, and subsequent impact with the ground. Factors in this accident were; flight into clouds, below freezing temperatures, and the inability of the pilot to detect ice, due to the lack of an ice detection system to determine ice build up on portions of the airframe that are not visible from the cockpit.

Findings

Occurrence #1: IN FLIGHT ENCOUNTER WITH WEATHER
Phase of Operation: CRUISE - NORMAL

Findings
1. LIGHT CONDITION - DARK NIGHT
2. FLIGHT INTO KNOWN ADVERSE WEATHER - ENCOUNTERED - PILOT IN COMMAND
3. (F) WEATHER CONDITION - CLOUDS
4. (F) WEATHER CONDITION - TEMPERATURE,LOW
5. (F) WEATHER CONDITION - ICING CONDITIONS
6. ANTI-ICE/DEICE SYSTEM - INADEQUATE
7. (F) ACFT/EQUIP INADEQUATE,VISUAL RESTRICTION - PRODUCTION/DESIGN PERSONNEL
8. INADEQUATE CERTIFICATION/APPROVAL - FAA(ORGANIZATION)

Occurrence #2: LOSS OF CONTROL - IN FLIGHT
Phase of Operation: DESCENT - UNCONTROLLED

Findings
9. AIRSPEED - NOT MAINTAINED - PILOT IN COMMAND
10. (C) AIRCRAFT CONTROL - NOT MAINTAINED - PILOT IN COMMAND
11. (C) STALL - INADVERTENT - PILOT IN COMMAND

Occurrence #3: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: DESCENT - UNCONTROLLED

Findings
12. TERRAIN CONDITION - ROUGH/UNEVEN
13. TERRAIN CONDITION - GROUND

Factual Information

HISTORY OF FLIGHT

On March 5, 1998, about 0520 central standard time, a Cessna 208B, N840FE, registered to Federal Express Inc., and operated by Baron Aviation Services, Inc., as flight SM8315 (call sign Show Me), was destroyed after impact with the ground, near Clarksville, Tennessee. The commercial-rated pilot was fatally injured. Instrument meteorological conditions (IMC) prevailed in the vicinity, and an IFR (instrument flight rules) flight plan had been filed. The scheduled domestic cargo flight from Memphis, Tennessee, to Bowling Green, Kentucky, was being conducted in accordance with Title 14 CFR Part 135. The flight had departed Memphis, at 0413.

The pilot of SM8315 was in radio contact with air traffic controllers at the FAA Memphis Air Route Traffic Control Center (ARTCC) and was level at an altitude of about 9,000 feet, on the Nashville VOR 315-degree radial, about 25 nautical miles, when radio and radar contact was lost. Witnesses in the area reported hearing the sound of the crash and the wreckage was located a short time later. The crash site was located on the Nashville VOR 315-degree radial about 35 nautical miles, or about 5 miles southeast of Clarksville.

The last radio communication with the pilot of SM8315 was at 0447, when he checked in on frequency with the Memphis ARTCC, and reported at 9,000 feet. About 0520, radar contact was lost. At 0521, the controller attempted to re-establish radio contact with the pilot, and said he had lost his transponder. No response from the pilot was received, and no further radar contacts were made. The airplane impacted in rough terrain, at a steep angle of impact.

Two other company pilots flying in the same vicinity at the time of the accident said they were at 7,000 feet msl (SM8314), and 5,000 feet msl (SM8316). They said they were in and out of the clouds. The pilot of SM8314 indicated that the outside air temperature (OAT) at 7,000 feet was between 0 degrees C (32F) and -1 degree C (30F). The pilot of SM8316 indicated that the OAT at 5,000 feet was between 3 degrees C (37F) and 5 degree C (41F). The other two company pilots also said they had radio contact with the pilot of SM8315 about 5 minutes before the accident. They said he sounded fine and did not say anything about any problems. A third company pilot flying about 100 miles behind SM8315, said he was at 9,000 feet and had picked up some ice crystals. The third pilot landed at Nashville, about 50 miles south of the crash site.

Radar data showing the flight's ground speed indicated that at 0512, the ground speed was 158 knots (182 mph). The ground speed then decreased to 153 (176 mph), 143 (165 mph), 138 (159 mph), and 132 (152 mph), until at 0519:40, when the ground speed of the flight was 125 knots (144 mph). After the radar readout at 0519:40, the next radar hit was "coast," no information, and then the flight disappeared from the radar scope. The sweep of the radar scope was 12-second intervals. During the change in ground speed the airplane's heading and altitude did not change.

The NTSB Office of Research and Engineering's Radar Data Study revealed that radar trajectory studies indicated the flight was cruising at about 9,200 feet msl (mean sea level) altitude and at roughly 135 knots (156 mph) calibrated airspeed (KCAS) en route from Memphis to Bowling Green. According to the NTSB Radar Data Study, calculated flight parameters indicated the airplane "...experienced a slow reduction of airspeed in the final 8

minutes of flight at altitude, and then abruptly exhibited a sharp nose down pitch attitude with a rapid increase in airspeed."

Radar plots showed that SM8315, "...maintained a steady altitude at 9,400 feet-msl, at an airspeed of close to 135 knots, and flying on heading 040 [degrees]. About 10 minutes before the upset...the aircraft's airspeed began to slightly reduce to close [to] 125 knots [144 mph] as the pitch angle and flight path remained steady. Five minutes before radar contact was lost, [the] airspeed began to further reduce at an increased rate, with a corresponding increase in angle of attack. About the time of the increased reduction in airspeed, pitch angle began to slowly increase also. When radar contact was lost, the calculated airspeed had reduced to less then 102 knots [118 mph], and calculated body angle of attack [AOA] had increased to 8.8 degrees. A large reduction in pitch angle, angle of attack, and flight path angle as the airspeed increases after peak AOA was reached." (See the NTSB Radar Data Study an attachment to this report.)

A witness, who had an aviation background, was located at his home about 1 mile south of the crash site. He told investigators he heard an aircraft directly above his house "at approximately 200 feet, having engine trouble. " He described the sound from the airplane as like the sound of a "pilot changing the prop setting [pitch angle]." He then heard the airplane crash.

The accident occurred during the hours of darkness approximately 36 degrees, 28 minutes north, and 087 degrees, 13 minutes west.

PERSONNEL INFORMATION

Information on the pilot is contained in this report on page 3, under First Pilot Information. The pilot had been employed by Baron Aviation Services Inc., for 7 1/2 years, with a date of hire of August 13, 1990. The company reported it was common practice for their pilots to fly the same route, and the majority of this pilot's time with the company was flying the same route as the accident flight. The duty time of the pilot on the day before the accident, March 4, 1998, was 7 hours 51 minutes. On the day of the accident, March 5, 1998, the pilot had a duty time of 6 hours 23 minutes. The pilot had a total flight time in this make and model airplane of 5,198 hours. His last check ride before the accident was February 26, 1998.

AIRCRAFT INFORMATION

At the time of the accident the total time on the airframe was 4,078.5 hours. The maximum gross weight was 8,750 pounds. The airplane was equipped with leading edge deicing boots on the wings, elevators, struts, and had a cargo pod deicing capability. Lights were installed to illuminate the leading edge of the wings, to aid the pilot in detecting ice on the leading edges of the wings during night operations. The airplane was not equipped with an ice detection device.

METEOROLOGICAL INFORMATION

Meteorological information is contained in this report on page 3, under Weather Information. A preliminary weather study for the accident area showed that at 9,000 feet the temperature was minus 4 degrees C (24.8 F), and the tops of the clouds were from 10,000 to 11,000 feet. There was also an AIRMET (Airman's Meteorological Information) issued that covered the area around the crash site that called for icing conditions.

The following AIRMET was found in the wreckage; "AIRMET ICE...Tennessee,

Mississippi, Alabama...FROM TRI TO CHA TO 50W ATL TO GWO TO DYR TO TRI, LGT OCNL MOD RIME ICGIC BTN 060 160. CONDS OVR NRN MS /WRN TENN, SPRDG TO RMNDR AREA BY 09Z...CONS CONTG BTD 09Z THUR 15Z."

[From Bristol/Johnson/Kingsport, Tennessee, to Chattanooga, Tennessee, to 50 miles west of Atlanta, Georgia, to Greenwood, Mississippi, to Dyersburg, Tennessee, to Bristol/Johnson/Kingsport, Tennessee, light occasional moderate rime icing between 6,000 feet msl and 16,000 feet msl. Conditions over northern Mississippi/ western Tennessee, spreading to the remainder of the area by 0900 UTC (0300)...conditions continuing beyond 0900 UTC thru 1500 UTC (0900).] A map trace of this AIRMET, showed that it included the flight path area, times and altitudes associated with the flight of SM8315.

The pilot of SM8314 said that his flight conditions at 7,000 were, "...IMC [instrument meteorological conditions] with an outside air temperature of 0 degrees C (32F) to -1 degree C (30 F), but no ice was forming on my airplane at any time."

At the request of the NTSB investigator-in-charge (IIC), additional questions in reference to the flight condition were asked of the pilot of SM8314, May 1998, by a Federal Express, Aircraft Safety Investigator. He was asked, "...did [he] take any anti-ice precaution? He answered: "Yes, he turned on the pitot-static heat and was watching for ice build up on the wings via ice detector light mounted in the left wing leading edge-to-fuselage fairing." The second question the Federal Express, Aircraft Safety Investigator asked the pilot, "...[if he was] aware of the AIRMET for ice in Tennessee, Mississippi, Alabama, covering portions of his route from Memphis to Bowling Green?" He answered, "...yes, he obtained the same weather information as the mishap pilot [SM8315], that particular AIRMET was included in the weather briefing and he was aware of it."

Upper air wind data was obtained for Nashville, Tennessee, at 0600, on March 5, 1998, located about 41 nautical miles southeast of Clarksville, and was chosen for its proximity to the crash site. The data obtained shows the height in meters mean sea level (meters times 3.2808 equals feet), temperature, dew point, wind direction (degrees true), wind speed (meters per second), level (pressure millibars). The following was determined for altitudes between 2,134 meters [7,001 feet msl] and 3,009.5 meters [9,874 feet msl]. (See the NTSB Radar Data Study attached to this report.)

Altitude 2,134 meters [7,001 feet], the temperature was -1.5 degrees C [about 28 degrees F], dew point -2 degrees C [about 28 degrees F], wind direction 280 degrees, wind speed 7.2 meters per second, pressure 781.5 millibars.

Altitude 2,439 meters [8,002 feet], the temperature was -3 degrees C [about 27 degrees F], dew point -3.5 degrees C [about 27 degrees F], wind direction 290 degrees, wind speed 7.7 meters per second, pressure 752.2 millibars.

Altitude 2,743 meters [8,999 feet], the temperature was -4.4 degrees C [about 25 degrees F], dew point -5 degrees C [about 23 degrees F], wind direction 295 degrees, wind speed 11.3 meters per second, pressure 724.1 millibars.

Altitude 2,765.8 meters [9,074 feet], the temperature was -4.5 degrees C [about 24 degrees F], dew point -5.1 degrees C [about 23 degrees F], wind direction 295.4 degrees, wind speed 11.5 meters per second, pressure 722 millibars.

Altitude 3,009.5 meters [9,874 feet], the temperature was -5.1 degrees C [about 23

degrees F], dew point -18.1 degrees C [about 0 degrees F], wind direction 300 degrees, wind speed 13.3 meters per second, pressure 700 millibars.

Altitude 3,156.7 meters [10,357 feet], the temperature was -5.5 degrees C [about 22 degrees F], dew point -16.5 degrees C [about 3 degrees F], wind direction 300 degrees, wind speed 14.2 meters per second, pressure 687 millibars.

The NTSB Meteorological Factual Report revealed that at 0515, about 5 minutes before SM8315 was lost on radar, the radiative temperature in an area centered at Clarksville (4 kilometer resolution data), in degrees Kelvin (K), showed that the mean radiative temperature was 266.9 degrees K, or -6.26 degrees C (21F). The minimum radiative temperature was 266.5 degrees K, or -6.66 degrees C (19F). The maximum radiative temperature was 267.1 degrees K, or -6.06 degrees C (21F). [Note: 273.16 degrees Kelvin (K) = 0 degrees C. To convert degrees K to degrees C, the following formula was used; C = (K - 273.16)]

According to the NTSB Meteorological Factual Report, addendum, the weather data taken from an Archive Level II Doppler weather radar tape from Nashville, Tennessee, revealed that the Plan Position Indicator (PPI) image for a beginning sweep time of 0508:10, showed that SM8315 had tracked into a weather echo from 0510:34, to 0516:28. The NTSB Radar Data Study had shown that the speed of the airplane began to decrease at 0512, and the last radar readout was at 0519:40.

The maximum weather radar reflectivity along SM8315's track was 10.0 dBZ (Note: dBZ is a measure of the weather radar echo intensity. dBZ = 10 LOG Z .. where Z = the concentration of uniformly distributed small water particles that would return the amount of power received. Z is in millimeters to the sixth power divided by meters cubed. Given dBZ = -1.0 results in Z = 0.1. Given dBZ = 60 results in Z = 1,000,000. A dBZ value of -1 to 2 is a weak weather echo. A dBZ value of 60 is an extreme weather echo. A value seen in thunderstorms).

The Table below relates dBZ to weather echo intensity.

Table A

dBZ	Intensity
<0 to 29	Weak
30 to 39	Moderate
40 to 44	Strong
45 to 49	Very Strong
50 to 54	Intense
55 or greater	Extreme

Cross-sections of weather radar reflectivity (dBZ) were prepared for the airplane's track data for several points along the flight path. The cross-section at 0505:18 showed no weather echoes above 7,000 feet. The cross-section at 0514:00, showed weather echo tops about 9,000 feet, from 0513:28 to 0514:28, and a weather echo top about 7,700 feet at 0515:28. The maximum weather echo intensity at 9,000 feet was about -1.0 to 2.0 dBZ. The cross-section for 0519:50, showed no weather echoes above 7,000 feet.

The Doppler Weather Radar data, revealed that SM8315, had entered a weak weather echo about the same time that the speed of the airplane started to decrease, and the airplane was in the weak weather echo for a few minutes. Based on the weather data, it was determined that in-flight airplane icing conditions were encountered by SM8315. The NTSB Meteorological Factual Report and attachments are attached to this report.

MEDICAL AND PATHOLOGICAL INFORMATION

An autopsy was performed on the pilot, on March 6, 1998, at the Medical Examiner's Office, Nashville, Tennessee, by Dr. Charles H. Harlan.

Toxicological tests were conducted at the Federal Aviation Administration, Research Laboratory, Oklahoma City, Oklahoma, and revealed, "No ethanol detected in Blood." Drugs, "...0.007 (ug/ml, ug/g) Tetrahydrocannabinol Carboxylic Acid (Marihuana) Detected in Kidney Fluid...0.01 (ug/ml, ug/g) Tetrahydrocannabinol Carboxylic Acid (Marihuana) Detected in Blood."

The toxicology report was reviewed by the NTSB Medical Officer, Washington, D.C. According to the Medical Officer, the drugs found indicates only that the pilot used marijuana in the "previous days or weeks." The remote marijuana use indicated by the toxicology findings almost certainly had "no direct" effect on the ability of the pilot to "operate the aircraft."

COMMUNICATIONS

According to the Air Traffic Control (ATC) transcripts of communications, SM8315 was issued an IFR clearance to Bowling Green, by Memphis ATC Clearance Delivery, at 0350, and was cleared for takeoff from runway 18L, at 0413. Communications between SM8315 and ATC were routine. The pilot of SM8315 reported on frequency at an altitude of 9,000 feet. He then requested and received a direct routing to Bowling Green. At 0447:05, the pilot of SM8315 was instructed by the Memphis ARTCC (Air Route Traffic Control Center), to "contact Memphis Center 125.85," and the pilot acknowledged the transmission.

At 0447:15, the pilot of SM8315, contacted the Memphis ARTCC Bowling Green Low Altitude Radar Control Position (R41) and said, "...Show Me 8315 level niner thousand."

There were no further transmissions until 0521:16, when the ARTCC controller called SM8315, and said, "...Show Me 8315 I've lost your transponder sir."

The ARTCC controller tried to call SM8315 again and did not get a response. The controller then contacted Show Me 8314 (SM8314), and at 0522:02 said, "...Show Me 8314...can you do me a favor and make a radio check to 8315, I've lost his transponder about ten miles in front of [you], I have no radar target any longer I'd like to see if you can get him on your frequency." SM8314, acknowledged, and attempted to call SM8315 on the company frequency, as well as the ATC frequency, without any success.

At 0522:31, the R41 controller called Nashville ATC and asked if they had a radar target on SM8315, and they responded, "...naw I lost the target on him...[I have a] point out for [you] about ten [miles] in trail and five in trail [from where SM8315 was lost on radar], ah 8314 and 8316 [SM8314 and SM8316] at seven [7,000 feet] and five [5,000 feet] respectively."

At 0523:53, the R41 controller asked the pilot of SM8314, "...what are your flight conditions." SM8314 said, "...three fourteen is IMC, temperature minus one, and that's about it." The R41 controller said, "negative icing," and the pilot of SM8314 answered, "negative icing."

At 0524:13, the R41 controller said, "eighty three fourteen would you be willing...to descend down to four thousand and see if you can break out to get ground contact."

The pilot of SM8314 agreed to help, and at 0524.23, the R41 controller said, "...descend and maintain 4,000, let me know if you break out and if you do, his position from your position should be about 3 to 4 miles in front of you from the last time I lost radar on him." The pilot of

SM8314 said, "...roger...leaving 7,000 for 4,000."

The R41 controller then asked the pilot of SM8314 if he could, "...continue your descent to 3,000 if you don't break out at four." The pilot of SM8314 said he would continue to 3,000 feet.

At 0527:11, the R41 controller said to the pilot of SM8314, "...I think...you're passed the spot I lost radar on that guy [SM8315], so you can just press on, and maintain 4,000, your company [SM8316] is about ten in trail, I'm gonna descend him down and see if he can't break out...."

At 0528:20, the pilot of SM8316 called the R41 controller and said, "...we was just kind of curious what's the lowest that you can take us down to in this area." The controller said 3,000 was the lowest, and that Fort Campbell had told SM8314 that 3,000 feet was still IMC.

At 0528:40, the pilot of SM8316 said, "...I just talked to them and they were reporting a two thousand overcast."

Show Me 8314 reported to ATC at 0529:04, "...we've come back into another layer at four thousand so we're solid IMC again."

Both Show Me 8314 and 8316, were informed by ATC at 0529, that ATC was going to call Fort Campbell and have someone make a ground search for SM8315.

At 0538:54, the pilot of SM8314 said, "...at two thousand seven hundred [feet] we got ground contact [at Bowling Green]."

The approach controller at Nashville reported at 0543:50, that someone "just called me, [and] that they said that they did find the airplane...on the ground."

At 0552:29, the R41 controller said to the pilot of SM8316, "...for your information ah Emergency Services Tennessee, at Nashville, Tennessee, I believe it ah Emergency Services has reported an aircraft on the ground in the vicinity where 8315 was last in radar contact...."

WRECKAGE INFORMATION

The airplane impacted on a downward slope of a small ridge that formed the northern side of a valley that ran east-west. The elevation at the crash was determined by the use of a topographical chart, and was estimated to be 470 feet. The slope of the ridge was about 20-25 degrees. The nose of the airplane, impact scars, and an impact crater about 15 feet south of the wreckage were oriented on a heading of 190 degrees. It was determined that the airplane impacted at a high angle, based on the angle of the crater, the absence of damage to the vegetation upslope of the crash site, and impact marks from both wings. The impact crater was elliptical in its shape. The crater measured about 10 feet wide, 15 feet long and 3 feet deep, at its deepest point. The airplane came to rest about 15 feet south of the crater, and about 20 feet from the bottom of the ridgeline, about 30 feet north of McAdoo Creek Road, an east-west hard surface road. The surface of the road had a strong smell of spilled turbine fuel.

The cargo pod had sheared off and was found just north of the crater, in about the same area that the main landing gear were found. All major parts of the airplane were found within the impact site. Small pieces of the airplane had hydrauliced forward of the crash site in a southerly direction, about 200 feet from the main wreckage, coming to rest in an open field, just south of the hard surface road.

The wreckage was removed from the crash site and taken to Outlaw Field, Clarksville, Tennessee, for further examination. The examination revealed that the airframe, except aft of the forward part of the empennage, was crushed. There was no evidence of fire damage observed on any of the airplane. The leading edges of both wings had sustained aft crushing damage along most of the surface. The tail section was found collapsed over the main fuselage, and had sustained aft crushing damage on the top of the vertical fin and rudder. All the parts of the airplane were accounted for within the crash site.

Elevator and rudder control cable connections were confirmed on the surface attachments and at the cockpit controls. The right elevator torque tube was found disconnected from the bell crank, left side. The torque tube fasteners were found sheared. The rudder and elevator control stops showed no visible distortion. The control cable connections were in place on the right side aileron/spoiler bell crank. The left side bell crank was not located.

Measurements of the left elevator tab revealed that its measured extension was 1.45 inches (both rods), or 14 degrees tab down deflection (nose up). Measurements of the right elevator tab revealed that its measured extension was 1.40 inches (both rods), or 16 degrees tab down deflection (nose up). The aileron tab revealed 2.4 inches extension (full travel), or 15+ degrees full tab up deflection. The wing flaps revealed 6.4 inches extension (full travel), or 0 degrees flap setting.

The engine was found under the nose of the airplane buried into the ground. The engine was removed from the crash site and examined at Outlaw Field. Examination revealed that the engine had sustained impact damage including complete structural separation of the reduction and accessory gearboxes, and rupture of the gas generator case.

The compressor blades, compressor turbine blades, and the turbine power blades were circumferentially fractured. All three displayed circumferential rubbing and scoring to their adjacent shrouds, due to radial contact under impact loads and external case distortion. Circumferential scoring was displayed by the compressor turbine and interstage baffle, the interstage baffle and power turbine, the reduction gearbox first stage carrier and second stage carrier, due to axial contact under impact loads and external case distortion. Examination of the engine did not reveal any discrepancies other than impact-related damage.

TEST AND RESEARCH

The engine Power Analyzer and Recorder (PAR) was removed from the airplane and taken to Avionics Specialties Inc., facilities Charlottesville, Virginia, to retrieve the stored information. The PAR was disassembled on March 16, 1998, under the supervision of the NTSB investigator-in-charge (IIC).

The purpose of tearing down the PAR was to recover the record from the EEPROM (Electrically Erasable Programmable Read-Only Memory) chip and the memory contents of the RAM (Random Access Memory) chip at the time of power being removed by the crash. The two chips were contained within the case on the J4 connector end of the box and this end had sustained impact damage and buckling.

The PAR had sustained impact damage to the internal parts and its contents. The mounting base plate had been torn off the case and a section of the airplane's seat track was imbedded in the front side passing through to the back side of the case.

The PAR RAM was found still connected to its clock chip and a voltage measurement was made that showed the RAM was receiving 2.9 VDC [volts direct current], which indicated that the chip should have contained readable information. The leads of the clock chip had been damaged. The leads were soldered into another socket so that data could be extracted.

The PAR computer samples the input parameters about 30 times a second, and only stores a log record on the conclusion of an event , such as a start. The unit records non exceedences events of starts, shutdowns, trend records, and power failures.

The information retrieved from the PAR in real time when the power was removed from the PAR was: Ng [speed of gas generator]= 79.29 percent; NP [power]= 1917 RPM; Torque = 680 FLB; Inlet Turbine Temperature = 530 degrees C; Fuel flow = 285 PPH; Horse Power = 248; Pressure Altitude = 308 feet; Indicated airspeed = 139 KTS (160 mph); Outside air temperature = -2 degrees C.

It was concluded that no exceedences were in progress at the time power was removed from the PAR. It was determined that no caution timing events were in progress. The PAR computer appeared to be operating correctly until power was removed at impact. (See Avionics Specialties' reported attached to this report.)

The annunciator panel was shipped to the NTSB Materials Laboratory in Washington, D.C. The NTSB Materials Laboratory Factual Report revealed that the filaments of a total of 44 bulbs were examined. The filaments in both bulbs of seven indicators, "...VOLTAGE LOW, ENGINE FIRE, OIL PRESSURE LOW, GENERATOR OFF, LEFT FUEL LOW, RIGHT FUEL LOW, and STANDBY ELECTRICAL POWER ON were severely or non-uniformly stretched, consistent of illumination during impact." The bulbs for DE-ICE PRESSURE, WINDSHIELD ANTI-ICE, revealed that both the left and right bulbs were "...Not stretched, Not broken." (See the NTSB Materials Laboratory Factual Report attached to this report.)

The NTSB IIC made an inquiry to Cessna, asking how the above lights could be illuminated at impact, since the facts of the investigation proved otherwise. Cessna replied in a letter dated January 26, 1999, and wrote; "...Pages 69 and 70 of Transport Canada Report TP 6254E...indicated that illumination times of the type bulbs used for this application can be on the order of 48-50 milliseconds. All annunciator lights can be illuminated by the 'press-to-test switch.' Considering the speed of the aircraft when electrical power was lost, the duration of the structural deformation stage, and the fact that the aircraft had a secondary impact (bounce), there is a possibility that this press-to-test switch was engaged by the forward motion of the pilot's body, or by deformation of the switches, or by shorting of an electrical wire. As indicated in report TP 6254E, false positives due to these various conditions can lead to misleading results...Based on the above and the other facts we determined in this investigation, I have concluded that the annunciator light bulb analysis is not relevant." (Cessna's letter to the IIC, and Transport Canada's report TP 6254E are attached to this report.)

The Allied Signal, Bendix/King KFC 250 Autopilot was removed from the wreckage and taken to Allied Signal's facility in Olathe, Kansas, on June 5-6, 1998, for further examination. The examination was done under the supervision of the NTSB IIC.

The examination of the autopilot revealed that the flight computer had sustained impact damage. Electrical testing was not possible due to impact damage.

The pitch trim servo displayed impact damage, and could not be electrically tested. The engage solenoid was found in the partially engaged position, and the solenoid plunger was

jammed. A similar solenoid was used to determine the full travel in the engaged and disengaged position. Full travel was measured at .240 inches. The accident airplane's servo was measured and found to be .080 inches from full engagement.

The pitch servo displayed slight impact damage, and the unit was electrically tested. The engage solenoid was found in the disengaged position. The solenoid functioned, both mechanically and electrically. The servo motor was electrically powered, and found to be fully functional in both directions of rotation.

The yaw servo displayed impact damage. The solenoid was found in the disengaged position. The solenoid and servo motor tested without discrepancies when powered electrically.

The roll servo displayed impact damage and could not be electrically tested. The engage solenoid was found in the disengaged position.

The mode controller was found destroyed. The AP engage switch appeared to be in the off position, but due to impact damage the position of the AP switch was not conclusive. The pitch modifier switch was found centered.

The yaw controller was destroyed. No testing was possible, and no information was obtained from the unit.

The directional gyro was destroyed. No electrical testing was possible. The gyroscope was disassembled. Rotational scoring was found on the rotor and inside the rotor housing.

The vertical gyro was found destroyed. No electrical testing was possible. The gyroscope was disassembled. Rotational scoring was found on the gyro rotor and the inside surface of the rotor housing.

Examination of the flight command indicator revealed that it was destroyed, and could not be electrically tested. The indicated attitude was found about 70 degrees nose down and about 30 degrees right bank.

The HSI [heading select indicator] displayed impact damage and could not be tested electrically. The indicated magnetic heading was about 185 degrees. No other information was obtained from the HSI.

The air data computer was found destroyed. No information was obtained from the unit.

Except for impact damage no discrepancies were found in the autopilot. Because of the damage sustained by the autopilot, a determination of whether the autopilot was engaged or disengaged at the time of impact was inconclusive. (See Allied Signal's report attached to this report.)

ADDITIONAL INFORMATION

Cessna Aircraft Company Airworthiness Directive (AD) 96-09-15; Amendment 39-9591; Docket No. 96-CE-05-AD, applicable to this airplane and complied with by Baron Aviation, on December 12, 1996, stated as follows:

"...to minimize the potential hazards associated with operating the airplane in severe icing conditions by providing more clearly defined procedures and limitations associated with such conditions, accomplish the following: (a) Within 30 days after the effective date of this

AD, accomplish the requirements of paragraphs (a) (1) and (a) (2) of this AD. Note 2: Operators must initiate action to notify and ensure that flight crewmembers are apprised of this change."

Paragraph No. 1: "...Revise the FAA-approved Airplane Flight Manual (AFM) by incorporating the following into the Limitation Section of the AFM. This may be accomplished by inserting a copy of this AD in the AFM...WARNING...Severe icing may result from environmental conditions outside of those for which the airplane is certificated. Flight in freezing rain, freezing drizzle, or mixed icing conditions (supercooled liquid water and ice crystals) may result in icing build-up on protected surfaces exceeding the capability of the ice protection system, or may result in ice forming aft of the protected surfaces. This ice may not be shed using ice protection systems, and may seriously degrade the performance and controllability of the airplane...during flight, severe icing conditions that exceed those for which the airplane is certificated shall be determined by the following visual cues. If one or more of these visual cues exists, immediately request priority handling from Air Traffic Control to facilitate a route or an altitude change to exit the icing conditions...unusually extensive ice accreted on the surface of the airframe in areas not normally observed to collect ice...accumulation of ice on the lower surface of the wing aft of the protected area [this AD does not address areas of the airframe not visible from the cockpit i.e. the tail or cargo pod]...since the autopilot may mask tactile cues that indicate adverse changes in handling characteristics, use of the autopilot is prohibited when any of the visual cues specified above exists, or when unusual lateral trim requirements or autopilot trim warnings are encountered while the airplane is in icing conditions [Note: The pilot of SM8315 was using an earmuff type head set during the flight. Unless he had any visual cues of a trim change, he could not hear the trim motor noise]...all icing detection lights must be operative prior to flight into icing conditions at night."

Paragraph No.2: "...Revise the FAA-approved Airplane Flight Manual (AFM) by incorporating the following into the Limitation Section of the AFM. This may be accomplished by inserting a copy of this AD in the AFM...THE FOLLOWING WEATHER CONDITIONS MAY BE CONDUCIVE TO SEVERE IN-FLIGHT ICING...visible rain at temperatures below 0 degrees Celsius [C] ambient air temperature...droplets that splash or splatter on impact at temperatures below 0 degrees Celsius ambient air temperature...PROCEDURES FOR EXITING THE SEVERE ICING ENVIRONMENT...these procedures are applicable to all flight phases from takeoff to landing. Monitor the ambient air temperature. While severe icing may form at temperatures as cold as -18 degrees [C], increased vigilance is warranted at temperatures around freezing with visible moisture present [SM8315 was at 9,000 feet in clouds, reported temperature -4 degrees C]. If the visual cues specified in the Limitations Section of the AFM for identifying severe icing conditions are observed, accomplish the following...Immediately request priority handling Air Traffic Control to facilitate a route or an altitude change to exit the severe icing conditions in order to avoid extended exposure to flight conditions more severe then those for which the airplane has been certificated [the pilot of SM8315 did not make such a request]...avoid abrupt and excessive maneuvering that may exacerbate control difficulties [Radar showed SM8315 had a gradual decrease in ground speed. Heading, and altitude remained the same]...do not engage the autopilot [autopilot was destroyed, whether it was engaged or not engaged could not be determined, autopilot on/off switched was found broken]...if autopilot is engaged, hold the control wheel firmly and disengage the autopilot...if an unusual roll response or uncommanded roll movement is

observed, reduce the angle-of-attack...." (See AD 96-09-15 attached to this report.)

Baron Aviation's General Operations Manual addresses winter flight operating procedures for the Cessna 208 and includes the requirements addressed in Cessna AD 96-09-15. (See excerpts from Baron's General Operations Manual attached to this report.)

The NTSB Hazardous Materials Group Factual Report revealed that the cargo aboard SM8315 consisted of documents, packages, and the following hazardous materials:

Product	UN	Hazard	Packing	Quantity
Number	Class	Group		
1,1,1 Trichloroethane	2831	6.1	III	1package
.125 ml Batteries wet	2800	8	III	1 battery non-spillable
weighing				40.8 kilograms Printing Ink
1210	3	III	4 packages	
with a total				weight
of			15 liters Adhesive	1133
3	II	1 package		
weighing just				over 1 liter

Hazardous materials shipping documentation for SM8315 included a "Notification of Dangerous Goods (Part A)" and three separate "Notification of loading of Dangerous Goods (Part Bs)." The Part A for the flight indicated three classes of hazardous materials were on board; flammable liquid (class 3); corrosive material (class 8); and toxic (class 6.1).

The third Part B, which listed the printing ink, xylenes, adhesives, and resin solution, contained incorrect quantities and listed products which were not on board the aircraft at the time of the accident. In addition, the seven packages of adhesives which were identified as Packing Group III were not on the flight, and only one of the eleven packages of the adhesives identified as Packing Group II was on board. The printing ink was the only entry on the third Part B which accurately reflected both the product and quantity which was on the airplane.

FedEx explained the discrepancy between the hazardous materials which were on board SM8315, and the hazardous materials shipping papers which accompanied the load by saying the printing ink, xylenes, adhesives and resin solution, listed on the third Part B originated in Japan. All of these products were delivered to Bowling Green, without clearing American Customs. Upon realizing the discrepancy, FedEX in Bowling Green prepared a Part B on February 27, 1998, and shipped all of the products back to Memphis for clearance. The xylenes, resin solutions, and some of the adhesive cleared customs and were shipped back to Bowling Green by highway. The printing ink and one package of adhesive were shipped to Bowling Green on Flight 8315. The Part B which was prepared on February 27, was utilized for this shipment although the load had been split and a portion sent by ground (see NTSB Hazardous Materials Group Factual Report attached).

The airplane was released to Mr. C.E. Schmidt, Jr., President, Baron Aviation, on March 6, 1998. The Power Analyzer Recorder was released to Mr. Michael Wales, Federal Express Corporation, on March 16, 1998. The autopilot was released to Mr. Michael Wales, Federal Express Corporation, on June 16, 1998.

Pilot Information

Certificate:	Commercial	**Age:**	45, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	Seatbelt
Instrument Rating(s):	Airplane	**Second Pilot Present:**	No
Instructor Rating(s):	None	**Toxicology Performed:**	Yes
Medical Certification:	Class 2 Valid Medical--no waivers/lim.	**Last Medical Exam:**	11/04/1997
Occupational Pilot:		**Last Flight Review or Equivalent:**	
Flight Time:	8398 hours (Total, all aircraft), 5198 hours (Total, this make and model), 7000 hours (Pilot In Command, all aircraft), 160 hours (Last 90 days, all aircraft), 50 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Cessna	**Registration:**	N840FE
Model/Series:	208B 208B	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	No
Airworthiness Certificate:	Normal	**Serial Number:**	C208B-0142
Landing Gear Type:	Tricycle	**Seats:**	2
Date/Type of Last Inspection:	01/15/1998, AAIP	**Certified Max Gross Wt.:**	8750 lbs
Time Since Last Inspection:	88 Hours	**Engines:**	1 Turbo Prop
Airframe Total Time:	4079 Hours	**Engine Manufacturer:**	P&W
ELT:	Installed, not activated	**Engine Model/Series:**	PT6A-114
Registered Owner:	FEDERAL EXPRESS CORP.	**Rated Power:**	600 hp
Operator:	BARON AVIATION SERVICES INC.	**Air Carrier Operating Certificate:**	On-demand Air Taxi (135)
Operator Does Business As:	FEDERAL EXPRESS	**Operator Designator Code:**	DEMA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument Conditions	**Condition of Light:**	Night/Dark
Observation Facility, Elevation:	HOP, 573 ft msl	**Observation Time:**	0537 CST
Distance from Accident Site:	5 Nautical Miles	**Direction from Accident Site:**	350°
Lowest Cloud Condition:	Scattered / 1000 ft agl	**Temperature/Dew Point:**	43°C / 36°C
Lowest Ceiling:	Overcast / 2000 ft agl	**Visibility**	5 Miles
Wind Speed/Gusts, Direction:	5 knots, 180°	**Visibility (RVR):**	0 ft
Altimeter Setting:	30 inches Hg	**Visibility (RVV):**	0 Miles
Precipitation and Obscuration:			
Departure Point:	MEMPHIS, TN (MEM)	**Type of Flight Plan Filed:**	IFR
Destination:	BOWLING GREEN, KY (BWG)	**Type of Clearance:**	IFR
Departure Time:	0410 CST	**Type of Airspace:**	Class C

Wreckage and Impact Information

Crew Injuries:	1 Fatal	**Aircraft Damage:**	Destroyed
Passenger Injuries:	N/A	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Fatal	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	ALAN J YURMAN	**Adopted Date:**	02/16/2001
Additional Participating Persons:	GARY SCHULER; NASHVILLE, TN JOE HUTTERER; WICHITA, KS MICHAEL C WALES; MEMPHIS, TN THOMAS A BERTHE; S. BURLINGTON, VT		
Publish Date:			
Investigation Docket:	NTSB accident and incident dockets serve as permanent archival information for the NTSB's investigations. Dockets released prior to June 1, 2009 are publicly available from the NTSB's Record Management Division at pubinq@ntsb.gov, or at 800-877-6799. Dockets released after this date are available at http://dms.ntsb.gov/pubdms/.		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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