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Aviation Charter, Inc.
Raytheon (Beechcraft) King Air A100, N41BE
Eveleth, Minnesota
October 25, 2002

Aircraft Accident Report

NTSB/AAR-03/03

PB2003-910403
Notation 7602

National
Transportation
Safety Board
Washington, D.C.

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490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

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

Abstract: This report explains the accident involving Aviation Charter, Inc., which crashed while the flight crew was attempting to execute the VOR approach to runway 27 at Eveleth-Virginia Municipal Airport, Eveleth, Minnesota, on October 25, 2002. The safety issues discussed in this report include flight crew proficiency, Aviation Charter operational and training issues, inadequate crew resource management (CRM) training, Federal Aviation Administration (FAA) surveillance, and the need for improved low-airspeed awareness. Safety recommendations concerning CRM training, FAA surveillance, and low-airspeed alert systems are addressed to the FAA.

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Abbreviations

AC	advisory circular
AFM	Aircraft Flight Manual
AFSS	Automated Flight Service Station
agl	above ground level
AIM	*Aeronautical Information Manual*
AIRMET	airmen’s meteorological information
ARAC	Aviation Rulemaking Advisory Committee
ASOS	automated surface observing system
ATC	air traffic control
ATCT	air traffic control tower
ATP	airline transport pilot
ATSS	Airway Transportation System Specialist
AWC	Aviation Weather Center
AWOS	automated weather observing system
BIS	Bismarck Municipal Airport
C	Celsius
CAMI	Civil Aerospace Medical Institute
CDI	course deviation indicator
CFI	certified flight instructor
CFR	*Code of Federal Regulations*
CG	center of gravity
CRM	crew resource management
CVR	cockpit voice recorder
DLH	Duluth International Airport
DME	distance measuring equipment
EVM	Eveleth-Virginia Municipal Airport

FA	area forecast
FAA	Federal Aviation Administration
FAF	final approach fix
FAR	*Federal Aviation Regulations*
FBO	fixed-base operator
FCM	Flying Cloud Municipal Airport
FGS	flight guidance system
fpm	feet per minute
FSDO	Flight Standards District Office
FSI	Flight Safety International
ft-lbs	foot-pounds
GOM	General Operations Manual
HSI	horizontal situation indicator
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
JAR	*Joint Aviation Requirements*
KCAS	knots calibrated airspeed
MAP	missed approach point
MDA	minimum descent altitude
msl	mean sea level
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NOTAM	notice to airmen
NWS	National Weather Service
PIC	pilot-in-command
PIREP	pilot report
POI	principal operations inspector

RASIP	Regional Aviation Safety Inspection Program
ROC	Rochester International Airport
RTCA	Radio Technical Commission of Aeronautics
SLD	supercooled large droplets
SOPs	Standard Operating Procedures
STP	St. Paul Downtown Airport
TAF	terminal aerodrome forecast
UTC	coordinated universal time
VOR	very high omnidirectional range

Executive Summary

On October 25, 2002, about 1022 central daylight time, a Raytheon (Beechcraft) King Air A100, N41BE, operated by Aviation Charter, Inc., crashed while the flight crew was attempting to execute the VOR approach to runway 27 at Eveleth-Virginia Municipal Airport, Eveleth, Minnesota. The crash site was located about 1.8 nautical miles southeast of the approach end of runway 27. The two pilots and six passengers were killed, and the airplane was destroyed by impact forces and a postcrash fire. The airplane was being operated under the provisions of 14 *Code of Federal Regulations* Part 135 as an on-demand passenger charter flight. Instrument meteorological conditions prevailed for the flight, which operated on an instrument flight rules flight plan.

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's failure to maintain adequate airspeed, which led to an aerodynamic stall from which they did not recover.

The safety issues discussed in this report include flight crew proficiency, Aviation Charter operational and training issues, inadequate crew resource management (CRM) training, Federal Aviation Administration (FAA) surveillance, and the need for improved low-airspeed awareness. Safety recommendations concerning CRM training, FAA surveillance, and low-airspeed alert systems are addressed to the FAA.

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1. Factual Information

1.1 History of Flight

On October 25, 2002, about 1022 central daylight time,[1] a Raytheon (Beechcraft) King Air A100,[2] N41BE, operated by Aviation Charter, Inc., crashed while the flight crew was attempting to execute the VOR[3] approach to runway 27 at Eveleth-Virginia Municipal Airport (EVM), Eveleth, Minnesota. The crash site was located about 1.8 nautical miles[4] southeast of the approach end of runway 27. The two pilots and six passengers were killed, and the airplane was destroyed by impact forces and a postcrash fire. The airplane was being operated under the provisions of 14 *Code of Federal Regulations* (CFR) Part 135 as an on-demand passenger charter flight. Instrument meteorological conditions (IMC) prevailed for the flight, which operated on an instrument flight rules (IFR) flight plan.

The accident flight was chartered for U.S. Senator Paul Wellstone. The flight was scheduled to depart St. Paul Downtown Airport (STP), St. Paul, Minnesota, about 0920 and arrive at EVM around 1020. The flight crew planned to drop off the passengers at EVM and then ferry the accident airplane from EVM to Duluth International Airport (DLH), Duluth, Minnesota, with a scheduled arrival of about 1054. The passengers were to be transported by car to DLH after their activities were concluded in Eveleth. The flight crew planned to remain at DLH until the flight back to STP, which was scheduled to depart at 2115.

According to Federal Aviation Administration (FAA) records, the pilot called the Princeton Automated Flight Service Station (AFSS) for an abbreviated weather briefing about 0716. The AFSS specialist informed the pilot that AIRMETs [airmen's meteorological information] for IFR and icing conditions were current over the entire route.[5] He added that IFR conditions were reported throughout central and northern Minnesota and that cloud conditions near STP were reported as broken between 800 and 1,000 feet[6] and overcast between 1,300 and 1,600 feet. He also stated that cloud

[1] Unless otherwise indicated, all times in this report are central daylight time, based on a 24-hour clock.

[2] Raytheon Aircraft Company acquired Beech Aircraft Corporation in February 1980.

[3] VOR stands for very high frequency omnidirectional range.

[4] Unless otherwise indicated, all distances in this report are reported in nautical miles.

[5] An AIRMET is an in-flight weather advisory issued by the National Weather Service (NWS) to indicate weather that may be hazardous to single-engine and other light aircraft and visual flight rules pilots. Operators of large aircraft may also be concerned with the information included in an AIRMET. For more information about the meteorological conditions that existed surrounding the time of the accident, see section 1.7.

[6] Altitudes referenced in this report from surface weather observations and terminal aerodrome forecasts (TAF) are reported as height above ground level (agl). Unless otherwise indicated, all other altitudes referenced in this report are reported as height above mean sea level (msl).

conditions at EVM were reported as scattered at 1,000 feet and overcast at 2,000 feet and that visibility was reported as 4 statute miles in light snow. He added that between STP and EVM the cloud ceilings were reported between 300 and 600 feet and visibility was reported as between 1 to 4 statute miles in light snow and mist.

The pilot then asked for freezing level information[7] and weather information for DLH in case he had to land there as an alternate to EVM. The AFSS specialist indicated that at that time, DLH was reporting an overcast cloud ceiling of 500 feet and visibility of 2 statute miles in light snow and mist. He added that the terminal forecast indicated an overcast cloud ceiling of 500 to 900 feet and visibility of 1 to 3 statute miles in rain or snow. About 0719, the pilot stated, "you know what[,] I don't think I'm going to take this flight."

According to the Senator's campaign scheduler, the pilot contacted her about 0720 and informed her that they might experience icing conditions during the flight. She stated that the pilot did not indicate that he was thinking of canceling the flight. The campaign scheduler stated that when she asked the pilot what he would do if icing became a problem, he told her that the airplane was equipped with deicing equipment and, if necessary, that he could turn the airplane back toward warmer air to melt the ice or divert to DLH. She stated that the pilot then reassured her that he was an experienced and conservative pilot.

About 0730, the pilot contacted Aviation Charter's headquarters in Eden Prairie, Minnesota, and asked the receptionist who answered his call to inform the company's scheduling office that the Senator's flight would be delayed because of the weather. The pilot then contacted the Million Air fixed-base operator (FBO) at STP and told its general manager that he would be departing about 1300 instead of 0920 and asked her to ensure that the airplane would be available at that time. However, the Senator's campaign scheduler stated that when she talked to the pilot again about 0800, he indicated that the cloud ceiling had improved, and they agreed to go ahead with the flight as originally scheduled.

According to FAA records, at 0817:57, the pilot contacted the Princeton AFSS and asked, "can you give me Eveleth weather right now?" The AFSS specialist stated that the latest automated weather for EVM was issued at 0754 and that it indicated calm winds, visibility of 3 statute miles in light snow, and an overcast cloud ceiling at 900 feet. He added that there was reported light mixed icing at 7,000 to 10,000 feet at Hibbing, Minnesota, and that the AIRMETs for IFR and icing conditions were still current.

At 0818:38, the pilot began filing an IFR flight plan with an estimated departure time from STP of 0920. While filing the flight plan, the pilot asked the AFSS specialist if any turbulence was forecast, and the AFSS specialist replied, "no just icing they've been collecting in the tops and…it's been running between ten and fifteen thousand." The pilot then asked for a cruise level of 13,000 feet.

[7] The AFSS specialist stated that the freezing level was reported to be from the surface to 7,000 feet in the northern portion of the area, sloping to 8,000 to 11,000 feet in the southern portion of the area.

According to Aviation Charter's director of charter, sales, and marketing, the pilot called her about 0840 and stated that he had done a weather check with the Senator's campaign staff and that they still wanted to depart as planned. He indicated that he was getting conflicting guidance from another of the Senator's staffs and that he did not feel comfortable deciding whether or not to make the flight. The director of charter, sales, and marketing stated that she told the pilot to contact the company's chief pilot and that the pilot indicated that he had tried to contact the chief pilot but had not been able to reach him. She stated that she suggested to the pilot that he speak to the company's director of operations. She also stated that the pilot did not seem overly stressed, just concerned about doing a good job.

Aviation Charter's director of operations stated that he did not speak with the pilot that morning but that the pilot had left him a voice message stating that there was some confusion about whether they should depart. He indicated that the pilot stated on the message that icing conditions might prevent them from returning to STP later that day as planned.

According to Million Air's general manager, the copilot checked with her before the flight to ensure that the airplane had been fueled and then went to the hangar to get catering items for the flight and to preflight the airplane. The airplane had been in the hangar overnight and was towed from the hangar after the copilot arrived at STP.

According to Million Air's general manager and another King Air pilot, the accident pilot arrived at STP shortly before 0900, and the Senator and his staff were already at the airport. The other King Air pilot, who had just arrived at STP from the DLH area, indicated that the accident pilot asked him about the weather conditions he had encountered on his flight and then asked him if he would mind sharing this information with the Senator. The other King Air pilot indicated that he told the Senator that the weather was at minimums, but he was sure the pilots could handle the flight.

According to FAA air traffic control (ATC) records, the flight departed STP about 0937 and was cleared to proceed directly to EVM at 13,000 feet. ATC services were provided by the Minneapolis Terminal Radar Approach Control and the Minneapolis Air Route Traffic Control Center for the en route portion of the flight, and these services were routine.

About 1001, the copilot[8] contacted the DLH Air Traffic Control Tower (ATCT)[9] and reported level at 13,000 feet proceeding direct to EVM. The DLH approach control south radar controller responded, "king air four one bravo echo duluth approach[,] when you have eveleth weather advise what approach you [would] like…had icing reports

[8] The accident airplane was not equipped with a cockpit voice recorder (CVR); therefore, the Operations Group listened to the recorded ATC voice communications to identify which flight crewmember was operating the radios for each transmission. Although the group determined that the copilot made all but one of the transmissions to ATC, it could not determine who was the flying pilot (that is, the pilot manipulating the airplane's flight controls) during the flight.

[9] The DLH ATCT provides radar approach control services to EVM.

through the morning[;] the last report was from a saab…descended into duluth had light rime ice but earlier just about an hour ago…a dc nine had moderate rime between niner thousand and one one thousand."[10] The copilot acknowledged the transmission. About 1002, the controller instructed the flight crew to descend to and maintain 4,000 feet at pilot's discretion.

About 1004, the copilot contacted the DLH approach control south radar controller indicating that he had the current EVM weather[11] and that he would like the VOR runway 27 approach. The controller advised, "expect vectors for the approach." The copilot acknowledged the transmission. About 1006, the controller asked the flight crew what they intended to do in the event of a missed approach. The pilot responded, "well let's hope we don't have that if we…do have a missed approach we'll go up and circle and figure this out[;] I'll hold at the vor."[12]

About 1009, the copilot reported leaving 13,000 feet for 4,000 feet. Radar data indicate that the airplane was approximately 34 miles south of EVM at this time. About 1012, the DLH approach control south radar controller instructed the flight crew to descend to 3,500 feet at pilot's discretion.[13] Radar data indicate that at 1015:17, the airplane was descending through 6,200 feet at about 194 knots calibrated airspeed (KCAS)[14] when the controller instructed the flight crew to turn right to a heading of 50°. At 1017:21, the controller instructed the flight crew to turn left to a heading of 360°. By 1017:35, the airplane had leveled off at 3,500 feet and was heading northward with the airspeed decreasing through about 190 KCAS.

At 1018:13, when the airplane was less than about 1/2 mile south of the published VOR runway 27 approach course (see figure 1), the DLH approach control south radar

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[10] In this report, the following terms are used to describe icing conditions: "rime," "trace," "light," and "moderate." According the to the *Aeronautical Information Manual* (AIM), rime ice is "rough, milky, opaque ice formed by the instantaneous freezing of small supercooled water droplets." The AIM states that the term "trace" should be used to describe ice that has become perceptible, the term "light" should be used to describe ice that is accumulating at a rate that may create a problem if flight in such an environment is prolonged (over 1 hour) and the occasional use of deice/anti-icing equipment prevents the problem, and the term "moderate" should be used to describe ice that is accumulating at a rate that can become potentially hazardous even in short encounters and use of deicing/anti-icing equipment or flight diversion becomes necessary.

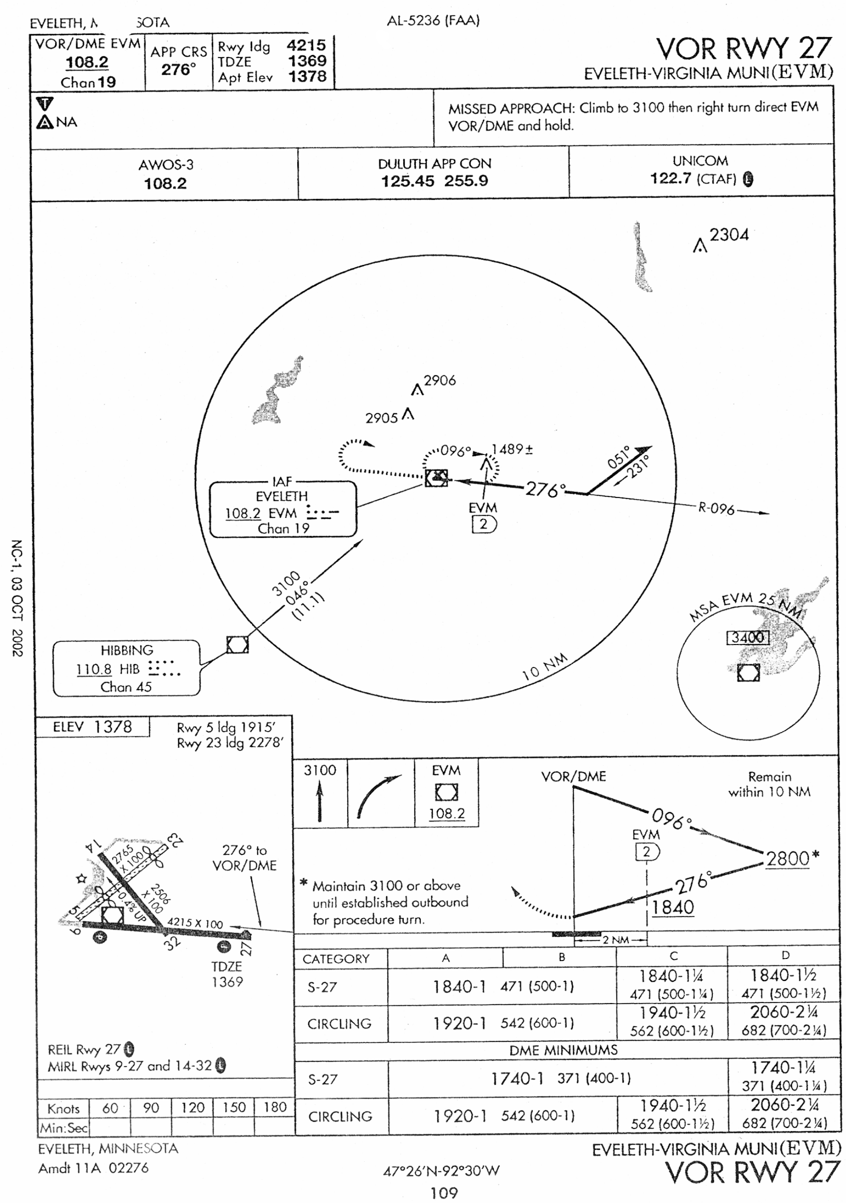
[11] The 0954 weather observation from the automated weather observing system (AWOS)-3, which is located at EVM about 2 miles northwest from the accident site, included a reported visibility of 2 1/2 statute miles in light snow and a sky condition of 400 feet scattered, 700 feet overcast. Visibility of 1 statute mile was required to execute the VOR runway 27 approach.

[12] For more information about Aviation Charter's Abandoned Approach procedure, see section 1.17.1.3.

[13] The VOR runway 27 approach procedure prescribes 2,800 feet as the initial approach altitude (within 10 miles of EVM). However, according to standard operating procedures for the DLH ATC facility, controllers assign a greater initial approach altitude than prescribed because intermittent radar coverage and radio communication exist below 3,000 feet in the vicinity of EVM. The DLH south radar controller stated that he assigned an initial approach altitude of 3,500 feet to ensure that he did not lose radar contact with the accident airplane.

[14] KCAS was derived from FAA and U.S. Air Force 84th Radar Evaluation Squadron radar and atmospheric data. Because of limitations inherent in radar data, all radar-derived calculations of the airplane's performance parameters presented in this report should be considered approximations.

controller advised, "one zero miles from the vor turn left heading three zero zero maintain three thousand five hundred [un]til established on the final approach course cleared for the vor runway two seven approach eveleth." The copilot acknowledged the instruction at 1018:31. Radar data indicate that shortly thereafter, the airplane began turning left while maintaining 3,500 feet and slowing through about 164 KCAS. Almost immediately after the airplane began its left turn, it overshot the approach course and traveled for almost 1 mile north of the course as it continued the turn toward the course until establishing a ground track of about 262°. See figures 1 and 2 for the ground track and profile view of the accident flight.



CATEGORY	A	B	C	D
S-27	1840-1 471 (500-1)		1840-1¼ 471 (500-1¼)	1840-1½ 471 (500-1½)
CIRCLING	1920-1 542 (600-1)		1940-1½ 562 (600-1½)	2060-2¼ 682 (700-2¼)
DME MINIMUMS				
S-27	1740-1 371 (400-1)			1740-1¼ 371 (400-1¼)
CIRCLING	1920-1 542 (600-1)		1940-1½ 562 (600-1½)	2060-2¼ 682 (700-2¼)

Knots	60	90	120	150	180
Min:Sec					

Figure 1. The published EVM VOR approach chart.

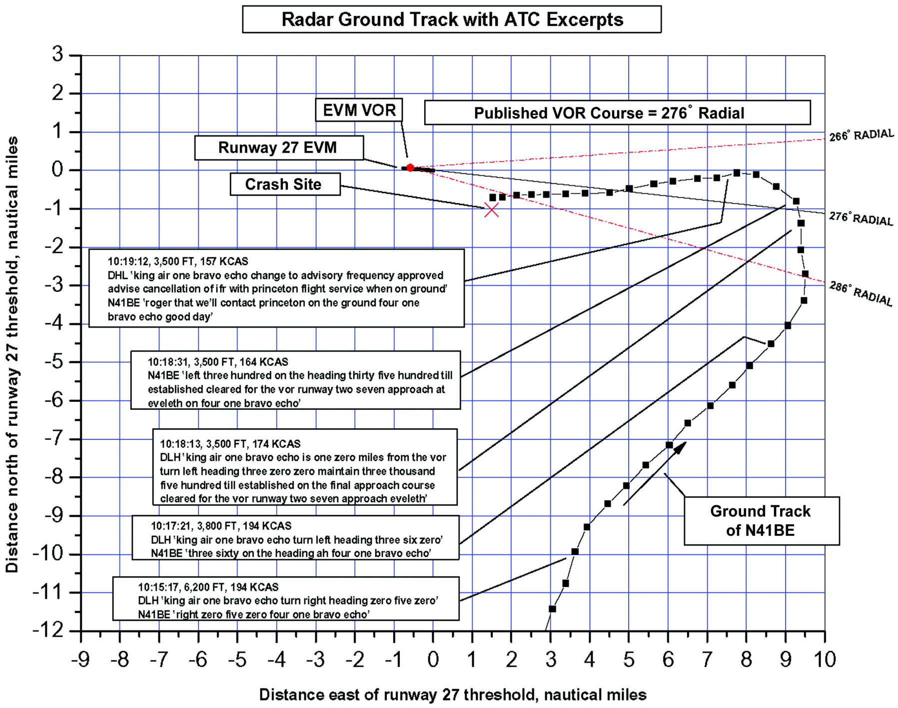


Figure 2. Ground track of the accident flight.

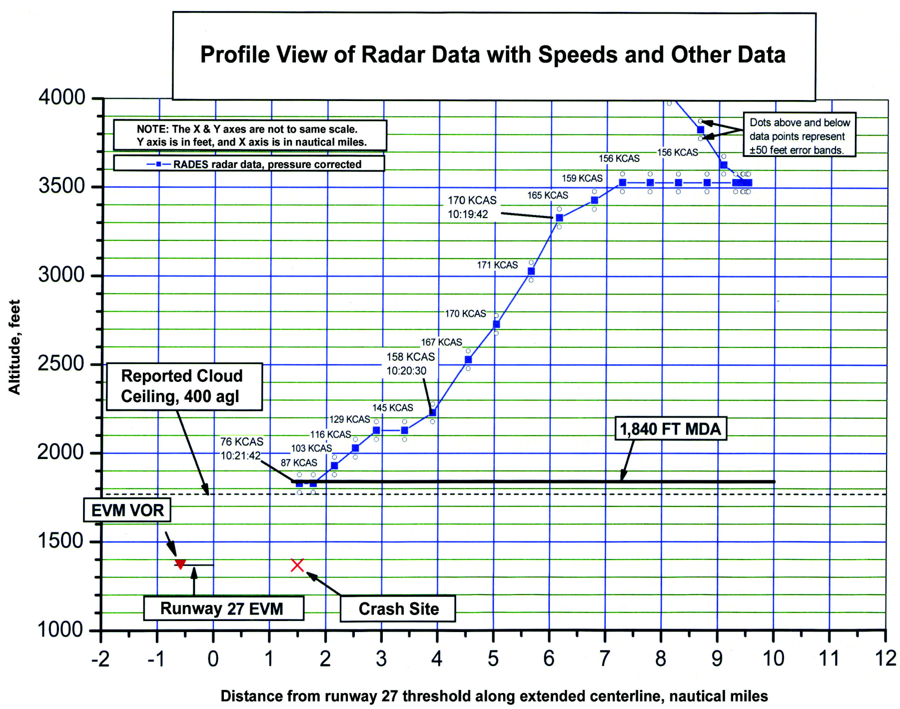


Figure 3. Profile view of the accident flight.

At 1019:12, the controller stated, "king air one bravo echo change to advisory frequency approved[;] advise cancellation of ifr with the princeton flight service when on the ground." The copilot acknowledged the instruction at 1019:20. This was the last transmission received by ATC from the accident airplane. Radar data indicate that at this time, the airplane began its descent from 3,500 feet and that its airspeed stopped decreasing about 155 KCAS and began increasing.

The airplane's airspeed increased to about 170 KCAS and its vertical speed increased through 1,000 feet per minute (fpm) as it descended through 3,200 feet. The airspeed stabilized briefly at about 170 KCAS and the vertical speed peaked at about 1,400 fpm. At 1020:06, as the airplane passed through (south of) the approach course about 5 miles east of the runway 27 threshold, a slight right turn was initiated, and the airplane's airspeed and vertical speed began decreasing. The airplane established a ground track of about 269° and maintained this track until the end of the radar data at 1021:42. The last two radar returns indicate that the airplane had slowed to about 76 KCAS at 1,800 feet.[15]

One witness indicated that he saw the airplane to the west of his location (approximately 4.5 miles east of the runway 27 threshold) "just beneath a low layer of clouds" and that "the top of the airplane may still have been in the clouds." He stated that he noticed the landing gear was down, but that he could not remember if any lights were illuminated on the airplane.

The airplane impacted the ground about 1.8 miles southeast of the approach end of runway 27. The main wreckage was found at 47° 24.36' north latitude and 92° 27.05' west longitude at an elevation of 1,361 feet. The wreckage location was about 1/4 mile south-southwest of the last radar return.

1.2 Injuries to Persons

Table 1. Injury chart.

Injuries	Flight Crew	Cabin Crew	Passengers	Other	Total
Fatal	2	0	6	0	8
Serious	0	0	0	0	0
Minor	0	0	0	0	0
None	0	0	0	0	0
Total	2	0	6	0	8

[15] Mode C radar data altitudes have a resolution of ± 50 feet.

1.3 Damage to Airplane

The airplane was destroyed by impact forces and a postcrash fire.

1.4 Other Damage

Trees and other vegetation at and surrounding the crash site were damaged as a result of this accident.

1.5 Personnel Information

1.5.1 The Pilot

The pilot, age 55, was hired by Aviation Charter on April 26, 2001. He held a multiengine airline transport pilot (ATP) certificate, issued August 4, 1989, with a type rating in the Cessna Citation (CE-500). (In April 1989, the pilot had been issued a notice of disapproval by the FAA following a flight check for his ATP certificate because of his unsatisfactory performance in several areas, including area arrivals, instrument landing system [ILS] approaches, normal/abnormal procedures, and judgment. He received additional training before retaking and passing the test on August 4, 1989.) The pilot's most recent FAA first-class medical certificate was issued on December 17, 2001, and contained the limitation that he must wear corrective lenses for near and distant vision.[16]

According to documentation provided by the pilot's wife, the pilot worked at Simmons Airlines (doing business as American Eagle) from November 1989 until April 27, 1990. Simmons could not provide investigators with any documentation regarding his employment at the company.[17] However, the pilot's personal records indicate that he reported for Simmons' ground training on November 27, 1989. The pilot's personal records indicated that Simmons' ground training program consisted of 17 days of ground instruction, 3 days of training in a Frasca 121 flight-training device, more than 30 hours of flight training, and about 20 hours of initial operating experience. One of the pilot's personal logbooks indicated that he had completed only 13.6 hours of flight training in Avions de Transport Regional 42 aircraft and that he had passed a checkride during this training. The pilot's logbook also indicated that he had flown four revenue service flights as a first officer for Simmons on January 29 and 30, 1990 (a total of 4.5 hours). The Safety Board's investigation was unable to determine if the pilot gained any additional flying experience while employed at Simmons.

[16] It could not be determined if the pilot was wearing corrective lenses at the time of the accident.

[17] The Pilot Records Improvement Act of 1996 requires any company hiring a pilot for air transportation to request and receive records from any aviation carrier, company, organization, or person that had employed a pilot applicant during the previous 5 years. Simmons did not have the pilot's employment records because he had last been employed at the company more than 5 years previously.

From February 2 to 20, 1990, the pilot stood trial on criminal charges for mail and wire fraud. He was convicted and sentenced to 2 years in prison and 5 years probation. The pilot submitted a letter of resignation to Simmons dated April 27, 1990. He began his prison sentence on June 8, 1990, and remained in prison until November 8, 1991, at which time he started serving the probation sentence, which he completed on November 7, 1996.

According to the employment application the pilot filled out at Aviation Charter, he worked as a registered nurse for four different employers between March 1992 and March 2001. The pilot's employment application did not contain any information regarding previous aviation-related employment.

According to Aviation Charter records, the pilot had flown approximately 5,116 total flight hours, 598 hours of which he flew with the company, 200 hours of which were as a company pilot-in-command (PIC) in King Airs.[18] He had flown approximately 101, 53, and 36 hours in the 90, 60, and 30 days, respectively, before the accident. His last recurrent ground training occurred on April 23, 2002. Since completion of his last simulator training on August 21, 2002, the pilot had flown 32 flights for Aviation Charter, 21 as PIC in King Airs and 11 as copilot in Cessna Citations. Six of the 21 King Air flights were conducted in the A100, including one flight the day before the accident in the accident airplane. His last proficiency and line checks occurred on October 23, 2002. A search of FAA and company records showed no accident or incident history or enforcement or disciplinary actions, and a search of the National Driver Register database found no record of driver's license revocation or suspension.

Aviation Charter's lead ground instructor stated that the pilot was average on learning airplane systems and that several company pilots had indicated that the pilot's flying skills were below average. Several Aviation Charter pilots who had flown with the accident pilot described him as "very meticulous," "by the book," "calm," and "laid back." The pilot was also described as "friendly," "cheerful," "pleasant," "calm," and "diligent in his use of checklists." According to several Aviation Charter copilots, the accident pilot was generally well liked by them because he had a reputation for letting them fly the airplane. A few copilots stated that because the pilot often let them handle the flight controls, they were not certain of his skill level. Several Aviation Charter pilots indicated that the accident pilot often allowed them to conduct the flights they flew with him as if they were single-pilot operations (that is, he allowed them to handle the flight controls and communications and perform all of the checklists without his assistance).

One Aviation Charter pilot expressed concerns about the pilot's flying skills, monitoring capabilities, and tendency to become distracted. Some company pilots stated that the accident pilot was not particularly assertive; however, other pilots stated that they thought the accident pilot could be assertive, if necessary. One company pilot, who had flown with the accident pilot shortly after Aviation Charter hired him, described him as "too timid to be a pilot." An Aviation Charter King Air pilot indicated that he had taken the airplane controls away from the accident pilot during an instrument approach because he

[18] For more information about the pilot's logbook history, see section 1.5.1.2.

could not maintain altitude. A company King Air copilot indicated that during level flight in IMC, he had to take the controls away from the accident pilot because he allowed the airplane to enter a 45° bank and a 1,000-fpm descent.

Further, another company King Air copilot indicated that during a flight with the accident pilot about 2 months before the accident, the pilot did not have his navigational radio tuned to the VOR in use for the approach, which caused the pilot's course deviation indicator (CDI) to provide erroneous indications during the entire approach. The copilot was the flying pilot and had his navigation radio tuned to the correct VOR and completed the approach without incident. The copilot stated that he later had to explain to the accident pilot the reason that his CDI was not indicating properly during the approach. According to Aviation Charter's director of operations and the company pilots who told Safety Board investigators about these incidents, none of them were ever reported to company management.

According to Aviation Charter, the pilot and copilot had flown four flights together before the accident flight, all of which were in King Airs.[19] The pilot's wife indicated that he had never mentioned having any problems flying with the copilot, and the copilot's fiancée indicated that he had never mentioned having any problems flying with the pilot.

According to company records, the pilot had landed at EVM on four previous occasions, twice in King Airs and twice in Citations.[20]

The pilot's wife indicated that he was generally "healthy," exercised regularly, was a nonsmoker, and did not drink alcohol or take prescription drugs. No significant life events occurred in the previous 12 months, and his personal situation was reported to be stable. In addition to working for Aviation Charter, the pilot occasionally worked as a nurse.

The pilot's logbook indicated that he had flown Senator Wellstone at least 12 times. According to the pilot's wife, he got along well with the Senator, who would often call her husband at home before scheduled trips.

1.5.1.1 The Pilot's 72-Hour History

On October 22, 2002, 3 days before the accident, the pilot flew Senator Wellstone from STP to Rochester International Airport (ROC), Rochester, New York, in a King Air 90.[21] The copilot of this flight, who had flown with the pilot many times, indicated that the pilot did not appear tired before the flight. The copilot, who was the flying pilot, stated that during takeoff, instead of activating the yaw damper switch, the pilot activated the adjacent autopilot switch, which caused the airplane to pitch down. The copilot stated that he (the copilot) immediately applied back pressure and then disconnected the

[19] Since the pilot's completion of simulator training in August 2002, the pilots had flown together in a King Air A100 on September 9, 2002, and in a King Air 200 on October 4, 2002.

[20] The pilot's most recent landings at EVM were in a Citation on September 19 and 20, 2002.

[21] The flight crew had to fly a positioning flight from Flying Cloud Municipal Airport (FCM), Flying Cloud, Minnesota, to STP to pick up the Senator for the flight to ROC.

autopilot, which caused the airplane to pitch up erratically before it returned to normal climb. The copilot stated that after the airplane was stabilized, he had to explain to the pilot that he had engaged the autopilot instead of the yaw damper and that the pilot replied, "Oh, that could have been pretty bad." The copilot stated that the remainder of the flight segment was uneventful.

The copilot reported that on the return flight to STP, the pilot repeatedly identified the airplane as "Citation 6356K" instead of "King Air 6356K." An air traffic controller eventually asked, "You wouldn't happen to be in a King Air today would you?" The pilot acknowledged his error and apologized to the controller. The copilot reported that the remainder of the flight segment was uneventful. The copilot also stated that after the pilot had completed the after-start and before-takeoff checklists at the beginning of each flight, he took control of the radios and told the copilot to fly the airplane. After arriving at FCM around 1830, the pilot returned home. The pilot's wife indicated that he engaged in routine activities during the evening and that she was unsure what time he went to bed.

On October 23rd, the pilot met Aviation Charter's chief pilot for his 6-month proficiency check. The chief pilot stated that the pilot was in a good mood when he arrived for the check. Maneuvers performed during the check included a recovery from a stall,[22] a steep turn, a recovery from an unusual attitude, an ILS approach, a missed approach, a go-around, a simulated engine failure during a VOR approach, and a no-flaps landing. A vision-obscuring device was used to test the pilot's ability to conduct IFR approaches. The chief pilot recalled that the checkride went smoothly and that the pilot's ILS and VOR approaches were precise. The chief pilot stated that after the simulated engine failure, he told the pilot to pick up the pace and to feather the engine "a couple of seconds faster for comfort." The pilot's wife indicated that he returned home after the proficiency check, engaged in routine activities, and went to bed early, between 1900 and 2000.

During the early morning of October 24th, the pilot was contacted by Aviation Charter and asked to fly a charter flight from STP to Bismarck Municipal Airport (BIS), Bismarck, North Dakota, for the Red Cross in the accident airplane; the flight was scheduled to depart at 0340. The Red Cross team coordinator stated that the pilot had indicated that he did not feel well that morning but that, although he looked tired, he did not show any signs of having a cold or the flu. The copilot for this flight indicated that the pilot slept in the BIS FBO from the time that they landed until about 20 minutes before they were to return to STP, which was a little over 1 hour. The copilot indicated that after the pilot had obtained their IFR clearance, he took over the radios and gave the copilot control of the airplane for both flights. The copilot stated that both flights were routine.

The pilot's wife stated that he returned home later that morning and that he was shortly thereafter contacted by his nursing supervisor at the North Memorial Medical Center and asked if he wanted to perform dialysis on a patient. She stated that the pilot indicated that he was interested but that he needed to get some sleep because he had just completed an early morning flight. Two nurses at the medical center indicated that the

[22] According to the chief pilot, the company did not allow its airplanes to enter a full stall during training or proficiency checks because of safety reasons.

pilot did not appear tired when he arrived at the center about 1500 to perform the dialysis. While at the center, the pilot was contacted by Aviation Charter and informed about the flight with Senator Wellstone the next morning. The customer service representative at Aviation Charter who spoke to the pilot about the flight indicated that he did not sound fatigued. According to the pilot's nursing supervisor, the pilot left the center about 2100.

The pilot's wife stated that he arrived home between 2130 and 2140 and went to sleep right away. Although the pilot's wife did not know exactly what time he awoke, she stated that he slept at least 8 hours the night before the accident flight.

1.5.1.2 The Pilot's Logbook History

After the accident, Safety Board investigators obtained five of the pilot's logbooks from his wife, the most recent of which began with a statement signed by the pilot and a notary public, dated January 23, 2001, which stated that the pilot had "lost his logbook(s) dating from 1979 to December 1994." The letter summarized the pilot's flight hours from 1979 to 1994 as 4,518 total hours, 3,379 hours of which were in multiengine airplanes. The notarized statement also stated that the pilot had "not operated an aircraft from 1994 to December 2000."

Safety Board investigators reviewed all of the logbooks provided by the pilot's wife. One logbook covered a period from December 1978, when the pilot received initial flight training, through May 1986. The pilot's flight time from May 1986 to May 1990 was recorded in two separate logbooks, and these logbooks contained conflicting accounts of his activity during this period. The disparities between these two logbooks included the following:

- different flight hours for the same flights;
- different departure and arrival airports for the same flights;
- different flight times and dates for the same flights;
- some flight segments mentioned in one logbook were not mentioned in the other logbook; and
- one logbook indicated that the pilot had flown 1,600 total flight hours from June 1986 to September 1987, and the other logbook indicated that he had flown 1,850 total flight hours during the same period.[23]

In addition, the two logbooks contained multiple entries by a certified flight instructor (CFI) who provided the pilot with training for his ATP certificate, but the signatures in the two logbooks were different. According to the CFI named in the logbooks, only one of the logbooks contained his actual signature.

The flight hours reported in the January 23, 2001, notarized statement contained in the pilot's most recent logbook represent an increase of more than 1,460 undocumented

[23] On FAA medical forms, the pilot listed "construction" as his primary occupation and "pleasure" as his primary purpose for flying during this period.

hours from the flight hour totals in the final entries of the two conflicting logbooks. Further, in August 1992, the pilot reported on an FAA medical certificate application form that he had a total of 3,250 flight hours, which is 1,268 fewer hours than he claimed in the notarized statement to have acquired as of December 1994.[24] Safety Board investigators did not find any records that could verify the hours reported by the pilot in his private logbooks. See figure 4 for a reconstruction of the pilot's reported flight hours.

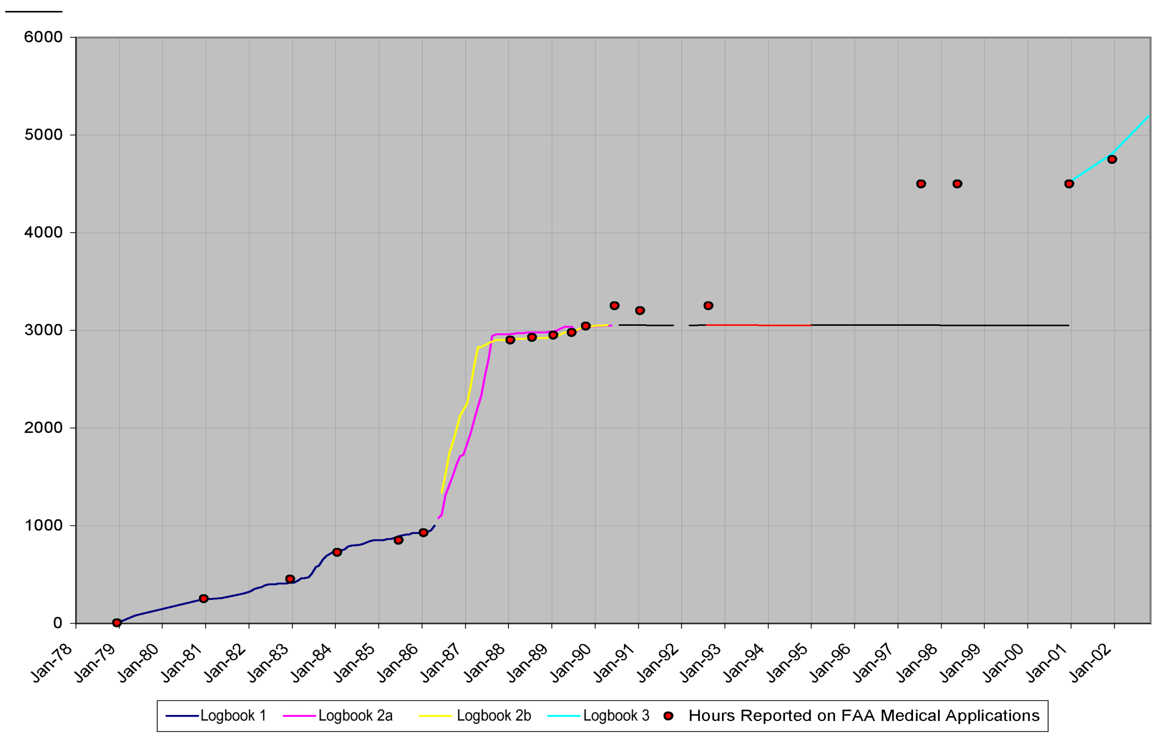


Figure 4. Reconstruction of pilot's reported flight hours.

1.5.2 The Copilot

The copilot, age 30, was hired by Aviation Charter on February 7, 2001. The copilot held a single- and multi-engine land, instrument airplane commercial pilot certificate, which was issued in May 1997. The copilot's most recent FAA first-class medical certificate was issued on August 2, 2002, with no restrictions.

[24] As mentioned previously, the pilot indicated on his employment application for Aviation Charter that he was working as a nurse during this period.

According to Aviation Charter employment records, the copilot had never been employed previously as a pilot. However, his logbook entries and other records indicated that he worked as a pilot for a skydive operator from October 1998 through March 1999. According to the skydive operator, the copilot was let go when he did not meet pilot qualifications standards for flying the Cessna 182.

In February 1999, Northwest Airlines hired the copilot to provide instruction to company pilots on Airbus A320 systems and procedures and cockpit procedures during initial and recurrent ground school. As part of his employment, the copilot observed two complete sequences of systems training lessons and one complete sequence of flight-training lessons. He also received seven flight-training lessons in an A320 simulator. The copilot's instructor during these lessons twice noted that the copilot needed to be reminded to keep his hands on the throttles during approaches.

After observing Northwest's systems and flight training, the copilot was trained to teach each of the systems and procedures lessons. During this training, the copilot had to thoroughly learn the systems of the A320 one at a time and then demonstrate his ability to teach each system before moving onto the next system. Northwest records indicate that the copilot was not able to successfully complete this stage of the training program. According to his supervisor, the copilot's ability to learn and retain the details of the A320 systems was far lower than that of fellow trainees with comparable flying experience. He added that, by the time the other trainees finished learning to teach all of the A320 systems lessons, the copilot had mastered less than half of the lessons. The company provided the copilot with special assistance, but he was still unable to master the material. He resigned from the company in October 1999 and began working as a customer service representative for another company located at the same training facility.

According to Aviation Charter records, the copilot had flown approximately 701 total flight hours, 304 hours of which were with the company, 107 hours of which were in King Airs.[25] He had flown approximately 69, 54, and 36 hours in the 90, 60, and 30 days, respectively, before the accident. His last recurrent ground training occurred on August 2, 2002. His last proficiency check occurred on August 3 and 4, 2002, and records from the check indicated that the check was satisfactorily completed.[26] A search of FAA and company records showed no accident or incident history or enforcement or disciplinary actions, and a search of the National Driver Register found no record of driver's license revocation or suspension.

Aviation Charter's lead ground instructor characterized the copilot's performance in ground school as below average and stated that he spent extra time working with him. He stated that the copilot had problems remembering memory items, calculating weights

[25] Aviation Charter did not have a minimum flight-hour requirement for copilot applicants; therefore, it was not uncommon for the company to hire a copilot with fewer than 1,000 total flight hours.

[26] The copilot's training records revealed that the proficiency check was discontinued on August 3rd because of weather. The records showed that the copilot did not perform a missed approach during the check. The record of the copilot's initial proficiency check, which occurred on July 18, 2001, also showed that the copilot did not perform a missed approach during the check. FAA guidance only requires that PICs demonstrate proficiency on this maneuver during checkrides.

and balances, and applying formulas. He added that the copilot's performance was acceptable at the conclusion of ground training. Pilots who had flown with the copilot described him as "friendly," "happy," "organized," "motivated," and "eager to learn." Several pilots who had flown with the copilot described him as "not assertive" and expressed concern about his flying skills, especially his inability to land the airplane without assistance. Two pilots stated that the copilot had difficulties with power management when flying an approach and that he had to be reminded to keep one hand on the throttles and to monitor his power gauges. One of these two pilots, who had been mentoring the copilot and flew with him often, stated that this was a consistent problem for the copilot.

1.5.2.1 The Copilot's 72-Hour History

On October 22nd, the copilot flew to Ontario, Canada, for Aviation Charter. The pilot of that flight, who had flown with the copilot on two previous occasions, stated that the copilot was in a good mood, looked healthy, and seemed rested and excited about the trip. The pilot added that the flight was uneventful. The copilot flew the return leg of the trip and logged two-tenths of an hour of instrument time for this flight, which was the only flight flown by the copilot in the 3 days before the accident.

The copilot's fiancée described his activities in the 3 days before the accident as routine. The copilot's fiancée stated that he went to sleep about 2200 the night before the accident, slept until about 0630 or 0645, and left the house some time after 0830. She indicated that the copilot was in great health, was a nonsmoker, and did not drink alcohol or take prescription drugs. The copilot was laid off from his job as a customer service representative at a flight-training academy in September 2002, but his fiancée reported that his financial situation remained stable. She reported that other aspects of his personal life were also stable.

1.6 Airplane Information

The accident airplane, serial number B245, was manufactured on January 28, 1979. The airplane was equipped with Pratt & Whitney Canada PT6A-28 turbine engines and Hartzell model HC-B4TN-3 four-bladed, constant-speed propellers. The time since new for the No. 1 (left) engine was 12,726.1 hours, and the time since overhaul was 6,102.5 hours. The time since new for the No. 2 (right) engine was 13,039.4 hours, and the time since overhaul was 6,102.5 hours. The time since overhaul for both the No. 1 (left) propeller and the No. 2 (right) propeller was 1,637.3 hours.

Aviation Charter and Raytheon provided Safety Board investigators with the estimated weight and balance information for the accident airplane.[27] According to these

[27] The original and a copy of the weight and balance load manifest that the two pilots completed before the accident flight were on board the airplane and destroyed by postcrash fire. The estimates provided by Aviation Charter and Raytheon were calculated using applicable information and graphs contained in the Raytheon King Air A100 Aircraft Flight Manual (AFM). For more information about Aviation Charter's weight and balance load manifest procedures, see section 1.17.2.3.

estimates, the accident airplane's takeoff weight was 11,052 pounds, including 2,345 pounds of fuel and 1,050 pounds of passenger weight,[28] and the airplane's takeoff center of gravity (CG) was 184 inches.[29]

The airplane was equipped with several ice protection systems, including heating elements in the windshield and pneumatic deicer boots on the wings and horizontal and vertical stabilizers, to prevent ice accumulation during flight.[30] The cockpit had a selector switch that allowed the pilot to select either automatic single cycle or manual operation of the deicer boots. The propellers were equipped with electrothermal boots on each blade that automatically cycle to prevent ice accumulation.

The airplane had a stall warning system designed to sound a horn in the cockpit 5 to 8 knots before the actual stall speed of the airplane in any configuration. The stall warning system included a heated lift transducer vane and faceplate on the leading edge of the left wing.[31] When the aerodynamic pressure on the lift transducer vane indicates that a stall is imminent, a switch is actuated to complete the circuit to the stall warning horn in the cockpit.

1.7 Meteorological Information

1.7.1 National Weather Service Information

NWS surface analysis chart station models showed that at 1000 the sky was overcast, dew point depressions[32] were less than or equal to 2° Celsius (C), surface winds ranged from calm to about 5 knots throughout most of the State of Minnesota, and surface temperatures were below freezing over most of northern Minnesota.

[28] This total does not include the weight of the flight crew. The combined weight of the flight crew is figured into the basic operating weight of the airplane.

[29] The maximum certificated takeoff gross weight for the accident airplane was 11,500 pounds, and the takeoff CG limits were between 182.8 and 191 inches.

[30] Regulated bleed air pressure and vacuum are cycled to the pneumatic boots for the inflation and deflation portions of the deicing cycle.

[31] The lift transducer vane and faceplate are protected from ice accumulation by heaters. The heater for the lift transducer receives power while the master switch is ON. The heater for the faceplate is activated by positioning the right pitot and stall warning switch to ON. Although the heaters on the lift transducer vane and faceplate protect them from ice accumulation, buildup of ice on the wing can disrupt the airflow and prevent the stall warning system from providing an adequate stall margin. For more information about Aviation Charter's guidance regarding operation in icing conditions, see section 1.17.2.2.

[32] Dew point depression is the difference between the atmospheric temperature and the dew point temperature. This value can be used as a measure of relative humidity.

A TAF[33] prepared by the Duluth Forecast Office for Hibbing, Minnesota (the closest TAF location to the accident site), which was valid starting at 0900 and transmitted at 0917, stated, in part, the following:[34] Wind variable at 5 knots, visibility 3 statute miles with mist, overcast 500 feet; Temporary conditions from 1400Z to 1800Z, visibility 2 statute miles, mist, overcast 200 feet.

An area forecast (FA)[35] covering northern Minnesota was issued about 0945 by the NWS Aviation Weather Center (AWC), Kansas City, Missouri, and was valid at the time of the accident. The FA stated, in part, the following:

> Northern Minnesota…AGL…scattered at 2,000 feet, scattered to broken at 4,000 feet, tops at 6,000 feet. 1200Z…AGL…scattered to broken at 1,500 feet, ceiling broken at 4,000 feet, broken at 7,000 feet and tops at 12,000 feet. Occasional visibility from 3 to 5 [statute] miles with mist. 1600Z ceiling broken at 1,500 to 2,500 feet, overcast at 4,000 feet. Occasional light snow.

An AIRMET prepared by the NWS AWC was issued about 0745 and covered the area surrounding the airplane's flightpath and the accident site. The AIRMET, which was valid at the times the pilot received the two preflight weather briefings, warned of occasional moderate rime or mixed icing in clouds and precipitation above freezing level to 20,000 feet. The AIRMET warned that the freezing level was from the surface to 7,000 feet over northern portions of the area and sloping to between 8,000 to 10,000 feet over southern portions of the area. According to the meteorologist responsible for issuing the next scheduled AIRMET at 0845, shortly after he issued it, he received a pilot report (PIREP) of moderate icing at 10,000 feet. He stated that, about 0905, he issued an updated AIRMET, which was valid at the time of the accident, warning of occasional moderate rime to mixed icing in clouds and precipitation below 10,000 feet.

The 0700 upper air sounding (that is, a vertical profile of atmospheric conditions) from Chanhassen, Minnesota (160 miles south-southeast of the accident site), showed a saturated boundary layer, with a surface temperature of 3° C and an easterly wind of about 3 knots. Freezing level was approximately 2,700 feet. The 1300 upper air sounding from International Falls, Minnesota (79 miles north-northwest of the accident site), did not show a completely saturated near-surface environment.[36] The sounding showed a surface temperature of -2° C and south-southeasterly surface winds of about 5 knots. The sounding also showed a saturated layer from about 3,400 to 7,000 feet, with southwesterly winds in this layer ranging from 10 to 23 knots. The NWS also provided

[33] TAFs are normally issued every 6 hours with amendments issued as conditions warrant.

[34] Weather forecasts are transmitted in coordinated universal time (UTC). The "Z" designation that follows the time in the weather observation stands for Zulu, which indicates UTC time. Central daylight time is 5 hours behind UTC time.

[35] The NWS AWC issues FAs at regular intervals and special reports as necessary, usually in the form of AIRMETs.

[36] Radiosonde balloons are typically launched a little after 0600 and 1800, and the nominal times of the data are 0700 and 1500. Because of problems with equipment at International Falls, a 0700 sounding was not accomplished. After notification of the accident, the DLH NWS office instructed staff at International Falls to launch a radiosonde balloon, and the sounding was accomplished at 1300.

Safety Board investigators with the Eta model[37] 1000 forecasted profile for Hibbing, Minnesota, which was consistent with the upper air sounding profiles. Specifically, the profile confirmed the existence of below-freezing temperatures and verified that saturated conditions existed between about 3,000 and 7,000 feet.

1.7.2 Airport Weather Information

Weather observations at EVM are made by an AWOS,[38] which is located about 2 miles northwest of the accident site at an elevation of about 1,380 feet. Observations from this station are reported every 20 minutes. At 1014 on the day of the accident, the AWOS reported that the visibility was 3 statute miles in light snow and that the sky condition was scattered clouds at 400 feet and overcast at 700 feet. At 1034, the AWOS reported that the visibility was 4 statute miles in mist and that the sky condition was overcast at 400 feet. Both AWOS reports indicated calm winds and temperatures of 1° C.

The Hibbing, Minnesota, ASOS, which is located about 16 miles west of the accident site at an elevation of 1,351 feet, provides high-resolution data that is recorded every 5 minutes. At 1005 on the day of the accident, the ASOS reported that the visibility was about 3 statute miles in mist and that the sky condition was overcast at 500 feet. At 1025, the ASOS reported that the visibility was 4 statute miles in mist and that the sky condition was overcast at 300 feet. Both ASOS reports indicated temperatures of 1° C.

1.7.3 Additional Icing and Cloud Information

On December 2, 2002, Safety Board investigators met with three scientists from the National Center for Atmospheric Research (NCAR), Boulder, Colorado, regarding the potential icing environment around the time of the accident. These scientists use an icing diagnostic program called the Current Icing Potential algorithm, which incorporates multiple sources of weather data to determine the icing and supercooled large droplets (SLD) potential. One of the scientists reported that his analysis of the program's output for the day of the accident indicated a high potential for icing from St. Paul to Eveleth but suggested a low potential for SLD around Eveleth. The scientist added that because of the increase in temperature and the lower water content expected at lower levels of the atmosphere, moderate icing was not likely to extend to the lower levels of the atmosphere.

[37] The Eta model is a numerical weather model used by the NWS.

[38] AWOS and ASOS (ASOS stands for automated surface observing system) are systems that continuously measure weather information, including wind speed and direction, visibility, precipitation, cloud cover, temperature, dew point, and altimeter setting.

> Several PIREPs were transmitted around the time of the accident in the area surrounding EVM. One PIREP, received about 0810 from a pilot flying a Piper Cheyenne around Ely, Minnesota, which is 43 miles northeast of EVM, reported moderate mixed icing between 11,000 and 8,000 feet and light rime icing below 8,000 feet. Another PIREP, received about 0908 from a pilot flying a DC-9 about 10 miles southeast of DLH, reported cloud tops at 11,000 feet and trace rime icing from 4,500 to 7,000 feet, light rime icing from 7,000 to 9,000 feet, and moderate rime icing from 9,000 to 11,000 feet. Another PIREP, received about 1118 from a pilot flying an RJ Avroliner in the Duluth area, reported the sky was overcast at 1,600 feet with cloud tops at 10,800 feet, trace icing from 5,000 to 7,000 feet, and light rime icing from 7,500 to 10,800 feet.

The first two PIREPs were discussed at the December 2002 NCAR meeting. According to an NCAR scientist, the reports indicate that icing was occurring around the time of the accident at two distinct altitude bands with differing intensities: moderate icing was present at upper elevations (8,000 to 11,000 feet), and light icing was present at lower elevations (4,500 to 8,000 feet).

Additionally, the last two pilots who landed at EVM before the accident (both pilots were flying QueenAire BE-80s) provided statements to Safety Board investigators. One of these pilots stated the following:

> I left Minneapolis for Eveleth…at 7 a.m. I climbed to 7,000 [feet] MSL and I was IMC all the way to Eveleth. The tops were at approximately 10,000 [feet] MSL. No icing was encountered until approximately 60 miles south of the Hibbing VOR. The temperature was 28 degrees [Fahrenheit] at 7,000 [feet] MSL. I started getting light to moderate rime ice at 7,000 [feet].

He added that as he descended to 5,000 feet, at which altitude he recorded the temperature to be about -1.1° C, the ice began to shed off the airplane's surfaces and that as he continued his descent to 3,500 feet, at which altitude he recorded the temperature to be about -0.5° to 0° C, most of the remaining ice shed off the airplane's surfaces during the approach. He concluded, "I did get the airport in sight at approximately 5 miles from the airport. I then landed at approximately 8 a.m."

The other pilot who landed at EVM before the accident stated the following:

> I flew at 5,000 feet en route and was IMC with light rime ice in the clouds. I flew the VOR/DME [distance measuring equipment]-A approach and circled to [runway] 27. I don't remember getting any more ice after descending from 5,000 feet. On the approach, I broke out of the clouds a little above the MDA [minimum descent altitude, which for the EVM VOR/DME-A final approach is 2,120 feet[39]]…and the best I can remember…the visibility was probably 1 ½ to 2 ½ miles. I landed in EVM at approximately 8:30 a.m. I do remember that the weather that the AWOS was reporting seemed accurate at the time and the VOR – both [Hibbing] and EVM seemed to work fine.

The first pilot to depart EVM after the accident also told Safety Board investigators that he experienced trace to light icing below 6,000 feet.

EVM's assistant airport manager stated that, when he was looking for the crash site from the air, he was flying at 1,800 feet (that is, about 420 feet agl), and he never entered the clouds. He stated that the AWOS (which was reporting a 700-foot overcast ceiling) seemed to be reporting correctly because the cloud tops appeared to be about 200 to 300 feet above his airplane. He added that the cloud bases were somewhat ragged and variable in height. He stated that he could see landmarks on the ground up to 4 to 5 miles away.

The Geostationary Operational Environmental Satellite 8 visible and infrared satellite imagery taken at 1015 showed a large distribution of clouds along the airplane's flightpath. Satellite-derived cloud top temperatures along the airplane's flightpath ranged from -11° to -16° C. During the descent portion of the airplane's flight, cloud top temperatures were mainly near -15° C. Comparisons between satellite-derived cloud top temperatures and sounding data indicated that the cloud tops were approximately 12,000 feet.

1.8 Aids to Navigation

1.8.1 EVM VOR

The EVM VOR is a low-power (50 watts), terminal-type VOR owned and maintained by the State of Minnesota. The EVM VOR is located on the airport property just north of runway 27, about 1,134 feet from the runway's departure end. A State of Minnesota technician ground checks the facility annually under oversight of an FAA representative, and the FAA flight checks the facility every 540 days.

According to postaccident interviews with the State of Minnesota technician and the FAA Airway Transportation System Specialist (ATSS) responsible for maintenance and oversight of the EVM VOR, the EVM VOR is continuously monitored using an

[39] For the EVM VOR runway 27 approach, which is the approach the accident flight crew was flying, if the airplane does not have DME, then the MDA for the final approach to EVM is 1,840 feet. If the airplane does have DME, then the MDA is 1,840 feet between 2 and 10 miles from the EVM VOR and 1,740 feet inside of 2 miles from the EVM VOR.

external receiver with an antenna located on the outer edge of the VOR counterpoise (elevated ground plane). If the radial position indicated by the monitoring receiver varies by >1°, or the modulation deviates appreciably from the nominal 85 percent, the facility will automatically shut down. Reactivation requires intervention and a ground check by a State of Minnesota technician.

1.8.1.1 Preaccident Flight Checks of the EVM VOR

The FAA's most recent periodic flight check of the EVM VOR occurred on June 12 and 13, 2001, and the facility status was listed as "satisfactory" on FAA Form 8240-2; however, the form also indicated that the EVM VOR remained restricted per a December 4, 1996, notice to airmen (NOTAM), which was still in effect at the time of the accident. The NOTAM indicated that the EVM VOR was unusable in the area from the 204° radial through the 264° radial and in the area from the 264° radial through the 204° radial beyond 20 miles and below 4,000 feet.

1.8.1.2 Postaccident Ground and Flight Checks of the EVM VOR

About 1530 on the day of the accident, technicians from the State of Minnesota conducted a standard ground check of the EVM VOR and found it to be transmitting normally.

On October 26 and 27, 2002, the FAA conducted a series of flight checks on the EVM VOR using a King Air A100. On both days, the signal was found to be misaligned about 2.3° to the north, but within tolerance (a maximum variation of ±2.5° is permitted) in the region between 5 to 10 miles from the station. However, the signal was found to be out-of tolerance for bends[40] (a maximum distortion of +4.1° was measured; a maximum distortion of ± 3.5° is allowed) in this same region.[41] On October 28th, a State of Minnesota technician conducted another, more comprehensive postaccident ground check of the EVM VOR under the supervision of the FAA ATSS. The EVM VOR was again found to be transmitting normally.

On December 16, 2002, the pilots who conducted the October 2002 flight checks told Safety Board investigators that the VOR runway 27 approach took them approximately 1 mile south of the field when hand-flying the approach, but that it took them to the correct aiming point (the position from which a normal transition to landing can be made) when flown coupled to the autopilot.[42] Further, in a January 8, 2003, written statement concerning the October 26, 2002, flight check, the PIC of the flights indicated that during the first test, while hand-flying the approach,

[40] Bends are fluctuations in the calculated VOR radial position that occur slowly enough to be followed by a pilot under normal conditions.

[41] For example, with a +4° error in the VOR signal, a pilot would need to fly the airplane inbound on the physical 100° radial from the station to center the CDI needle on an indicated 096° radial inbound.

[42] According to the FAA's Flight Inspection Standard Operating Procedures Manual, approaches should be flown by autopilot whenever possible during flight checks.

> approximately 7 miles from the runway we noticed that the approach radial was leading us to the right of runway centerline extended. As we continued the approach, we remained to the right of runway centerline extended until about 4 miles out. Then the approach radial began to lead us to the left of centerline. We crossed centerline extended and continued left of centerline. We ended up between 1 to 2 miles to the left of the runway at the MAP [missed approach point].[43] We completed the approach again and the results were close to the same as the first run. On our third run we coupled the autopilot to the flight director and let it fly the approach. For most of the approach the autopilot held us approximately ½ dot left of course. The autopilot took us to the runway, just left of centerline[;] however[,] the approach radial was found to have an out of tolerance bend.

On December 23, 2002, a special demonstration flight was conducted at the Safety Board's request to resolve the discrepancy between the hand-flown and autopilot-flown approaches made in October 2002. On this demonstration flight, the pilots reported to Safety Board investigators that the airplane was brought to a position at the approach end of runway 27 appropriate for normal transition to landing.

1.8.1.3 VOR Navigation System Special Study

To further study the accuracy of the EVM VOR, the Safety Board requested that the December 23rd demonstration flight be flown using an airplane capable of digitally storing the signal obtained by the on-board VOR receiver. The study also used data derived from the October 2002 flight checks.

The results of the study confirmed that the EVM VOR was misaligned to the north by about 2.3° in the area between 5 to 10 miles from the station, which caused the on-board VOR receiver to calculate that the airplane was at a radial position north of its actual physical location with respect to the station. This is consistent with flight check radar data from the October 2002 flight tests. Further, the study showed that the VOR signal measured on December 23rd had changed little in character from the signal measured on the flight checks in October; however, the misalignment was slightly smaller, deviating about 1.5° to the north.

Data collected from the October 2002 flight tests and radar data were analyzed to estimate what was likely indicated by the CDI needle in the accident airplane's cockpit during the approach to EVM. The computations estimated that the CDI needle was likely about three dots to the left (indicating the airplane was north of course) when the airplane was approximately 8.5 miles from the EVM VOR. The computations also estimated that the CDI likely indicated on-course at a position approximately 5 miles from the station and that the needle would have continued to move to the right (indicating the airplane was now moving off-course to the south). Finally, computations estimated that the CDI needle was likely fully deflected approximately 2.6 miles from the EVM VOR.[44]

[43] Radar data from the FAA's October 26th flight checks show that the check airplane maintained a track slightly south of course throughout the approach and that it passed within 1/2 mile of the field at the end of all three approaches.

1.9 Communications

No communication problems were reported with any of the ATC facilities that handled the accident flight.

1.10 Airport Information

EVM is located 3 miles southeast of Eveleth, Minnesota, near the western shore of Lake Superior and is bordered by dense forest to the east and west. EVM has an elevation of 1,378 feet and is a nontowered airport. Because the EVM VOR is located slightly north of and near the middle of runway 27, the published EVM VOR approach course is aligned about 2° south of the runway centerline to bring aircraft in near the runway threshold.

Runway 27 is 4,215 feet long and 100 feet wide with no displaced threshold. Runway 27's magnetic heading was determined to be 274°. Runway 27 is equipped with a medium-intensity approach lighting system, a runway-end identifier light system, and a four-light precision approach path indicator, which is located on the left side of the runway. The runway lights are pilot-controlled on the common traffic advisory frequency 122.7, which is monitored at EVM in the airport manager's office. The EVM assistant airport manager stated in postaccident interviews that he heard the accident pilots report their position before the accident and the runway lights being activated on 122.7 after the pilots' position report and that he saw that the runway lights were on at the time of the accident.

1.10.1 Air Traffic Control

The Duluth ATCT has three radar positions: approach control south, approach control north, and approach control local. At the time of the accident, all of the radar positions were combined at the approach control south workstation, which is located in the facility's radar room. The approach control south radar controller was responsible for airspace within a 30-mile radius of DLH from the surface to 12,000 feet and for airspace that extended 20 miles northwest of Hibbing, Minnesota, from the surface to 8,000 feet; EVM lies within this area of airspace.

The DLH approach control south radar controller began working for the FAA on December 2, 1984, and was assigned to the Duluth ATCT on March 21, 1985. He became fully certified at the Duluth ATCT on February 27, 1987.

The DLH approach control south radar controller stated that at the time he was handling the accident airplane, the range of his radar display was set at 60 miles. He stated that he remembered observing the accident airplane's radar target intercepting the final approach course about 9 miles from the runway threshold and that it appeared to him that the radar target was aligned correctly on final approach at a steady 3,500 feet.

[44] The error bands for these calculations could not be determined with certainty.

The controller stated that he was surprised to see the accident airplane off course when he reviewed the radar playback at a closer range after the accident.

The DLH approach control south radar controller stated that about 1019, he instructed the flight crew to report cancellation of IFR with the Princeton AFSS, and he noted the airplane's estimated arrival time at EVM on the flight progress strip. He stated that when he did not receive an IFR cancellation after about 15 minutes had passed, he called the flight data controller via the interphone and asked him to check to see if the airplane had landed at EVM; the flight data controller responded that the airplane had not landed.

The DLH approach control south radar controller stated that he did not recall any NOTAMs reporting problems with the EVM VOR and added that the VOR runway 27 approach was the most commonly used approach at the airport. The controller stated that NOTAMs were provided to the Duluth ATCT by the Princeton AFSS and that any NOTAMs are annotated in the facility's daily log and on the system information area in the tower cab and radar room. The controller indicated that if the facility does receive a PIREP about a malfunctioning navigational aid, a second PIREP would be solicited and, if the reports were the same, the information would be forwarded to the facility's flight data controller and then to Mid States Operations for Airways Facilities.

1.11 Flight Recorders

The accident airplane was not equipped with either a CVR or a flight data recorder nor was either required by Federal regulations.

As a result of a previous investigation of an accident involving a Cessna 208B, operating as an on-demand charter flight for the Department of the Interior, on February 8, 2000, the Safety Board issued Safety Recommendation A-99-60, which asked the FAA to "require, within 5 years of a technical standard order's issuance, the installation of a crash-protective video recording system on all turbine-powered nonexperimental, nonrestricted-category aircraft in 14 *Code of Federal Regulations* Part 135 operations that are not currently required to be equipped with a crashworthy flight recorder device." Safety Recommendation A-99-60 is on the Safety Board's Most Wanted List.[45]

On May 3, 2000, the FAA responded that this issue should be submitted to the Radio Technical Commission of Aeronautics (RTCA) Future Flight Data Collection Committee for consideration. The FAA added that the committee will look at future trends in flight data collection to support safety investigations and operational efficiencies, with a primary focus on the appropriateness, timing, economic impact, and social acceptance of the proposed data collection concepts.

[45] In October 1990, the Safety Board adopted a program to identify the "most wanted" safety improvements. The purpose of the Board's Most Wanted List, which is drawn up from safety recommendations previously issued, is to bring special emphasis to the safety issues the Board deems most critical.

On September 8, 2000, the Safety Board replied to the FAA that it disagreed with the FAA on the appropriateness of the RTCA committee's involvement in the implementation of this safety recommendation because the committee's goal is to look 10 to 15 years into the future to set the course for recorder technology and determine how it will be used to solve problems. The Board stated that it had no evidence that the RTCA committee was going to address the use of video recorders in the near term for the small aircraft for which this recommendation was targeted. Pending the implementation of the recommended actions, Safety Recommendation A-99-60 was classified "Open—Unacceptable Response."

1.12 Wreckage and Impact Information

1.12.1 General

The accident airplane's wreckage was located about 1.8 miles southeast of the EVM runway 27 threshold. The majority of the airplane sustained severe damage consistent with impact forces and/or postimpact fire. Several of the airplane's systems, including the stall warning and deicing systems, were too damaged by postimpact fire and impact forces to determine their preimpact configuration and operability.

The horizontal distance from the point at which the airplane entered the trees to the resting place of the aft section of the fuselage was about 130 feet. Crash site damage included blunt force tree damage consistent with airframe impact and cleanly severed trunks and limbs consistent with cuts resulting from propeller blade strikes. Handheld tape measurements, survey data, and aerial observations indicated that the airplane descended through the trees wings level and upright on about a 26° downward flightpath angle on a ground track of about 180°.

The majority of the wreckage, which consisted of the forward fuselage, the cockpit, and most of the wings, was found at the southern end of the main wreckage field. The left horizontal stabilizer was found essentially intact with a substantial crease approximately 41 inches from its root. The horizontal stabilizer trim actuator was found still attached to the tail structure, and the exposed actuator lengths were both found to be 3.25 inches. (According to Raytheon documentation, this measurement equals a horizontal stabilizer trim setting of 1° airplane nose down.) The left elevator was found intact and attached to the horizontal stabilizer at both hinges. The vertical stabilizer was found intact with damage to the leading edge. None of these components exhibited evidence of in-flight fire or preimpact structural damage. The right elevator was found attached to the stabilizer and exhibited severe impact and fire damage.

Sections of both wings were recovered and exhibited postimpact fire damage. The flap actuators were recovered. (According to Raytheon documentation, the measurements taken of the flap actuators were consistent with the flaps being in the approach position [about 30 percent] at the time of the accident.)

Inspections of the nose and main landing gear found indications consistent with the gear having been down at the time of impact. However, because of extensive impact and fire damage, it could not be determined if the gear were in the locked position.

From November 19 to 22, 2002, the engines were examined at Pratt & Whitney Canada's facility in Longueuil, Quebec, under Safety Board supervision. These examinations revealed evidence of normal engine operation at the time of impact. From November 12 to 14, 2002, the propellers were examined at Hartzell Propeller's facility in Piqua, Ohio, under Board supervision. These examinations revealed evidence of low-power system operation at the time of impact. The blade angles calculated from the propellers' piston positions (19.3° and 21.3°) correspond to power settings just above flight idle at the time of impact. (As installed in a properly rigged King Air A100, selection of the flight-idle power setting will result in a blade angle of 19.0° ±0.1°.)

Most of the components of the deicing system were destroyed by postimpact fire. Deicer boots were present on the remaining leading edges of the horizontal and vertical stabilizers. All of the surviving pneumatic deicing lines leading to the tail deicer boots were assessed visually and determined to be in good condition. The deicer boots were also present on the leading edges of the wings; however, they were extensively damaged.

1.12.2 Cockpit Instrumentation

The cockpit instrument panel was extensively damaged by postimpact fire, and all of the instruments were found settled into a large pile under the cockpit window frame. Several of the instruments were recovered and transported to the Safety Board's Materials Laboratory for further examination. Several of the cockpit instruments were too damaged to warrant further examination.

The left-side airspeed indicator's case was severely burned, melted, and distorted, and the indicator's data plate was missing. All of the exterior markings and paint were burned off, and the glass face was broken and discolored. The dial assembly was found attached to the mechanism assembly and had distinct blackened areas on it, one of which was located directly above a small screw that is above the 100-knots-airspeed mark (despite the fire damage, the airspeed numbers were still legible on the dial assembly). The airspeed indicator needle was not found with the indicator; however, the maximum airspeed indicator needle was still attached and was pointing to 195 knots.[46] The right-side vertical speed indicator was found with the indicator needle pointing to about 2,200 fpm (rate of descent).

The right-side horizontal situation indicator (HSI) was badly damaged by fire but exhibited less severe impact damage than the pilot-side HSI. The right-side CDI faceplate was found contained within the indicator and dial ring. The head of the course indicator needle was not found; however, the needle base was still attached to the CDI faceplate,

[46] The maximum airspeed pointer is designed to indicate the "never exceed" airspeed limit for an aircraft at a given altitude.

and the tail of the needle was located adjacent to the number 9 on the heading dial. The heading bug was visible on the heading dial at a position of approximately 307°. The heading warning flag was not found; however, the flag needle was found in the retracted position.[47]

The right-side radio magnetic indicator was severely damaged by impact forces and fire, the glass plate was shattered, and the flag positions could not be determined. The compass card and both indicator needles were contained within the plate display and were damaged by heat; however, the numbers were legible. The compass card was positioned with the number 180 directly beneath the lubber line. Indicator needle No. 1 was pointing to approximately 335°, and needle No. 2 was pointing to approximately 332°.

1.13 Medical and Pathological Information

Tissue and fluid specimens from both pilots were transported to the FAA's Civil Aerospace Medical Institute (CAMI) for toxicological analysis. The CAMI laboratory performed analysis for a wide range of legal and illegal drugs,[48] and the results were negative. The analysis detected no ethanol or carbon monoxide in either of the pilot's blood and tissue specimens.

1.14 Fire

A fuel-fed fire erupted after the airplane impacted the ground.

1.15 Survival Aspects

According to the Saint Louis County Medical Examiner's autopsy reports, the cause of death for the pilot, copilot, and all of the passengers was multiple traumatic injuries sustained during impact. Three of the individuals showed evidence of postimpact smoke and soot inhalation.

[47] According to the Honeywell (Sperry) Component Maintenance Manual for the HSI, the unit requires both a.c. and d.c. power to operate. The heading warning flag is displayed when power is lost to either the primary a.c. power supply or the d.c. signal for the instrument.

[48] The drugs tested for included the following: marijuana, cocaine, opiates, phencyclidine, amphetamines, benzodiazapines, barbiturates, antidepressants, antihistamines, meprobamate, mathaqualone, and nicotine.

1.16 Tests and Research

1.16.1 Airplane Performance

The Safety Board conducted an airplane performance study to establish a history of the accident airplane's motions and the pilot's actions. As stated in section 1.1, radar data from the last two recorded radar returns indicate that the accident airplane had slowed to about 76 KCAS at 1,800 feet. The Raytheon King Air A100 AFM and Raytheon calculations indicate that the wings-level, gear-down stall speed, assuming an estimated landing weight of about 10,500 pounds with the flaps in the approach setting, would have been about 77 KCAS with the power at flight idle.

Safety Board investigators also planned and executed flight simulations at Flight Safety International (FSI) using a King Air C90B simulator.[49] These simulator tests were conducted to determine whether the airplane's flightpath and time histories, as shown by the radar data during the final approach, could be matched or approximated with and without simulated airframe icing and which configurations and control inputs were required to match the data. To conduct the test, the accident airplane's weight and CG values (about 10,500 pounds and 184 inches, respectively) were scaled to equivalent values for the C90B.

Several tests were performed starting at 3,500 feet and descending to 1,800 feet to try to match the final approach descent of the accident airplane as shown by the radar data. An additional test was conducted starting at 13,000 feet and descending to 3,500 feet as the airplane was vectored onto the approach course. For simulation purposes, the airplane's descent from 3,500 feet was broken down into three time periods, each with linear approximations of vertical speed and airspeed decay based on the radar data. During the tests, the landing gear was extended just after the airspeed decreased below the maximum gear extension speed of 156 KCAS, which occurred as the accident airplane was descending through 2,200 feet. Various engine power and pitch control inputs and simulated icing effects were used to try to match the radar data.

The tests conducted without simulated airframe icing showed that the flightpath and speed of the accident airplane, as indicated by the radar data, could be reasonably matched making minor pitch control inputs and engine power reductions. The stall warning occurred during these tests between 81 and 84 KCAS. During the tests, increasing the power quickly resulted in an increase in airspeed and no further stall warnings.

The tests conducted with light to moderate simulated airframe icing[50] showed that the flightpath and speed of the airplane, as indicated by the radar data, could also be

[49] According to Raytheon and FSI, no known King Air A100 simulators exist. The Airplane Performance Group chose the King Air C90B model for simulations because it has a similar configuration and stall speeds to the A100 model; however, it is not fully certified to replicate the A100's flight characteristics.

reasonably matched making minor pitch control inputs and engine power reductions. However, occasional use of the deicer boots was required, and the engine power settings were significantly higher between the boot cycles than they were during the tests conducted without simulated airframe icing. Tests conducted with heavy icing required frequent cycling of the deicer boots, and the engine power settings often exceeded the power limits shown on the cockpit gauges.[51]

1.16.2 Operational Factors and Human Performance Simulations

In April 2003, the Operational Factors/Human Performance Group conducted flight simulations at FSI using a U-21, which is the military version of the C90 and has similar cockpit controls and displays to the accident airplane,[52] to observe and evaluate Aviation Charter's procedures and interaction between a company pilot and copilot. In addition, flight characteristics were observed during slow flight, stall recovery, and various airplane configurations.

The Aviation Charter pilot who participated in the simulations had worked for the company for over 5 years and had about 5,200 hours total flight time, about 2,400 hours of which were in King Airs. The Aviation Charter copilot who participated in the simulations had worked for the company for over 3 years and had about 2,100 hours total flight time, about 600 hours of which were in King Airs. These two crewmembers nearly always flew together during revenue operations for Aviation Charter.

The simulator was programmed with weight and CG parameters scaled to match those of the accident airplane and used to fly simulated VOR approaches to runway 27 at EVM.[53] During the simulations, both pilots were given the opportunity to act as the pilot flying during the approach. Numerous approaches were executed to observe company procedures and piloting techniques, including briefing the approach and preparing and executing the VOR runway 27 approach. Particular attention was focused on cockpit setup, duties for the flying pilot and the nonflying pilot, callouts, and checklist usage.

During the simulations, approach procedures and callouts were in accordance with Aviation Charter's procedures. The simulator exhibited normal characteristics during slow flight and stall maneuvers and immediately recovered from a stall when power was increased.

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[50] The FSI King Air simulators allow selection of simulated airframe icing as a percentage of a maximum, with the selection of 0 percent resulting in no simulated icing and selection of 100 percent resulting in maximum simulated icing. The FSI King Air C90B icing model introduces lift, drag, and other aerodynamic degradations based on FSI data.

[51] The King Air A100 has about 130 horsepower more per engine than the C90B; therefore, the A100 power settings may not exceed the limits in heavy icing, as occurred during the C90B simulations.

[52] Although the U-21 has cockpit controls and displays similar to the A100, it is not certified to fully replicate the A100's flight characteristics.

[53] The simulator was not capable of displaying EVM or its surrounding terrain.

To observe flight crew workload, the following three VOR approaches to runway 27 were conducted consecutively with simulated weather conditions matching those reported at EVM at the time of the accident:[54]

- a straight-in approach from 13.5 miles east of the runway 27 threshold,
- an approach using ATC vectors similar to those given to the accident flight crew, and
- an approach using ATC vectors similar to those given to the accident flight crew during which the flight crew was instructed to delay the descent from 3,500 feet until 7.5 miles from the runway 27 threshold and to delay landing gear extension until 3.5 miles from the runway 27 threshold.

During each scenario, the flight crew made a successful approach and landing. During the second and third scenarios, the flight crew initially overshot the approach course but was able to reintercept the course from the north, establish a stabilized approach, and land successfully.[55]

After each approach, the pilots completed a National Aeronautics and Space Administration (NASA) Task Load Index questionnaire, which gave them the opportunity to rate the following six aspects of workload: mental and physical demand, time pressure, effort, performance, and frustration level.[56] The questionnaire completed by the flying pilot after the second approach indicated that it was more difficult than the first approach in terms of time pressure, effort, and frustration level. The questionnaire completed by the flying pilot after the third approach indicated that it was more difficult than the second approach in terms of mental and physical demand, time pressure, effort, and frustration level. Regarding the third approach, the flying pilot commented that there was a "noticeably higher workload – with gear delayed, I felt behind the airplane." The questionnaire completed by the nonflying pilot after the third approach indicated that the "fast, late turn, [at] high altitude increased workload."

Another scenario was flown to duplicate the descent profile and ground track of the accident flight. Investigators noted that when the pilots were attempting to maintain a low-descent rate at a low-torque setting (about 400 foot-pounds [ft-lbs]) with the airspeed lower than 100 knots, a gradual, significant pitchup was necessary to maintain altitude. The stall warning horn sounded when the airplane was at 82 knots.

[54] During these approaches, the Aviation Charter pilot was the flying pilot.

[55] The distance by which the flight crew overshot the approach course to the north was not precisely measured during these simulations.

[56] S.G. Hart and L.E. Staveland, "Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research," eds. P.A. Hancock and N. Meshkati, *Human Mental Workload* (Amsterdam: North-Holland, 1988) 139-183.

1.17 Organizational and Management Information

At the time of the accident, Aviation Charter,[57] which is headquartered in Eden Prairie, Minnesota, operated about 120 flights per month with a fleet of 24 turbojet, turboprop, and piston-powered airplanes, 4 of which were King Air A100s. According to FAA documents, the company employed 25 pilots, 8 copilots, and 3 check airmen. The company also used copilots employed by Eagle Jet International, which had an airline first officer program through which it would place both new and experienced pilots with various companies so that they could gain additional flying experience.

Following an accident in December 1997 involving a King Air A100,[58] Aviation Charter instituted a policy to have two flight crewmembers in the cockpit for all 14 CFR Part 135 charter flights, even though the King Air A100 is certified to operate for Part 135 on-demand revenue flights with only one pilot in visual flight rules conditions and with one pilot and an operable, FAA-approved autopilot in IFR conditions. (See 14 CFR 135.105.) Further, according to Aviation Charter's director of operations, the company changed insurance carriers in April 2000, and the new carrier required that all Part 135 flights have two flight crewmembers.

1.17.1 Company Training

Aviation Charter had a Part 135 Multiengine Turbopropeller Aircraft Maneuvers Guide[59] and a Part 135 Aircraft Training Manual, which received approval from the FAA on March 3, 1995, and September 19, 1996, respectively. All pilots hired by the company were required to attend its FAA-approved, in-house ground and flight training at its headquarters. All company pilots were also required to take and pass the appropriate Part 135 checkrides, which were conducted by a company check airman, before being assigned line flights.

In addition, Aviation Charter's insurance carrier required company PICs to receive flight simulator training.[60] Aviation Charter contracted with SimuFlite, Inc., to provide all PICs additional training in a flight-training device, which satisfied the insurance requirement for simulator training (about 8 to 10 hours of training in the simulator was required), at SimuFlite's Quick Turn subsidiary in Dallas, Texas. PICs received this additional training after successfully completing the company's FAA-approved, in-house ground and flight training. Company copilots were not required to and did not attend the training at Quick Turn.[61]

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[57] Aviation Charter operates as an on-demand charter operation in partnership with Executive Aviation, which operates as an FBO at FCM.

[58] For more information about this accident, see section 1.18.1.

[59] Pilots were not provided copies of the Maneuvers Guide; however, copies of the guide were provided to the chief pilot and each company flight instructor, who used the guide to train and evaluate pilots. Pilots were expected to adhere to the procedures contained in the Maneuvers Guide during line operations. Copies were maintained at the company's headquarters (the master copy) and the FAA's Minneapolis Flight Standards District Office (FSDO).

[60] This training was not required by the FAA.

According to a Quick Turn instructor, SimuFlite offered 3- and 2-day recurrent training courses in the flight-training device; Aviation Charter sent its PICs to the 3-day course annually. The instructor added that when two PICs attended training, the pilot in the right seat was responsible for operating the gear, flaps, and radios, and the pilot in the left seat received training and was evaluated on single-pilot operations. According to Aviation Charter's chief pilot, when two PICs attended training, the pilot in the right seat performed Aviation Charter's normal copilot duties (for example, standard callouts and checklist assistance routinely performed during 14 CFR Part 135 on-demand charter flights).

1.17.1.1 Crew Resource Management

On May 21, 1997, the FAA approved Aviation Charter's ground school training module on crew resource management (CRM), and the module was subsequently added to the company's training manual. The CRM training module did not indicate a specific hourly requirement for instruction and completion.[62]

The suggested CRM curriculum topics included the following: communication processes and decision behavior; briefings; inquiry, advocacy, and assertion; crew self critique (decisions and actions); team building and maintenance;[63] theory and practice in using communication, decision-making, and team building techniques and skills; training for new copilots in performing the nonflying-pilot role to establish a positive attitude toward monitoring and challenging errors made by the flying pilot; training for pilots in giving and receiving challenges of errors; and training for all crewmembers that identifies conditions in which additional vigilance is required, such as holding in icing or near convective activity (the manual states that this training should emphasize the need for maximum situational awareness and the appropriateness of sterile cockpit discipline, regardless of altitude).

According to Aviation Charter's training manual, pilots were required to complete an oral or written examination given by a company instructor to determine adequate knowledge of CRM. Further, according to the training manual, instructors and check airmen evaluated a pilot's CRM knowledge and techniques during company flight training and checkrides, and the pilots were graded as either satisfactory or unsatisfactory in that area.[64] According to Aviation Charter's director of operations and its agent for service, CRM training was also incorporated into the training at Quick Turn, and pilots received CRM evaluations during this training. However, the chief pilot stated that he could not recall being briefed on CRM at Quick Turn. Further, according to a Quick Turn instructor,

[61] Subsequent to the accident, Aviation Charter started sending all of its pilots to full-motion simulator training at FSI.

[62] For information about an April 1997 FAA Regional Aviation Safety Inspection Program (RASIP) finding regarding CRM training at Aviation Charter, see section 1.17.3.5.

[63] Subtopics of team building and maintenance included leadership, interpersonal relationships, workload management and situational awareness, and individual factors and stress reduction.

[64] Both accident pilots' most recent proficiency check records indicated that they were evaluated on CRM and graded as satisfactory.

pilots who attended training at Quick Turn were not evaluated on CRM because its training specifically evaluated pilot competency during single-pilot operations.

During postaccident interviews, Aviation Charter's lead ground instructor stated that he was not aware of the CRM module but that he did teach CRM techniques, including standard callouts and operating procedures, during ground school. The FAA principal operations inspector (POI) at the time the CRM module was added to the training manual stated that he did not remember if he had ever reviewed the CRM training module or observed the training.[65] He also stated that because a CRM module was in the company's training manual, the lead ground instructor should have been aware of it. Aviation Charter's chief pilot and its director of operations stated that even though its training manual contained a module on CRM, it was not required by any rule or regulation.[66]

The FAA POI for Aviation Charter at the time of the accident stated that, subsequent to the accident, he encouraged Aviation Charter to conduct line checks during nonrevenue flights to evaluate CRM procedures. Further, he stated that he encouraged the company to put an instructor in the left seat and a copilot in the right seat during proficiency checks so that the company could monitor CRM procedures.

1.17.1.2 Stall Recovery Maneuvers

Aviation Charter's Multiengine Turbopropeller Maneuvers Guide contains guidance on stall recovery maneuvers to "afford familiarization with the airplane handling characteristics in the initial stall buffet region and provide training in stall recognition and proper recovery techniques." The Maneuvers Guide contains guidelines to determine acceptable pilot performance during training of the stall recovery maneuver. According to the Maneuvers Guide, a pilot's performance of the stall recovery maneuver is acceptable if the following conditions, in part, are met:

a. Exhibits adequate knowledge of the factors, which influence stall characteristics, including the use of various drag configurations, power settings, pitch attitudes, weights, and bank angles. Also, exhibits adequate knowledge of the proper procedure for resuming normal flight…

e. Initiates recovery [from stall] at the first indication of buffeting, decay of control effectiveness, other cues related to specific aircraft design characteristics, or as directed by the instructor.

f. Recovers to a reference airspeed, altitude and heading, allowing only the acceptable altitude, airspeed, heading loss, or deviation.

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[65] This POI was replaced by another POI in June 2002, who was responsible for the oversight of Aviation Charter's operating certificate at the time of the accident. The original POI was reassigned to Aviation Charter in December 2002.

[66] For information about a previously issued CRM-related recommendation to the FAA, see section 1.18.2.

g. Demonstrates smooth, positive airplane control during entry, stall regime, and recovery.

Specific stall recovery initiation procedures, including how to respond if the stall warning horn sounds in flight, were not noted in any of Aviation Charter's manuals. However, one Aviation Charter copilot stated that during company flight training, she was instructed to initiate stall recovery when the stall warning horn sounded. Further, a Quick Turn instructor indicated that because the flight-training device was not a motion-based device, pilots were expected to initiate stall recovery when the stall warning horn sounded.

1.17.1.3 Instrument Approaches

Aviation Charter's Multiengine Turbopropeller Maneuvers Guide states that the flying pilot must brief the nonflying pilot before executing an instrument approach. The Maneuvers Guide indicates that the instrument approach briefing should include the type of approach, minimums, missed approach procedure, and the required callouts, including altitudes, times, airport in or not in sight, MDA, and deviations. Although the Maneuvers Guide states that an instrument approach briefing is a required item that must be accomplished by the flight crew before executing an instrument approach, Aviation Charter's General Operations Manual (GOM) did not contain this requirement, and none of its company checklists called for conducting an approach briefing.[67]

The Maneuvers Guide also contains procedures for making an approach when the PIC is the flying pilot.[68] The guide states that the nonflying pilot should tune and identify the VHF navigational receiver and set the course selector for the approach. The guide further states that an in-range checklist[69] must be accomplished immediately before commencing an approach to reduce workload and permit the flying pilot to concentrate on the approach. The guide states, "the landing checklist may be accomplished at any time during the approach with the exception of landing gear and flaps." The guide states that upon passing the final approach fix (FAF), the flying pilot should begin the descent to the MDA or step-down fix and that the landing gear should be extended at the FAF. The guide adds that landing flap extension can be delayed until the landing is assured. Aviation Charter's chief pilot stated that pilots were instructed to extend the landing gear and reduce the power simultaneously once they have started the descent to the MDA.

Aviation Charter's Maneuvers Guide states that the recommended approach speed for precision approaches is 120 knots. However, neither the guide nor any other Aviation Charter manual specified the approach speed for nonprecision approaches.[70] According to Aviation Charter's chief pilot, he instructed pilots to fly all approaches at 130 knots and

[67] At the time of the accident, the approach briefing was contained in SimuFlite's Standard Operating Procedures (SOPs) located in Aviation Charter's Differences Manual. Subsequent to the accident, the approach briefing was incorporated into the company's FAA-approved GOM.

[68] The Maneuvers Guide did not contain procedures for making an approach when the copilot is the flying pilot.

[69] No in-range checklist could be found by Safety Board investigators in any of Aviation Charter's manuals, and the company's chief pilot and agent for service acknowledged that the company did not have an in-range checklist.

that 130 knots should be maintained from the FAF (or before starting descent) until the runway is in sight. He added that he instructed pilots to cross the threshold and touch down at 100 knots. The chief pilot further indicated that with the gear down, about 400 ft-lbs of torque, and 130 knots of airspeed, the airplane should descend at a rate just under 1,000 fpm. He stated that 100 feet before reaching the MDA, the torque would normally be brought up to 800 ft-lbs, and 130 knots would be maintained as the airplane was leveled off. He added that, at that point, the flying pilot should have his eyes inside the cockpit, not looking out, unless the nonflying pilot has called the airport in sight.

The Maneuvers Guide contains criteria to determine acceptable pilot performance of a stabilized VOR approach. According to the guide, a pilot's performance of a stabilized approach is acceptable if the following conditions, in part, are met:

f. Recognizes if heading indicator and/or attitude indicator is inaccurate or inoperative, advises controller, and proceeds with approach…

i. Maintains, prior to beginning the final approach segment, altitude within 100 feet [of the initial approach or assigned altitude], heading within 10 degrees [of initial approach or assigned heading] and allows less than a full-scale deflection of the CDI…and maintains airspeed within 10 knots [of initial approach or assigned airspeed]…

k. Establishes a rate of descent and track that will ensure arrival at the MDA prior to reaching the MAP with the aircraft continuously in a position from which descent to a landing on the intended runway can be made at a normal rate using normal maneuvers.

l. Allows, while on the final approach segment, no more than a three-quarter-scale deflection of the CDI…and maintains airspeed within 10 knots [of the approach airspeed].

m. Maintains the MDA, when reached, within +100 feet, -0 feet to the MAP.

Standard callouts to be made during an approach and conditions that would warrant abandoning an approach were contained in SimuFlite's SOPs, which were contained in Aviation Charter's Differences Manual. The chief pilot stated that the Differences Manual was provided to all pilots during initial training. According to the Abandoned Approach procedure contained in the SOPs, within 500 feet agl, the airplane must be within the following approach window: the airspeed must be within ±10 knots of approach speed, and the vertical speed must be no greater than 1,000 fpm. If the airplane is not within this window, the flight crew must execute a go-around.

1.17.1.4 Standard Operating Procedures

At the time of the accident, Aviation Charter did not have its own documented SOPs; however, as mentioned, the company was using Simuflite's SOPs, which were in the Aviation Charter's Differences Manual. The SOPs included the following: flying-pilot

[70] According to Aviation Charter, it clarified its approach speed guidance subsequent to the accident by making 120 knots the recommended speed for all approaches.

and nonflying-pilot responsibilities, challenges and standard callouts that the flight crew should make during checklist completion in all phases of flight, emergency response procedures, and instrument approach criteria and procedures.

According to Aviation Charter's chief pilot, who conducted most of Aviation Charter's King Air flight training, company pilots were taught SOPs during ground and flight instruction and were expected to use them. He added that since the accident, the company had started reviewing and incorporating SimuFlite's SOPs into the company's training manual and GOM. A company check airman rated the company's standardization as 6 on a scale of 1 to 10. Another company pilot stated that the company's standardization was fair to good, and the lead ground instructor stated that it was fair. The lead ground instructor also indicated that he suspected that some pilots were following SOPs and that some were not. One company pilot indicated that if the company was going to continue operating with two crewmembers, she would like to see the company adopt SOPs.

Regarding callouts, one Aviation Charter pilot stated that she used the callouts that she used while employed at another company and added that she had never seen any standard callouts documented in any company manual. A company copilot stated that no formal airspeed callouts were required during an approach but that the company's Differences Manual did document the approach briefing format and airspeed callouts.

On April 3, 2003, the FAA approved revision 14 to Aviation Charter's GOM. This revision incorporated Aviation Charter's newly developed SOPs into its GOM, Section R, "Company Policies." According to the company's chief pilot and director of operations, following the accident, the company started teaching pilots SOPs during training and implemented random line checks to evaluate SOPs, CRM, and crew coordination.

1.17.2 Operational Guidance

1.17.2.1 Manufacturer's Guidance on Operation in Icing Conditions

The Raytheon King Air A100 AFM, Section I, "Limitations," states that for sustained operation in icing conditions, the minimum airspeed should be 140 knots and adds that sustained flight in icing conditions with flaps extended is prohibited except for approach and landing. Raytheon's AFM, Section II, "Normal Procedures," contains the following caution regarding operation in icing conditions:

> Stalling airspeeds should be expected to increase when ice has accumulated on the airplane due to the distortion of the wing airfoil. For the same reason, stall warning devices are not accurate and should not be relied upon. Keep a comfortable margin of airspeed above the normal stall airspeed when ice is on the airplane.

Further, Raytheon's AFM states that an airplane's surface deicer system should be operated when 1/2 to 1 inch of ice has accumulated on the airplane's surfaces. The AFM also states that when the temperature is 5° C or lower, pitot heat,[71] engine heat, and stall warning heat should be on before any visible moisture is encountered.

1.17.2.2 Company Guidance on Operation in Icing Conditions

At the time of the accident, Aviation Charter's GOM, Section R, "Company Policies," Chapter R-2.4, "Enroute Icing Conditions Procedures," stated that its company policy is to avoid moderate icing conditions if possible but that if moderate icing is encountered, the flight crew should request an altitude change before the ice becomes heavy. The GOM added that because the additional weight of the ice will make it harder for the airplane to maintain airspeed, additional power will be needed. The GOM also stated that the deicer boots "should be used only after the ice has accumulated to 1/2 inch." The manual adds that if the deicer boots "are prematurely activated the ice may form a shell around the boot[s] and render them useless."

Aviation Charter's lead ground instructor stated that the procedure for activating the deicer boots was taught in ground school and that the company used to instruct pilots to wait until 1/2 inch of ice had accumulated to activate the boots. However, he stated that because of recent NASA research that recommended that deicer boots be activated at the first sign of ice buildup, he was instructing his students to activate the boots once about 1/4 inch of ice had built up. The lead ground instructor indicated that he was aware that the procedures taught in the company's ground school were different from those contained in Raytheon's AFM and the company's GOM. He stated that this discrepancy was only discussed with the pilots during ground school. He stated that the training included a test on tailplane stall and icing conditions and that he covered winter operations as part of recurrent and initial training. When asked about the company's deicing procedures, several Aviation Charter pilots indicated that there were no clear standardized procedures regarding how much ice should accumulate before activating the deicer boots.

The POI responsible for Aviation Charter at the time of the accident told Safety Board investigators that he believed that a bulletin had been issued stating that deicer boots should be activated at the first sign of ice rather than waiting until 1/2 inch of ice had accumulated. The POI stated that he thought the FAA had issued the bulletin but that he was unsure if it was regulatory or overrode the AFM.[72] The current POI also stated that a bulletin had been issued regarding activation of the deicer boots immediately upon encountering any kind of ice and that he believed that the lead ground instructor was teaching in accordance with the bulletin.

Subsequent to the accident, Aviation Charter standardized its deicer boot operations training and adopted the Raytheon AFM recommendation to wait until the accumulation of 1/2 inch of ice before activating the deicer boots.

1.17.2.3 Weight and Balance Load Manifest Procedures

At the time of the accident, Aviation Charter's GOM, Section R, Chapter R-1.1, "Load Manifest," indicated that the pilot was responsible for preparing a load manifest in

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[71] According to Aviation Charter's chief pilot, company pilots were trained to use pitot heat for the entire flight.

[72] The POI could not locate the bulletin for Safety Board investigators.

duplicate before each takeoff and ensuring its accuracy. The GOM added that the original copy of the load manifest must be carried in the aircraft to the company's base of operations. It stated further that "Although FAR [*Federal Aviation Regulations*] 135.63(c) and (d) does not specify the disposition of the duplicate copy, it is Company policy to either FAX or mail the duplicate to the company base of operations" before station departure. The GOM stated that if a pilot was unable to mail or fax a copy of the load manifest, a copy should be carried in the most aft compartment of the airplane that is accessible to the pilot.

As mentioned previously, the original and a copy of the accident airplane's weight and balance load manifest were destroyed by postcrash fire. Subsequent to the accident, Aviation Charter issued revision 13 to the GOM to modify the load manifest form and to require that pilots leave a copy of the manifest at each departure station in a place where it could be located at a later time if needed. The FAA approved Aviation Charter's revised manifest form on January 13, 2003.

1.17.3 FAA Surveillance

1.17.3.1 General

Aviation Charter's operating certificate was effective as of November 30, 1988, and was managed by the FAA's Minneapolis FSDO. According to the FAA, at the time of the accident, the POI was responsible for 8 Part 135 operators, 37 Part 137 operators (agricultural airplanes), 1 Part 141 pilot school, 7 designated airmen, and 5 check airmen. In a postaccident interview in January 2003, the POI told Safety Board investigators that he was the only general aviation inspector in the Minneapolis FSDO and that he was responsible for 37 Part 135 operators, 155 Part 137 operators (agricultural airplanes), 4 Part 133 operators (heavy-lift helicopters), 11 Part 141 pilot schools, 79 designated airmen, 17 check airmen, and 168 Part 91 noncertificated operators.[73]

During an interview in January 2003, the Minneapolis FSDO's operations supervisor told Safety Board investigators that the general aviation airworthiness unit, which is authorized to have five inspectors, had three inspectors; the general aviation operations unit, which is authorized to have six inspectors, had two inspectors; and the general aviation avionics unit, which is authorized to have two inspectors, had two inspectors. Both the FSDO's manager and its operations supervisor stated that the office was not fully staffed with general aviation inspectors because of a hiring freeze and budget constraints.[74] The operations supervisor stated that if the POI could not complete his

[73] Although this POI was not responsible for Aviation Charter's operating certificate from late June 2002 through the date of the accident, he was responsible for conducting surveillance of the company from about December 1997 through June 2002 and was reassigned the certificate in December 2002. The POI responsible for Aviation Charter at the time of the accident did not perform any surveillance of the company during the time he was responsible for the company's operating certificate. For more information about the Minneapolis FSDO's oversight of Aviation Charter, see section 1.17.3.3.

[74] According to the FAA, the hiring freeze was lifted in March 2003, and three general operations inspectors and three air carrier operations inspectors have been hired at its Minneapolis FSDO.

current work program for 2003, certain items would be moved to other inspectors in the office.

1.17.3.2 FAA Surveillance Guidance

FAA Order 1800.56C, "National Flight Standards Work Program Guidelines," contains guidance for the development and execution of annual surveillance work programs, the planning and the performance of which was the responsibility of the regional Flight Standards division. According to the order, "the primary objective of surveillance is to provide the FAA with accurate, real-time, comprehensive information for the evaluation of the safety status of the air transportation system" and to ensure that the "highest level of safety is maintained within the aviation community."

FAA Order 1800.56C, Appendix 1, "Work Program Activities," states that the Flight Standards work program comprises required (R-items) and planned (P-items) surveillance activities. R-items comprise the mandatory core inspection program, which is based on critical oversight issues that have been identified at a national level, and provide an essential level of surveillance activity for certificate holders. Specifically, appendix 1, Paragraph 5, "Required Surveillance," states that one inspection in each of the following areas is required for Part 135 on-demand charter operations: manual/procedures, training program, crew/dispatcher records, and trip records. In addition to the R-items, each field office is tasked to design a mandatory P-items inspection program to provide comprehensive targeted inspections that meet special surveillance requirements for each certificate holder operating within a field office's geographic district.

1.17.3.3 Minneapolis FSDO Oversight of Aviation Charter

Each general aviation inspector at the Minneapolis FSDO was responsible for a combined total of about 630 hours of surveillance (R- and P-items) at their assigned operators. According to the Minneapolis FSDO's operations supervisor, inspectors were required to complete at least 25 percent of their work program requirements every 3 months. The operations supervisor also stated that, in addition to their surveillance responsibilities, POIs shared the following extra duties: accident standby, processing enforcement actions and parachute waivers, assisting walk-in customers, approving and supervising air shows, and other FAA support activities.

The POI responsible for the surveillance of Aviation Charter at the time of the accident did not perform any surveillance activities at the company from June 2002, when he was assigned the certificate, through the date of the accident (about 4 months). He stated that he had not visited the company during this time because of his workload, which he characterized as "high." The POI also stated that it was a struggle to "keep his head above water" and that he wished the office had more people. He added that Aviation Charter still received a high level of surveillance compared to other operators because its headquarters was near the Minneapolis FSDO.

According to the Minneapolis FSDO's manager, this POI was not required to perform any surveillance activities from June to October 2002 because the previous POI had already completed all of Aviation Charter's R- and P-items before he left for his new assignment. FAA work program records indicated that for fiscal year 2002 (October 1, 2001, to September 30, 2002),[75] the previous POI conducted the following surveillance activities at Aviation Charter: 1 operations manual inspection, 10 training program inspections, 8 crewmember training records inspections, 1 trip records inspection, 1 ramp inspection, and 2 operations inspections of aircraft/line operations. According to the previous POI, he was prevented from attending to such things as approving manual revisions because of his high workload.[76]

The Minneapolis FSDO's operations supervisor and its manager stated that, subsequent to the accident, the principal inspectors for Aviation Charter were tasked to visit the company once every week or two, and other inspectors in the office were also encouraged to conduct surveillance of the company if time permitted.

1.17.3.4 FAA En Route Inspections

According to FAA Order 8400.10, "Air Transportation Operations Inspector's Handbook," the FAA conducts en route inspections to observe and evaluate a certificate holder's in-flight operations. The order adds that en route inspections are the most effective method for accomplishing surveillance objectives and responsibilities and that such inspections can be conducted from either the forward observer's seat in the cockpit (jumpseat) or from a forward cabin seat if no jumpseat is available. According to the order, the following elements could be observed and evaluated during an en route inspection: crewmember proficiency; operator's use of manuals, checklists, approved procedures, and safe operating practices; and crew coordination and resource management. FAA Order 8400.10 also states that POIs are responsible for coordinating with their assigned operators to ensure that established procedures are used by FAA inspectors for scheduling the jumpseat/forward passenger seat and that the operator's procedures allow inspectors to have free and uninterrupted access to the jumpseat/forward passenger seat. En route inspections are required to be conducted at Part 121 operations and 135 scheduled (commuter) operations; however, they are not required to be conducted at Part 135 unscheduled (on-demand) charter operations.

According to Aviation Charter's POI and the Minneapolis FSDO's operations supervisor, en route inspections are rarely conducted at Aviation Charter because they are not a required oversight item for POIs of 14 CFR Part 135 on-demand charter operators. The POI added that other reasons that en route inspections are rarely conducted for such operations were because on-demand charter flights are scheduled with little advance notice, most of the smaller airplanes used in these operations do not have jumpseats installed, and the passengers on such flights tended to desire privacy. He stated that he had tried to perform surveillance of actual charter flights at Aviation Charter, but he stated that

[75] As stated previously, the previous POI conducted his last surveillance activity before the accident on June 27, 2002.

[76] This POI was reassigned to Aviation Charter in December 2002.

he found it difficult because of limited passenger accommodations on the airplanes. He added that the best way for him to ensure adequate oversight of an operator was to monitor ground training.

1.17.3.5 Preaccident FAA Regional Aviation Safety Inspection Program Inspection

A team of aviation safety inspectors conducted a RASIP inspection at Aviation Charter from April 7 to 11, 1997. The RASIP Inspection Report included seven operations-related findings (two Category A, three Category B, and two Category C findings).[77] Specifically, the report stated that CRM was only addressed in the training curriculums for two types of airplanes flown by the company. The report added that CRM should be addressed in all of the company's training curriculums because, if not, "it could possibly result in improper crew coordination requirements in aircraft operated with a flight crew of more than one member." Another operations finding indicated that Aviation Charter's GOM was contrary to 14 CFR 135.63(c), which states that it is the certificate holder's responsibility for preparation and accuracy of the load manifest. The report noted that the company used load computer and flight manuals for weight and balance calculations, but that the information was not being retained to determine load manifest accuracy at a later date.[78] The RASIP report also noted that starting in January 1997, Aviation Charter had a Safety Officer to heighten safety awareness throughout the company; however, at the time of the accident, this position no longer existed. Subsequent to the October 2002 accident, Aviation Charter hired a Director of Safety (this action was not required by the FAA).

1.18 Additional Information

1.18.1 Previous Aviation Charter Operations-Related Accident

On December 21, 1997, an Aviation Charter King Air A100 crashed at Colorado Springs, Colorado, after encountering ground fog during landing. The pilot and one passenger were killed. The Safety Board determined that the probable causes of the accident were the failure of the pilot to follow IFR procedures and maintain the MDA. As mentioned previously, subsequent to the accident, the company began operating with

[77] The FAA defines the three categories of findings as follows: a Category A finding is any noncompliance with FARs; a Category B finding is a failure of the certificate holder to adhere to documented company procedures regarding regulations and safety; and a Category C finding is a lack of systems that would ensure that the certificate holder complies with continuing or reoccurring FAR requirements. The RASIP Inspection Report notes that compliance issues raised during the inspection were discussed with company personnel and principal inspectors and that issues that were not satisfactorily resolved became findings in the body of the report.

[78] Aviation Charter's agent for service indicated that this finding referred to the pilots not being required to leave a copy of the manifest at the departure station.

two flight crewmembers. According to the Minneapolis FSDO's manager, the FAA did not implement any changes to its oversight of Aviation Charter after the Colorado Springs accident.

1.18.2 Previous CRM-Related Safety Recommendation

As a result of its investigation of the March 29, 2001, accident involving a Gulfstream III operated by Avjet Corporation as a Part 135 on-demand charter passenger flight, the Safety Board issued Safety Recommendation A-02-12, which asked the FAA to "revise 14 *Code of Federal Regulations* (CFR) Part 135 to require on-demand charter operators that conduct operations with aircraft requiring two or more pilots to establish a Federal Aviation Administration-approved crew resource management training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O."

On February 3, 2003, the FAA announced a comprehensive regulatory review of 14 CFR Parts 125 and 135, including a review of CRM training. The FAA also stated that it was finalizing its notice to inspectors who have oversight responsibility for Part 135 on-demand operators to remind them of the circumstances of the Avjet accident and to direct them to point out to their assigned operators information contained in Advisory Circular (AC) 120-5 lD, "Crew Resource Management Training." According to the FAA, the notice will also state that the FAA strongly endorses CRM training. On August 7, 2003, the Board classified Safety Recommendation A-02-12 "Open—Acceptable Response."

2. Analysis

2.1 General

The flight crewmembers were properly certificated and had received the training for pilot certification prescribed by Federal regulations.[79] No evidence indicated any preexisting medical or other physical condition that might have adversely affected the flight crew's performance during the accident flight. Fatigue most likely did not degrade the performance of either pilot on the day of the accident.

The accident airplane was properly certificated, equipped, and maintained in accordance with Federal regulations and approved company procedures. The recovered components showed no evidence of preexisting powerplant, system, or structural failures.

The weight and balance of the airplane were within limits for dispatch, takeoff, climb, cruise, and landing.

This analysis discusses the accident sequence, including weather, ATC, and EVM VOR issues, and flight crew actions and competence. This analysis also discusses operational and training issues at Aviation Charter, FAA surveillance of the company, and the need for low-airspeed alert systems.

2.2 Determination of Flying Pilot

ATC recordings indicated that the accident copilot made all but one of the transmissions to ATC during the approach and descent. Typically, dual-pilot operations are conducted with the flying pilot handling the flight controls and the nonflying pilot handling the communications. Aviation Charter company practices were in accordance with this standard. However, several Aviation Charter pilots interviewed by Safety Board investigators indicated that the accident pilot often allowed them to conduct the flights they flew with him as if they were single-pilot operations (that is, he allowed them to handle the flight controls and communications and perform all of the checklists without his assistance). Therefore, the Safety Board could not determine who was flying the airplane at the time of the accident.

[79] As discussed in section 1.5.1.2, there were numerous discrepancies with the pilot's logbooks that called into question the accuracy of his flight time record-keeping. However, the investigation found no evidence indicating that the pilot lacked the required flight time or that these discrepancies in the logbooks were related to the cause of this accident.

2.3 Accident Sequence of Events

2.3.1 Flight Crew's Inadequate Setup for the Approach

About 1009, 7 minutes after being instructed to descend from 13,000 feet to 4,000 feet at pilot's discretion, the copilot reported leaving 13,000 feet. About 1012, the DLH approach control south radar controller cleared the flight to 3,500 feet. During the descent to 3,500 feet, the airplane slowed from about 220 to about 190 KCAS. By 1017:35, the airplane had leveled off at 3,500 feet with the airspeed continuing to decrease. Shortly after 1018:31, as the airplane approached the published EVM VOR runway 27 final approach course from the south at about 164 KCAS and decreasing, ATC instructed the flight crew to turn left to a heading of 300° until established on the final approach course.[80] However, the flight crew overshot the approach course almost immediately after being issued the turn, and the airplane ultimately traveled for almost 1 mile north of the course as it continued the turn toward the course until establishing a ground track of about 262°.

The airplane began its descent from 3,500 feet, and the airspeed began increasing about 1019:20. The airplane should have been at 130 knots at the start of the descent[81] with flaps at the approach setting and the landing gear down. Because the airplane was fast at this point in the approach, the flight crew had to lose a significant amount of airspeed and altitude in a short amount of time. As the airplane descended through 3,200 feet, its airspeed and vertical speed peaked at about 170 KCAS and 1,400 fpm, respectively.

At 1020:06, as the airplane descended through 2,700 feet about 5 miles east of the runway 27 threshold, a right turn was initiated and the airspeed began decreasing from about 170 KCAS. When the airplane was approximately 4 miles from the runway threshold, it was still at 2,300 feet and about 160 KCAS; however, at this point in the approach, the airplane still should have been at an airspeed of about 130 knots.

Further, Aviation Charter's chief pilot stated that the landing gear should be extended when the flight crew starts the descent to the MDA and that the power should simultaneously be reduced to get down to approach speed. However, the maximum speed for landing gear extension is 156 knots. The airspeed exceeded 156 knots when the airplane started its descent to the MDA and during most of the descent. The chief pilot and other Aviation Charter pilots indicated that it would have been difficult to exceed 156 knots with the gear extended. Therefore, it appears that the flight crew did not properly configure the airplane at the start of the approach (extending the landing gear or reducing power before descending from 3,500 feet).

[80] For analysis of this ATC instruction, see section 2.5.

[81] As noted previously, according to Aviation Charter's chief pilot, the company instructed its pilots to fly nonprecision approaches at 130 knots until short final and to cross the runway threshold and touch down at 100 knots.

As previously discussed, simulations performed by the Safety Board indicated that the later stages of the approach flown by the accident flight crew were more difficult in terms of mental and physical demand and time pressure than it would have been if they had not overshot the approach course and had not delayed their descent and landing gear extension. The flying pilot of these simulations commented that during this approach there was a "noticeably higher workload – with gear delayed, I felt behind the airplane." The flight crew's failure to monitor the airspeed and correct their course and airspeed deviations early in the approach and the fact that the flight crew did not properly configure the airplane at the start of the approach would have made the later stages of the approach more difficult.

2.3.2 Flight Crew's Failure to Stabilize the Approach

As stated previously, the flight crew initiated a slight right turn at 1020:06, as the airplane again passed through the final approach course (this time flying from north to south) about 5 miles east of the runway 27 threshold. The airplane continued its slight right turn until it established a ground track of 269°, which it maintained until the end of the radar data. At this point, the airplane was south of the published approach course (of 276°); therefore, this turn did not allow the airplane to intercept the course, and the flight crew never effectively maneuvered the airplane to remain near the approach course.[82]

At 1020:36, the airplane's airspeed was about 156 knots about 3.7 miles from the runway 27 threshold and it was descending through about 2,200 feet. At 1020:54, when the airplane was 3 miles from the runway threshold, it was descending through about 2,100 feet and slowing through about 130 KCAS. The last two radar returns indicate that the airplane was at approximately 1,800 feet[83] and slowing through about 76 KCAS, which is the approximate stall speed for the configuration in which the airplane was found after the accident. The last radar return was about 2 miles southeast of the runway threshold.

Airplane simulations showed (and the stall warning system design indicates) that the flight crew should have received at least several seconds of aural stall warning in the cockpit if the airspeed decreased below 81 to 84 knots, if the stall warning system was working properly, and if the airplane was not affected by ice accumulation. Further, the flight crew should have had other indications of low airspeed, such as increased pitch attitude and a quieter slipstream, and might have experienced buffeting and less responsive flight controls, depending on the airspeed and whether there was any ice accumulation. However, because the airplane was not equipped with a CVR, because of the approximate nature of the airspeed calculations, and because airplane maneuvering or small amounts of ice accumulation can increase an airplane's stall speed, the Safety Board

[82] As further discussed in section 2.6, the bends (which, as noted previously, are fluctuations in the calculated VOR radial position that occur slowly enough to be followed by a pilot under normal conditions) in the VOR signal played no role in the flight crew's failure to intercept the course.

[83] Because of the ± 50-foot accuracy of the radar data, it could not be determined exactly how close the airplane was to the MDA of 1,840 feet at the time of the last radar returns.

was not able to determine when or whether the stall warning horn activated on the accident flight or if buffeting or loss of flight control effectiveness occurred. Nevertheless, it is clear that the flight crew failed to monitor the airplane's airspeed and allowed it to decrease to a dangerously low level (as low as about 50 knots below the company's recommended approach airspeed) and to remain below the recommended approach airspeed for about 50 seconds. Further, the flight crew failed to recognize that a stall was imminent.

According to the stabilized approach criteria contained in Aviation Charter's Turbopropellers Maneuvers Guide, while on the final approach segment of a nonprecision approach, pilots should allow no more than a three-quarter-scale deflection of the CDI needle and maintain airspeed within 10 knots of the approach airspeed. Further, according to the Abandoned Approach procedure contained in Aviation Charter's SOPs, when the flight is within 500 feet agl, the airspeed must be within ± 10 knots of the recommended approach speed. If the airplane does not meet these acceptable margins, the flight crew is expected to execute a go-around. Computations showed that the airplane's position relative to the VOR course would result in the CDI needle likely at full deflection approximately 2.6 miles from the VOR station. Further, at this point in the approach, the airspeed had fallen to about 110 knots and was still decreasing, ultimately reaching a low of about 76 knots. Therefore, the inadequate airspeed or the full CDI needle deflection should have prompted the flight crew to execute a go-around.

2.3.3 Summary of Flight Crew's Performance During the Approach

In sum, the Safety Board concludes that the flight crew failed to maintain an appropriate course and speed for the approach and did not properly configure the airplane at the start of the approach, making the later stages of the approach more difficult. Further, the Safety Board concludes that, during the later stages of the approach, the flight crew failed to monitor the airplane's airspeed and allowed it to decrease to a dangerously low level (as low as about 50 knots below the company's recommended approach airspeed) and to remain below the recommended approach airspeed for about 50 seconds. The Board further concludes that the flight crew failed to recognize that a stall was imminent and allowed the airplane to enter a stall from which they did not recover. The Board also concludes that the inadequate airspeed or the full CDI needle deflection should have prompted the flight crew to execute a go-around; however, they failed to do so.

Lastly, the Safety Board notes that if the flight crew had been adhering to Aviation Charter's approach procedures and effectively applying CRM techniques in the cockpit, at least one of the flight crewmembers should have been monitoring the instruments. The evidence clearly indicates that neither flight crewmember was monitoring the airspeed indicator or CDI during the approach. Therefore, the Safety Board concludes that the flight crew was not adhering to Aviation Charter's approach procedures and was not effectively applying CRM techniques during the approach segment of the flight.

2.4 Weather Issues

2.4.1 Clouds

Because the surface visibility around the time of the accident was about 3 statute miles, the flight crew probably would have been able to see the airport to the right of their course if the airplane had been completely clear of the clouds. However, EVM and Hibbing surface observations and pilot statements indicate that around the time of the accident, the cloud bases at and near EVM were somewhere between 1,800 and 2,100 feet.[84] The last two recorded radar returns indicate that the airplane was at approximately 1,800 feet and within 2 miles of the runway 27 threshold. Further, a witness indicated that he saw the accident airplane "just beneath a low layer of clouds" but that "the top of the airplane may still have been in the clouds." Therefore, because the airplane was most likely in and out of the clouds before the accident, the Safety Board concludes that clouds might have prevented the flight crew from seeing the airport.

2.4.2 Airframe Icing

The Safety Board considered whether airframe icing could have been a factor in the accident. Several pilot reports made in the vicinity of EVM about the time of the accident and an analysis of those reports indicated that icing was likely occurring in two distinct bands around the time of the accident: moderate icing was present between approximately 8,000 and 11,000 feet, and light/trace icing was present between approximately 5,000 and 8,000 feet. Icing studies conducted for the Board indicated that there was a low potential for SLD around Eveleth and, further, that moderate icing most likely did not extend to the lower levels of the atmosphere.

One of the last two pilots who landed at EVM before the accident reported experiencing light to moderate rime icing at 7,000 feet, at which level the temperature was approximately -2° C. He added that after descending to 5,000 feet, the ice began to shed off the airplane and that the temperatures at this level were between about -0.5° to 0° C. The other pilot who landed at EVM stated that he encountered light rime icing at 5,000 feet. This pilot and the first pilot to depart EVM after the accident told Safety Board investigators that they experienced very little icing below 5,000 feet.

Further, radar data show that the airplane was maintaining high airspeeds throughout the region in which icing might have been accumulated and lost airspeed at lower altitudes where performance would have been improving if any accumulated ice was shedding (as a result of warmer temperatures or activation of the deicer boots), indicating that icing was not affecting the airplane's performance.

On the basis of cloud top and base values, investigators determined that the airplane was in the clouds for approximately 9 1/2 minutes during the descent portion of

[84] This equates to about 420 to 720 feet above the EVM runway 27 elevation.

the flight. Specifically, the airplane was in the clouds in which moderate icing was present (between approximately 8,000 and 11,000 feet) for about 2 minutes 35 seconds, in the clouds in which light/trace icing was present (between approximately 5,000 and 8,000 feet) for about 2 minutes 24 seconds, and in the clouds in which very little icing was present and in which it was reported that any accumulated ice began shedding (below 5,000 feet) for about 4 minutes 23 seconds.

On the basis of all of this evidence, the airplane was most likely not in the cloud layer in which moderate icing was present for enough time to accumulate any significant airframe icing. Further, any icing that the airplane might have accumulated would have been shed by the deicing equipment, or it would have begun shedding off the airplane's surfaces as it was descending through 5,000 feet because of the warming temperatures. In addition, the airplane's performance was not consistent with the effects of icing, and flight simulations showed that the performance could be matched with and without simulated icing with enough reserve engine power available to increase the airspeed during the descent. Therefore, the Safety Board concludes that icing did not affect the airplane's performance during the descent.

2.5 ATC Issues

At 1018:13, when the accident airplane was about 9.5 miles from the runway 27 threshold and less than about 1/2 mile from the published EVM VOR runway 27 final approach course at an airspeed of about 164 KCAS and a heading of about 360°, the DLH approach control south radar controller instructed the flight crew to turn left to a heading of 300° and issued an approach clearance for the EVM VOR runway 27 approach. The controller's instruction provided a final approach course interception angle of about 25°. However, the airplane did not intercept the VOR approach course.[85] Instead, it overshot the intended course and then began turning back toward the approach course a few seconds later.

The airplane's speed and close proximity to the VOR final approach course when the controller issued the 300° interception heading precluded the flight crew from completing their left turn in time to initially intercept the final approach course. However, the controller's radar display was set at a range of 60 miles, which is an appropriate resolution for normal coverage of the DLH airspace, and, at that range, the controller would have had difficulty discerning the airplane's exact position relative to the approach course or even its overshoot of the course. Further, if the pilots were unsure of their ability to intercept the approach course or safely execute the approach, they were responsible for requesting additional vectors from ATC. No evidence exists that the flight crew expressed any concerns about the execution of the approach to the DLH controller. Further, the controller's instruction should not have prevented the flight crew from correcting their overshoot and properly intercepting and becoming established on the approach course. Lastly, during postaccident airplane simulations, the flight crew that flew an approach

[85] As previously mentioned, the approach course is 276°.

using ATC vectors similar to those given to the accident flight crew initially overshot the approach course but were able to reintercept the course from the north, establish a stabilized approach, and land successfully. Therefore, the Safety Board concludes that the DLH approach control south radar controller's instructions did not prevent the flight crew from intercepting the EVM VOR runway 27 final approach course at a sufficient distance to safely execute an approach and landing.

2.6 EVM VOR Issues

FAA flight checks indicated that the EVM VOR signal within the area between 5 to 10 miles from the station was out-of-tolerance for bends (a maximum distortion of +4.1° was measured; a maximum distortion of ± 3.5° is allowed). Despite the slight inaccuracy, the VOR signal positioned the airplane within an acceptable aiming point for landing.

Within the area between 5 to 8 miles from the EVM VOR, the airplane was on a fairly steady course of 262° moving toward 276°, which is the VOR inbound approach course for runway 27. Therefore, because the airplane was converging on the inbound course in the area between 5 to 10 miles from the VOR, it is clear that the slight bends in the VOR signal were not misleading the flight crew or noticeably affecting the airplane's operation. Further, when following a VOR, flight crews are expected to maneuver the airplane to keep the CDI needle centered. Accordingly, if they had been following the VOR, the accident flight crew most likely would not have perceived a slight bend in the course as they continued to maneuver the airplane to keep the CDI needle centered. Therefore, the Safety Board concludes that the out-of-tolerance condition and slight bends in the EVM VOR signal were not a factor in this accident.

2.7 Flight Crew Proficiency

Although several changes and adjustments would had to have been made in a relatively short amount of time to stabilize the approach (with regard to speed, course, and airplane configuration), the pilots should have been able to handle the changes and successfully complete the approach.

As noted previously, because the flight crew did not properly configure the airplane for the start of the approach and failed to monitor the airspeed and correct their course and airspeed deviations early in the approach, they increased the difficulty of the later stages of the approach. It is possible that the flight crew could not keep up with the multiple concurrent tasks that they would have needed to complete during the final phase of the flight. In addition, the multiple concurrent tasks would have required efficient coordination between the two crewmembers; however, as concluded previously, the flight crew likely was not effectively applying CRM techniques during the approach segment of the flight. Therefore, these tasks likely were not being effectively handled during the approach. Further, the Safety Board's investigation revealed that the pilots often performed poorly when flying approaches.

During the investigation, Safety Board investigators talked with company instructors and with pilots and check airmen who had flown with the pilot and copilot. These interviews identified several concerns about the flight proficiency of the pilot and copilot. Aviation Charter's lead ground instructor, who was previously a check airman for the company, stated that some company pilots indicated that the pilot's flying skills were below average. Several company pilots' statements indicated that the pilot performed below average during flight operations. Specifically, one Aviation Charter pilot stated that he had concerns about the accident pilot's flying skills, monitoring capabilities, and tendency to become distracted. Other company pilots indicated that the pilot occasionally lost awareness of the airplane's altitude, attitude, and position during flight operations. A company copilot indicated that during a flight with the pilot about 2 months before the accident, he had to complete an approach for the pilot because the pilot did not have his navigational radio tuned to the VOR in use for the approach, which caused the pilot's CDI to provide erroneous indications, and that he then had to explain to the pilot the reason his CDI was not indicating properly. Two pilots reported having to assume control of the airplane when the pilot failed to adequately control the airplane during instrument conditions. In addition, the pilot reportedly had a reputation for allowing his copilots to perform most of the flying, which might have reduced his flight proficiency and skills.

Regarding the accident copilot, Aviation Charter's lead ground instructor reported that the copilot's performance during ground school was below average. Several statements made by company pilots indicated that the copilot performed below average during flight operations. Specifically, two pilots stated that he had difficulties with power management when flying an approach and that he had to be reminded to keep one hand on the throttles and to monitor power settings. Several pilots expressed concern about the copilot's inability to land the airplane without assistance and described him as "not assertive." Further, although the copilot claimed no previous aviation employment history on his employment application for Aviation Charter, his logbook entries and résumé indicated that he had been employed previously at two aviation operations: a skydive operator and Northwest Airlines. Records from the two companies indicate that he was let go from the skydive operator because he could not meet its pilot qualifications standards for flying the Cessna 182 and that he resigned from Northwest Airlines because he was unable to complete its systems and procedures training program.

Postaccident statements from Aviation Charter pilots and other personnel indicate that both pilots often exhibited potentially serious performance deficiencies during flight operations. Therefore, the Safety Board concludes that both pilots had previously demonstrated potentially serious performance deficiencies during flight operations consistent with below-average flight proficiency.

2.8 Aviation Charter Operational and Training Issues

2.8.1 Operational Guidance

Although Aviation Charter's Multiengine Turbopropeller Maneuvers Guide stated that the flying pilot must brief the nonflying pilot before executing an instrument approach, its GOM did not contain this requirement, and none of its company checklists called for issuing an approach briefing. Also, although the Maneuvers Guide stated that an in-range checklist must be accomplished immediately before commencing an approach, an in-range checklist was not contained in any of the company's manuals. Further, Aviation Charter's Maneuvers Guide does not contain specific stall recovery initiation procedures, including how to respond if the stall warning horn sounds in flight, and such procedures were not contained in any of Aviation Charter's other manuals. Further, although Aviation Charter's GOM required pilots to either fax or mail a duplicate of the weight and balance load manifest form for every flight to the company base of operations, the company was not following this policy at the time of the accident. Lastly, company guidance on when to operate the deicer boots was inconsistent.

On the basis of this evidence, the Safety Board concludes that at the time of the accident, Aviation Charter was not operating in accordance with its weight and balance load manifest procedures, it did not have adequate stall recovery guidance, it did not have consistent deicer boot operational guidance, and it did not have an in-range checklist. The Safety Board is aware that subsequent to the accident, Aviation Charter incorporated an approach briefing as part of the descent procedures contained in the SOPs in the GOM and revised the GOM to modify the weight and balance load manifest form and to require that pilots leave a copy of the manifest at each departure station in a place where it can be located at a later time if needed.

SOPs are typically developed for each airplane type within a company's fleet to ensure safe, logical, and efficient flight operations and to provide pilots with step-by-step guidance for completing all phases of ground and flight operations, especially in multicrew, complex, or high-performance aircraft. SOPs typically include flying-pilot and nonflying-pilot responsibilities, challenges and standard callouts that the flight crew should make during checklist completion in all phases of flight, emergency response procedures, and instrument approach criteria and procedures.

The Safety Board's review of the SOPs in effect at Aviation Charter at the time of the accident revealed that its approach procedures were adequate and determined that if the accident flight crew had adhered to these procedures, the accident might have been prevented. As noted, these SOPs were SimuFlite's SOPs, which were located at the back of the Aviation Charter's Differences Manual. The chief pilot indicated that SOPs were being taught to and used by company pilots, and both he and the director of operations stated that all pilots were given a Differences Manual during initial training. However, according to a company check airman, on a scale of 1 to 10, the company's standardization was a 6. Another company pilot stated that the company's standardization was fair to good, and the lead ground instructor stated that it was fair. The lead ground instructor also indicated that he suspected that some pilots were following SOPs and that some were not. One company pilot indicated that if the company was going to continue operating with two crewmembers, she would like to see the company adopt SOPs. In addition, one company pilot stated that she had never seen any standard callouts documented in any company manual, and a company copilot stated that no formal airspeed callouts were required during an approach.

Therefore, on the basis of all of these statements and because the circumstances of the accident indicate that the accident flight crew was most likely not adhering to the SOPs for a nonprecision approach during the approach, the Safety Board concludes that Aviation Charter was not adequately making company pilots aware of its SOPs. The Safety Board is aware that subsequent to the accident, Aviation Charter incorporated the SOPs, with some revisions, into its company GOM.

2.8.2 CRM Training

According to the FAA, Aviation Charter was not required by Federal regulations to provide CRM training to its pilots. However, it became mandatory to teach CRM in accordance with the CRM training module once the module was approved by the FAA. However, postaccident interviews with Aviation Charter's lead ground instructor and its chief pilot and the FAA POI for the company revealed that CRM was not being taught during ground school in accordance with the training manual curriculum. Therefore, the Safety Board concludes that at the time of the accident, Aviation Charter was not training its pilots on CRM in accordance with its FAA-approved CRM training module.

2.9 FAA Surveillance Issues

2.9.1 FAA Surveillance of Aviation Charter

FAA Order 1800.56C, "National Flight Standards Work Program Guidelines," lists four required surveillance items for Part 135 on-demand charter operations, including annual manual/procedures and training program inspections. Between October 1, 2001, and June 27, 2002, the POI for Aviation Charter conducted 1 manual inspection, 2 line checks, 1 ramp inspection, 10 training program inspections, and 9 other operations-related inspections; however, during these inspections he failed to detect any of the operational discrepancies determined by the investigation to have existed at Aviation Charter at the time of the accident. On the basis of this evidence and the fact that the POI had not conducted any en route inspections, the Safety Board concludes that although the FAA's surveillance of Aviation Charter was in accordance with its standard guidelines, it was not sufficient to detect the discrepancies that existed at Aviation Charter.

2.9.2 FAA Surveillance of Part 135 On-Demand Operations

FAA Order 8400.10, "Air Transportation Operations Inspector's Handbook," states that "en route inspections are one of the most effective methods for accomplishing surveillance objectives and responsibilities" and that the primary objective of these inspections is to evaluate in-flight operations, including, but not limited to, crew coordination, cockpit procedures, and crewmember proficiency, of a certificate holder. However, although FAA Order 1800.56C requires inspectors to conduct en route inspections at Part 121 operations and 135 scheduled (commuter) operations, it does not require inspectors to conduct en route inspections at Part 135 unscheduled (on-demand) charter operations. Further, the Safety Board is aware that POIs of Part 121 operations routinely observe flight training and proficiency checks as a means to provide adequate surveillance of these operations.

Aviation Charter's POI and the Minneapolis FSDO's operations supervisor indicated that because there was no FAA requirement to conduct en route inspections of 14 CFR Part 135 on-demand charter flights, such inspections were rarely performed. The POI added that the best way for him to ensure adequate oversight of an on-demand Part 135 operator was to monitor ground training. The Safety Board does not concur with the POI's statement. Although ground school surveillance is a valuable tool that allows POIs to evaluate an instructor and the adequacy of course content, it does not allow POIs to conduct comprehensive and in-depth assessments of an operator's policies and procedures or to determine how well the trained procedures are being assimilated into line operations, which could be accomplished through en route inspections and through observations of flight training and proficiency checks (in addition to ground school observations).

The Safety Board is concerned that even though the FAA's surveillance of Aviation Charter was in accordance with FAA Order 1800.56C, the POI did not detect the discrepancies that existed at Aviation Charter during his manual/procedures or training inspections, some of which might have been detected through en route inspections or through observations of flight training or proficiency checks. The Board is also concerned that the FAA requires en route inspections of Part 135 scheduled operations, but not for Part 135 on-demand operations, despite its own acknowledgement that en route inspections are one of the best means for ensuring adequate surveillance.

The Safety Board is aware that subsequent to the accident, Aviation Charter implemented random line checks to evaluate SOPs, CRM, and crew coordination. Although the Board commends the company for its actions, it is concerned about the FAA's relying too much on company check airmen and not enough on its own staff to evaluate these areas. Therefore, the Safety Board concludes that en route inspections, combined with ground training, flight training, and proficiency check observations, are essential for ensuring adequate oversight of a company's operations and should be conducted on flights operated by 14 CFR Part 135 on-demand charter operators. Therefore, the Safety Board believes that the FAA should conduct en route inspections and observe ground training, flight training, and proficiency checks at all 14 CFR Part 135 on-demand charter operations as is done at Part 121 operations and Part 135 commuter operations to ensure the adequacy, quality, and standardization of pilot training and flight operations.

2.9.3 FAA CRM Training Requirements

Most Part 121 and scheduled Part 135 operators provide several days of dedicated CRM training in which accidents are reviewed and skills and techniques for effective crew coordination, resource allocation, and error management are presented. CRM training augments technical training and enhances pilots' performance in the cockpit.

In its April 1997 RASIP report, the FAA stated that CRM should be addressed in all of Aviation Charter's training curriculums because, if not, "it could possibly result in improper crew coordination requirements in aircraft operated with a flight crew of more than one member." On May 21, 1997, the FAA approved the company's CRM training module. However, as previously noted, the Safety Board concluded that Aviation Charter was not teaching CRM in accordance with its CRM training module.

As a result of its investigation of the March 29, 2001, Avjet Corporation accident in Aspen, Colorado, the Safety Board issued Safety Recommendation A-02-12, asking the FAA to "revise 14 *Code of Federal Regulations* (CFR) Part 135 to require on-demand charter operators that conduct operations with aircraft requiring two or more pilots to establish an FAA-approved CRM training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O." The Safety Board concludes that the circumstances of the October 2002 Aviation Charter accident indicate that CRM training should be extended to include all 14 CFR Part 135 on-demand charter operations that conduct dual-pilot operations regardless of whether the aircraft requires two or more pilots. Therefore, the Safety Board believes that the FAA should require that 14 CFR Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement an FAA-approved CRM training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O. Because of the issuance of this recommendation, Safety Recommendation A-02-12 is classified "Closed—Superseded."

2.10 Low-Airspeed Alert Systems

2.10.1 Background

Current Federal airworthiness standards require that airplanes be equipped to provide a clear and distinctive stall warning to the flight crew at a speed that is at least 5 knots higher than stall speed. However, stall warnings do not always provide flight crews with timely notification of developing hazardous low-airspeed conditions. For example, abrupt maneuvering can increase angle-of-attack so rapidly that a stall could occur nearly simultaneously with the stall warning, and ice accumulation, which raises the stall speed, could degrade the stall warning margin to the point at which little or no stall warning is provided.

The accident airplane was equipped with a stall warning system designed to sound a horn in the cockpit 5 to 8 knots before the actual stall speed of the airplane in any configuration. However, as discussed previously, because the airplane was not equipped with a CVR, because of the approximate nature of the airspeed calculations, and because abrupt airplane maneuvering or even small amounts of ice accumulation can defeat the airplane's stall warning system, the Safety Board was not able to determine when or if the stall warning horn activated before the onset of the stall. Regardless of when or whether the stall warning horn activated, it is clear that the accident flight crew failed to maintain airspeed during the approach. As discussed in section 2.3, radar data indicate that the accident flight was operated below Aviation Charter's recommended approach speed for about the last 50 seconds of the flight.

The Safety Board has investigated numerous accidents and incidents involving commercial flight crews that inadvertently failed to maintain adequate airspeed. For example, the Board has investigated at least 11 events since 1982 involving Part 135 flights and at least 7 events involving Part 121 flights in which stall or failure to maintain airspeed during the approach or landing phases was cited as a causal or contributing factor and in which icing was not cited as a factor. In addition, the Board has investigated other events in which the drag associated with airframe ice and pilot inattention led to a critical loss of airspeed. Failure to maintain airspeed during these flights resulted in catastrophic and other unsafe circumstances, such as loss of control, impact with terrain or water, hard landings, and tail strikes.

A 1996 FAA Human Factors Team[86] Report titled, "The Interfaces Between Flight Crews and Modern Flight Deck Systems," expressed concern about the history of accidents involving lack of low-airspeed awareness in the context of flight crews monitoring automated systems. This report states the following:

> flight crews may not be provided adequate awareness of airplane energy state, particularly when approaching or trending toward a low energy state…Transport category airplanes are required to have adequate warnings of an impending stall, but at this point the airplane may already be in a potentially hazardous low energy state. Better awareness is needed of energy state trends such that flight crews are alerted prior to reaching a potentially hazardous low energy state.[87]

This accident history was also cited by the Flight Guidance System Harmonization Working Group of the Aviation Rulemaking Advisory Committee (ARAC), when, in March 2002, it proposed revisions to FAR 25.1329 and AC 25.1329[88] to provide low-airspeed protection and alerting during autopilot operations for newly certified

[86] This team comprised FAA and industry representatives.

[87] Federal Aviation Administration, Human Factors Team Report, *The Interfaces Between Flightcrews and Modern Flight Deck Systems* (Washington, DC: FAA, 1996).

transport-category airplanes. The proposed regulatory revision would require, "[w]hen the flight guidance system [FGS] is in use, a means…to avoid excursions beyond an acceptable margin from the speed range of the normal flight envelope." The proposed new AC, which is intended to provide an acceptable means for showing compliance with this new requirement, states the following:

> The requirement for speed protection is based on the premise that reliance on flight crew attentiveness to airspeed indications, alone, during FGS…operation is not adequate to avoid unacceptable speed excursions outside the speed range of the normal flight envelope….Standard stall warning and high speed alerts are not always timely enough for the flight crew to intervene to prevent unacceptable speed excursions during FGS operation….A low speed alert and a transition to the speed protection mode at approximately 1.2 $V_{s,}$[89] or an equivalent speed defined in terms of $V_{sr,}$[90] for the landing flap configuration has been found to be acceptable.

The proposed changes to FAR 25.1329 reflect the advanced avionics capabilities characteristic of modern transport-category airplanes. However, the Safety Board notes that a low-airspeed alert system has been developed for Embraer EMB-120 airplanes; installation of the alert system was mandated by FAA Airworthiness Directive 2001-20-17.[91] The system is designed to alert flight crews of low-airspeed conditions in certain airplane configurations and in icing conditions through the use of an amber-colored indicator light installed in the control panel and an audible alert. The Board is also aware that several avionics manufacturers offer low-airspeed alert devices associated with approach and maneuvering speeds for use in less sophisticated general aviation airplanes. This demonstrates that it may be feasible to develop low-airspeed alert systems for most airplane types.

2.10.2 Need for Improved Low-Airspeed Awareness

The Safety Board recognizes that the development and requirement of a low-airspeed alert system is a departure from the previously accepted premise that adequate low-airspeed awareness is provided by flight crew vigilance and existing stall warnings. However, the circumstances of this accident and the history of accidents involving flight crew lack of low-airspeed awareness suggest that flight crew vigilance and existing stall warnings are inadequate to reliably prevent hazardous low-airspeed situations and that this unsafe condition is not unique to autopilot operations or flight in

[88] Similar changes were also proposed to *Joint Aviation Requirements* (JAR) 25.1329 and Advisory Circular Joint 25.1329. The FAR/JAR and ACs are currently titled, "Automatic Pilot System"; the proposed new titles would be "Flight Guidance System."

[89] V_s is the stall speed or the minimum steady flight speed at which the airplane is controllable.

[90] V_{sr} is the reference stall speed.

[91] This low-airspeed alert system was developed as a result of the January 9, 1997, accident involving Comair flight 3272, an EMB-120RT that crashed near Monroe, Michigan, during a rapid descent after an uncommanded roll excursion in icing conditions and the March 19, 2001, accident involving Comair flight 5054, an EMB-120 that departed controlled cruise flight and descended 10,000 feet after it encountered icing conditions.

icing conditions. If a low-airspeed alert system had been installed on the accident airplane, it might have directed the attention of the flight crew to the airplane's decaying airspeed in time for them to initiate appropriate corrective action. For example, if a low-airspeed alert had activated when the airspeed dropped below 1.2 V_s (about 92 knots for the accident airplane), the flight crew would have received about 15 seconds advance notice before reaching the airplane's estimated stall speed. In addition, if the flight crew had maintained an airspeed at or above the threshold set by such an early low-airspeed alert, the additional airspeed could have prevented an accelerated stall initiated by an abrupt last-second maneuver or provided an improved speed margin above a premature stall caused by ice accumulation on the wings.

This change in philosophy is evident in the ARAC's proposed changes to FAR 25.1329 and AC 25.1329, Embraer's requirement for a low-airspeed alert system on the EMB-120, and the fact that several avionics manufacturers offer low-airspeed alert devices for general aviation airplanes. The Safety Board supports this change in philosophy. A low-airspeed alert associated with the minimum operationally acceptable speed for a particular phase of flight would likely help flight crews maintain airspeed awareness in much the same way that altitude alert systems help flight crews maintain altitude awareness. Enhanced airspeed awareness would also likely provide an additional safety margin against stall and loss of control events at low altitudes where recovery is difficult, as was the case in this accident.

The Safety Board recognizes that there are unresolved technical, operational, and human factors issues that will need to be carefully evaluated and addressed in connection with the design and implementation of a low-airspeed alert system.[92] The Board encourages the FAA to consult with representatives from NASA and other aviation industry specialists in resolving and addressing these issues. Despite these unresolved issues, the Safety Board concludes that the development of and requirement for the installation of low-airspeed alert systems could substantially reduce the number of accidents and incidents involving flight crew failure to maintain airspeed. Therefore, the Safety Board believes that the FAA should convene a panel of aircraft design, aviation operations, and aviation human factors specialists, including representatives from NASA, to determine whether a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 CFR Parts 121 and 135 would be feasible, and submit a report of the panel's findings. The Safety Board further recommends that if the requested panel determines that a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 CFR Parts 121 and 135 is feasible, the FAA should establish requirements for low-airspeed alert systems, based on the findings of this panel.

[92] Some of the issues that should be addressed include the following: defining the target speed at which the alert system would activate, effectively integrating such a system with other aircraft systems, preventing nuisance alarms and flight crew over-reliance on such a system (see, for example, A.R. Pritchett, "Reviewing the Role of Cockpit Alerting Systems," *Human Factors and Aerospace Safety* Vol. 1, No. 1 [2001]: 5-38), differentiating such an alert from other kinds of cockpit alerts and warnings, and developing flight crew procedures on and training for the use of such systems.

3. Conclusions

3.1 Findings

1. The flight crewmembers were properly certificated and had received the training for pilot certification prescribed by Federal regulations. No evidence indicated any preexisting medical or other physical condition that might have adversely affected the flight crew's performance during the accident flight. Fatigue most likely did not degrade the performance of either pilot on the day of the accident.

2. The accident airplane was properly certificated, equipped, and maintained in accordance with Federal regulations and approved company procedures. The recovered components showed no evidence of preexisting powerplant, system, or structural failures.

3. The weight and balance of the airplane were within limits for dispatch, takeoff, climb, cruise, and landing.

4. The flight crew failed to maintain an appropriate course and speed for the approach and did not properly configure the airplane at the start of the approach, making the later stages of the approach more difficult.

5. During the later stages of the approach, the flight crew failed to monitor the airplane's airspeed and allowed it to decrease to a dangerously low level (as low as about 50 knots below the company's recommended approach airspeed) and to remain below the recommended approach airspeed for about 50 seconds.

6. The flight crew failed to recognize that a stall was imminent and allowed the airplane to enter a stall from which they did not recover.

7. The inadequate airspeed or the full course deviation indicator needle deflection should have prompted the flight crew to execute a go-around; however, they failed to do so.

8. The flight crew was not adhering to Aviation Charter's approach procedures and was not effectively applying crew resource management techniques during the approach segment of the flight.

9. Clouds might have prevented the flight crew from seeing the airport.

10. Icing did not affect the airplane's performance during the descent.

11. The Duluth approach control south radar controller's instructions did not prevent the flight crew from intercepting the Eveleth-Virginia Municipal Airport VOR runway 27 final approach course at a sufficient distance to safely execute an approach and landing.

12. The out-of-tolerance condition and slight bends in the Eveleth-Virginia Municipal Airport VOR signal were not a factor in this accident.

13. Both pilots had previously demonstrated potentially serious performance deficiencies during flight operations consistent with below-average flight proficiency.

14. At the time of the accident, Aviation Charter was not operating in accordance with its weight and balance load manifest procedures, it did not have adequate stall recovery guidance, it did not have consistent deicer boot operational guidance, and it did not have an in-range checklist.

15. Aviation Charter was not adequately making company pilots aware of its Standard Operating Procedures.

16. At the time of the accident, Aviation Charter was not training its pilots on crew resource management (CRM) in accordance with its Federal Aviation Administration-approved CRM training module.

17. Although the Federal Aviation Administration's surveillance of Aviation Charter was in accordance with its standard guidelines, it was not sufficient to detect the discrepancies that existed at Aviation Charter.

18. En route inspections, combined with ground training, flight training, and proficiency check observations, are essential for ensuring adequate oversight of a company's operations and should be conducted on flights operated by 14 *Code of Federal Regulations* Part 135 on-demand charter operators.

19. The circumstances of the October 2002 Aviation Charter accident indicate that crew resource management training should be extended to include all 14 *Code of Federal Regulations* Part 135 on-demand charter operations that conduct dual-pilot operations regardless of whether the aircraft requires two or more pilots.

20. The development of and requirement for the installation of low-airspeed alert systems could substantially reduce the number of accidents and incidents involving flight crew failure to maintain airspeed.

3.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's failure to maintain adequate airspeed, which led to an aerodynamic stall from which they did not recover.

4. Recommendations

4.1 New Recommendations

As a result of its investigation of the October 25, 2002, Aviation Charter, Inc., accident, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Conduct en route inspections and observe ground training, flight training, and proficiency checks at all 14 *Code of Federal Regulations* Part 135 on-demand charter operations as is done at Part 121 operations and Part 135 commuter operations to ensure the adequacy, quality, and standardization of pilot training and flight operations. (A-03-51)
>
> Require that 14 *Code of Federal Regulations* (CFR) Part 135 on-demand charter operators that conduct dual-pilot operations establish and implement a Federal Aviation Administration-approved crew resource management training program for their flight crews in accordance with 14 CFR Part 121, subparts N and O. (A-03-52)
>
> Convene a panel of aircraft design, aviation operations, and aviation human factors specialists, including representatives from the National Aeronautics and Space Administration, to determine whether a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 *Code of Federal Regulations* Parts 121 and 135 would be feasible, and submit a report of the panel's findings. (A-03-53)
>
> If the panel requested in Safety Recommendation A-03-53 determines that a requirement for the installation of low-airspeed alert systems in airplanes engaged in commercial operations under 14 *Code of Federal Regulations* Parts 121 and 135 is feasible, establish requirements for low-airspeed alert systems, based on the findings of this panel. (A-03-54)

4.2 Previously Issued Recommendation Classified in This Report

The following previously issued recommendation is classified in this report:[93]

Safety Recommendation A-02-12 (previously classified "Open—Acceptable Response) is classified "Closed—Superseded."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

ELLEN G. ENGLEMAN
Chairman

MARK V. ROSENKER
Vice Chairman

CAROL J. CARMODY
Member

JOHN J. GOGLIA
Member

RICHARD F. HEALING
Member

Adopted: November 18, 2003

[93] For the text of this recommendation, see section 2.9.3.

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1. Appendix

Appendix A
Investigation and Public Hearing

Investigation

The National Transportation Safety Board learned about the accident about 1130 on October 25, 2002. A go-team was assembled, and it departed that same day and arrived on scene about 2045 that evening. Accompanying the team was Acting Chairman Carol J. Carmody and representatives from the Safety Board's Offices of Government, Public, and Family Affairs.

Parties to the investigation were the Federal Aviation Administration; Aviation Charter, Inc.; Raytheon Aircraft Company; and Hartzell Propeller, Inc. An accredited representative from the Transportation Safety Board of Canada and a technical advisor from Pratt & Whitney Canada also assisted in the investigation.

Public Hearing

No public hearing was held for this accident.