National Transportation Safety Board
Washington, D.C. 20594

Aircraft Accident Brief

Accident Number:	DCA01MA034
Operator:	Avjet Corporation
Aircraft and Registration:	Gulfstream III, N303GA
Location:	Aspen, Colorado
Date:	March 29, 2001

HISTORY OF FLIGHT

On March 29, 2001, about 1901:57 mountain standard time,[1] a Gulfstream III, N303GA, owned by Airbourne Charter, Inc., and operated by Avjet Corporation of Burbank, California, crashed while on final approach to runway 15 at Aspen-Pitkin County Airport (ASE), Aspen, Colorado. The charter flight had departed Los Angeles International Airport (LAX) about 1711 with 2 pilots, 1 flight attendant, and 15 passengers. The airplane crashed into sloping terrain about 2,400 feet short of the runway threshold. All of the passengers and crewmembers were killed, and the airplane was destroyed. The flight was being operated on an instrument flight rules (IFR) flight plan under 14 *Code of Federal Regulations* (CFR) Part 135.

The captain and first officer for the charter flight reported to the Avjet facility at the Burbank-Glendale Pasadena Airport (BUR), Burbank, California, sometime before 1300 (1200 Pacific standard time) on the day of the accident.[2] An Avjet captain stated, in a postaccident interview, that he saw the captain checking the ASE weather on a computer display and discussing the ASE weather with an Avjet charter department scheduler while at BUR. Another Avjet captain stated, in a postaccident interview, that he saw the first officer performing what appeared to be a routine airplane preflight inspection on N303GA on the ramp at BUR.

About 1200 (1100 Pacific standard time), the first officer contacted the Hawthorne, California, Automated Flight Service Station (AFSS) specialist for a weather briefing. A review of the audiotape indicated that the specialist informed the first officer of three National Weather Service (NWS) AIRMETs [Airman's Meteorological

[1] Unless otherwise indicated, all times are mountain standard time, based on a 24-hour clock.

[2] The exact times that the flight crewmembers reported for duty could not be determined because Avjet does not use sign-in sheets for its pilots. The time frame for crew check-in was based on information from postaccident interviews and, for the first officer, the time that he contacted the Hawthorne, California, Automated Flight Service Station for a weather briefing.

Information][3] pertinent to the flight to ASE, an 1141 weather observation for ASE, and the ASE forecast for 1300 to 1900.[4] The specialist also informed the first officer that the approach procedure had been updated and that circling minimums were no longer authorized at night.[5] During the briefing, the first officer filed the flight plan, identifying Garfield County Regional Airport in Rifle, Colorado, as the alternate airport.

The captain and first officer departed BUR at 1538 (1438 Pacific standard time) for a positioning flight to LAX, arriving there 11 minutes later. While at LAX, the captain and a charter department scheduler discussed the status of the passengers' arrivals (none were at the airport when the airplane arrived) and the weather currently being forecast for the flight's arrival time at ASE. Also, the captain and another Avjet captain discussed the nighttime landing restriction at ASE that required the airplane to land within 30 minutes after sunset.[6] ASE's nighttime airport operating hours, according to an airport chart dated November 1, 1994, indicated that aircraft that did not meet FAA stage III noise criteria were not authorized to land at the airport on March 29 after 1858.

The airplane's departure from LAX at 1711 (1611 Pacific standard time) was 41 minutes later than originally scheduled because of the late arrival of the passengers, including the charter customer. The flight was planned for 1 hour 35 minutes, so the estimated arrival time at ASE was 1846—12 minutes before the airport's nighttime landing curfew.

Statements early in the cockpit voice recorder (CVR) recording indicated that the flight crew was aware of the nighttime landing restriction at ASE. The CVR transcript indicated that, about 1831:06, the captain stated, "well, there's the edge of night right here." About 1831:24, the first officer asked the captain about the time of official sunset for ASE. The captain replied "six twenty eight" and then stated, "so we get thirty minutes after sunset. so six fifty eight…about…seven o'clock."

About 1837:04, the first officer called for the approach briefing.[7] The captain then stated, "we're…probably gonna make it a visual…if we don't get the airport over here we'll go ahead and shoot that approach" and "we're not going to have a bunch of extra gas so we only get to shoot it once and then we're going to Rifle."[8] The first officer

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[3] An AIRMET is an in-flight weather advisory issued by the NWS Aviation Weather Center in Kansas City, Missouri. An AIRMET advisory indicates weather that may be hazardous to single-engine and other light aircraft and visual flight rules (VFR) pilots. Operators of large aircraft may also be concerned with the information included in an AIRMET.

[4] For more information on this weather briefing, see the section of this brief titled, "Automated Flight Service Station Briefing," under the heading titled, "Meteorological Information."

[5] For more information on the updated approach procedure, see the section of this brief titled, "Notice to Airmen," under the heading titled, "Airport Information."

[6] ASE is closed from 2300 to 0700. Aircraft that do not meet FAA stage III noise criteria must land within 30 minutes after sunset because of local noise restrictions. N303GA was a stage II aircraft.

[7] According to Avjet's Operations Manual, the captain is required to conduct an approach briefing as part of the descent checklist. For more information on this briefing, see the section of this brief titled, "Flight Manual," under the heading titled, "Additional Information."

[8] N303GA's flight log indicated that, between March 26 and 29, 2001, the airplane was on the ramp at BUR with 4,000 pounds of fuel. The airplane received an additional 8,710 pounds of fuel before

acknowledged this information. About 1839:56, the flight crew began to receive automated terminal information service (ATIS) information Hotel.[9] Afterward, the first officer read back the wind, visibility, sky condition, and temperature information, and the captain acknowledged this information.

About 1844:22, the first officer made initial contact with ASE approach control. About 1844:43, the flight crew heard, over the ASE approach control frequency, the request of a Canadair Challenger 600 airplane, N527JA, for another approach to ASE. The approach controller then cleared N527JA to continue on the published missed approach procedure. About 1845:00, the first officer stated, "I hope he's doing practice approaches." About 3 seconds later, the captain asked the controller whether the pilot of N527JA was practicing or had actually missed the approach. The controller replied that the pilot had missed the approach and indicated that he had seen the airplane at 10,400 feet.[10] The controller also informed the captain that two other airplanes were on approach to ASE. About 1845:32, the controller instructed the flight crew to turn to a 360º heading for vectors for the approach sequence.

While the airplane was descending into the terminal area, the CVR recorded the flight crew discussing the location of a highway near the airport. About 1845:45, the captain stated, "where's that…highway? can we get down in there?" About 11 seconds later, the captain stated, "can you see?" and the first officer stated, "I'm looking I'm looking…no." About 1846:26, the captain indicated, "I got it," and, about 2 seconds later, he asked the first officer, "can't really see up there can ya?" The first officer replied, over the next several seconds, "nope not really" and "I see a river but I don't see nothing else." About 1847:19, the first officer stated, "I see…some towns over here and the highway's leading that way but I'm not sure."

About 1847:30, the approach controller made a blanket broadcast that the pilot of an airplane (a Cessna Citation, N900MF) saw the airport at 10,400 feet and was making a straight-in approach, to which the first officer stated, "ah, that's good." (This airplane landed without incident at the airport about 10 minutes before the accident.) About 1847:41, the captain informed the controller that, "I can almost see up the canyon from here but I don't know the terrain well enough or I'd take the visual." About 1847:51, the

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departing for LAX. A page from N303GA's flight log that was found in the wreckage indicated that, on March 29, the airplane landed at LAX with 10,700 pounds of fuel remaining. The airplane received an additional 1,750 pounds of fuel before departing for ASE. After the accident, Gulfstream generated sample flight plans that were based on the accident airplane's cruising altitude, historical winds, and known fuel quantity. The sample flight plans showed that the amount of fuel aboard the accident airplane would have exceeded the amount required by 14 CFR 135.223 (that is, IFR aircraft must carry enough fuel to complete the flight to the destination airport, a flight from the destination airport to the alternate airport, and 45 additional minutes of flight at normal cruising speed).

[9] ATIS information Hotel was based on the 1753 local weather observation and stated that the wind was from 030º at 4 knots, visibility was 10 miles, sky condition was scattered clouds at 2,000 feet with a ceiling of 5,500 feet broken and 9,000 feet broken, temperature was 2º C, dew point was -3º C, and altimeter setting was 29.86 inches of mercury (Hg). Visibility is expressed in statute miles; all other references to miles in this brief are expressed in nautical miles.

[10] Unless otherwise indicated, all altitudes are mean sea level (msl). According to air traffic control (ATC) radar data, N527JA did not descend below 10,300 feet.

first officer stated, "could do a contact[[11]] but…I don't know," followed by his statement, "probably we could not…." The first officer also stated, about 1848:04, "remember that crazy guy in this Lear[jet] when we were…on the ground in Aspen last time and he [stated that he could] see the airport but he couldn't see it." The captain did not respond to either of the first officer's statements.

About 1848:51, the captain stated, "there's the highway right there." The first officer then asked the captain if he wanted to be set up on the approach, and the captain indicated that he was ready. About 1849:28, the captain asked the first officer whether he could see the highway, to which the first officer replied, "no it's clouds over here on this area I don't see it." About 1850:42, the captain stated, "but it's right there." About 6 seconds later, he stated, "oh I mean we'll shoot it from here I mean we're here but we only get to do it once." About 1850:54, the captain indicated to the flight attendant that, if the attempt to execute the approach was not successful, they would have to go to Rifle because "it's too late in the evening then to come around."

About 1851:54, the approach controller instructed the flight crew to turn to a heading of 050º. About 1853:09, the approach controller instructed the flight crew to turn to a heading of 140º to intercept the final approach course and maintain an altitude of 16,000 feet. Afterward, the controller made a blanket broadcast that the last airplane (a Canadair Challenger 600, N898R) had missed the approach, to which the first officer remarked, "that's…not…good."

About 1853:57, the flight attendant asked whether a male passenger could sit on the jumpseat in the cockpit. About 11 seconds later, the flight attendant instructed that passenger to make sure his seatbelt was on, and the CVR recorded a sound consistent with a seatbelt buckle. About 1855:05, the flight crew heard, over the approach control frequency, the pilot of N898R transmit his intention to execute a missed approach. Afterward, the captain stated, "the weather's gone down they're not making it in," and an unidentified male voice in the cockpit stated, "oh really."[12] The approach controller subsequently cleared N898R to continue on the missed approach procedure.

About 1856:06, the approach controller cleared the flight crew for the VOR/DME-C approach,[13] advised the crew that the airplane was 5 miles from the Red

[11] A contact approach is a procedure in which an aircraft on an IFR flight plan proceeds to the destination airport by visual reference with the surface. ATC only authorizes this approach when requested by the pilot and when the reported ground visibility at the airport is at least 1 mile. The pilot must remain clear of clouds and have a reasonable expectation of continuing to the destination airport under this condition.

[12] According to 14 CFR 135.100, flight crewmembers cannot engage in any activity that could distract them from their duties or interfere in any way with the proper conduct of those duties once the airplane has descended below 10,000 feet msl, including engaging in nonessential conversations within the cockpit. N303GA was above that altitude at the time.

[13] The VOR/DME [very high frequency omnidirectional radio range/distance measuring equipment]-C approach is the only public use standard instrument approach procedure at ASE. The "C" part of the approach title indicates that the approach does not have straight-in landing minimums because it does not meet the criteria for the maximum descent gradient. This approach is also referred to as the VOR/DME or GPS-C procedure, which indicates that the approach procedure is included in approved

Table VOR (the initial approach fix), and instructed the crew to cross the VOR at or above an altitude of 14,000 feet. The first officer acknowledged this information. Figure 1 shows the ASE approach plate, dated February 18, 2000, that was in effect at the time of the accident.

About 1856:23, the first officer said, "after VOR you are cleared to twelve thousand seven hundred." About 1856:42, the approach controller made a blanket broadcast that ATIS information India[14] was current and that the visibility north of the airport was 2 miles.[15] The approach controller then instructed the flight crew to contact ASE local control, and the crew established contact with the local controller about 1857:28. The local controller informed the flight crewmembers that they were following a Challenger airplane (N527JA) that was 2 miles from the runway, reported the wind at 240º at 5 knots, and cleared the airplane to land on runway 15. About 1857:55, the first officer acknowledged the clearance to land. The captain then asked the first officer for the DME[16] at the 12,700-foot step-down fix. The first officer replied, 3 DME (south of the Red Table VOR).

About 1858:00, the local controller asked the pilot of N527JA whether he had the airport in sight, to which he replied, "negative, going around." About 1858:13, an unidentified male voice in the cockpit asked, "are we clear?" The captain replied, "not yet" and "the guy in front of us didn't make it either." About 1858:27, the captain asked the first officer about the next step-down altitude, and he answered that it was 12,200 feet. The first officer also indicated that the next step-down fix was at 6 DME (south of the Red Table VOR). (This step-down fix, ALLIX, is the final approach fix and the beginning of the final approach segment.) About 1859:11, the captain asked the first officer about the next step-down altitude, and the first officer answered, 10,400 feet.

About 1859:30, the captain called for the landing gear, and the CVR recorded the sound of two "clunks" and an increase in background noise immediately afterward. The captain called for landing flaps about 1859:34, and the CVR recorded a "click" and a "clunk" sound about 2 seconds later. About 1859:39, the first officer indicated that the step-down fix at 10,400 feet was 9.5 DME (south of the Red Table VOR). About 1859:46, the first officer stated, "three greens." About 1900:04, the first officer indicated that the missed approach point was 11 DME (south of the Red Table VOR). About 1900:08, an unidentified male voice in the cockpit stated, "snow." About 1900:22, when

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global positioning system (GPS) receiver databases. Minimum visibility is 3 statute miles for category C aircraft, such as the Gulfstream III. (Aircraft in category C have approach speeds of 121 knots or greater but less than 141 knots. These speeds are based on 1.3 times the power-off stall speed at the aircraft's maximum certificated landing weight in the landing configuration. According to Gulfstream Aerospace's GIII Flight Manual, the Gulfstream III has a stall speed of 106 knots in this configuration; 1.3 times this stall speed is 138 knots.)

[14] ATIS information India, which was mostly based on the 1853 local weather observation, indicated that the wind was from 250º at 3 knots, visibility was 10 miles in light snow, sky condition was a few clouds at 1,500 feet with a ceiling of 2,500 feet broken and 5,000 feet broken, temperature was 1º C, dew point was -3º C, and altimeter setting was 29.89 inches of Hg.

[15] The Safety Board notes that the 3-mile category C minimum visibility requirement was met because the controlling visibility for the approach was 10 miles, as reported in ATIS information India.

[16] DME is expressed in nautical miles.

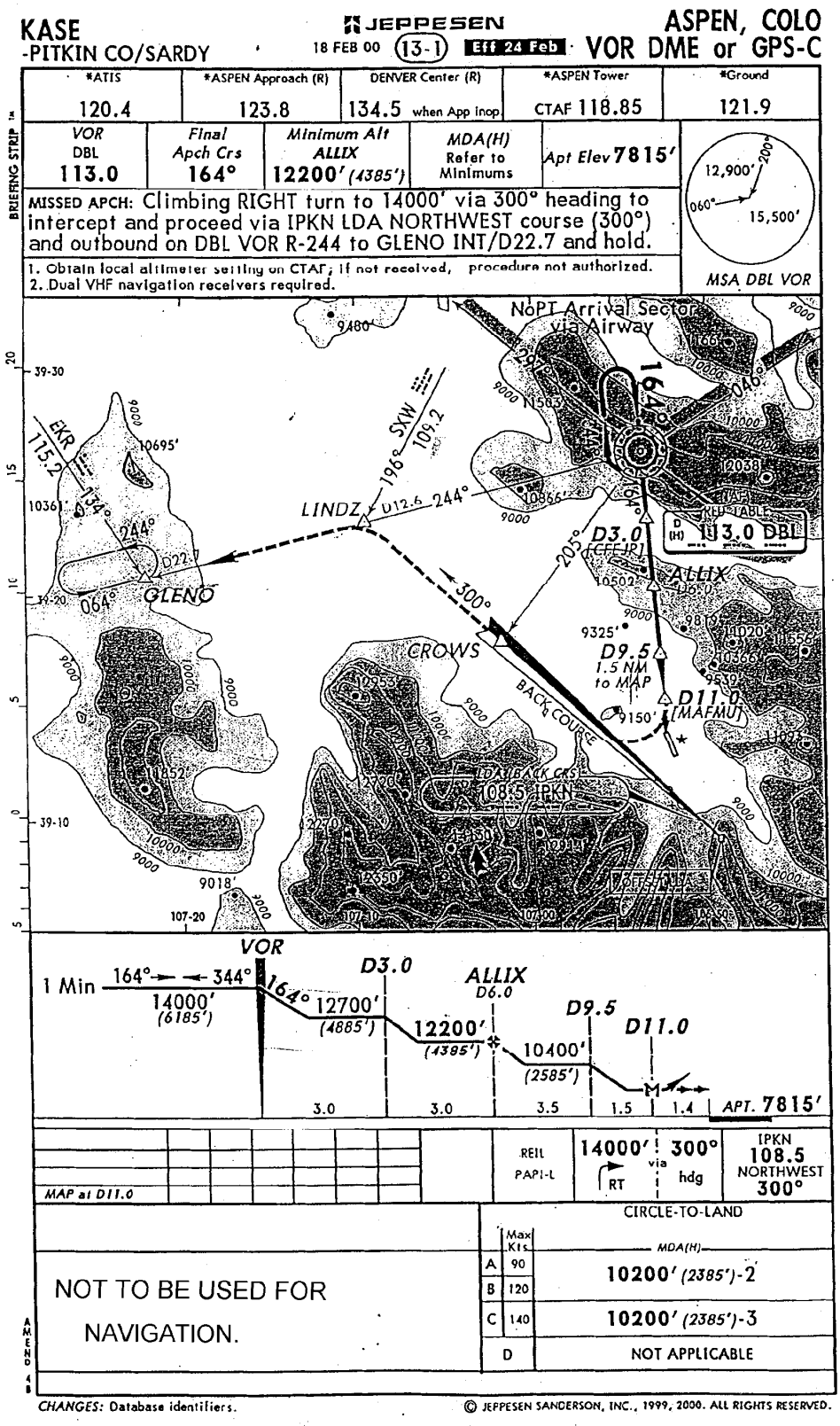

Figure 1. Jeppesen approach plate for ASE.

the airplane was at an altitude of 10,400 feet, the captain stated, "okay…I'm breaking out," and asked the local controller, about 5 seconds later, whether the runway lights were all the way up. The controller indicated, "affirmative they're on high." About 1900:30, the first officer said, "okay you can go…ten thousand two hundred [the minimum descent altitude]."[17]

About 1900:43, the captain asked the first officer whether he could see the runway, and the CVR recorded an unintelligible statement made by the first officer about 2 seconds later. About 1900:46, when the airplane was at an altitude of 10,000 feet, the captain asked the first officer whether he could see the highway, and he replied, about 1 second later, "see highway." The local controller asked the flight crewmembers, about 1900:49, whether they had the runway in sight. About 2 seconds later, the first officer stated, "affirmative," and the captain stated, "yes now yeah we do." About 1 second afterward, the first officer advised the controller that the runway was in sight. About 1901:13, the first officer stated, "…to the right is good." According to radar data, the airport was to the left of the airplane at this time.

About 1901:21, the CVR recorded a sound consistent with the airplane's configuration alarm, which continued for 9 seconds. About 1901:28, the CVR recorded the airplane's flight profile advisory (FPA) unit announce the 1,000-foot callout,[18] and the first officer stated, "one thousand to go." About 1901:31 and 1901:34, the CVR recorded the sound of the FPA's 900- and 800-foot callouts, respectively. About 1901:36, the captain stated, "where's it at?" The CVR recorded the FPA's 700- and 600-foot callouts about 1901:38 and 1901:42, respectively. About 1901:42, the first officer stated, "to the right," which the captain repeated about 1 second later. Radar data indicated that the airport was still to the left of the airplane at this point.

About 1901:45, the CVR recorded the airplane's GPWS and FPA unit simultaneously announce the 500-foot callout. According to radar data, the airplane started a turn to the left about 1901:47. About 1901:49, the GPWS announced a sink rate alert,[19] and the FPA announced the 400-foot callout. About 1901:52, the CVR again recorded a GPWS sink rate alert and the FPA 400-foot callout. Also, the CVR recorded a rumbling noise that continued until the end of the recording.[20] According to the CVR Sound Spectrum Study performed for this accident, the engines increased to maximum power about 1901:53. The FPA 300-foot callout was recorded about 1901:54, and the GPWS and FPA 200-foot callouts were recorded about 1 and 2 seconds later, respectively. About 1901:57, the CVR recorded the GPWS bank angle alert when the airplane was banked about 40º left wing down.[21]

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[17] This altitude is 2,385 feet above airport elevation.

[18] All FPA and ground proximity warning system (GPWS) altitude callouts are expressed as feet above ground level.

[19] The sink rate alert indicates a rate of descent that exceeds predetermined thresholds.

[20] For more information on this noise, see the section of this brief titled, "Cockpit Voice Recorder Sound Spectrum Study," under the heading titled, "Tests and Research."

[21] The bank angle alert occurs when the airplane enters a steep bank angle; the threshold for the alert ranges from 50º of bank at 190 feet above ground level to 15º of bank at ground level.

The airplane crashed into terrain while in a steep left bank about 2,400 feet short of the runway 15 threshold, 300 feet to the right (west) of the runway centerline and 100 feet above the runway threshold elevation.[22] The accident occurred at 39º 14.315 minutes north latitude and 106º 52.637 minutes west longitude. The time of the accident was 34 minutes after official sunset. The CVR stopped recording about 1901:58.

DAMAGE TO AIRPLANE

The airplane was destroyed by impact forces and, in isolated areas, postcrash fire. According to Avjet, the airplane was valued at $10 million.

PERSONNEL INFORMATION

The Captain

The captain, age 44, was hired by Avjet in October 2000. He held a Federal Aviation Administration (FAA) Airline Transport Pilot certificate and a first-class medical certificate dated October 16, 2000, with a limitation that required lenses to correct for near vision. The captain received his initial Gulfstream III type rating in January 1990.

According to Avjet employment records, the captain had accumulated 9,900 hours total flying time, including 7,900 hours as pilot-in-command and 1,475 hours in the Gulfstream III (175 of which were with Avjet as a pilot-in-command). He had flown approximately 87, 21, and 2 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. According to FAA records, the captain's last recurrent ground training occurred on November 9, 2000, and his last proficiency check occurred on December 8, 2000. FAA records also indicated no accident history[23] or enforcement action, and a search of the National Driver Register database indicated no record of driver's license suspension or revocation.

In a postaccident interview, the captain's fiancée indicated that he was in good health and was not taking any medications. She also indicated that he was a "light" smoker who was in the process of quitting and that he consumed alcoholic beverages occasionally. Further, the captain's fiancée stated that, on the morning of the accident, he awoke about 0700 (Pacific standard time) and that he had no sleeping difficulties.

According to the Avjet Director of Operations, the captain had been paired with the first officer for 5 months, and they had flown to ASE two times before the accident flight. These flights were reported to have occurred during daylight conditions.

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[22] The approach end of runway 15 is at an elevation of 7,674 feet, and its opposite end is at an elevation of 7,815 feet, which gives the runway an upward slope.

[23] FAA records indicated that the captain had been involved in an incident on January 20, 1999. The captain was landing a Gulfstream 1159-series airplane at Chino, California, but the airplane departed the end of the runway and went 150 feet into the paved overrun area. No action was taken against the captain.

The First Officer

The first officer, age 38, was hired by Avjet in November 2000. He held an FAA Airline Transport Pilot certificate and a first-class medical certificate dated December 8, 2000, with no limitations. He received his initial Gulfstream III type rating on February 9, 2001.

According to Avjet employment records, the first officer had accumulated 5,500 hours total flying time, including 4,612 hours as pilot-in-command and 913 hours in the Gulfstream II and III (110 of which were with Avjet as a Gulfstream III second-in-command). He had flown approximately 49, 10, and 2 hours in the 90 days, 30 days, and 24 hours, respectively, before the accident. According to FAA records, the first officer's initial ground training occurred on November 9, 2000, and his last proficiency check occurred on February 9, 2001.[24] FAA records also indicated no accident or incident history or enforcement action, and a search of the National Driver Register database indicated no record of driver's license suspension or revocation.

In a postaccident interview, the first officer's wife indicated that he was in good health and was not taking any medications. She also indicated that he was a nonsmoker and consumed alcoholic beverages infrequently. Further, the first officer's wife stated that, on the night before the accident, he went to sleep about 2330 (Pacific standard time) and that, on the morning of the accident, he awoke about 0745 (Pacific standard time).

AIRPLANE INFORMATION

The accident airplane, serial number 303, was manufactured in 1980 by Gulfstream Aerospace Corporation and was issued an Export Airworthiness Certificate and Ivory Coast registration number TU-VAF. The airplane's records indicated that it had been substantially damaged in Africa in 1988,[25] shipped to the manufacturer for repairs, and placed back in service in October 1989 with a U.S. airworthiness certificate and registration number N1716W. In April 1990, Gulfstream sold the airplane to Airbourne Charter, Inc., which changed the registration number to N303GA. At the time of the accident, the airplane had accumulated 7,266 flight hours and 3,507 cycles.[26]

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[24] FAA records for the first officer indicated the following information: On June 2, 1993, the first officer failed his first check ride for an instrument rating in the areas of ATC and navigation systems; he passed his second check ride the next day. On June 27, 1994, the first officer failed his first check ride for a flight instructor rating in the areas of ground reference maneuvers and approach and landing; he passed his second check ride on June 30, 1994. On May 24, 1998, the first officer failed his first check ride for an Airline Transport Pilot certificate in the area of VOR and circling approaches; he passed his second check ride on June 13, 1998. On March 25, 1999, the first officer was performing a GIII simulator competency check ride, during which time it was determined that he needed additional training to gain proficiency in normal takeoff, takeoff with engine failure, and nonprecision approaches.

[25] According to Gulfstream, the airplane's landing gear was torn off and its wings were damaged after landing on a closed runway and going through a ditch.

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

The airplane was equipped with two Rolls-Royce Spey MK 511-8 turbofan engines. These two-shaft engines have a 5-stage low-pressure compressor driven by a 2-stage low-pressure turbine and a 12-stage high-pressure compressor driven by a 2-stage high-pressure turbine. The left engine, serial number 11005, had a time since new of 7,116 hours (3,499 cycles). The right engine, serial number 11006, had a time since new of 7,563 hours (3,822 cycles). Both engines had a time since overhaul (in December 1995) of 2,368 hours (2,572 cycles). The airplane was also equipped with a Garrett Model GTCP36-100 auxiliary power unit, which had accumulated 3,942 hours time since new.

The airplane was equipped with a Collins FPA-80 unit. The FPA unit was designed to announce radio altitudes every 100 feet between 1,000 and 100 feet above the ground and deviations from a selected altitude. The airplane was also equipped with an AlliedSignal Mark VI GPWS computer. The GPWS was designed to announce the 500- and 200-foot radio altitude callouts and alerts for excessive descent rate, excessive closure rate to terrain, insufficient terrain clearance, and excessive bank angle. The CVR indicated that the FPA and the GPWS provided overlapping callouts at the 500- and 200-foot altitudes.

Maintenance Records

The airplane was maintained in accordance with an FAA-approved program that consisted of four regularly scheduled operations inspections. Operations inspection number 1 was to be accomplished every 150 flight hours; it was last accomplished when the accident airplane had accumulated 7,176 flight hours (90 flight hours before the time of the accident). Operations inspection number 2 was to be accomplished every 12 months; it was last accomplished on the accident airplane on March 23, 2001. Operations inspections numbers 3 and 4 were to be accomplished every 24 months; they were last accomplished on the accident airplane on February 11, 2000, and March 23, 2001, respectively. A review of the scheduled maintenance items revealed that no inspections were overdue.

The airplane's maintenance records for scheduled maintenance for January through March 2001 and unscheduled maintenance for March 2001 showed no discrepancies. The maintenance records also showed that all of the airplane's applicable FAA airworthiness directives had been accomplished.

The airplane's interior was refurbished on March 24, 2001. According to the maintenance records, the airplane's weight and balance and center of gravity were recalculated and found to be within limits.

METEROLOGICAL INFORMATION

Weather observations at ASE are made by an Automated Surface Observing System (ASOS), which is maintained by the NWS. The ASOS anemometers are located east of the approach end of runway 15. The ASOS continuously measures wind,

visibility, precipitation and obstructions to vision, cloud height, sky cover, dew point, and altimeter setting. The measurements are backed up and augmented by air traffic controllers who have been certified in weather observation. These controllers can provide observations for any other operationally significant information. The controllers can also override the automated mode if it malfunctions or provides unrepresentative values.

The ASOS transmits an official Meteorological Aerodrome Report (known as a METAR) about 53 minutes past each hour and a special weather observation (known as a SPECI) as conditions warrant. The ASOS hourly observations for 1753:26 and 1853:26 were the source for ATIS information Hotel and India, respectively (see the History of Flight section).[27] The ASOS transmitted a SPECI at 1912:26 (10 ½ minutes after the accident), indicating that the visibility had decreased to 1 ¾ miles in light snow. At 1920:26 (18 ½ minutes after the accident), the ASOS transmitted another SPECI, indicating that the visibility had increased to 3 miles in light snow and mist. The ASOS 5-minute observations surrounding the time of the accident (1900:31 and 1905:31) indicated that the visibility was 9 and 6 miles in light snow, respectively. The ASOS 1-minute visibility value about the time of the accident was 8 miles. In addition, at 1902 the ASOS reported that the wind was 277º at 1 knot.

Weather observations at the airport at Rifle (the alternate destination airport) are also made by an ASOS—but only in the automated mode. The ASOS observation for 1853 indicated that the wind was from 190º at 5 knots, sky condition was clear at or below 12,000 feet, visibility was 10 miles, temperature was 4º C, dew point was 2º C, and altimeter setting was 29.86 inches of Hg.

The NWS office in Grand Junction, Colorado, operates a Weather Surveillance Radar 1988 Doppler (WSR-88D) system. The WSR-88D's 0.5º elevation angle at 1857 and 1902 showed weak weather radar echoes at or near the Red Table VOR and along the accident airplane's flight track from about 8 to 4 miles from the approach end of runway 15. These images also indicated that the weak weather echoes in the airport area were moving to the southeast.

Two AIRMETs were issued by the NWS Aviation Weather Center on March 29, 2001, at 1345 and were valid until 2000 for an area that included ASE. One AIRMET indicated the following: "mountains occasionally obscured in clouds and precipitation." The other AIRMET warned of "occasional moderate rime or mixed icing in cloud and in precipitation above the freezing level to FL [flight level] 180."

In addition, the NWS Aviation Weather Center issued an area forecast for Colorado (mountains and west section) on March 29, 2001, at 1345 that was valid until March 30, 2001, at 0200. The area forecast indicated the following:

[27] The 1753:26 METAR indicated that a trace of precipitation (less than 0.01 inch) had been recorded since the time of the preceding hourly observation. The 1853:26 METAR indicated that snow had begun at 1851 and that a trace of precipitation had been recorded since the time of the preceding hourly observation.

> Clouds 8,000 to 10,000 broken to overcast. Tops to FL 180. Broken cirrus. Widely scattered light rain and snow showers. Isolated thunderstorms, light rain, lowering ceilings/visibilities 1,500 feet overcast to 2,500 feet overcast with visibility 3 to 5 miles. Becoming March 29, 2001 at 2000 to March 30, 2001 at 0200, isolated light rain and snow showers. Cumulonimbus tops to FL 310.

Automated Flight Service Station Briefing

Three NWS AIRMETs pertinent to the flight to ASE were provided to the first officer during the AFSS weather briefing. These AIRMETs were issued on the day of the accident at 0745 and were valid until 1400. One AIRMET warned of "occasional moderate turbulence below 15,000 feet. Another AIRMET warned of "occasional moderate rime or mixed icing in cloud and in precipitation above the freezing level to FL 180." The last AIRMET indicated the following: "mountains occasionally obscured in clouds and precipitation."

The 1141 ASE weather observation indicated that the wind was variable at 3 knots; visibility was 7 miles in light snow; sky condition was a few clouds at 1,100 feet, scattered clouds at 1,600 feet, and a ceiling of 3,000 feet overcast; temperature was 1º C; dew point was -2º C; and altimeter setting was 29.85 inches of Hg. The AFSS specialist informed the first officer that the visibility reported in this observation had recently increased from 1 mile in heavier snow showers.

The ASE forecast for 1300 to 1900 indicated that the wind was 330º at 10 knots, visibility was greater than 6 miles with showers in the vicinity, and sky condition was scattered clouds at 3,000 feet with a ceiling of 5,000 feet broken. This forecast also included a report of temporary conditions (known as a TEMPO), indicating that the wind was variable at 10 knots with gusts to 15 knots, visibility was 3 miles in light snow showers, and sky condition was a ceiling of 2,500 feet broken and 5,000 feet overcast.

AIRPORT INFORMATION

ASE, also known as Sardy Field, is owned and operated by Pitkin County, Colorado. The airport is located about 3 miles northwest of the city of Aspen at an elevation of 7,815 feet msl and is surrounded on all sides by high terrain. The airport has only one runway, 15/33. Figure 2 shows the final approach course to runway 15 and the surrounding terrain.

Runway 15/33 is constructed of asphalt with a porous friction course overlay. The runway is 7,006 feet long and 100 feet wide and is equipped with medium intensity runway lights (MIRL) and threshold lights. Runway end identifier lights (REIL) are installed at the threshold of runway 15.[28] Also, runway 15 is painted with nonprecision

[28] The three intensity settings for the MIRL and REIL are controlled in the tower by a single switch. The ASE air traffic control tower's (ATCT) standard operating procedure manual indicates that the lights are to be operated in accordance with FAA Order 7110.65, "Air Traffic Control." Paragraph 3-4-1-3

instrument runway markings and is equipped with a precision approach path indicator system for visual glideslope guidance.

The airport is certified by the FAA as an aircraft rescue and fire fighting (ARFF) index B facility.[29] ASE has one four-wheel-drive ARFF vehicle (radio call sign "ARFF 699") with the capacity to carry 1,500 gallons of water and 205 gallons of aqueous film forming foam (AFFF). It also carries 500 pounds of Purple-K dry chemical fire-fighting agent.

The most recent FAA annual airport certification inspection before the accident occurred on July 26 and 27, 2000. The most recent triennial full-scale disaster drill was held on September 23, 2000.

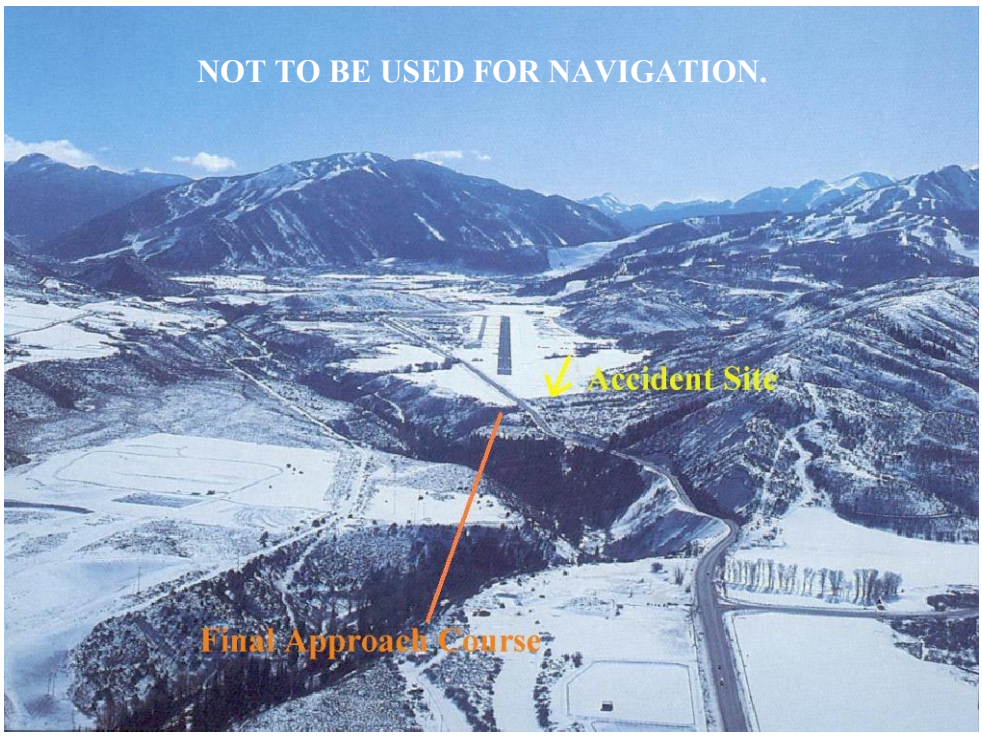

Figure 2. Airborne view of runway 15.

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of the FAA order states that the MIRL should be set at step 3 (the highest intensity) when visibility is less than 2 miles or when the pilot requests this setting.

[29] According to 14 CFR 139.315, the index determination of an airport is derived from the number of daily departures of aircraft of a certain size. Because ASE has an average of five or more daily departures of air carrier aircraft that are at least 90 feet but less than 126 feet in length, the airport meets the criteria for an index B facility. Title 14 CFR 139.317 requires index B facilities to have one or two ARFF vehicles carrying a combined minimum of 1,500 gallons of water and AFFF, and one of these vehicles is required to carry a minimum of 500 pounds of sodium-based dry chemical or halon 1211.

Instrument Approach Procedure

According to FAA file information, the VOR/DME-C instrument approach does not include straight-in minimums because of excessive descent gradients. However, the approach does meet the FAA's straight-in alignment criteria.

Change 17 to FAA Order 8260.3B, "Terminal and Enroute Procedures" (also known as TERPS), states that, to establish straight-in minimums, the final approach course must be aligned within 30º of the runway extended centerline and intercept it no more than 3,000 feet from the threshold. ASE's final approach course for runway 15 is aligned within 16º of the runway extended centerline and intercepts it 2,912 feet from the threshold. However, TERPS paragraph 252 indicates that, for straight-in minimums, the maximum gradient between the final approach fix minimum altitude and the runway threshold crossing height must be no more than 400 feet per mile and that, if this value is exceeded, only circling minimums may be established regardless of the course alignment. The descent gradient between ALLIX (the final approach fix at an altitude of 12,200 feet) and the threshold crossing height at the end of runway 15 (55 feet above ground level, or 7,729 feet msl) is 700 feet per mile. Thus, straight-in minimums cannot be included as part of the instrument approach procedure.

The FAA's Aeronautical Information Manual, paragraph 5-4-18d, states the following:

> The fact that a straight-in minimum is not published does not preclude pilots from landing straight-in if they have the active runway in sight and have sufficient time to make a normal approach for landing. Under such conditions and when ATC [air traffic control] has cleared them for landing on that runway, pilots are not expected to circle even though only circling minimums are published. If they decide to circle, they should advise ATC.

Notice to Airmen

On March 21, 2001, a flight inspection crew from the FAA's Oklahoma City, Oklahoma, Flight Inspection Field Office performed a commissioning flight check at ASE to support a proposed GPS standard instrument approach procedure to runway 15. After the inspection, the flight inspection crew noted, on the procedural control form, that circling should not be allowed at night[30] because areas of unlighted terrain conflicted with traffic patterns and circling descent maneuvers near the airport. Afterward, the flight inspection crew provided its comments to FAA staff at the National Flight Procedures Office in Oklahoma City.

The National Flight Procedures Office decided to add a restriction on nighttime operations to the VOR/DME-C procedure and issued a permanent Notice to Airmen

[30] When the ASE VOR/DME-C approach was first established in December 1988, the procedure was not authorized at night. According to postaccident interviews with staff from the FAA's Flight Standards Service, the night restriction on the approach was removed in October 1994 because of complaints from user groups.

(NOTAM) that stated, "circling NA [not authorized] at night." According to FAA flight procedures specialists, the NOTAM eliminated all circling minimums at night and therefore implied that the entire procedure was not authorized because no straight-in minimums are published.[31] The NOTAM was sent to the U.S. NOTAM Office in Herndon, Virginia; the National Flight Data Center in Washington, D.C.; and the Seattle, Washington, Flight Procedures Office on March 27, 2001. The Denver Air Route Traffic Control Center (ARTCC) Flight Data Communications position received the NOTAM the same day. The specialist at this position was responsible for distributing NOTAMs to affected ARTCC sectors and associated towers and facilities, including the ASE ATCT. The Denver ARTCC specialist did not send this particular NOTAM to the ASE ATCT (because of human error), but the NOTAM was received at the Hawthorne, California, AFSS and was included in the first officer's preflight briefing.

After the accident, the FAA became concerned about potential pilot confusion regarding the wording of the NOTAM issued on March 27, 2001. Specifically, the FAA was concerned that pilots might infer that straight-in landings to runway 15 were authorized at night. As a result, a revised NOTAM was issued on March 30, 2001, which stated, "procedure NA at night."

Title 14 CFR 1.1 defines "night" as "the time between the end of evening civil twilight and the beginning of morning civil twilight." The U.S. Naval Observatory explains "evening civil twilight" as follows: "to end in the evening when the center of the Sun is geometrically 6 degrees below the horizon. This is the limit at which twilight illumination is sufficient, under good weather conditions, for terrestrial objects to be clearly distinguished…. Complete darkness, however…begins sometime after the end of evening civil twilight." On the night of the accident, evening civil twilight officially ended at ASE at 1855, 27 minutes after sunset and about 7 minutes before the accident.

Air Traffic Control Tower Information

The ASE ATCT is a combined tower cab and terminal radar approach control (TRACON). The ATCT is located about 2,500 feet southeast of the approach end of runway 15.

The ATCT is equipped with a BI-5 beacon radar system (also known as secondary radar); transponder equipment on board aircraft actively replies to signals from the ground station with a four-digit code. (No primary radar coverage is available.) The beacon interrogator is located about 2,000 feet west of the approach end of runway 15. Coverage exists out to about 50 miles from the airport, but low-altitude coverage is masked in many areas because of the high terrain. The beacon information is processed by an Automated Radar Terminal Systems 2E system and is displayed on two Digital Bright Radar Indicator Tower Equipment units in the tower. A Minimum Safe Altitude

[31] FAA Order 8260.19C, "Flight Procedures and Airspace," paragraph 226b, states that the NOTAM text should use "plain language" and that "specialists must keep in mind that the NOTAM is directed to the pilot, and should be worded so that the intended change will not be misinterpreted."

Warning System is not installed at the ATCT because of the high number of false alarms that would be created by the high terrain surrounding ASE.

The ATCT operates between 0700 and 2300 each day, corresponding with the airport's hours of operation. The Denver ARTCC assumes responsibility for ATC services for the airspace surrounding ASE during the time that the ATCT and airport are not in operation.

The air traffic controllers are trained to closely monitor the progress of airplanes executing the VOR/DME-C approach. The training concentrates on ensuring that the controllers pay close attention to an airplane's proximity to the required minimum step-down fix altitudes published in the approach procedure. Controllers are trained to advise pilots immediately when they see an aircraft pass below a required step-down minimum altitude. In postaccident interviews, controllers at the ATCT indicated that, when they observe an airplane's altitude about 200 feet lower than the published altitude (to account for altimeter or transponder error), they ask the pilot whether the runway is in sight. If the pilot does not report the runway in sight, the controller issues a low-altitude alert and may issue missed approach instructions.

Four controllers were on duty on the night of the accident—the local controller, the radar approach controller, a ground controller, and a controller-in-charge. The local controller was certified in all positions except radar approach control. (She was in training for that position.) She began her ATC career in 1981 at Elmendorf Air Force Base in Alaska and started work with the FAA in March 1986 as an air traffic assistant at the ATCT at Anchorage International Airport, Alaska. Between 1990 and 1997, she worked at various flight service stations in Alaska and, in October 1997, began working at the Denver Flight Service Station. She started as a terminal controller at ASE in August 1999.

During a postaccident interview, the local controller stated that her first interaction with N303GA was when one of its pilots reported on frequency. (She indicated that the airplane was near the Red Table VOR about that time.) The local controller also stated that, after clearing the airplane to land, she saw it descend below a step-down altitude. (Radar data indicated that this altitude was 10,400 feet). During the exchange with the pilots regarding whether they had the runway in sight, the local controller was not able to see the airplane. About 1 minute later, she saw the airplane "come out of the snow, pointed at Shale [Bluffs]." (Shale Bluffs is located northwest of ASE and the runway.) The local controller said that the airplane appeared low and to the right of the centerline. She indicated that the pilot then apparently "got the runway and turned toward it." She noted that the airplane looked as if it were accelerating, with its lights pointed directly at the tower, and that the airplane was rolling rapidly to its left. The local controller thought the airplane was going to crash and immediately reached for the crash phone. As she saw the explosion, she immediately hit the emergency siren switch to alert ARFF.

FLIGHT RECORDERS

The accident airplane was equipped with a Fairchild A100A CVR, serial number 54667. The exterior CVR case was slightly dented but was intact. The crash-survivable interior box did not appear to have sustained any structural damage, but the tape assembly unit within it had detached. The tape was contained on its spool and was intact. The CVR exterior, interior, and tape did not exhibit heat or fire damage.

The CVR was sent to the Safety Board's audio laboratory in Washington, D.C., for readout and evaluation. The CVR recording started about 1830:18 and continued until 1901:58. A transcript was prepared for the entire 31-minute 40-second recording. The recording consisted of three channels of "good quality" audio information.[32] The three channels contained the captain's audio panel information, the cockpit area microphone (CAM), and the first officer's audio panel information.

The airplane was not equipped with a flight data recorder. Title 14 CFR Parts 91 and 135 did not require the airplane to be so equipped.

WRECKAGE AND IMPACT INFORMATION

A ground scar indicated that the left wing tip made the initial impact with the terrain. Measurements obtained from tree strikes near the ground scar showed that the airplane initially impacted terrain in a 49º left-wing-down attitude, with a flightpath angle of -15º. The ground scar was about 72 feet long.

Airplane debris was spread over a 300-foot-long path that began at the initial impact point, continued through a 40-foot ravine, and ended with the airplane's tail section.[33] The debris path followed a 147º heading. The impact subjected the airplane to severe accordion-type crushing, causing components to separate and structure to fracture. The fuselage was destroyed by impact forces.

The left wing was fractured about 9 feet from the wingtip. The left wing was also fractured from the separated tip inboard to the main portion of the wing box, but the wing was intact from the fractured tip to the wing box. The right wing was fractured about 30 feet inboard from the wing tip. About 12 feet of the right wing and its inboard wing root were attached to the wing box. Both airplane flaps were separated from the wing in the full-down (39º) position.[34] Both ailerons had separated from the wing.[35]

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[32] The Safety Board ranks the quality of CVR recordings in five categories: excellent, good, fair, poor, and unusable. For a recording to be considered good quality, most of the crew conversations need to be accurately and easily understood. The transcript developed from the recording might indicate several words or phrases that were not intelligible; such losses are attributed to minor technical deficiencies or momentary dropouts in the recording system or simultaneous cockpit/radio transmissions that obscure one another.

[33] The location of the main wreckage was 39º 14.278 minutes north latitude and 106º 52.621 minutes west longitude.

[34] The Gulfstream III has one single-slotted trailing flap on each wing. Each flap can be moved to one of four positions: 0º (up), 10º (takeoff), 20º (approach), and 39º (down).

The airplane's left and right engines had separated from their pylons, and neither engine showed any signs of any uncontainments or fires. The fan and compressor blades were bent opposite the direction of rotation of the compressor rotor. The second-stage low-pressure turbine blades and second-stage low-pressure turbine nozzles were all intact and undamaged with metal spray on the blades and nozzles.

The horizontal stabilizer remained attached to the vertical stabilizer and was in an approximately 6º leading-edge-down position.[36] Both elevators were attached to the horizontal stabilizer, and the rudder was attached to the vertical stabilizer. The trailing edges of the elevators and rudder sustained minor damage.

The left and right main landing gear were mostly undamaged and were found in their wheel wells. The nose gear fractured in two places: the shock strut piston fractured below the steering unit, and the steering shock strut cylinder fractured near the upper trunnion attachment point. The landing gear handle was not located. The landing gear handle knob, which contains lights that illuminate when the landing gear is in transit, was located. However, examination by the Safety Board did not provide conclusive evidence whether the lights were illuminated at the time of impact.

MEDICAL AND PATHOLOGICAL INFORMATION

Fluid specimens from the captain and the first officer were sent to the FAA's Civil Aerospace Medical Institute in Oklahoma City, Oklahoma, for toxicological analysis. The specimens tested negative for major drugs of abuse and prescription and over-the-counter medications. The specimens also tested negative for ethanol.

SURVIVAL ASPECTS

Autopsy results for the captain, first officer, and flight attendant indicated that all died from multiple blunt force injuries. According to the Pitkin County Coroner, the cause of death for all of the passengers was massive blunt force trauma.

EMERGENCY RESPONSE

As previously stated, the local controller indicated that she immediately reached for the crash phone as she saw the airplane roll to the left and that she hit the emergency siren switch after she saw the explosion. The crash phone simultaneously connects the ATCT with the ARFF communications center, the airport operations office, and the Aspen-Pitkin County Communications Center. The emergency siren is located atop the ARFF building and is activated by a toggle switch in the tower cab.

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[35] The Gulfstream III has one aileron on each wing located just outboard of the flap.

[36] The Gulfstream III's horizontal stabilizer moves only as a function of flap position. With the flaps in the full-down position, the horizontal stabilizer moves to 6º leading edge down (±¼º).

According to a timed audiotape from the Aspen-Pitkin County Communications Center, the initial Alert 3 notification[37] was received from the tower cab at 1901:53.[38] The audiotape also indicated that a radio call from the dispatch office to all Aspen fire and ambulance units (including ARFF 699) occurred at 1903:41.

The ARFF crew chief at the time of the accident stated that she immediately departed the station in ARFF 699 and proceeded toward the standard staging site. An off-duty airport firefighter, who was working in the main terminal building when the alarm sounded, was also aboard ARFF 699. About 1903:28, the crew chief contacted the ATCT ground controller, asking for emergency information. She was provided with the Alert 3 status, the airplane type and registration number, and an approximate location of the accident site (the Shale Bluffs area). About 1904:22, the crew chief stated, "ARFF 699, roger, we will respond." The crew chief proceeded to a perimeter gate, rather than continuing to the staging area, after learning that the accident site was north of the airport area.

The on-duty ASE Airport Operations Officer was in the ARFF station when the crash alarm sounded. He followed ARFF 699 in a separate airport vehicle. About 1904:57, the on-duty airport operations officer radioed that ARFF 699 should "stand down" because the accident site, although on airport property, was outside of the airport operations area (the portion of the airport that is contained within the perimeter fencing and considered a controlled access area).[39] The crew chief stated that she then asked the on-duty airport operations officer to call the ASE Director of Aviation for authorization for ARFF 699 to leave the airport. She reported that, about 3 minutes later, ARFF 699 received clearance to proceed to the accident site.[40]

The Aspen Fire Protection District maintains a four-wheel-drive vehicle (radio call sign "Tender One") at the airport with a capacity to carry 3,000 gallons of water and 30 gallons of AFFF. The vehicle is staffed by members of the all-volunteer force. Two Aspen volunteer firefighters staffed Tender One on the night of the accident. The ASE Airside Operations Supervisor/Fire Chief stated that the second firefighter aboard ARFF 699 reported that he observed Tender One traveling toward the accident scene at the time that ARFF 699 was awaiting permission to leave the airport. About 1908:28, ARFF 699 radioed ATCT ground control, stating that the vehicle was off the airport. When ARFF 699 arrived at the accident site, Tender One was the only other fire truck on scene.

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[37] "Alert 3" indicates that an aircraft has been or is expected to be involved in an accident near or on the airport. It is the most serious of the three alert categories.

[38] The times in this section could not be correlated with ATC and CVR transcript times and radar data information.

[39] The ASE Airside Operations Supervisor/Fire Chief stated that ARFF crews had been trained to respond to off-airport emergencies but that, about October 2000, the Pitkin County Sheriff's Office notified airport officials that the airport had no jurisdiction beyond the airport perimeter. As a result, the airport began instructing ARFF crews that they were not to leave the airport without first receiving permission from the airport director.

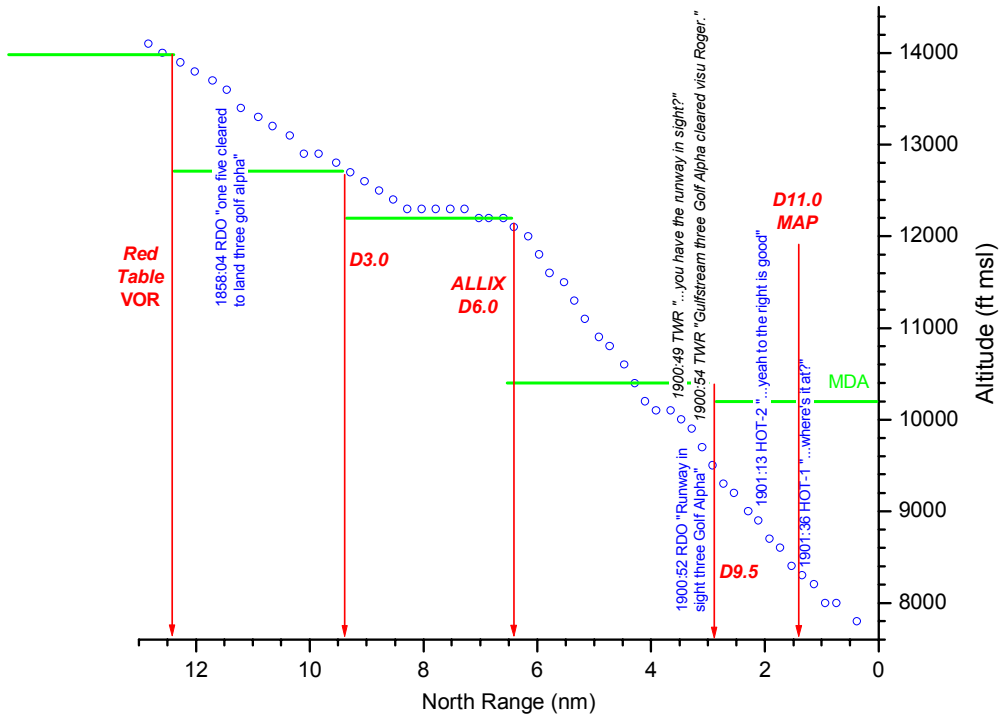
[40] On April 5, 2001, the ARFF Fire Chief issued a memorandum to all ARFF staff. The memorandum stated that, "effective immediately, ARFF 699 may leave the Airport Operations Area for downed aircraft emergencies at the discretion of the Crew Chief, with permission of the on-duty Operations Officer (Airport Director approval is not required)."

The fire was extinguished about 10 minutes after ARFF 699 arrived on scene. According to Aspen Fire Protection District records and Aspen-Pitkin County Communications Center transcripts, 5 fire-fighting units, 2 rescue vehicles, 1 jeep, at least 2 medical units, and 30 Aspen Fire Protection District personnel responded to the accident.

TESTS AND RESEARCH

Airplane Performance Study

The Safety Board conducted an airplane performance study to develop the time history of the airplane's motion and to calculate various performance and orientation parameters. To perform the study, several sources of information were used, including information from the CVR and ATC transcripts, Airport Surveillance Radar (ASR) radar data from the ASE TRACON, National Track Analysis Program (NTAP) radar data from the Denver ARTCC, aerodynamic data from the airplane's manufacturer, and upper-level wind data from Grand Junction (located about 77 miles west of the accident site). The times for the ASR and NTAP data and the CVR and ATC transcript information were correlated. Figure 3 shows a profile view of the airplane's approach to ASE.



RDO, radio communication transmitted to and from N303GA; TWR, radio transmission from ASE local controller; HOT-2, first officer's audio panel information; MAP, missed approach point; HOT-1, captain's audio panel information; MDA, minimum descent altitude.

Figure 3. Profile view of N303GA's approach to ASE.

According to the study, N303GA crossed the Red Table VOR (the initial approach fix) about 1857:49 at an altitude of 14,000 feet, a magnetic heading of 168º, and an airspeed of about 160 knots.[41] The airplane crossed the step-down fix located 3 DME south of the Red Table VOR about 1858:40 at an altitude of 12,700 feet and an airspeed of about 150 knots. About 1859:00, the airplane started to level off near 12,200 feet, and the airplane's speed decreased to approximately 125 knots by about 1859:30. About 10 seconds later, the airplane crossed ALLIX (the final approach fix) at an altitude of 12,100 feet (about 100 feet below the minimum altitude for ALLIX).

After passing ALLIX, N303GA maintained a descent rate of about 2,200 feet per minute and an airspeed of about 125 knots. (The reference airspeed for landing [V_{ref}] for the airplane's weight was 123 knots indicated airspeed.) The airplane leveled off at an altitude of 10,100 feet (about 300 feet below the minimum specified altitude for the 9.5 DME step-down fix) about 1900:39 but began to descend again about 10 seconds later. At that point, the airplane's heading increased about 15º as the airplane turned slightly to the right. (About that time, the CVR recorded the exchange between the controller and the flight crewmembers regarding whether they had the runway in sight.)

The airplane continued its descent at a rate of about 2,200 feet per minute and an airspeed of about 125 knots. The airplane passed the step-down fix located 9.5 DME south of the Red Table VOR about 1901:00 at an altitude of 9,500 feet (900 feet below the minimum specified altitude). About 1901:13, the airplane's heading started to decrease slightly while the airplane was at an altitude of 9,000 feet. (At this time, the CVR recorded the first officer's comment, "…to the right is good.") Radar data showed that, at this time, the airport was to the left of the airplane.

The FPA's 1,000-foot callout (about 1901:28) occurred when the airplane was at an altitude of 8,600 feet. At the time of the FPA's 800-foot callout (about 6 seconds later), the airplane's bank angle started to increase in the right-wing-down direction, and the airplane's magnetic heading of about 185º started to increase. When the CVR recorded the captain asking, "where's it at?" about 1901:36, the airplane was banked to the right with its heading increasing. When the first officer's response "to the right" was recorded by the CVR about 6 seconds later, the airplane was still banked to the right, but the bank angle was decreasing.

N303GA was flying on a 200º magnetic heading when the 500-foot callout was announced by both the FPA and GPWS about 1901:45. The airplane started to turn to the left about 1901:47. At the time of the FPA's 400-foot callout about 1901:49, the airplane was banked 10º left wing down with its heading starting to decrease. The last recorded radar return occurred at 1901:50 when the airplane was at an altitude of 8,000 feet. The GPWS' 200-foot callout was recorded about 1901:55 when the airplane was at an altitude of about 7,900 feet. At the time of the GPWS' bank angle alert (about 1901:57), the airplane's bank angle exceeded 40º left wing down, consistent with the ground scar and tree strike evidence found at the accident scene.

[41] The airspeeds in this section are calibrated airspeeds that were calculated from radar groundspeed and track data, wind data, magnetic variation, and atmospheric data.

As indicated in the History of Flight section, the CVR recorded two 400-foot callouts about 1901:48 and 1901:52. The Airplane Performance Study determined that, during this part of the approach, the airplane's descent rate was mostly constant, but the terrain below the airplane changed. Specifically, at the time of the second 400-foot callout, the airplane was crossing a riverbed, and the terrain dropped 140 feet in elevation from the bank to the lowest point in the riverbed. The terrain rose again as the airplane crossed the riverbed, during which time the 300- and 200-foot callouts were recorded on the CVR. After the FPA's 200-foot callout (recorded 1 second after the GPWS' 200-foot callout), the terrain rose another 25 feet (the elevation of the accident site).

Cockpit Voice Recorder Sound Spectrum Study

A CVR sound spectrum study was performed to (1) determine if sounds similar to landing gear retraction could be heard toward the end of the CVR recording, (2) confirm the cockpit aural advisories and warnings that were transcribed from the CVR recording, (3) investigate the unidentified rumbling noise at the end of the CVR recording, and (4) document the recorded engine signatures. The results of this study are discussed in the following paragraphs.

First, as stated in the History of Flight section, the captain called for the landing gear about 1859:30, and the sound of two clunks and an increase in background noise followed immediately. Two sections of the CAM channel recording were reviewed: the landing gear movement series of noises and the time of the FPA's 1,000-foot callout through the end of the recording (from about 1901:28 to about 1901:58). An aural and spectral comparison of the two sections of the recording indicated the last 30 seconds of the recording did not contain any acoustic evidence of landing gear movement or operation.

Second, the Gulfstream III aural advisories and warnings were identified, and the aural advisories and warnings recorded on the accident airplane's CVR were confirmed. The GPWS and FPA unit aural advisories and warnings recorded by the CVR were distinctly identifiable: the GPWS voice gender was male, whereas the FPA unit voice gender was female. The GPWS' advisories and warnings were consistently recorded on the CAM channel only, and the FPA unit's advisories and warnings were consistently recorded on the captain's and first officer's channels and the CAM channel until the 500-foot callout. At that point, the GPWS' 500-foot callout was recorded on the CAM channel, and the FPA's 500-foot callout was recorded only on the flight crew channels. The FPA's 400-foot callouts were not recorded on the CAM channel but continued to be recorded on the flight crew channels, the 300-foot callout was partially recorded on the captain's channel (recorded as "three hun" and followed by sounds indicative of a microphone key that continued to the end of the recording) and fully recorded on the first officer's channel, and the 200-foot callout was recorded only on the first officer's channel. In addition, the frequencies of the system tones recorded by the accident airplane's CVR were confirmed.

Third, the CVR transcript indicated that a rumbling noise began about 1901:52, blended into the background about 1901:57, and continued until the end of the recording.[42] A spectrogram (a graphic depiction of signal frequency and energy versus time) of the last 7 seconds of the CAM channel recording indicated a broadband noise with a cycle of 16.5 Hertz (Hz). The stick shakers from a similar Gulfstream III stall warning system were recorded during a ground test. Spectrograms of the two stick shaker systems from the test airplane's CAM channel recording contained characteristics similar to the rumbling noise on the accident airplane's recording. Specifically, one stick shaker system produced a broadband noise with a cycle of 16.1 Hz, and the other stick shaker system produced the same noise but with a cycle of 17.2 Hz. (The stick shaker motor operates between 13.3 and 23.3 Hz.)

Fourth, the spectrogram of the last 6 minutes of the CAM channel recording indicated a signature that ranged between about 260 and 510 Hz. According to the airplane and engine manufacturers, such a signature recorded by the CAM channel is typically associated with the engine-driven hydraulic pump; as a result, it was possible to determine the corresponding engine speeds (N_2).[43] A spectrogram of the last 6 minutes of the CAM channel recording showed two separate signatures, which indicated that the two engines were operating independently. Also, the spectrogram indicated that the engine speeds ranged from about 53 to 102 percent N_2, with both engines indicating 102 percent N_2 at the end of the CVR recording.

ADDITIONAL INFORMATION

Company Information

According to Avjet's Director of Operations, the company was formed in 1977. All of the airplanes managed by Avjet are privately owned. When the owners are not using the airplanes under 14 CFR Part 91, they are available for on-demand charter flights conducted under 14 CFR Part 135. The Director of Operations also stated that all cockpit crews are assigned to a specific airplane and owner and that most pilots are certified under both Parts 91 and 135. The director further stated that, at the time of the accident, the company employed 55 pilots and 4 check airmen, all of whom were full-time employees. At the time of the accident, the company's Part 135 certificate listed 18 airplanes, 15 of which were Gulfstream airplanes.

According to Avjet's Director of Operations, the company considered ASE to be a special airport. He explained that, for operations into special airports, the charter manager would discuss the flight crew's qualifications with upper managers and might not assign a captain to an airport with which he/she was not familiar.

[42] Calculated airspeeds between 1901:52 and 1901:57 ranged from 120 to 127 knots. At 40º of bank and the airplane's weight at the time of the accident, the stall speed was about 134 knots.

[43] N_2 is the rotational speed of the high-pressure spool in a gas turbine engine.

Operations Manual

The Avjet Operations Manual in effect at the time of the accident was dated July 15, 2000. Page 3-6 states that the pilot-in-command "will ensure that the flight is conducted in complete compliance with all Federal, Local, and Company regulations and policies."

Page 4-4 indicates that, during the descent, the captain is responsible for conducting an approach briefing after leaving 18,000 feet but before reaching 10,000 feet. The manual instructs the captain to emphasize the following: configuration; approach speed; final approach fix altitude; decision height/minimum descent altitude; visual descent point; circling maneuver; missed approach heading, altitude, and intentions; runway information; and abnormal conditions. The manual indicates that the first officer is responsible for calling "one thousand to go" at 1,000 feet above the assigned altitude.

Pages 4-4 and 4-5 indicate the flight crew callouts that are required during the final approach segment of an instrument approach. The captain is responsible for announcing his intentions at the decision height or missed approach point. The first officer is responsible for the following:

- When intercepting the final approach course: call "Needle alive."
- At initial downward movement of the glideslope indicator: call "Glideslope alive."
- At FAF [final approach fix]: Call "Outer marker" or "Final fix." Start timing. Visually cross-check altimeters. Then call "Altimeters check, no flags."
- At 1000 feet above minimums: Call "1000 to go, no flags."
- At 500 feet above minimums: Call "500 to go."
- At 100 feet above minimums: Call "Approaching minimums."
- At MDA (Non-precision): Call "At minimums (time) (distance) to go."
- At MAP (Non-precision): Call "Missed approach point, runway in sight" or "Missed approach point, runway not in sight."

Training Manual

The Avjet Part 135 Training Manual that was in effect at the time of the accident was dated November 30, 2000. Appendix C of the manual, pages C-53 through C-67, describes the Gulfstream G1159 series recurrent training program. According to the manual, the recurrent ground training consists of 13 general operational subjects, aircraft systems, and systems integration. The manual also states that the recurrent flight training consists of aircraft orientation and normal procedures, abnormal and emergency procedures, and an instrument proficiency and competency check in the flight simulator and/or the airplane. (These same areas are covered during initial ground and flight

training but in more detail.) Avjet requires its pilots to receive recurrent flight training every 12 months.

Section 2 of the manual, pages 2-32 and 2-33, describes the company's controlled flight into terrain (CFIT) training module. The manual lists the following CFIT ground training module items: CFIT hazards, enhancement of situational awareness, recognition and evaluation of potential dangers, risk assessment/reduction factors, and GPWS. Also, the manual states that the CFIT flight simulator module consists of the ground proximity escape maneuver. Avjet pilots receive 3 hours of initial CFIT training. Pilots receive recurrent CFIT training as required, but the manual stipulates that the ground proximity escape maneuver must be practiced every 24 months. Simuflite—one of Avjet's FAA-approved contractors for pilot training—provided the captain with his most recent recurrent training and the first officer with his initial company training. Simuflite's training form indicated numerous curriculum segments that were covered during ground and flight training, but CFIT training was not specifically cited on this list.

In addition, Appendix C of the Avjet Training Manual, pages C-56 and C-58, indicates that crew resource management (CRM) is 1 of 13 general operational subjects addressed during Gulfstream G1159 series initial and recurrent ground training. The manual did not indicate any stand-alone CRM module. Although the FAA mandated CRM training in 1997 for 14 CFR Part 121 operators and 14 CFR Part 135 commuter operators that conduct scheduled operations with aircraft requiring 2 pilots or having 10 or more passenger seats, CRM training is currently not required for pilots conducting 14 CFR Part 135 on-demand operations.[44] As a result, Avjet was not required to establish an FAA-approved CRM training program for its pilots.

Postaccident Actions

On April 10, 2001, Avjet's Director of Operations issued a memorandum to all company flight crews and charter department schedulers, informing them that airport operations at ASE and three other mountain airports were now prohibited between sunset and sunrise.[45] This prohibition applies to all Part 91 and 135 IFR and VFR operations.

The memorandum states that

> if you cannot accomplish a landing and be on the ground at one of these airports before sunset you must divert to a suitable alternate. All passengers for one of these destinations must be informed of this policy. Flight crew members must report any violation of this policy or pressure from passengers to violate this policy to the Director of Operations or Chief Pilot.

[44] To address this issue, the Safety Board adopted Safety Recommendation A-02-12 on June 11, 2002. Safety Recommendation A-02-12 asked the FAA to "revise 14 CFR Part 135 to require on-demand charter operators that conduct operations with aircraft requiring two or more pilots to establish an FAA-approved crew resource management training program for its flight crews in accordance with 14 CFR Part 121, subparts N and O."

[45] The three other mountain airports are Telluride, Colorado; Eagle, Colorado; and Hailey (Sun Valley), Idaho.

According to the memorandum, its contents and additional guidance regarding weather minimums for mountain operations would be incorporated in the next revision of the Avjet Operations Manual. This revision has not yet been issued.

On October 10, 2001, the Van Nuys, California, Flight Standards District Office revised the Operations Specifications of the 12 turbojet air carriers for which the office provides oversight (one of which was Avjet). The revised Operations Specifications dealt specifically with ASE and indicated that, "before beginning the VOR-DME approach, reported weather must be at least ceiling 4400 feet and visibility 5 miles." The specifications also indicated that "the flying pilot must be type rated in the aircraft and have made a takeoff and landing at this airport within the previous twelve (12) calendar months in a turbojet airplane."

On December 19, 2001, Avjet issued revisions to its Standard Operating Procedures. Page 4-1 of the Avjet Operations Manual was revised to state the following:

> Sterile Cockpit
>
> Whenever the aircraft is moving on the ground or during flight below 10,000 feet msl, the crew shall limit conversation to matters concerning the operation of the aircraft only. At airports with a field elevation of 5,000 feet or higher, sterile cockpit procedures shall apply from 18,000 feet msl to the ground.
>
> Cockpit Observers Seat (Jump Seat)
>
> Only an Avjet assigned crewmember, check airman, or FAA observer may occupy the observer's seat (jump seat) in any Avjet aircraft. Charter passengers shall never be allowed to occupy the observer's seat at any time.

Manufacturer Information

Gulfstream Aerospace's GIII Flight Manual, section 1, "Limitations," page 1-16, dated December 3, 1991, indicates that, "speed brakes [spoilers] may be extended with flaps at 10º and 20º but may not be extended with flaps at 39º or with landing gear extended." Section 2, "Normal Procedures," page 2-22, dated October 14, 1999, states that, for high-pressure rpm, "maintain power levers at or above the minimum approach high pressure RPM (64%) until crossing runway threshold in order to obtain prompt engine acceleration and thrust used in landing climb performance should a go-around be necessary."

Federal Aviation Administration Oversight

The FAA Principal Operations Inspector (POI) assigned to the Avjet certificate had been in that position since December 1999. At the time of the accident, he had oversight responsibilities for 7 operators (including Avjet), which had a total of 85 airplanes, 270 pilots, and 19 check airmen. He had an assistant until the fall of 2000.

Records provided by the POI indicated that, in the 2 years before the accident, he performed 6 surveillance inspections of Avjet and 23 technical or administrative activities for the company, including evaluating initial training and technical documents and approving minimum equipment lists and revisions to operations specifications. FAA records indicated that other FAA operations inspectors performed 4 surveillance inspections of Avjet and 18 technical and administrative activities for the company, including check rides and line checks, in the 2 years before the accident.

Landing Minimums

According to 14 CFR 91.175(c), "Operating Below DH or MDA," no pilot may operate an aircraft at any airport below the authorized MDA (or continue an approach below the DH) unless the following requirements are met:

> (1) The aircraft is continuously in a position from which a descent to a landing on the intended runway can be made at a normal rate of descent using normal maneuvers, and for approaches conducted under part 121 or part 135 unless that descent rate will allow touchdown to occur within the touchdown zone of the runway of intended landing;
> (2) The flight visibility is not less than the visibility prescribed in the standard instrument approach being used; and
> (3) Except for a Category II or Category III approach where any necessary visual reference requirements are specified by the [FAA] Administrator, at least one of the following visual references for the intended runway is distinctly visible and identifiable to the pilot:
>
> (i) The approach light system, except that the pilot may not descend below 100 feet above the touchdown zone elevation using the approach lights as reference unless the red terminating bars or the red side row bars are also distinctly visible and identifiable.
> (ii) The threshold.
> (iii) The threshold markings.
> (iv) The threshold lights.
> (v) The runway end identifier lights.
> (vi) The visual approach slope indicator.
> (vii) The touchdown zone or touchdown zone markings.
> (viii) The touchdown zone lights.
> (ix) The runway or runway markings.
> (x) The runway lights.

Charter Information

The business assistant of the client who chartered N303GA stated, in a postaccident interview, that his employer had chartered the airplane because he was hosting a party in Aspen. The business assistant indicated that Avjet called him about 1630 and informed him that the passengers were not at the airport and that the latest time the airplane could depart was 1655. He stated that he immediately began to track down the passengers and found out that all but two (including his employer) were in the airport parking lot. The charter department scheduler who handled N303GA on the day of the

accident indicated that she told the business assistant that the flight would instead have to go to the airport at Rifle if the two passengers did not arrive shortly.

According to the business assistant, the passengers that had arrived boarded the airplane. The business assistant indicated that one of the pilots had spoken to one or more passengers and stated that the airplane might not be able to land at ASE because of the nighttime landing curfew. The charter customer, upon learning about this conversation, instructed his business assistant to call Avjet and relay a message to the pilot that he should "keep his comments to himself."

The business assistant stated that, when he told his employer about the possibility that the flight might have to divert, his employer became "irate." According to the business assistant, he was told to call Avjet and tell the company that the airplane was not going to be redirected.[46] Specifically, he was told to say that his employer had flown into ASE at night and was going to do it again. The business assistant stated that he called Avjet to express his employer's displeasure about the possibility of not landing in ASE.

The charter department scheduler who handled N303GA on the day of the accident indicated that the captain stated, during an en route conversation about 1830, that it was important to land at ASE because "the customer spent a substantial amount of money on dinner."

[46] In a postaccident interview, an Avjet pilot stated that the company would have placed no pressure on the captain to land at ASE.

ANALYSIS

General

The captain and the first officer were properly certificated and qualified under Federal and company requirements. No evidence indicates any preexisting medical or behavioral conditions that might have adversely affected the flight crew's performance during the accident flight. Also, no evidence indicates that fatigue was a factor in this accident.

The accident airplane was properly certified, equipped, and maintained in accordance with Federal regulations. No evidence indicated any preexisting engine or system failures. The substantial damage to the airplane's structure that resulted from a 1988 landing accident in Africa was not a factor in this accident.

Navigational aids (the VOR and DME) and airport lighting systems (the runway end identifier lights, the medium intensity runway lights, and the precision approach path indicator) were also not factors in this accident. The accident was not survivable for any of the airplane occupants because they were subjected to impact forces that exceeded the limits of human tolerance.

This analysis focuses on the flight crew's performance in conducting the instrument approach procedure to Aspen-Pitkin County Airport (ASE), including operational and human factors that may have played a role in the flight crew's decision to continue the approach to an intended landing. This analysis also discusses visual factors that affected the flight crew's ability to see and safely avoid the mountainous terrain.

Accident Sequence

The accident airplane was required to land at ASE no later than 30 minutes after sunset because of a local regulation regarding noise restrictions. Sunset on the day of the accident occurred at 1828, so the airplane had to land by 1858 to comply with the regulation. CVR evidence early in the recording and postaccident interviews indicated that the flight crew was aware of the landing restriction.

The FAA issued a Notice to Airmen (NOTAM) on March 27, 2001, stating "circling NA [not authorized] at night" for runway 15 at ASE. The NOTAM was intended to mean that the instrument approach procedure was no longer authorized at night because only circling minimums were authorized for that procedure. Thus, the NOTAM was vaguely worded because pilots could infer that an approach without a circle-to-land maneuver to runway 15 was still authorized. The first officer received the NOTAM during his preflight briefing with a specialist at the Hawthorne, California,

Automated Flight Service Station (AFSS).[47] The first officer did not ask for further clarification of the NOTAM. According to the Federal Aviation Regulations, night begins at the end of evening civil twilight (when the center of the sun is geometrically 6º below the horizon), which occurred at 1855 on the day of the accident. The U.S. Naval Observatory publishes the precise times for the end of evening civil twilight; however, flight crews do not have a practical method for accessing this information. As a result, many flight crews estimate the end of evening civil twilight as 30 minutes after sunset.

CVR evidence early in the recording indicated that the flight crew expected to encounter visual conditions during the approach and to have only one attempt to execute the approach. For example, the captain's approach briefing indicated, "we're…probably gonna make it a visual…if we don't get the airport over here we'll go ahead and shoot that approach" and "we're not going to have a bunch of extra gas so we only get to shoot it once and then we're going to Rifle."[48] Also, the captain later indicated to the flight attendant that, if the attempt to execute the approach was not successful, the airplane would have to go to Rifle because it was too late in the evening.

The CVR indicated that the captain did not discuss the instrument approach procedure during his approach briefing, as required by the Avjet Operations Manual. The CVR also indicated that the captain did not brief the missed approach procedure, even though he discussed the possibility that the airplane might have to go to the alternate airport because of the landing restriction and the fuel status. Thus, the flight crew was not adequately prepared to perform ASE's instrument and missed approach procedures. In addition, Avjet's manual indicates that the captain was to brief the airplane's configuration and approach speed, final approach fix altitude, minimum descent altitude (MDA), visual descent point, circling maneuver, runway information, and abnormal conditions. The CVR did not record the captain briefing any of this information.

While the airplane was descending into the terminal area, the flight crew attempted to locate a specific highway because a visual approach to the airport follows parallel to this highway, but that effort was mostly unsuccessful. Afterward, the captain informed the approach controller, "I can almost see up the canyon from here but I don't know the terrain well enough or I'd take the visual." The controller acknowledged this information and provided the flight crew with instructions for intercepting the final approach course.

According to Doppler weather radar and weather satellite information, the cloud tops were near 16,000 feet while the airplane was on approach to ASE. After descending through this altitude, the airplane was in and out of the clouds.

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[47] The AFSS specialist did not read the NOTAM verbatim and told the first officer that circling minimums were not authorized at night. The addition of the word "minimums" made the information conform somewhat closer to the intent of the NOTAM because the NOTAM modified the VOR/DME-C procedure and not the landing maneuver.

[48] As stated in the "History of Flight" section, the sample flight plans provided by Gulfstream showed that the amount of fuel aboard the accident airplane would have exceeded the amount required by the Federal Aviation Regulations.

Execution of the Instrument Approach Procedure

According to the intent of the NOTAM, the instrument approach procedure to ASE was not authorized after 1855. As a result, the flight crew should not have been attempting this procedure to the airport. The CVR did not record any discussion between the flight crewmembers about the NOTAM. However, the flight crew was likely not aware that official nighttime began 3 minutes before the 1858 landing restriction at ASE. Also, the flight crewmembers might have believed that the NOTAM, because of its unclear wording, did not apply to a flight that would not have to execute a circling maneuver to runway 15. If the FAA had worded the NOTAM more clearly (as in the revision issued the day after the accident), it might have made more of an impression on the first officer when he received the preflight briefing from the Hawthorne AFSS and might have affected the conduct of the flight. Finally, it is also possible that the first officer did not brief the captain about the NOTAM and, therefore, that the captain might not have been aware of the NOTAM.

About 1856:06, the approach controller cleared the flight crew for the VOR/DME-C instrument approach procedure. The controller did not know about the NOTAM because the Denver Center had not sent a copy to the ASE tower. If the tower had received the NOTAM, the controller would have been required to notify the flight crew of the NOTAM either verbally or on the ATIS broadcast.[49] About 1856:42, the controller informed all airplanes on frequency that the visibility north of the airport was 2 miles.

The VOR/DME-C instrument approach procedure required the flight crew to maintain at least 14,000 feet until passing the Red Table VOR, the initial approach fix, and 12,700 feet until passing the intermediate step-down fix located 3 DME miles south of the Red Table VOR. (See figure 1.) The Airplane Performance Study for this accident indicated that N303GA crossed the Red Table VOR and the intermediate step-down fix at the altitudes specified by the approach procedure. (See figure 3.) The airplane crossed the Red Table VOR about 1857:49 at an airspeed of 160 knots and then crossed the step-down fix about 1858:40 at an airspeed of 150 knots. However, by this time, the flight crew could no longer comply with the local regulation that required the airplane to be on the ground by 1858. In addition, the captain was no longer in compliance with Avjet's policy that required the pilot-in-command to ensure that the flight was conducted "in complete compliance" with local regulations.

About 1858:03, the pilot of N527JA (a Canadair Challenger 600 airplane, which was preceding the accident airplane into ASE) reported that he did not have the airport in sight and that he would be going around. (Two previous reports of missed approaches had been transmitted over the ASE approach control frequency, one about 1844:43 and one about 1853:35.) The three reports of missed approaches and the deteriorating

[49] FAA Order 7110.65, paragraph 4-7-12(b), states that, "on first contact or as soon as possible thereafter, and subsequently as changes occur, inform an aircraft…of destination airport conditions that you know of which might restrict an approach or landing. This information may be omitted if it is contained in the ATIS broadcast and the pilot states the appropriate ATIS code."

visibility to the north should have alerted the flight crewmembers that they might also need to execute a missed approach because of the weather. However, the CVR did not record any discussion between the crewmembers at this point regarding a possible missed approach.

The final approach segment required the flight crew to maintain 12,200 feet until passing ALLIX, the final approach fix located 6 DME south of the Red Table VOR; 10,400 feet until passing a step-down fix located 9.5 DME south of the Red Table VOR; and 10,200 feet until passing the missed approach point located 11 DME south of the Red Table VOR. (See figure 1.) The Airplane Performance Study indicated that the airplane crossed ALLIX about 1859:40 at an altitude of 12,100 feet, 100 feet below the minimum specified altitude (see figure 3), and at a speed of about 125 knots.

After passing ALLIX, the airplane maintained a descent rate of about 2,200 feet per minute and an airspeed of about 125 knots. When the airplane reached altitudes of 11,200, 10,700, and 10,300 feet, Avjet's Operations Manual required the first officer to call out, "1000 to go [until landing minimums]," "500 to go," and "approaching minimums," respectively. However, the CVR did not record any of these callouts.

About 1900:22, when the airplane was at an altitude of 10,400 feet and was about 4.4 miles north of the airport, the captain stated, "okay…I'm breaking out," which was the first indication that the captain might have made visual contact with the ground. About 5 seconds later, the captain asked the controller whether the lights were all the way up. Postaccident interviews and CVR evidence determined that, by this time, the ground controller had set the airport lights at their highest intensity; thus, the captain's query could suggest that he did not have the runway or its environment in sight. It is also possible that the captain could have perceived the lights as dim because of an obscuration and wanted to make sure the lights remained visible.

The airplane leveled off about 1900:39 at an altitude of 10,100 feet and about 3.7 miles north of the airport. The CVR did not record any announcement by the first officer that the airplane was 300 feet below the minimum step-down altitude of 10,400 feet. Also, the airplane was now operating below the 10,200-foot MDA without any indication, according to the CVR, that either pilot had made visual contact with the runway or its environment. The CVR indicated that the first officer did not verbally challenge the captain, and radar data showed that the captain did not correct the descent or initiate a missed approach.

About 1900:43, the captain asked the first officer whether he could see the runway, but the CVR recorded an unintelligible statement made by the first officer about 2 seconds later. About 1900:46, the captain asked the first officer whether he could see the highway. (The highway, as viewed from the approach, was located slightly to the right of the runway extended centerline and thus would have been more easily visible on the first officer's side of the cockpit.) The CVR recorded the first officer's statement "see highway" 1 second later, but this statement does not clearly indicate whether he actually had the highway in sight. Because the first officer provided no specific

information about the highway's location, it is possible that he was repeating the captain's words while looking for the highway. The captain made no statements about this time to indicate that he had established visual reference with either the runway or the highway.

The airplane began to descend again about 1900:49 at a rate of 2,200 feet per minute. The local controller noticed that the airplane had prematurely descended below the 10,400-foot step-down altitude and asked the flight crewmembers whether they had the runway in sight. About 1900:51, the first officer and the captain stated, almost simultaneously, "affirmative" and "yes now yeah we do," respectively. These statements were communicated only to the other pilot, but, about 1 second later, the first officer informed the controller that the runway was in sight. Radar data indicated that the airplane was at an altitude of 9,750 feet at the time but that it had not started maneuvering toward the airport.

Evidence indicated that, at that point, the flight crew probably did not have the runway in sight or had it in sight only briefly. Specifically, the CVR did not record any previous independent indication from either flight crewmember that he had visually identified the runway; both pilots stated that they saw the runway only after being queried by the controller. Also, the CVR did not record any further discussion throughout the rest of the flight that would be consistent with a flight crew that could see a runway. Neither flight crewmember commented about the threshold or its markings or lights; the runway end identifier lights; the precision approach path indicator; the touchdown zone or its markings or lights; or the runway or its markings or lights—one of which needed to be in sight to make a landing in accordance with 14 CFR 91.175(c)(3). In addition, the local controller stated that she did not see the airplane when the pilot reported the runway in sight. Further, the airplane would have had to make a left turn to align with the runway, but radar data showed that the airplane was turning slightly to the right (2.5º right wing down).

The airplane passed the step-down fix located 9.5 DME south of the Red Table VOR about 1901:00 at an altitude of 9,500 feet, 900 feet below the specified minimum altitude (see figure 3). Because the airplane was still in instrument meteorological conditions, the first officer should have announced this altitude deviation to the captain, but the CVR did not record any such callout.

The 1853 Automated Surface Observing System hourly observation indicated that the lowest cloud base was near 9,315 feet. Once the airplane had descended below this altitude, the pilots were likely encountering visibilities of about 2 miles in light snow showers. The airplane was 2.7 miles from the airport at this time.

About 1901:13, the CVR recorded the first officer's statement, "…to the right is good." Radar data indicated that the airplane was at an altitude of 9,000 feet. It is not apparent what the first officer could see from the cockpit when he made his statement because the runway would have been to the left of the nose of the airplane. It is possible that the first officer could have seen the runway at this point; however, the captain did not

verbally acknowledge the first officer's directional guidance, and radar data indicated that the airplane did not make a turn to the right. The airplane continued on its heading, which would have still positioned the airplane to the right of the runway.

About 1901:21, the CVR recorded a sound, which continued for 9 seconds, that was consistent with the airplane's configuration alarm. This warning indicated that the captain had deployed the spoilers after the landing gear had been extended and the final landing flaps had been selected.[50] Also, the CVR Sound Spectrum Study determined that, while the spoilers were deployed, engine power was set to 55 percent N_2. The captain likely extended the spoilers and reduced engine power to increase the airplane's rate of descent to get below the snow showers and visually acquire the runway. However, these actions were contrary to spoiler information in the Gulfstream GIII Flight Manual, which indicates that the spoilers are not to be extended with flaps in the landing configuration (39º) or with the landing gear extended and that the high-pressure rpm power setting on final approach should not be below 64 percent N_2 to meet FAA-required go-around standards.

About 1901:34, the airplane's attitude started to increase in the right-wing-down direction. (The airplane should have been turning to the left to align with the runway.) The airplane passed the missed approach point about 1901:36 at an altitude of about 8,300 feet, 485 feet above field elevation rather than the specified 2,385 feet above field elevation (see figure 3). The first officer was required to call out, "missed approach point, runway in sight" or "missed approach point, runway not in sight," and the captain was required to announce his intentions. However, the CVR did not record either of these callouts.

About the same time as the airplane passed the missed approach point, the captain asked, "where's it at?" This statement suggests that the captain had not identified, or had lost visual contact with, the runway. At this point, the captain should have abandoned the approach, especially because the airplane was close to the ground in mountainous terrain.[51] The first officer stated, "to the right," about 6 seconds after the captain's query.[52] Again, it is not apparent what the first officer could see from the cockpit when he made this statement. After the first officer's response, the captain stated, "to the right," but calculations from radar data indicated that the airplane's right bank angle was

[50] The CVR indicated that the captain had called for the landing gear and landing flaps about 1859:30 and 1859:34, respectively. (The airplane was at an altitude of 12,200 feet when the captain called for the landing gear.) The first officer's statement, "three greens," about 1859:46 indicated that the landing gear was in the down and locked position.

[51] The captain and the first officer should have realized the proximity of the airplane to the ground because the flight profile advisory (FPA) unit had announced the 1,000-, 900-, and 800-foot callouts before the captain's question about the location of the runway. Although the airplane was less than 500 feet above airport elevation at the time of the captain's question, the ground proximity warning system (GPWS) and FPA 500-foot altitude were not announced then because, according to the Airplane Performance Study, the airplane was flying over a river valley at that point and the terrain elevation directly below the aircraft was 7,600 feet—over 700 feet lower than the airport elevation. The terrain below the airplane dropped some more and then rose slightly as the airplane continued its descent.

[52] The FPA announced the 700- and 600-foot callouts before the first officer's response.

decreasing.[53] At this point, the airplane was at an altitude of 8,100 feet and was 1.2 miles from the runway.

Title 14 CFR 91.175(c)(3) states that at least one specified visual reference for the intended runway needs to be "distinctly visible and identifiable to the pilot" for the airplane to operate below the MDA. The captain's statement "where's it at?" indicated that he did not see any of these visual references. Even if the first officer had the runway in sight at this point, the captain, as the flying pilot, should not have been relying on the first officer for directional guidance during the visual transition from the instrument approach to the landing.

Radar data indicated that, about 1901:47, the airplane stopped turning to the right and began turning to the left. The Safety Board regards this maneuver as the first clear indication that the captain may have seen the runway after the MDA. About 1901:49, the airplane was at an altitude of 8,000 feet, was about 0.9 miles north of the runway, and was descending at a rate of 900 feet per minute. At that point, the airplane was banked 10º left wing down. The airplane's bank angle continued to increase.[54] The local controller saw the airplane emerge from a snow shower (at a low altitude and west of the runway extended centerline) and rapidly enter a steep left bank. On the basis of the ATC voice recordings and information from a postaccident interview, the Board estimates that the airplane crashed about 5 seconds after the controller saw the airplane.

At the time of the accident (1901:57), the airplane was banked more than 40º left wing down, and the left wing tip was the first airplane part that struck the terrain. The CVR contained no indication regarding why the airplane was turning so steeply to the left. It is possible that the captain saw the runway or the highway and was making a steep turn to align the airplane with the runway without a substantial overshoot.[55] It is also possible that the captain was starting to see terrain that had been obscured by the darkness and the weather conditions and was banking the airplane to avoid the terrain.

The left and right main landing gear were found in their wheel wells. However, no evidence on the CVR and from the CVR Sound Spectrum Study indicated that the gear was being raised for a missed approach. In addition, the airplane manufacturer stated that a warning horn would sound if the gear were being raised while the flaps were in the landing configuration. The CVR did not record the sound of this warning horn.

[53] While the airplane was still banked to the right, the GPWS and FPA announced the 500-foot altitude callout.

[54] As the airplane's left bank angle was increasing, the FPA announced the 400-, 300- and 200-foot altitude callouts, and the GPWS announced the 200-foot callout, two sink rate alerts, and one bank angle alert.

[55] Radar data showed that the airplane was substantially to the right of the runway extended centerline.

Summary of the Flight Crew's Performance

During the final 2 minutes of the approach, the flight crewmembers were apparently focusing more of their attention outside, rather than inside, the cockpit as they tried to locate the runway and the highway. As a result, the captain continued flight below the authorized MDA after failing to establish or maintain visual contact with the runway. The first officer did not challenge the captain's actions.

In addition to their numerous errors during the instrument approach procedure, the flight crewmembers demonstrated poor crew coordination during the accident flight. Specifically, the captain and the first officer did not make required instrument approach callouts,[56] the captain provided an incomplete approach briefing, and he did not follow Gulfstream's procedures regarding in-flight spoiler operation and minimum engine power during an approach.

The flight crewmembers should have abandoned the approach because the airplane descended below the MDA without an adequate visual reference of the runway. Also, the flight crew should have considered diverting to an alternate airport after receiving information about the deteriorating visibility along the approach course and the three reports of missed approaches. Operational and human factors that may have played a role in the flight crew's decision to continue the approach to an intended landing are discussed in the next section. Visual factors affecting the flight crew's ability to see and avoid the terrain are discussed later.

Operational and Human Factors

The flight crew was dealing with various sources of operational pressure during the accident flight. These sources were the airplane's late departure from LAX, the ASE nighttime landing curfew, and the charter customer's strong desire to land at ASE.

Because of the late arrival of the passengers (including the charter customer), the airplane was not able to depart LAX until 1711—41 minutes later than scheduled. The late departure delayed the flight's estimated arrival at ASE to 1846—only 12 minutes before the airport's landing curfew. These factors would not have allowed the flight crew to perform a second approach if the first one had to be abandoned. (The captain recognized this fact, as demonstrated by his approach briefing to the first officer.) As a result, the flight crewmembers initially tried to establish and maintain contact with ground references so that they would be able to fly visually to the airport.

After the captain informed the controller that he did not know the terrain well enough to "take the visual," the first officer indicated, "could do a contact but…I don't know," but then stated, "probably we could not." A contact approach would have exposed the flight to greater risk because of that approach's 1-mile visibility requirement

[56] In addition to the callouts previously discussed in the "Execution of the Instrument Approach Procedure" section, the first officer also did not call out required course, fix, and altimeter information.

and the mountainous terrain surrounding ASE. However, the first officer likely considered this approach as an option, albeit briefly, because of the limited time available to arrive at the airport.

The charter customer's communications both before and during the flight, stressing the importance of landing at ASE, most likely heightened the pressure on the flight crew. According to the charter customer's business assistant, his employer became "irate" when he was informed about the possible diversion to an alternate airport. The business assistant also stated that he was told to call Avjet and emphasize that the airplane was not going to be redirected. The Avjet charter department scheduler indicated that the captain felt that it was important to land at ASE because of the substantial amount of money that the customer spent for a dinner party.

In addition, the CVR indicated that, about 1853:57, the flight attendant escorted an unidentified male passenger to the jumpseat, which he occupied for the remainder of the flight. Comments by the captain indicated that he likely felt the need to explain the status of the approach to the passenger.[57] For example, about 1855:14, the captain stated, "the weather's gone down they're not making it in," to which this passenger replied, "oh really." Also, when this passenger asked "are we clear?" about 1858:13, the captain responded, "not yet" and "the guy in front of us [N898R] didn't make it in either." This passenger again replied, "oh really." The CVR did not record any other comments by this passenger, except for an unintelligible comment about 1900:08 regarding the snow. However, the presence of this passenger in the cockpit, especially if it were the charter customer, most likely further heightened the pressure on the flight crew to land at ASE.

The operational pressure on the flight crew probably resulted in the crew's intent to continue with its original plan to land at ASE. FAA Advisory Circular 60-22, "Aeronautical Decision Making," indicates that pilots, particularly those with considerable experience, try to complete flights as planned, please passengers, and meet schedules, which can compromise safety and impose an unrealistic assessment of piloting skills under stressful conditions. Also, human performance researchers have noted that pilots tend to adhere to their original plan of action, which interferes with critical analysis processes that are needed to adequately reevaluate the suitability of the original plan and explore an alternate course of action. As a result, "plan continuation errors" occur; that is, pilots elect to continue with an original plan of action despite the presence of cues suggesting that the course of action needs to be modified.[58] In addition, research has demonstrated that individuals, when faced with a choice between alternatives, generally seek out information that confirms a chosen hypothesis and ignore or fail to fully

[57] As previously indicated, 14 CFR 135.100 did not prohibit the captain from allowing this passenger to sit on the jumpseat and from conversing with him because the airplane had not yet reached the sterile cockpit altitude of 10,000 feet msl.

[58] J. Orasanu, "Plan Continuation Errors: A Factor in Aviation Accidents?" *Proceedings of the Fourteenth Triennial Congress of the International Ergonomics Association and Forty-forth Annual Meeting of the Human Factors and Ergonomics Society* (Santa Monica, CA: Human Factors and Ergonomics Society, 2000).

consider contradictory information, particularly when workload is high and time constraints are imposed.[59]

In this accident, the flight crew focused on cues that supported the goal of landing at ASE, such as occasional breaks in the clouds and the report of one airplane (N900MF) that had landed at the airport without incident. By focusing on such cues, the crew did not adequately consider information that supported a change of plans, such as the deteriorating visibility, the three reports of missed approaches (the last of which, involving N527JA, occurred after the accident airplane passed the Red Table VOR), and the failure to establish and maintain visual contact with the runway environment as the approach proceeded. Instead, the flight crewmembers might have viewed this information as a barrier to achieving their intended goal of landing at ASE, causing them not to recognize the increasing evidence supporting the need for an alternate course of action.

Visual Factors

When the VOR/DME-C instrument approach procedure was first established at ASE in December 1988, the procedure was not authorized at night. The FAA removed the night restriction from the procedure in October 1994 because of complaints from user groups. In March 2001, the instrument approach procedure was again restricted at night after an FAA flight inspection determined that areas of unlighted terrain conflicted with traffic patterns and circling descent maneuvers near the airport.

The night restriction on the VOR/DME-C instrument approach procedure did not restrict the procedure during evening civil twilight. However, the decrease in ambient illumination during civil twilight results in a decrease in contrast between objects and the background scene, which diminishes a pilot's ability to visually distinguish between terrain features and the sky and to visually detect unlighted objects.

The amount of ambient light decreases by two orders of magnitude (that is, about 100 times) from the beginning to the end of evening civil twilight. Also, the sky during civil twilight can be much brighter than terrain features, and pilots may be exposed to higher ambient light levels at altitude before descent. Pilots may also experience rapid decreases in ambient illumination during approach and descent, especially in mountainous areas where terrain features may rise above the horizon and reduce the amount of ambient illumination at lower elevations. The mountainous terrain surrounding ASE reduces the amount of ambient lighting during evening civil twilight at lower elevations, including positions on and near the airfield.

Although this accident occurred only 7 minutes after the end of evening civil twilight and the beginning of night, the mountainous terrain created twilight and nighttime conditions much earlier. The controller-in-charge stated, in a postaccident interview, that the sky was "very dark" in the minutes before the accident. In fact, the

[59] C.D. Wickens, *Engineering Psychology and Human Performance*, 2nd ed. New York: Harper Collins, 1992.

Safety Board calculated that the sun had set below the mountainous terrain about 25 minutes before the official sunset time[60] and that evening civil twilight ended about 1830 rather than 1855. Also, the shadow for the ridge immediately to the west of the accident site would have crossed the accident site 79 minutes earlier than official sunset. As a result, the dark conditions would have significantly degraded the flight crew's ability to see and safely avoid terrain while making the visual transition from the instrument approach to an intended landing. The reduced visibility and light snow showers near the airport would have further degraded the flight crew's ability to see and safely avoid the terrain.

This accident reveals that the aeronautical definition of night does not adequately take into account darkness in mountainous terrain. Specifically, because pilots do not have sufficient ambient lighting to see and safely avoid unlighted terrain during periods of darkness before official night, the night restriction on the VOR/DME-C approach is not enough to ensure safety of flight. Thus, nighttime restrictions may not sufficiently mitigate potential hazards associated with flight operations into ASE and other airports with mountainous terrain during periods of darkness.[61]

[60] On February 21, 2002, an ASE tower controller observed the sun fully set behind the terrain about 1725. At that time, the elevation of the sun was 4.2º, resulting in a visible sunset that was about 26 minutes earlier than the official sunset of 1751. On the night of the accident, the sun was at an elevation of 4.2º about 1803, resulting in a visible sunset that was about 25 minutes earlier than official sunset.

[61] To address this issue, the Safety Board issued Safety Recommendation A-02-08 on April 15, 2002. Safety Recommendation A-02-08 asked the FAA to "revise any restrictions and prohibitions that currently reference or address 'night' or 'nighttime' flight operations in mountainous terrain so that those restrictions and prohibitions account for the entire potential period of darkness or insufficient ambient light conditions, and establish a method to clearly communicate to flight crews when such restrictions and prohibitions apply."

SUMMARY

1. The flight crew made numerous procedural errors and deviations during the final approach segment of the VOR/DME approach to Aspen (ASE).

- The flight crew crossed step-down fixes below the minimum specified altitudes.
- The flight crew descended below the minimum descent altitude (MDA), even though airplane maneuvers and comments on the cockpit voice recorder (CVR) indicated that neither pilot had established or maintained visual contact with the runway or its environment.
- Contrary to the airplane manufacturer's procedures, the captain deployed the spoilers after the landing gear had been extended and the final landing flaps had been selected, and he set engine power to 55 percent N_2 rather than 64 percent N_2.
- When the airplane was 1.4 miles from the runway (about 21 seconds before the accident), the captain asked, "where's it at?" but did not abandon the approach, even though he had not identified, or had lost visual contact with, the runway.
- Radar data and CVR comments indicated that, until the airplane began turning to the left about 10 seconds before the accident, the flight crew probably did not have the runway or its environment in sight.

2. The crew demonstrated poor crew coordination during the accident flight.

- The captain did not discuss the instrument approach procedure, the missed approach procedure, and other required elements during his approach briefing because he expected to execute a visual approach to the airport.
- The captain and the first officer did not make required instrument approach callouts, and the first officer did not call out required course, fix, and altimeter information.
- The flight crew did not discuss a missed approach after receiving a third report of a missed approach to the airport and a report of deteriorating visibility in the direction of the approach course.

3. The flight crew was under pressure to land at ASE.

- Because of the flight's delayed departure from Los Angeles International Airport and the landing curfew at ASE, the flight crew could attempt only one approach to the airport before having to divert to the alternate airport.
- The charter customer had a strong desire to land at ASE, and his communications before and during the flight most likely heightened the pressure on the flight crew.

- The presence of a passenger on the jumpseat, especially if it were the charter customer, most likely further heightened the pressure on the flight crew to land at ASE.

4. **Darkness, reduced visibility, and light snow showers near the airport at the time of the accident significantly degraded the flight crew's ability to see and safely avoid terrain.**

5. **The March 27, 2001, Notice to Airmen (NOTAM) regarding the nighttime restriction on the VOR/DME-C approach was vaguely worded and ineffectively distributed.**

   - The NOTAM stated, "circling NA [not authorized] at night," but the intended meaning of the NOTAM was to prohibit the entire instrument approach procedure at night.
   - Pilots might have inferred that an approach without a circle-to-land maneuver to runway 15 was still authorized.
   - If the FAA had worded the first NOTAM more clearly, it might have made more of an impression on the first officer when he received the preflight briefing from the Automated Flight Service Station and might have affected the conduct of the flight.
   - The local controller could not notify the flight crew of the NOTAM because the Denver Center had not sent a copy to the ASE tower.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of this accident was the flight crew's operation of the airplane below the minimum descent altitude without an appropriate visual reference for the runway.

Contributing to the cause of the accident were the Federal Aviation Administration's (FAA) unclear wording of the March 27, 2001, Notice to Airmen regarding the nighttime restriction for the VOR/DME-C approach to the airport and the FAA's failure to communicate this restriction to the Aspen tower; the inability of the flight crew to adequately see the mountainous terrain because of the darkness and the weather conditions; and the pressure on the captain to land from the charter customer and because of the airplane's delayed departure and the airport's nighttime landing restriction.