



National Transportation Safety Board Aviation Accident Final Report

Location:	HOUSTON, TX	Accident Number:	FTW98MA096
Date & Time:	01/13/1998, 0810 CST	Registration:	N627WS
Aircraft:	Gates Learjet 25B	Aircraft Damage:	Destroyed
Defining Event:		Injuries:	2 Fatal

Flight Conducted Under: Part 91: General Aviation - Positioning

Analysis

The flight crew was positioning the airplane in preparation for a revenue flight when it crashed 2 nautical miles (nm) short of the runway during a second instrument landing system approach in instrument meteorological conditions. Except for the final 48 seconds of the 25-minute flight, the captain was the flying pilot, and the first officer was the nonflying pilot. When the airplane was about 0.5 nm inside the outer marker on the first approach, the compass warning flag on the captain's course deviation indicator appeared, indicating that the heading display was unreliable. The airplane deviated from the localizer centerline to the left but continued to descend. After about 1 minute, during which time the airplane's track continued to diverge from the localizer centerline, the flight crew executed a missed approach. The flight crew then unsuccessfully attempted to clear the compass flag by resetting circuit breakers. The captain directed the first officer to request a second approach. Contrary to company crew coordination procedures, the flight crew did not conduct an approach briefing or make altitude callouts for either approach. Although accurate heading information was available to the captain on his radio magnetic indicator, he experienced difficulty tracking the localizer course as the airplane proceeded past the outer marker on the second approach. The captain transferred control to the first officer when the airplane was 1.9 nm inside the outer marker. The airplane then began to deviate below the glideslope. The descent continued through the published decision height of 200 feet above ground level, and the airplane struck 80-foot-tall trees. Postaccident testing revealed that the first officer's instruments were displaying a false full fly-down glideslope indication because of a failed amplifier in the navigation receiver. The glideslope deficiency was discovered 2 months before the accident by another flight crew. An FAA repair station attempted to resolve the problem and misdiagnosed it as "sticking" needles in the cockpit instruments. The operator was immediately advised of the problem. The operator's minimum equipment list for the airplane required that the problem be repaired within 10 days, but the operator improperly deferred maintenance on it for 60 days and allowed the unairworthy airplane to be flown by the accident flight crew. The airplane was not equipped with, nor was it required to be equipped with, a ground proximity warning system, which would have sounded 40 seconds before impact.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: The flight crew's continued descent of the airplane below the glideslope and through the published decision height without visual contact with the runway environment. Also, when the captain encountered difficulty tracking the localizer course, his improper decision to continue the approach by transferring control to the first officer instead of executing a missed approach contributed to the cause. In addition, the following were factors to the accident: (1) American Corporate Aviation's failure to provide an airworthy airplane to the flight crew following maintenance, resulting in a false glideslope indication to the first officer; (2) the flight crew's failure to follow company crew coordination procedures, which called for approach briefings and altitude callouts; and (3) the lack of an FAA requirement for a ground proximity warning system on the airplane.

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: APPROACH - FAF/OUTER MARKER TO THRESHOLD (IFR)

Findings

1. FLIGHT/NAV INSTRUMENTS,COURSE INDICATOR - FAILURE,PARTIAL
2. MISSED APPROACH - PERFORMED - FLIGHTCREW

Occurrence #2: IN FLIGHT COLLISION WITH TERRAIN/WATER
Phase of Operation: APPROACH - FAF/OUTER MARKER TO THRESHOLD (IFR)

Findings

3. (F) PROCEDURES/DIRECTIVES - NOT FOLLOWED - FLIGHTCREW
4. (F) MISSED APPROACH - NOT PERFORMED - PILOT IN COMMAND
5. (F) IN-FLIGHT PLANNING/DECISION - IMPROPER - PILOT IN COMMAND
6. (F) COMM/NAV EQUIPMENT, GLIDE SLOPE RECEIVER - FALSE INDICATION
7. (F) MAINTENANCE - NOT PERFORMED - COMPANY/OPERATOR MANAGEMENT
8. (C) PROPER GLIDEPATH - NOT MAINTAINED - FLIGHTCREW
9. (C) DECISION HEIGHT - NOT COMPLIED WITH - FLIGHTCREW
10. (F) GROUND PROXIMITY WARNING SYSTEM - NOT INSTALLED
11. (F) INSUFFICIENT STANDARDS/REQUIREMENTS,AIRCRAFT - FAA(ORGANIZATION)

Factual Information

HISTORY OF FLIGHT

On January 13, 1998, about 0810 central standard time, a Gates Learjet 25B, N627WS, impacted terrain approximately 2 nautical miles (nm) east of the runway 26 threshold at George Bush Intercontinental Airport (IAH), Houston, Texas, during an instrument landing system (ILS) approach. (All times in this report are central standard time, based on a 24-hour clock.) The airplane was operated by American Corporate Aviation, Inc., of Houston and was registered to First Star, Inc., of Wilmington, Delaware. The positioning flight, which was operating under 14 Code of Federal Regulations (CFR) Part 91, had departed from Houston's Hobby Airport (HOU) about 0745 with a destination of IAH. The captain and first officer were the sole occupants aboard the flight. Instrument meteorological conditions prevailed for the flight, and an instrument flight rules (IFR) flight plan had been filed. Both flight crewmembers were killed, and the airplane was destroyed by impact forces and fire. Five people were waiting at IAH to board the airplane for a 14 CFR Part 135 charter flight to Fargo (FAR), North Dakota.

The airplane had been operated from Raytheon Aircraft Services, a fixed-base operator (FBO) at HOU, for about 1 month before the accident flight. Raytheon's records indicated that, on January 12, 1998, the Director of Operations for American Corporate Aviation verbally requested fuel for the airplane and that the wing and tip tanks were "topped off" with 372 gallons of jet fuel. During the afternoon of January 12, the captain of the accident flight taxied the airplane from Raytheon Aircraft Services to Fletcher Aviation, another FBO at HOU, and the airplane was placed in a hangar. About 1700, the director of operations and the captain removed a stretcher from the airplane and installed two passenger seats in its place. According to the director of operations, he discussed the next day's trip to Fargo with the captain and informed him who the first officer for the flight would be. The director of operations stated that he later observed the captain giving the first officer a preflight briefing.

The proposed round trip consisted of four flight segments: HOU to IAH, IAH to FAR, FAR to IAH, and IAH to HOU. According to the transcript of the telephone call, about 0528 on January 13, 1998, the captain called Montgomery County Automated Flight Service Station (CXO AFSS) and filed an instrument flight plan for a flight in N627WS from HOU to IAH and then from IAH to FAR. The proposed departure times from HOU and IAH were 0645 and 0800, respectively. When the briefer at CXO AFSS asked the captain if he could do anything else, the captain said, "yeah tell me how bad the weather is I know it is foggy as a son-of-a-gun." The captain was then given a weather briefing for the Houston and Fargo areas. The weather at IAH was reported as 1/4-mile visibility restricted by fog, vertical visibility of 100 feet, and temperature and dew point within 1 degree of each other. The forecast weather for FAR after 0900 called for unrestricted visibility and scattered clouds at 12,000 feet, becoming overcast at 10,000 feet between 1200 and 1400. The captain concluded the conversation about 0534 after saying, "well ok I'm just going to take my time and mosey on out to the airport after it gets a little better I'll get an update with you then we'll go."

While this briefing was being conducted, CXO AFSS received another telephone call about 0532 requesting a weather briefing for N627WS departing HOU at 0800 for a flight to IAH and then FAR. In an interview conducted during the accident investigation, the Chief Executive Officer (CEO) of American Corporate Aviation indicated that he placed this call to CXO AFSS. The CEO was told that the weather at HOU was calm winds, 1/8-mile visibility restricted by

fog, an indefinite ceiling at zero feet, and both the temperature and dew point at 19 degrees Celsius (C). The weather at IAH was reported as calm winds, 1/4-mile visibility restricted by fog, an indefinite ceiling at 100 feet, and both the temperature and dew point at 17 degrees C. The call was concluded about 0540.

A line service technician employed by Fletcher Aviation stated that, when he arrived for work about 0605, the captain was already at the FBO. About 0612, the captain called CXO AFSS again, asking if the weather at IAH had gotten any better. He was told that the weather was reported as 3/4-mile visibility restricted by fog with an indefinite ceiling at 100 feet. CXO AFSS received a third call from the captain about 0646 requesting IAH weather. The captain was given a special weather report issued about 0606; the reported conditions included 1/4-mile visibility restricted by fog, light rain, indefinite ceiling at 100 feet, temperature and dew point within 1 degree, and occasional lightning in clouds from a thunderstorm to the south moving northeast. About 0706, CXO AFSS received a fourth call from the captain, asking if IAH weather had improved. The captain was told that the weather was reported as 1/4-mile visibility restricted by mist, an overcast ceiling at 100 feet, surface visibility of 4 miles, and a thunderstorm in the vicinity.

According to the Fletcher Aviation line service technician, the first officer arrived at the airport between 0645 and 0700. The airplane was then moved from inside the hangar to the ramp, and the technician connected a power cart to the airplane. At that time, the technician heard fuel being transferred to the fuselage fuel tank. The technician observed the first officer fill out a "trip log" form, which the technician faxed to American Corporate Aviation's "dispatch" office after the airplane taxied out. Safety Board investigators obtained a copy of this document from the CEO of American Corporate Aviation. The form was a copy of page 9.28 of American Corporate Aviation's Operations Manual, entitled "Dispatch Record." The form indicated that the route of flight would be HOU--IAH--FAR--IAH--HOU and that the IAH--FAR--IAH portion of the flight would be operated under 14 CFR Part 135.

According to cockpit voice recorder (CVR) data, the captain was the flying pilot on the flight from HOU to IAH, and the first officer was the nonflying pilot. After an uneventful takeoff from HOU, the first officer made initial contact with the IAH Terminal Radar Approach Control (TRACON) Departure North controller about 0746:21. The controller began vectoring the flight for an ILS approach to runway 26 at IAH and transmitted the following IAH automatic terminal information service (ATIS) weather conditions:

[information] Echo is current. wind is three four zero at seven.
visibility's one half, mist. ceiling is two hundred broken, six hundred
broken, nine hundred overcast. temperature one eight. our Humble
altimeter three zero, zero one. remarks, surface visibility is five.
runway two six RVR [runway visual range] is more than six thousand.

The Departure North controller then handed off the flight to the Arrival East controller. After a series of turns, the flight was cleared about 0751:43 for the approach to IAH and instructed to contact the IAH tower. The CVR recording does not indicate that the flight crew conducted a verbal approach briefing.

About 0752:51, the IAH Air Traffic Control Tower (ATCT) Local West controller cleared the flight to land on runway 26. Radar data indicated that the airplane began a descent from

2,000 feet mean sea level (msl) about 0753:17 from about 0.5 nm inside NIXIN (the final approach fix) on the left edge of the localizer course. The airplane descended to 1,600 feet msl, where it intercepted the center of the localizer course approximately 1.5 nm inside NIXIN. About 0753:47, the CVR recorded the captain stating, "I got a compass flag." Immediately after the captain's comment, the airplane departed the localizer centerline to the left, establishing a course about 25 degrees left of the final approach course. The airplane continued on this course for approximately 50 seconds and descended to about 700 feet msl.

According to CVR data, about 0754:36 the first officer said, "you wanna go missed and go back? it shows you right of course." The captain responded, "yeah yeah tell him we go missed." About 0754:41, the local controller said, "Lear uh, seven Whiskey Sierra uh, say heading." The first officer responded, "uh, we need to go missed.... we're going missed approach." A missed approach was then initiated from about 0.8 nm from the threshold of runway 27 on its extended centerline. (Runway 27 is south of and parallel to runway 26.) The flight was assigned an altitude and heading to fly and switched from local control back to approach control.

About 0756:05, the first officer told the controller, "we need to go back to Intercontinental or uh back to uh, Houston Hobby." The captain said to the first officer, "no, we just need to fly around a bit." The first officer then told the controller, "captain says, uh, we're gonna fly around if you can put us out uh, we're gonna try to straighten something out." The controller asked, "do you have a problem with the aircraft?" The first officer replied, "just the compass. we're working on it." According to CVR data, the captain and first officer spent the next few minutes attempting to clear the compass flag by resetting circuit breakers. The CVR recording provides no indication that the problem was resolved.

About 0759:10, the captain said, "well let's go back to Hobby, we can't, we can't do a trip like this," but then said, "well now let's think about this a second." The first officer asked the captain about the weather conditions in North Dakota. The captain replied that it was "severe clear" and then said, "uh, let's go on and try Intercontinental again." About 0759:42, the first officer requested another approach to IAH.

The controller began vectoring the flight for a second ILS approach to runway 26, instructing the flight crew to "fly heading three five zero." About 0759:58, the captain said, "right turn to three five zero?" and the first officer replied "yeah." Radar data indicated the airplane began to turn right from an eastbound heading toward the south. The controller noticed that the airplane was turning southbound and instructed the flight crew to "turn northbound heading three, six, zero." The first officer acknowledged the controller's correction, and the airplane began to turn left. Afterward, the first officer made three statements to the captain about his radio magnetic indicator (RMI). The first officer said, "threeee six zero. watch your RMI" (about 0801:32); "RMI three six zero going...." (about 0801:44); and "watch the RMI" (about 0802:12).

About 0801:55, the controller transmitted the following IAH ATIS weather conditions:
information Foxtrot is current.... the wind three five zero at six. the
uh, weather is less than a quarter mile visibility light rain and uh,
mist. two hundred broken uh, measured ceiling two hundred broken
six hundred overcast. altimeter three zero zero one the runway

two six RVR's more than six thousand.

After a series of turns, the flight was cleared about 0806:22 for the approach and instructed to contact the IAH tower. The CVR recorded no discussion or briefing on how the approach would be flown. About 0807:53, the Local North controller cleared the flight to land on runway 26. About 0808:03, the first officer said, "OK, you are cleared to land. apparently, it the glideslope (isn't) working. I can't watch it...." At this point, radar data indicated that the airplane was about 1.1 nm outside NIXIN on the glideslope and inside the left half of the localizer course.

The airplane remained within the left half of the localizer course and on or slightly above the glideslope until it reached a point approximately 0.6 nm inside NIXIN. The airplane then traveled momentarily outside the left edge of the localizer course. About 0808:34, the first officer said, "...quit turning, quit turning. we're gonna go through it. follow mine right here." After the first officer's comment, the airplane's course varied slightly to the right and began to converge with the localizer course. As the airplane neared the localizer centerline (about 0808:52), the first officer said, "OK, ease your wings back. to the right, to the right, to the right...." The captain then stated, "all right. Can you fly it?" The first officer replied, "yeah, I think so."

When the transfer of control from the captain to the first officer took place, the airplane was approximately 1.9 nm inside NIXIN (3.8 nm from the runway threshold), slightly below the glideslope and on the localizer centerline. About 0809:08, the captain asked, "where's your glideslope?" The first officer replied "right here," and the captain said, "look at it." About 0809:21, the first officer stated, "...we are way above glideslope." The captain responded, "right. ease it on down." At this point, the airplane was between 200 and 300 feet below the glideslope. About 0809:30, the first officer said, "all right, where's the missed approach point...?" The captain replied, "two hundred feet." (The published decision height for the approach was 296 feet msl, or 200 feet above ground level (agl).) About 0809:45, the first officer said, "OK. three hundred feet to missed. OK, I'm breaking out." The captain responded, "don't don't you look up."

The last radar position for the airplane, recorded about 0809:48, was approximately 2.2 nm from the runway threshold, about 400 feet below the glideslope, at an altitude of approximately 400 feet msl. About 0809:54, the CVR recorded a slapping sound that was followed by the sound of impact. The CVR stopped recording about 0809:56.

The accident occurred during daylight approximately 2 nm from the threshold of runway 26 and along the extended runway centerline. The elevation of the accident site was approximately 100 feet msl. The airplane initially struck trees about 80 feet tall. The cockpit/cabin area was found approximately 860 feet west of the initial tree strike at 29 degrees 59.563 minutes north latitude and 095 degrees 17.26 minutes west longitude. There were no witnesses to the accident.

PERSONNEL INFORMATION

Neither the captain nor the first officer had any Federal Aviation Administration (FAA) record of airplane accidents, incidents, or enforcement actions. Interviews with immediate family members and acquaintances disclosed no evidence of any activities that would have prevented either flight crewmember from obtaining sufficient rest in the 72 hours before the accident.

The Captain

The captain, age 52, held an airline transport pilot certificate with the ratings and limitations of airplane multiengine land; commercial privileges for airplane single-engine land; and type ratings for the Learjet, IA-JET, and HS-125. The captain obtained his Learjet type rating on February 6, 1987. His most recent FAA first-class medical certificate was issued on October 7, 1997, with the limitation that he wear corrective lenses for distant vision and possess corrective lenses for near vision while acting as a pilot.

According to the captain's flight logbook, he had accumulated 8,777 total flying hours, of which 2,512 were in the Learjet. He had flown 19, 100, and 610 hours in the past 30 days, 90 days, and 1 year, respectively. The logbook indicated that the captain had flown one previous trip in N627WS; that trip occurred on December 23, 1997, and included about 6.9 hours of flying time. The captain's most recent Learjet recurrent simulator training was accomplished in October 1997 at the facilities of SimuFlite Training International. This training consisted of 12 hours of ground school and 9 hours of flight simulator time.

Pilot training records reviewed during the accident investigation indicated that the captain had satisfactorily completed the training and testing requirements to act as pilot-in-command (PIC) of a Learjet 24 or 25 for three Houston-area 14 CFR Part 135 operators. These operators were Aviex Jet, American Corporate Aviation, and Executive Air Charter, and the required training and testing for each were completed on January 22, August 15, and December 9, 1997, respectively. The captain was qualified to act as PIC of a Learjet 25 for Aviex Jet and American Corporate Aviation and of a Learjet 24 for Executive Air Charter.

At the time of the accident, the captain was working as a contract pilot and had no full-time employment. From July to December 1997, Linrose Aviation, Inc., of Longview, Texas, employed the captain as PIC of a Learjet 25D. According to the vice president of Linrose Aviation, the captain's employment was terminated because of his failure to follow company rules and not because of unsatisfactory flying skills.

Interviews were conducted with pilots and check airmen who had flown with the captain in the Learjet. These personnel described the captain as an experienced pilot with an outgoing, friendly personality. Comments concerning the captain's flying skills were generally favorable. However, the check airman for Aviex Jet stated that the captain was "well above average, but not the best in pilot skills."

The First Officer

The first officer, age 39, held a commercial pilot certificate with the ratings and limitations of airplane single- and multiengine land, instrument airplane, and a visual flight rules (VFR)-only DC-3 type rating. Additionally, she held a flight instructor certificate with airplane single- and multiengine land and instrument airplane ratings. Her most recent FAA first-class medical certificate was issued on November 6, 1997, with no limitations or restrictions.

According to the first officer's flight logbook, she had accumulated 2,237 total flying hours, of which 350 hours were in the Learjet. She had flown 38, 143, and 597 hours in the past 30 days, 90 days, and 1 year, respectively. The logbook indicated the first officer had flown six previous trips in N627WS for a total of 21.4 flight hours; the most recent trip occurred on December 24, 1997. Her initial Learjet simulator training was accomplished in April 1997 at the facilities of Flight Safety International. This training consisted of 14 hours of ground school and 18 hours of flight simulator time.

Pilot training records reviewed during the accident investigation indicated that the first officer

had satisfactorily completed the training and testing requirements to act as second in command of a Learjet 25 or 35 for three Houston-area 14 CFR Part 135 operators. The operators were Aviex Jet, Air America Jet Charter, and American Corporate Aviation, and the required training and testing for each was completed on June 30, July 31, and August 6, 1997, respectively. The first officer was qualified to act as second in command of a Learjet 25 for all three operators and of a Learjet 35 for Air America Jet Charter. At the time of the accident, the first officer was working as a contract pilot and part-time flight instructor. She had no full-time employment.

Interviews were conducted with captains and check airmen who had flown with the first officer in the Learjet. These personnel described the first officer as a hard worker with a strong desire to improve her knowledge of the airplane and obtain a type rating. Regarding the first officer's piloting skills, comments by captains included "for a low-time pilot [she] did a pretty good job" and "[she] flew like she was ready to get her Learjet type rating." However, the check airman for Aviex Jet stated that the first officer "was at minimum proficiency and capability." The check airman believed that the first officer was not "cut out to be a charter pilot," stating that "her biggest problem was basic hand-eye coordination. She was easily overloaded. She would be fine if she were paired with a strong pilot in command."

AIRPLANE INFORMATION

N627WS, a Gates Learjet 25B, serial number (S/N) 170, was issued an airworthiness certificate on June 5, 1974. The airplane was configured to carry eight passengers and two pilots and was equipped with two General Electric model CJ610-6 turbojet engines rated at 2,950 pounds of thrust. The last major inspection of N627WS, which had been operated by American Corporate Aviation since July 1997, was a 600-hour inspection accomplished on August 31, 1997. At that time, the airplane had accumulated 8,913 flight hours. The CEO of American Corporate Aviation estimated that the airplane had flown approximately 30 hours since the time of the last inspection.

Weight and Balance

The airplane's weight and balance were calculated for both takeoff at HOU and landing at IAH. The calculated takeoff gross weight of 13,283 pounds and center of gravity (CG) of 28.85 percent mean aerodynamic chord (MAC) were within the takeoff limits (15,000 pounds and 13.9 to 30 percent MAC, respectively). The calculations for landing at IAH, predicated on a fuel burn of 1,042 pounds, indicated that the landing weight would have been 12,241 pounds and that the CG would have been 29.05 percent MAC. These values were within the landing limits of 13,300 pounds and 12.5 to 30 percent MAC, respectively. According to the Gates Learjet 25B/25C Flight Manual, the landing approach speed (VREF) for the calculated landing weight was 121 knots.

Flight Director System

The airplane was equipped with two Bendix FD-60 Flight Director Systems, one each for the captain and first officer positions. An FD-60 system consists of a course deviation indicator (CDI), horizon and director indicator (HDI), control panel, flight steering computer, and flight instrument amplifier. Each system also receives input from a remote directional gyro for heading information. The system consolidates navigational and attitude information, computes combined roll and pitch steering commands, and displays all information on the CDI and HDI. The FD-60 functions independently of the airplane's autopilot.

The CDI is a primary cockpit instrument that displays magnetic (or compass) heading and provides a pictorial presentation of aircraft displacement relative to VOR radials, localizers, and glideslope beams. It is also referred to as a horizontal situation indicator (HSI). According to the Pilot's Familiarization Handbook for the FD-60 system, the CDI has an emergency mode that allows continued use of data from radio aids when heading information is unreliable. The pilot selects this mode by pulling out the course crank (or knob). Once in the pulled-out position, the knob can be turned to manually rotate the compass card and associated displays in relative positions to orient the course deviation needle parallel to the instrument's vertical axis. The HDI is a primary cockpit instrument that displays aircraft attitude, localizer, and glideslope beam information; speed command deviation; and computed pitch and roll steering commands. It is also referred to as an attitude director indicator (ADI).

The appearance of a compass warning flag on the CDI indicates that the heading display is unreliable. According to technical specifications published by the manufacturer, a compass warning flag would come into view on the CDI if one of the following events occurred: (1) a loss of electrical power to system components, (2) a failure of the remote directional gyro, or (3) the function of the compass display servomechanisms becomes unreliable. The compass display servomechanisms are controlled by the flight instrument amplifier with input from the remote directional gyro.

Maintenance Records Review

The aircraft maintenance logbook for recording mechanical irregularities, which was required by 14 CFR Section 135.65 to be on board the airplane, could not be identified during examination of the airplane wreckage. On January 16, 1998, 3 days after the accident, the CEO of American Corporate Aviation sent a facsimile to the Safety Board, stating the following:

I have found notes from a flight 11-12-97 of avionics problems that were entered on the aircraft Discrepancy Maintenance Log.

#1 VOR will not channel 117.6 & 101.9

GPS [global positioning system] falls off the keeps re-cap and holding sig 5 to 10 min.

Copies of work order authorizations that described the avionics problems were obtained from Raytheon Aircraft Services. The records indicate that three discrepancies, or "squawks," were reported to Raytheon on November 13, 1997, for repair.

The first squawk read, "#1 NAV OUT ON 117.6." The associated inspection card stated that the following corrective actions were taken:

Removed nav RX [receiver] bench checked good hot & cold, removed Gables control cleaned & lubricated ops check good in a/c. NOTE: NOT VERIFIED.

The second squawk read, "#2 GLIDESLOPE OUT ON 109.9." The associated inspection card stated that the following corrective actions were taken:

Ground checked operation confirmed both ADI & HSI G.S. [glideslope] pointers sticks. Note: advised customer, repairs deferred until such time available to send units out to mfr.

The third squawk read, "GPS LOSES POSITION." The associated inspection card stated that the following corrective actions were taken:

Ground checked operation system does not receive satellites suspect ANT [antenna] problem. Connected another GPS ANT for test system worked OK. Note: original antenna no longer available. Consulted with Northstar. They provided an acceptable substitute. This unit required rework of the mounting area on the aircraft. Customer contracted with local facility (Flight Vehicles) for mounting of replacement antenna. Still have problem. M6 GPS sensor S/N 688, CDU [control display unit] S/N R00142 sent to mfr for repair 12-11-97.

Examination of the airplane's maintenance records revealed an entry on November 13, 1997, that corresponded to the three squawks. This entry, which was the last one in the maintenance records, stated the following:

Removed #1 VIR-30A VOR/ILS rcvr. s/n 1672, and Gables control for the Nav, s/n 001, VIR-30A checked to specs, no trouble found. Cleaned and lubricated control unit. Checked #2 Glideslope in the aircraft, found Glideslope pointer in both ADI and HSI to be sticking, co-pilots position. No action taken at this time. Removed Northstar M6 GPS sensor s/n 688 and CDU s/n R00142 for evaluation by the manufacturer.

In an interview conducted during the accident investigation, the Director of Operations for American Corporate Aviation was asked if he was aware of any problems with the airplane before the accident. The official replied that he was aware of only a problem with the GPS, which had been removed and sent to the manufacturer for repair. The director of operations further stated that he did not think there were any other problems with the airplane and that his company was "good" about fixing maintenance discrepancies. According to the official, N627WS did not fly very much, so taking it out of service for maintenance for a short time did not greatly affect the company's operations.

Minimum Equipment List

Title 14 CFR Section 135.179 provides for the operation of an aircraft under 14 CFR Part 135 with inoperable instruments or equipment installed. The rule requires that the certificate holder (operator) have an approved minimum equipment list (MEL) for the specific make and model of aircraft and that the use of the approved MEL be authorized in the certificate holder's operations specifications. Additionally, the rule states that the aircraft must be "operated under all applicable conditions and limitations contained in the Minimum Equipment List and the operations specifications authorizing use of the Minimum Equipment List."

Review of the operations specifications for American Corporate Aviation indicated that the company was authorized to use an FAA-approved MEL. A copy of the approved MEL applicable to N627WS was obtained from the CEO of American Corporate Aviation. According to page 34-2 of the MEL, dated April 15, 1997, the airplane was equipped with two "VHF

Navigation Systems (VOR/ILS)." The MEL stated that "both may be inoperative provided flight is made VFR outside TCA [terminal control area]. COMPLY WITH PM 2,3." (The Procedures Manual section of the MEL identified PM 2 and PM 3 as Placarding Procedures and Crew Operating Procedures, respectively.) The MEL indicated the navigation systems were Category C repair interval items. According to the Definitions section of the MEL, Category C items "shall be repaired within ten (10) consecutive calendar days (240 hours), excluding the day the malfunction was recorded in the aircraft maintenance record/logbook."

Title 14 CFR Section 91.213 provides for the operation of an aircraft under 14 CFR Part 91 with inoperative instruments or equipment installed. The rule states that "a person authorized to use an approved Minimum Equipment List issued for a specific aircraft under part 121, 125, or 135 of this chapter shall use that Minimum Equipment List in connection with operations conducted with that aircraft under this part without additional approval requirements."

METEOROLOGICAL INFORMATION

The 0600 and 0900 surface analysis charts of the National Weather Service (NWS) depicted a cold front approaching the accident area, stretching from southern Texas to central Louisiana. The Houston area remained south of the front. In this warm air sector, an extensive area of fog and mist was reported along the Texas and Louisiana coastline along with scattered rain showers and thunderstorms.

The NWS-reported weather conditions at IAH surrounding the time of the accident were as follows:

At 0753, winds 350 degrees at 6 knots, tower visibility less than 1/4 mile in light rain and mist, ceiling broken at 200 feet and overcast at 600 feet, temperature 18 degrees C, dew point 17 degrees C, altimeter setting 30.01 inches of mercury [Hg]. Remarks: ASOS [automated surface observation system], surface visibility 6 miles, ceiling 100 variable 500 feet, sea level pressure 1016.1 millibars, precipitation within the last hour 00.00 inches.

At 0804, winds 360 degrees at 8 knots, tower visibility less than 1/4 mile in light rain and mist, scattered clouds at 200 feet, ceiling broken at 800 feet, temperature 18 degrees C, dew point 17 degrees C, altimeter 30.02 inches of Hg. Remarks: ASOS, surface visibility 6 miles, ceiling 600 feet variable 900 feet, precipitation 00.01 inches.

At 0820, winds 340 degrees at 4 knots, tower visibility less than 1/4 mile in light rain and mist, scattered clouds at 600 feet, ceiling overcast at 1,000 feet, temperature 18 degrees C, dew point 17 degrees C, altimeter setting 30.02 inches of Hg. Remarks: ASOS, surface visibility 5 miles, precipitation 00.01 inches.

The NWS terminal forecast for IAH, issued at 0540 and pertinent for the indicated times, called for the following:

Beginning at 0600, winds calm, visibility 1/4 mile in fog, vertical visibility 100 feet into the obscuration, temporarily between 0600 and 0800, light rain showers. From 0800, winds 350 degrees at 9 knots, visibility 3 miles in mist, clouds scattered at 100 feet, ceiling overcast at 1,200 feet, temporarily between 0800 and 1000, visibility 1 mile in light showers of rain and mist, ceiling broken at 100 feet.

Amendment at 0609, temporarily between 0600 to 0800, thunderstorms and light rain, ceiling broken at 100 feet with cumulonimbus clouds.

IAH Terminal Doppler Weather Radar (TDWR) archive data from 0745 to 0815 showed no microburst, wind shift, gust front, or other wind-shear features. The TDWR system identified a few level 1 radar echoes within the 5-mile range of IAH; however, no radar echoes were noted over runway 26 or eastward along the 4-mile approach area. At the 15-mile range, the system identified a small area of level 1 radar echoes beyond 5 miles on the extended centerline of runway 26.

AIDS TO NAVIGATION

Runway 26 is served by an ILS with distance measuring equipment. An outer compass locator, identified as NIXIN, is co-located with the outer marker, 5.7 nm from the runway threshold. After the accident, the ILS was flight checked by the FAA. All components, except for the inner marker, were found to be operating within prescribed tolerances. (The inner marker is used only for Category II and III approaches, which are ILS approaches to reduced weather minimums under special rules of certification for the crews, runways, and equipment.)

AIRPORT INFORMATION

IAH is owned and operated by the City of Houston, Texas. The airport is located approximately 15 miles north of Houston and has an elevation of 98 feet msl. IAH has four runways: 08/26, 09/27, 14L/32R, and 14R/32L. Runway 08/26 is 9,401 feet long and 150 feet wide with a grooved asphalt/concrete surface. It is equipped with a high-intensity approach lighting system with centerline sequenced flashers; high-intensity runway edge lights; and a touchdown, midpoint, and rollout RVR system. The runway's touchdown zone elevation is 96 feet msl.

FLIGHT RECORDERS

A flight data recorder (FDR) was not installed in N627WS, and 14 CFR Part 91 and 135 did not require the airplane to be so equipped. The CVR installed on the airplane was a Fairchild model GA100. The voice recording consisted of three channels of good-quality audio information. One channel contained the cockpit area microphone audio information, and the two other channels contained the captain's and first officer's audio panel information. A transcript was prepared of the entire 30-minute 56-second recording.

WRECKAGE AND IMPACT INFORMATION

Accident Site Details

The terrain at the accident site was level and consisted of soft, wet dirt with numerous trees measuring about 80 feet in height. Evidence of a freshly severed treetop marked the beginning of the wreckage distribution path. The cockpit/cabin area was found about 860 feet on a magnetic bearing of 263 degrees from this tree.

The initial piece of wreckage, found about 155 feet beyond the initial severed treetop, was a piece of wing skin. More pieces of wing skin were found along the wreckage path, including the cover-plate of the left wing flap push-pull tube, which was found about 300 feet beyond the initial severed treetop. This piece of wreckage was followed, in order, by the left and right main landing gear (MLG) doors, right flap, right horizontal stabilizer tip, left horizontal stabilizer skin pieces, and stinger cap. Evidence of scorched tree limbs was found beginning about 470 feet beyond the initial severed treetop. This evidence was followed, in order, by the airplane's radome, left elevator, left wing spoiler, left wing flap, tail surfaces, wing structure, MLG struts, and right engine. The final pieces of wreckage found included portions of the fuselage structure, the cockpit/cabin area, and the left engine.

Most of the wreckage that was found along the final one-third of the distribution path sustained extensive thermal damage. However, the avionics equipment that was installed in the nose of the airplane, which was found downrange of the burnt cockpit/cabin area, did not receive any thermal damage. No evidence of an in-flight structural failure or in-flight fire was found at the accident site.

Powerplants

The left engine, a General Electric model CJ610-6, S/N 240088, had separated from the airframe and was found about 870 feet from the initial severed treetop along the wreckage path. This engine was resting about 5 feet beyond the cockpit/cabin area and 90 feet beyond the right engine. A gross external examination of the engine did not reveal any evidence of an uncontained engine failure or preimpact mechanical malfunction. The thrust reverser was found in the stowed position. The stage 1 compressor rotor blades exhibited chordwise leading edge tip curling and tearing. Obstructed views of stage 1 stator vanes and stage 2 rotor blades revealed additional leading edge and trailing edge distortion and tearing. All stator airfoil damage was in the direction of rotation, and all rotor airfoil damage was opposite the direction of rotation. To allow a visual examination of the combustor section, Safety Board investigators removed both combustor borescope covers. The examination revealed significant volumes of burnt compressed wood particles adhering to the forward facing step along the aft edge of each of the two borescope ports.

The right engine, a General Electric model CJ610-6, S/N 249105, had separated from the airframe and was found about 780 feet along the wreckage path from the initial severed treetop. This engine was resting about 80 feet up-range of the cockpit/cabin area and 90 feet up-range of the left engine. Examination of the engine did not reveal any evidence of an uncontained engine failure or preimpact mechanical malfunction. The thrust reverser was found in the stowed position. All stage 1 and stage 2 rotor blades were severely bent opposite the direction of rotation. The outboard two-thirds of each stage 1 rotor blade was bent about 45 to 60 degrees opposite the direction of rotation. To allow a visual examination of the combustor section, Safety Board investigators removed the left combustor borescope cover. The examination revealed a small amount of compressed wood particles adhering to the

forward facing step along the aft edge of the borescope port and the mating location of the port cover. The wood particles were partially burnt, oil soaked, and black in color.

Airframe

Most of the fuselage structure was found near the end of the wreckage distribution path. Fire and impact forces destroyed about 90 percent of the structure. The cabin door was found in its correct, stowed position and was intact on its frame. The forward portion of the fuselage structure was found lying upright, and the rearward portion of the fuselage was found twisted around a tree and lying upside down. The horizontal stabilizer, both elevators, and the rudder had separated from the fuselage. The vertical stabilizer remained attached to the fuselage.

The entire cockpit area was completely consumed by the fire. No readings or positions of instruments, switches, circuit breakers, and/or controls could be obtained. Both of the CDIs were identified and extracted from the wreckage, but only their chassis had survived the fire. The CDI compass cards and associated servomechanisms were destroyed. An examination of the course cranks, spline shafts, and gear teeth revealed that both cranks were found in the "normal" operational mode position.

Both wings had separated from the fuselage and broken into numerous sections. An examination of the separated pieces revealed evidence of tearing and tensile overload.

The largest section of the right wing was found about 690 feet from the initial severed treetop. This section had the right spoiler attached to it and was about 3 feet in length and width. The right spoiler and its actuator were found retracted. The right wing fuel tip tank, aileron, and flap were found separated and scattered along the wreckage path. The right wing flap, which had lodged in a tree, exhibited evidence of impact damage on its lower surface and leading edge. The flap actuator was found extended beyond its maximum travel limit of 45 degrees.

The largest section of the left wing was found about 730 feet from the initial severed treetop. This section was the outboard portion of the wing, including its attached fuel tip tank and aileron. The left flap and spoiler were found separated from the left wing and scattered along the wreckage path. The left spoiler actuator was not recovered. The left wing flap was recovered in two pieces and exhibited evidence of impact damage. The flap actuator was found extended beyond its maximum travel limit of 45 degrees.

All flight controls were found along the wreckage path. No evidence of a preimpact flight control malfunction was found. However, flight control cable continuity could not be established because of extensive impact and fire damage. The aileron and rudder trim tabs were found in their neutral positions. The horizontal stabilizer was trimmed to approximately 4.3 degrees leading edge down.

The left MLG assembly, including its actuating rod, had been torn away from the wing and was found lying in the cockpit/cabin area. The assembly incurred substantial fire damage. An examination of the left MLG actuator revealed that it was in the extended position. The right MLG assembly had also separated from the wing and was broken apart into several sections. These sections were found between 730 and 780 feet from the initial severed treetop. Impact damage to the right MLG actuator precluded a determination of its position. The nose wheel tire assembly and lower strut were found about 650 feet from the initial severed treetop and about 60 feet to the south of the wreckage path.

MEDICAL AND PATHOLOGICAL INFORMATION

Autopsies conducted by the Harris County, Texas, Medical Examiner determined that the cause of death for both pilots was blunt force injuries and extensive thermal body burns. The medical examiner took specimens from both pilots, including liver, lung, kidney, spleen, and muscle tissues. Blood, urine, and vitreous humor samples were not available because of the effects of the fire.

The FAA Civil Aeromedical Institute's (CAMI) Forensic Toxicology and Accident Research Center examined the specimens taken by the medical examiner. According to CAMI, the specimens showed no indication of drugs of abuse. For both pilots, values of ethanol, acetone, and acetaldehyde exceeded concentration levels normally reported. Because of the lack of blood, urine, and vitreous humor samples, CAMI was unable to determine whether these concentrations were derived from post-mortem microbial action or pre-mortem alcohol ingestion. The medical examiner's toxicological analysis, performed closer to the time of death, indicated that no alcohol or performance-impairing drugs were present at the time of death.

FIRE

Fire damage to the airplane wreckage was consistent with a fuel-fed fire erupting on impact.

SURVIVAL ASPECTS/EMERGENCY RESPONSE

The accident was not survivable.

The initial notification of a missing airplane was made about 0817. The IAH ATCT contacted the Houston Fire Department stations on the airport, via the crash phone network. About 0855, after searches of the IAH aircraft operating area failed to locate the airplane, a search began beyond the operating area in the woods east of Lee Road (approximately a 3/4 by 2-mile area east of runway 26). Personnel from the Houston Fire and Police Departments, Harris County Sheriff's Department, and IAH Aviation Department participated in the search. Limited visibility, thick woods, swampy grounds, and the lack of roads or paths in the area hampered the ground search.

About 0906, the IAH Aviation Department requested assistance from the Houston Police Department helicopter unit, but it was unable to respond because of the IFR weather conditions. About 0910, the aviation department requested the assistance of a U.S. Coast Guard helicopter. IAH Aviation Department personnel located the airplane about 1012. Other emergency response personnel began to arrive at the accident scene about 1017, and they reported that the two occupants had not survived the accident.

TESTS AND RESEARCH

Flight Instrument Amplifiers

Both flight instrument amplifiers were mounted in the nose compartment of the airplane. They exhibited external impact damage but were not burned. An examination of the maintenance records did not reveal which amplifier S/N was part of the captain's flight director. Therefore, both amplifiers were tested for any anomalies that could have resulted in the extension of a compass flag in the captain's CDI.

The flight instrument amplifier marked as S/N 7404101 was examined first. Its case was dented and had one entire side missing. Dirt was found imbedded in the cannon plug connector. All three fuses were intact and not blown. The case was pried away from the circuit boards, and all four cards were removed. An examination of the boards did not reveal any

evidence of thermal damage, crushing, or loose debris. A capacitor lead on the 412-A1 command circuit card was separated from the board, and a corroded lead from another capacitor was found on the same board; however, this board is not used to excite the compass flag.

The power supply circuit card was extracted from the unit and tested according to the manufacturer's overhaul instructions. The results of the testing were all within published specifications, and no anomalies were found.

The 412-A3 heading circuit card was also tested. However, test equipment for the amplifier, because of its age, was no longer provided by the manufacturer and could not be found at numerous avionics shops contacted by the Safety Board. With the use of schematics provided by the manufacturer, circuitry that simulated the manufacturer's test equipment was fabricated and used to test the heading circuit card according to the manufacturer's overhaul instructions. The results of the testing were all within published specifications, and no anomalies were found.

The flight instrument amplifier marked as S/N 7504102 was examined second. Its case was dented and had one entire side missing. All three fuses were intact and not blown. The case was pried away from the circuit cards, and all four cards were removed. An examination of the cards did not reveal any evidence of thermal damage, crushing, or loose debris. A small amount of dried dirt adhered to sections of all of the cards.

The power supply circuit card and heading circuit card were extracted from the unit and tested according to the manufacturer's overhaul instructions. The results of the testing were all within published specifications, and no anomalies were found.

Directional Gyros (Directisyns)

The airplane was equipped with two remote directional gyros, known as directisyns. The directisyns were manufactured by Jet Electronics and Technology, Inc., and were designated as model no. DN 101D01. They were installed in the nose compartment of the airplane. Both units received impact damage but were not burned. Wiring diagrams provided by Learjet indicated that one directisyn provided heading information to the captain's CDI and the first officer's RMI. The other directisyn provided heading information to the first officer's CDI and the captain's RMI.

According to maintenance records, the captain's CDI received heading information from the directisyn marked as S/N G1704. An examination of the unit's electrical power fuse revealed that it was intact and not blown. The power circuit board was extracted and tested, and all output specifications were met. The case surrounding the gyro was cut away to afford an internal view. The gimbal hardware surrounding the spinning mass assembly was bent. The bending damage was consistent with the impact marks on the case. The spinning mass assembly was extracted from the directisyn. When electrical power was applied to the assembly, the spinning mass inside the housing began to rotate. Electrical power was then removed, and the gyro was disassembled. An examination of the exterior of the spinning mass and the mating surface of the housing revealed distinct rotational score marks, which were oriented along the direction of impact damage.

According to maintenance records, the first officer's CDI received heading information from the directisyn marked as S/N G1562. Examination of the first officer's directisyn revealed damage similar to that found during examination of the captain's directisyn.

Navigation Receivers

The airplane was equipped with two Collins VIR-30A analog navigation receivers, one each for the captain and first officer positions. The control heads for the units were mounted in the cockpit and were completely consumed by fire. The remote receiver units were mounted in the nose compartment and survived the fire, but they did not contain nonvolatile electronics or mechanical linkages from which to obtain any information regarding frequency selection. According to maintenance records, the captain's CDI and HDI displayed navigation information via signals sent from the Collins VIR-30A remote unit marked as S/N 1672. The maintenance records also showed that the first officer's CDI and HDI received navigation information from the Collins VIR-30A remote unit marked as S/N 12489.

Attempts were made to conduct a bench test of each VIR-30A as a full unit; however, impact damage precluded testing. Both the units were then disassembled, and individual modules were extracted. The VOR/localizer module on both units was too damaged to be tested.

The captain's glideslope module remained intact. A sampling of glideslope channels was evaluated for general operation, as characterized by instrument flag position and deviation response. The evaluation revealed that the receiver provided proper responses and deviation indications on 20 separate channels but did not provide any response on 10 other channels. The non-responsive channels always provided a signal to trip an instrument navigation warning flag. According to Collins, this pattern of working and non-working channels is consistent with the failure of one or more of the fragile discreet crystals that are installed in the unit and used to tune to specific glideslope channels.

The first officer's glideslope module remained intact. A sampling of glideslope channels was evaluated. The evaluation revealed that the deviation output resulted in a maximum "fly down" indication regardless of the channel tuned. The glideslope warning flag operated erratically for most channels evaluated. Additional evaluation revealed that an operational amplifier, designated as No. A1U202A, had failed. An examination of electrical schematics of the glideslope module revealed that the failed amplifier controls the deviation of the glideslope needle and that the amplifier's function occurs downstream of the glideslope flag circuitry.

Collins provided the Safety Board with a VIR-30A repair history. According to Collins, 1,336 repair actions on VIR-30A units were recorded between January 1990 and March 1998. Of those repair actions, the A1U202A amplifier was replaced in 12 instances. Of those 12 instances, 3 repair action reports cited that the glideslope warning flag came into view during the failure, and 6 reports cited a "glideslope deviation problem."

ORGANIZATIONAL AND MANAGEMENT INFORMATION

According to information provided by American Corporate Aviation, the company has held an air carrier certificate since 1968, when it commenced operations in Kansas City, Missouri, flying on-demand freight and passengers. By the early 1970s, the company was operating as an air ambulance and a scheduled freight carrier for the U.S. Postal Service. The company relocated to Houston in the spring of 1992.

At the time of the accident, American Corporate Aviation was authorized by the FAA to conduct operations under the provisions of 14 CFR Part 135 using the following nine airplane types: Beech King Air E90, Cessna 208B, Cessna 421B, Learjet 25B, Learjet 25D, Learjet 35A, Mitsubishi MU-2B-25, Mitsubishi MU-2B-60, and Gulfstream Commander 681. American Corporate Aviation was also authorized to conduct its operations under the business names of

Medical Express International and Royal Jet. According to the CEO of American Corporate Aviation, Medical Express International is an air ambulance service with a business office located in Scottsdale and a base of operations in Show Low, Arizona.

Review of the Safety Board's accident database indicated that American Corporate Aviation experienced one previous accident involving a Rockwell Commander 681 on an air ambulance flight on March 12, 1994, at Phoenix, Arizona. The airplane sustained substantial damage during landing with the MLG partially extended. The pilot, two flight nurses, and two passengers were not injured. The Safety Board determined that the probable cause of the accident was "the failure of the hydraulic and nitrogen system pressure lines, due to an inadequate maintenance inspection program, which failed to detect the corrosion condition of the lines."

FAA Surveillance

The FAA Flight Standards District Office (FSDO) responsible for surveillance of American Corporate Aviation is located in Houston. The principal operations inspector (POI) assigned to American Corporate Aviation joined the FAA in 1987 and became a POI in 1989. He was assigned to American Corporate Aviation in 1996.

In an interview conducted during the accident investigation, the POI stated that he was responsible for approximately 37 to 39 operators. He categorized these operators as follows: 8 to 9 Part 91 executive operators, 20 Part 135 charter operators, 7 to 8 Part 137 agricultural operators, and 2 Part 141 pilot school operators. The POI stated that he was also responsible for four pilot examiners and one pilot proficiency examiner. The POI said that, during an inspection, he "looks at everything but sometimes wonders if it's as complete as it should be" because he is "doing essentially a spot check."

The POI said that he had accomplished four or five inspections of American Corporate Aviation in the year preceding the accident. During one of these inspections, in July 1997, he observed the director of operations give a check ride, which the POI said was done "by the book." The POI stated that he does not have time to sit in on training but that he sometimes "sticks his head in." He also said that it is difficult to get the opportunity to do en route inspections and that he had never done an en route inspection of American Corporate Aviation.

The FAA's Program Tracking and Reporting Subsystem showed that FAA inspectors conducted a total of 42 and 51 surveillance activities on American Corporate Aviation in fiscal years 1996 and 1997, respectively. The system reported a total of 41 surveillance activities from October 1, 1997, to January 12, 1998.

Safety Board investigators interviewed the POIs of two other Houston-area 14 CFR Part 135 operators: Aviex Jet and Air America Jet Charter. The POI assigned to Aviex Jet stated that he was responsible for approximately 46 other operators. The POI assigned to Air America Jet Charter stated that he was responsible for a total of 15 operators.

Safety Board investigators also interviewed the Houston FSDO Manager. The manager stated that, at the time of the accident, the FSDO was responsible for surveillance of 57 Part 135 operators, 51 Part 137 operators, 7 Part 141 operators, 5 Part 133 operators, 175 Part 91 executive operators, and 37 pilot proficiency and pilot examiners. According to the manager, the workload of the FSDO, which she characterized as "heavy," was about the same as that of

the FSDOs in San Antonio, Texas, and Indianapolis, Indiana.

ADDITIONAL INFORMATION

The Flight Operator

The charter flight to take five Paracelsus HealthCare Corporation executives from Houston to Fargo was originally scheduled to be flown by Executive Air Charter of Houston. In an interview conducted during the accident investigation, the Director of Operations for Executive Air Charter stated that, as the date of the flight neared, the company realized that it would not have an airplane available to operate the flight. The director of operations further stated that the captain of the accident flight suggested that he call the Director of Operations for American Corporate Aviation. Executive Air Charter's Director of Operations said that "the trip was accepted [by American Corporate Aviation], and it was decided that Executive Air Charter would collect payment for the flight."

In an interview conducted during the accident investigation, the Director of Operations for American Corporate Aviation stated that Executive Air Charter brokered the accident flight. In a February 4, 1998, letter to the CEO of American Corporate Aviation, the director of operations reported that the captain had contacted him in January 1998 about using N627WS. The director of operations further reported that he advised the captain that he "did not have dispatch authority" and directed him to call the CEO of American Corporate Aviation. According to the letter, the CEO later contacted the director of operations and told him that he "had given authority for the trip" in exchange for time in another Learjet.

In an interview conducted during the accident investigation, the CEO of American Corporate Aviation stated that he received a call from the captain, requesting the use of N627WS for a trip to Fargo on January 13. The CEO further stated that he "assumed" the trip was a 14 CFR Part 91 flight for Linrose Aviation because he "knew" the captain worked for Linrose Aviation. The CEO said that he proposed trading the flight time on the Fargo trip for future flight time on Linrose Aviation's Learjet. (The Linrose Learjet, N245BS, was authorized for use under the 14 CFR Part 135 operations specifications of American Corporate Aviation.) Additionally, the CEO stated that he approved the flight but that, if he had known that the trip was for Executive Air Charter, he would never have approved it without getting paid in advance.

In an April 10, 1998, letter to the Safety Board investigator-in-charge, the CEO of American Corporate Aviation wrote that, when the captain called him to request the use of N627WS, the captain "introduced himself" as a pilot for Linrose Aviation and explained that the Linrose Learjet "was unavailable." The CEO further wrote that "[the captain] and others used fraud and misrepresentation for their financial gain to cause me to release Lear N627WS for their use on January 13, 1998." The letter concluded with a statement indicating that the CEO did not believe American Corporate Aviation should be considered the operator of the flight. The CEO reiterated this position in a November 12, 1998, letter to the investigator-in-charge.

American Corporate Aviation's Flight Dispatching

Under the heading "Flight Dispatching," page 9.5 of American Corporate Aviation's Operations Manual, dated December 31, 1995, stated that "the Director of Operations will be responsible for dispatching flights." This section of the manual also listed three other individuals who were "authorized to act as operations manager and be responsible for dispatching flights." One of the listed individuals was the CEO of American Corporate Aviation.

The specific duties of the director of operations were listed in the Operations Manual on page 8.3, dated February 8, 1994, under the heading "Director of Operations - Duties and Responsibilities." Two of the listed duties stated, "schedules aircraft to available flight crew members and establishes personnel duty hours" and "schedules aircraft into applicable inspections and maintenance and coordinates all flights."

American Corporate Aviation's Approach Procedures

The Crew Coordination Procedures section of American Corporate Aviation's Training Manual, which was dated February 15, 1992, contained "procedures to be used by the crew which are in addition to the normal checklist." Under the heading "APPROACH," the following items were listed:

Captain:

1. Sets Navigational Radios To Proper Frequencies And Bearings
2. Gives Co-Pilot The Final Approach Briefing

Co-Pilot:

1. Reviews Approach After The Captain Gives Final Briefing
2. Before Landing Briefing To Passengers
3. On Step Down Approaches Calls Out The Next Altitude After Leaving The Previous Altitude, On ILS, Calls Glide Slope Intercept
4. Calls 1,000 Ft To Go to Missed Approach or MDA [minimum descent altitude]
5. Calls 500 Ft To Go and Every 100 Ft Thereafter Until Reaching MDA or Missed Approach Point
6. Calls Missed Approach Point
7. Calls Runway In Sight

Ground Proximity Warning System

N627WS was not equipped with a Ground Proximity Warning System (GPWS), and none was required under 14 CFR Part 91 or 135. According to data supplied by a U.S. manufacturer of GPWS equipment, the flight profile of the accident airplane indicated that a mode 5, Descent Below Glideslope, aural warning would have sounded approximately 40 seconds before initial impact at an altitude of 1,100 feet msl. Two additional mode 5 warnings would have sounded approximately 34 and 14 seconds before impact. A mode 1, Excessive Sink Rate, aural warning would have sounded approximately 11 seconds before impact at an altitude of 600 feet msl and continued to the end of the flight.

Minimum Safe Altitude Warning

IAH TRACON is equipped with an Automated Radar Tracking System (ARTS) IIIA radar data processing system, which includes Minimum Safe Altitude Warning (MSAW) software to monitor aircraft separation from terrain and obstacles. MSAW provides air traffic controllers

with both a visual alarm indication and an aural tone if an aircraft is below or predicted to descend below a prescribed minimum altitude. These minimum altitudes vary according to geographic location and the type of flight operation being conducted.

For ARTS IIIA systems, MSAW configuration data is found in "Minimum Safe Altitude Warning," National Airspace System document no. MD-633. MSAW operates in three modes: general terrain monitoring, approach path monitoring, and satellite airport monitoring. General terrain monitoring services are provided to aircraft not imminently arriving to or departing from primary or satellite airports. Satellite airport monitoring is applied to aircraft operating in the vicinity of airports other than the airport adapted as "primary" in the ARTS software (in this case, IAH). Because of its position, heading, and status as an IAH arrival, N627WS was subject to approach path monitoring at the time of the accident.

The approach path monitor defines a rectangular area along the final approach course. Aircraft within the area are monitored based on a comparison between their current Mode C reported altitude and a specified minimum altitude. The alert threshold altitude is calculated by subtracting the airport elevation plus a 100-foot buffer from the lowest non-precision MDA for instrument approaches to the specified runway. If an aircraft is in the monitor area and above the alert threshold, its altitude is extrapolated 15 seconds ahead and compared with the alert threshold. If the aircraft is predicted to be below the threshold altitude on two consecutive scans, an approach warning is declared.

For IAH runway 26, the monitor area extended from the final approach fix to a point 2 nm from the runway threshold and 1 nm left and right of the centerline. At the time of the accident, the IAH runway 26 alert threshold was set to 100 feet agl. This computation was based on subtracting 100 feet from the decision height for the ILS 26 approach (200 feet agl). No alerts were generated during either approach of N627WS.

After the accident, FAA personnel recalculated the MSAW parameters for all IAH runways. The lowest non-precision MDA for runway 26 is 600 feet msl, found on the GPS 26 procedure. The new alert threshold altitude calculated for runway 26 is 500 feet msl, or 402 feet agl.

At the request of the Safety Board, the FAA Technical Center configured its ARTS IIIA test and development system to emulate the IAH ARTS, using both the old and new MSAW parameters. Data from N627WS were reprocessed using ARTS "Retrack" software, which permits examination of system performance using archived radar data. The last five observed target times and altitudes shown by "Retrack" were as follows:

- 0809:29.943 and 800 feet msl,
- 0809:34.565 and 700 feet msl,
- 0809:39.183 and 700 feet msl,
- 0809:43.750 and 500 feet msl, and
- 0809:48.402 and 400 feet msl.

With the original MSAW adaptation, the N627WS flight path generated no alerts. With the new parameters, MSAW alerts were displayed from 0809:50 to 0809:59. A single predicted alert occurred at 0809:27.389, but the alert would not have been displayed to controllers because it was not repeated on the next consecutive scan.

Administrative Information

The Safety Board was notified of the accident about 0915 on January 13, 1998. A partial go-team was dispatched, and the following groups were formed: Operations/Human Performance, Air Traffic Control, Airworthiness, and Cockpit Voice Recorder. Additionally, Safety Board specialists provided assistance in the areas of Meteorology, Airports, and Radar.

Parties to the investigation were the FAA; Learjet, Inc.; General Electric Aircraft Engines; AlliedSignal, Inc.; Rockwell Collins, Inc.; and the National Air Traffic Controllers Association.

The airplane wreckage was released to First Star, Inc., on December 7, 1998.

Pilot Information

Certificate:	Airline Transport; Commercial	Age:	52, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	Yes
Medical Certification:	Class 1 Valid Medical--w/ waivers/lim.	Last Medical Exam:	10/07/1997
Occupational Pilot:		Last Flight Review or Equivalent:	
Flight Time:	8777 hours (Total, all aircraft), 2512 hours (Total, this make and model), 5542 hours (Pilot In Command, all aircraft), 100 hours (Last 90 days, all aircraft), 19 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	Gates Learjet	Registration:	N627WS
Model/Series:	25B 25B	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	No
Airworthiness Certificate:	Transport	Serial Number:	170
Landing Gear Type:	Retractable - Tricycle	Seats:	10
Date/Type of Last Inspection:	08/31/1997, Continuous Airworthiness	Certified Max Gross Wt.:	15000 lbs
Time Since Last Inspection:	30 Hours	Engines:	2 Turbo Jet
Airframe Total Time:	8943 Hours	Engine Manufacturer:	GE
ELT:		Engine Model/Series:	CJ610-6
Registered Owner:	FIRST STAR, INC.	Rated Power:	2950 lbs
Operator:	AMERICAN CORPORATE AVIATION	Air Carrier Operating Certificate:	On-demand Air Taxi (135)
Operator Does Business As:		Operator Designator Code:	ANDA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument Conditions	Condition of Light:	Day
Observation Facility, Elevation:	IAH, 98 ft msl	Observation Time:	0804 CST
Distance from Accident Site:	2 Nautical Miles	Direction from Accident Site:	260°
Lowest Cloud Condition:	Scattered / 200 ft agl	Temperature/Dew Point:	64° C / 63° C
Lowest Ceiling:	Broken / 800 ft agl	Visibility	0.25 Miles
Wind Speed/Gusts, Direction:	8 knots, 360°	Visibility (RVR):	0 ft
Altimeter Setting:	30 inches Hg	Visibility (RVV):	0 Miles
Precipitation and Obscuration:			
Departure Point:	(HOU)	Type of Flight Plan Filed:	IFR
Destination:	(IAH)	Type of Clearance:	IFR
Departure Time:	0745 CST	Type of Airspace:	Class B

Airport Information

Airport:	G. BUSH INTERCONTINENTAL (IAH)	Runway Surface Type:	Concrete
Airport Elevation:	98 ft	Runway Surface Condition:	Wet
Runway Used:	26	IFR Approach:	ILS
Runway Length/Width:	9401 ft / 150 ft	VFR Approach/Landing:	

Wreckage and Impact Information

Crew Injuries:	2 Fatal	Aircraft Damage:	Destroyed
Passenger Injuries:	N/A	Aircraft Fire:	On-Ground
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	2 Fatal	Latitude, Longitude:	

Administrative Information

Investigator In Charge (IIC):	GEORGIA R SNYDER	Adopted Date:	04/20/1999
Additional Participating Persons:	LISTED IN INDIVIDUAL		
Publish Date:			
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