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A precision instrument approach that was flown “outside the stabilized approach window” ended when the Gulfstream III struck a light pole and terrain about 3 nm (6 km) from the runway, said the U.S. National Transportation Safety Board (NTSB) in its final report on the Nov. 22, 2004, accident. The airplane was destroyed, and the pilots and flight attendant were killed. An occupant of a vehicle received minor injuries.

NTSB concluded that the probable cause of the accident was “the flight crew’s failure to adequately monitor and cross-check the flight instruments during the approach,” and that contributing factors were “the flight crew’s failure to select the instrument landing system [ILS] frequency in a timely manner and to adhere to approved company approach procedures, including the stabilized-approach criteria.”

The airplane’s ground-proximity warning system (GPWS) remained silent during the approach, but the investigation did not reveal why the system failed. The air traffic control (ATC) minimum safe altitude warning (MSAW) system generated one warning, but it came too late to prevent the accident. Nevertheless, the report said that the MSAW system had “performed as designed, given the alert thresholds established for the [Houston] airport area” (see “Tightening a Safety Net,” page 33).

The accident occurred near William P. Hobby Airport in Houston, where the crew was scheduled to pick up former U.S. President George H.W. Bush and others for a charter flight to Ecuador. The airplane was operated by Business Jet Services, an aviation-management company that conducts on-demand flights under U.S. Federal Aviation Regulations Part 135. “At the time of the accident, the company had about 100 employees, including 35 Part 135 pilots, and a fleet of 13 airplanes, seven of which were Gulfstreams,” the report said.

The captain, 67, had about 19,000 flight hours, including 15,700 flight hours as pilot-in-command (PIC) and 1,000 flight hours in Gulfstreams. He was a check airman and former chief pilot for the company. The first officer, 62, had about 19,100 flight hours, including 17,700 flight hours as PIC and 1,700 flight hours in Gulfstreams. He had been named chief pilot after the captain retired from the position in July 2004 to reduce his work schedule.

Dense Fog

The pilots were scheduled to begin the positioning flight from Dallas Love Field to Houston Hobby at 0500 local time, but the departure was delayed 30 minutes by weather conditions at both airports. An advisory for dense fog had been issued for the area. The terminal forecast for Houston Hobby called for 1/4 mi (400 m) visibility in fog and 100 ft vertical visibility.

Cockpit voice recorder (CVR) data indicate that at 0543, the flight crew obtained the automatic terminal information service (ATIS) report for Houston Hobby. The ATIS report said that the winds were calm, visibility was 1/8 mi (200 m) in fog, runway visual range (RVR) for Runway 04 was variable between 1,600 and 2,400 ft (400 and 800 m), and the ceiling was broken 100 ft above ground level (AGL).

The first officer briefed the captain on the ILS approach to Runway 04, which had published minimums of 244 ft and 1,800 ft (550 m) RVR. The positioning flight was being conducted under the general operating rules of Part 91, which does not prohibit pilots from beginning an instrument approach when the reported visibility is below the published minimums.

The report said that the approach briefing did not adhere to company standard operating procedures (SOPs), which call for the pilot flying, the captain in this case, to conduct the briefing. The first officer also omitted two required briefing items: airplane configuration and the final approach fix (FAF) altitude.

At the captain’s request, the first officer entered waypoints for the following ILS/localizer approach fixes into the flight management system (FMS): CARCO, an intermediate fix

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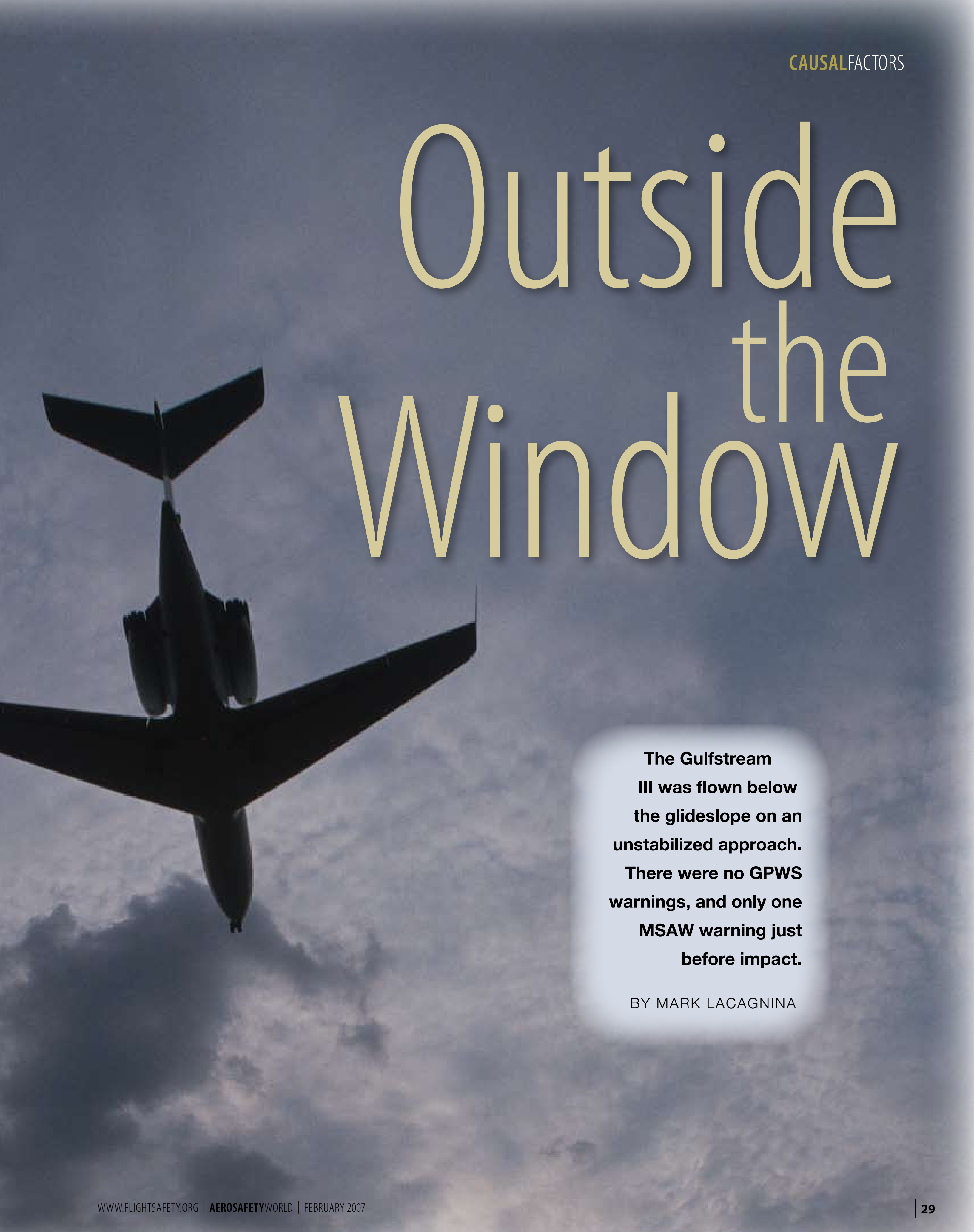


Outside the Window

The Gulfstream III was flown below the glideslope on an unstabilized approach. There were no GPWS warnings, and only one MSAW warning just before impact.

BY MARK LACAGNINA

14.3 nm (26.5 km) from the runway threshold; ELREN, a stepdown fix for the localizer approach, 7.3 nm (13.5 km) from the threshold; and EISEN, the FAF, 4.3 nm (8.0 km) from the threshold. The Hobby VOR (VHF omnidirectional radio), which is on the airport, had previously been entered into the FMS. The report said that after a brief discussion with the captain about whether the VOR was required for the approach, the first officer likely deleted it from the waypoint sequence.

"The MFD [multifunction display] only displays a chronological number for each approach waypoint; therefore, it is possible that the flight crew forgot that the first officer removed the [VOR] waypoint from the FMS, causing them to mistakenly believe that the last waypoint displayed on the MFD (EISEN) was the airport," the report said. "Regardless, an FMS serves as a secondary navigation aid on an ILS approach. The pilots should have been relying on the primary navigational aids during the approach."

Gulfstream III

© John Padgett/airliners.net

The Grumman American — now Gulfstream Aerospace — G-1159A Gulfstream III first flew in 1979. Compared with its predecessor, the Gulfstream II, the airplane has a longer fuselage, more fuel capacity and a redesigned wing, with extended-chord leading edges and winglets.

The airplane accommodates two pilots and up to 14 passengers. Maximum fuel capacity is 28,300 lb (12,837 kg). Maximum takeoff weight is 69,700 lb (31,616 kg). Maximum landing weight is 58,500 lb (26,536 kg).

Each of the two Rolls-Royce Spey 511-8 turbofan engines produces 11,400 lb static thrust (50.7 kilonewtons). Maximum cruise speed is Mach 0.85. Long-range cruise speed is Mach 0.77. Maximum operating altitude is 45,000 ft. Range is 4,100 nm (7,593 km). Stall speed at maximum landing weight is 105 kt.

Production was terminated in 1986, after 202 G-IIIs were built.

Source: *Jane's All the World's Aircraft*

Tuned to the VOR

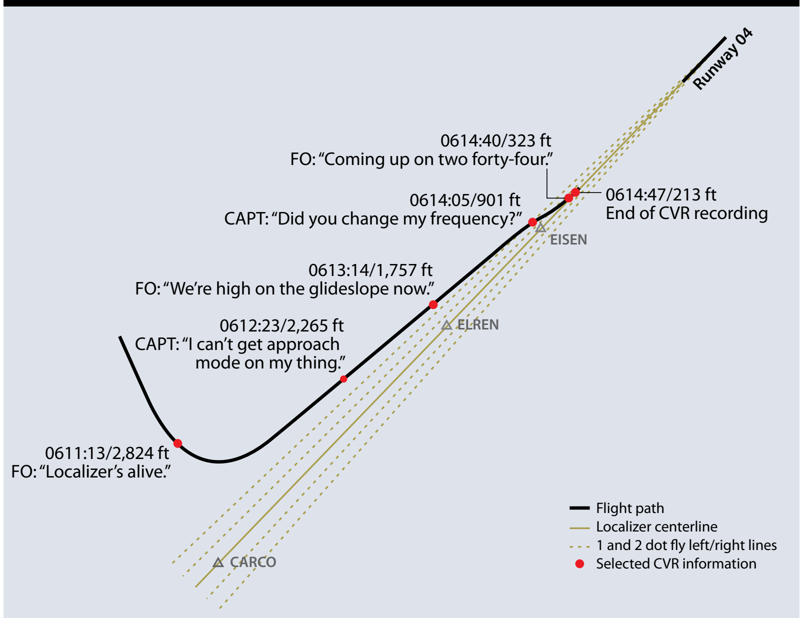
At 0558, the approach controller cleared the crew to fly directly to CARCO "for the ILS runway four." The first officer told the captain, "I'll set up our ILS in here, one oh nine nine." When the first officer entered the localizer frequency, 109.9 MHz, into the navigation receivers, it would have been the standby frequency until selected as the active frequency. He neglected to select it as the active frequency and to check the Morse-code identifier of the active frequency. As a result, the previously selected Hobby VOR frequency remained active.

The airplane was 29 nm (54 km) northwest of the airport at 11,000 ft when the approach controller told the crew to descend to 3,000 ft. At 0609, the first officer told the captain that they were "five miles … from CARCO." The approach controller then told the crew to turn left to 070 degrees and to maintain 2,000 ft or above until established on the localizer.

The airplane was descending through 2,900 ft at 0611 when the first officer said, "Localizer's alive" (Figure 1). Neither pilot was aware that the navigation receivers were still tuned to the VOR. The captain began a left turn and asked the first officer to obtain a current RVR report. The tower controller told the crew that RVR was 1,600 ft.

The captain then told the first officer, "I can't get approach mode on my thing." The first officer said that he also was unable to select the autopilot/flight director approach mode. "What [is] wrong with this?" the first officer asked. The captain said, "I don't know. What do we have set wrong?"

Flight Path Relative to Localizer



CAPT = captain   CVR = cockpit voice recorder   FO = first officer

Times are local.

Source: U.S. National Transportation Safety Board

Figure 1

The report said that the approach mode could not be selected because the navigation receivers were not tuned to a valid ILS frequency and were not receiving ILS signals.

Display Confusion

When the airplane descended through 2,000 ft at 0613, it was about 1,000 ft below the glideslope (Figure 2, page 32). Nevertheless, the first officer told the captain, "We're high on the glideslope now." Later, while descending through 1,700 ft, 700 ft below the glideslope, the first officer said that the airplane was "on the glideslope now."

Both pilots likely misidentified the airspeed fast/slow indicators on their electronic attitude director indicators (EADIs) as glideslope indicators.

Both pilots likely misidentified the airspeed fast/slow indicators on their electronic attitude director indicators (EADIs) as glideslope indicators. "The fast/slow indicator shows airspeed guidance relative to a target airspeed," the report said. "The glideslope and fast/slow indicators are the same color and about the same size. Each indicator consists of a moving pointer on a rectangular display, and each display has markers above and below the rectangle to indicate the degree of deviation."

The fast/slow indicator is displayed continuously. The glideslope indicator is displayed only when a valid ILS frequency has been selected as the active frequency in the navigation receiver. "If a valid [ILS] frequency has not been selected, the side of the screen where the glideslope indicator should appear remains blank," the report said.

According to standards recommended by the U.S. Federal Aviation Administration (FAA), glideslope indicators should be displayed on the right side of electronic instruments, as shown in Figure 3 (page 32).[1] However, the standards were published in 1987, three years after the accident airplane was manufactured. The EADIs in the accident airplane were configured to display the glideslope indicator on the left side.

"Five other company airplanes flown by the accident pilots were configured with the glideslope indicator on the left," the report said. "Of these airplanes, four had fast/slow indicators on the right side, and one had no indicator on the right side. Three of the company airplanes flown by the accident pilots had the glideslope on the right side."

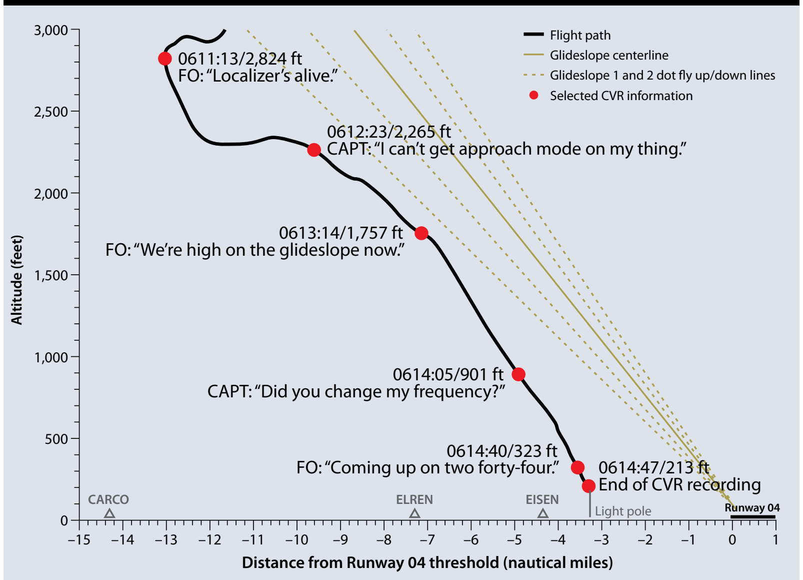
'What Happened?'

The airplane was descending through 1,000 ft at 0614 — about one minute before impact — when the first officer selected the ILS frequency as the active frequency. The captain said, "What happened? Did you change my frequency?" The first officer said, "Yeah. … The VOR frequency was on. We're all squared away now. … You got it."

At this point, the EADIs would have displayed a full-scale deviation below glideslope and nearly a full-scale deviation left of the localizer course. The report said that the absence of any comment by either pilot about the glideslope deviation indicates that they continued to misidentify the fast/slow indicators as the glideslope indicators.

The captain, in an apparent reference to the localizer course, said, "I don't know if I can get

Flight Path Relative to Glideslope



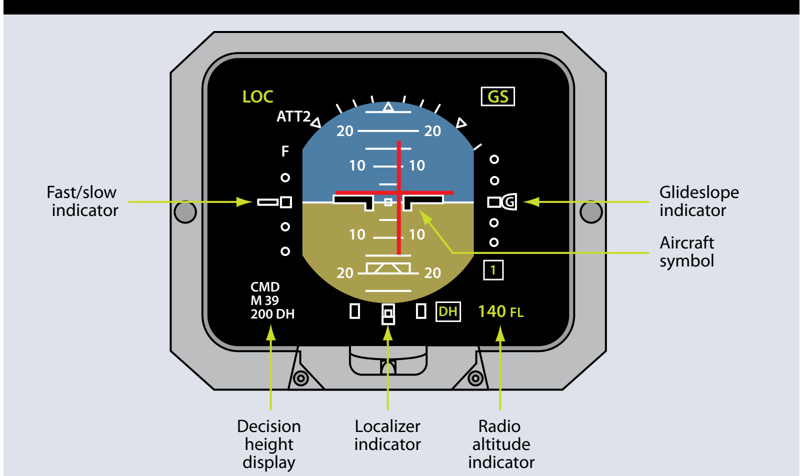
CAPT = captain CVR = cockpit voice recorder FO = first officer

Times are local.

Source: U.S. National Transportation Safety Board

Figure 2

Standard EADI



EADI = electronic attitude director indicator

This display arrangement conforms to U.S. Federal Aviation Administration recommended standards published in 1987. The EADI in the accident airplane, which was built in 1984, displayed the fast/slow indicator on the right side and the glideslope indicator on the left side.

Source: U.S. National Transportation Safety Board

Figure 3

back on it in time." The first officer said, "Yeah, you will. … You're squared away now." The captain conducted a right turn. The airplane was beyond EISEN and descending through 900 ft — 800 ft below the glideslope — when it intercepted the localizer course.

The first officer did not make altitude callouts or course-deviation callouts required by company SOPs. "The [pilot monitoring] is required to call out when the airplane is 1,000, 500, 200 and 100 ft above the DH [decision height, 200 ft] and when the localizer and glideslope [indications] deviated one dot or more," the report said.

The company's criteria for a stabilized approach required that within 500 ft of touchdown zone elevation, deviations from the localizer and glideslope must be less than one dot, and descent rate must be less than 1,000 fpm. "If the airplane is not within these criteria, the [pilot monitoring] should call out 'missed approach,' and a go-around should be executed," the report said. "The CVR did not record either pilot call for a missed approach or initiate a go-around."

At 0614:40, the first officer said, "OK, coming up on two forty-four," the decision altitude. The captain completed the "Before Landing" checklist at 0614:42 and told the first officer to select full flaps.

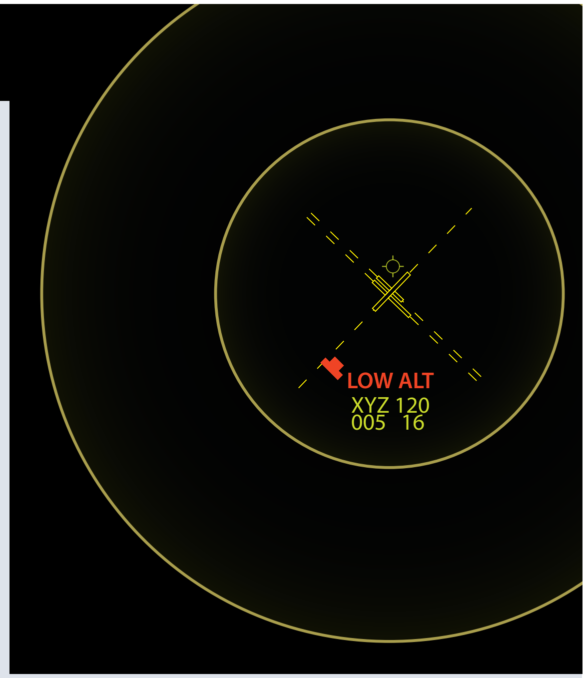
Beginning at 0614:45, the first officer said "up" seven times in quick succession. Simultaneously, the tower controller told the crew to "check your altitude." The airplane struck the light pole at 0614:47.

No Ground Prox Warnings

The report said that flight simulations and bench tests approximating the accident flight profile indicated that the GPWS should have generated warnings that the airplane was below the glideslope and too close to terrain, as well as aural alerts at radar altitudes of 500 ft, 300 ft and 200 ft.

Maintenance personnel had conducted a functional check of the GPWS about eight months before the accident.[2] Company pilots

Tightening a Safety Net



The Gulfstream III crash was among 10 controlled flight into terrain (CFIT) accidents cited by the U.S. National Transportation Safety Board (NTSB) last summer when it called for improvements to the minimum safe altitude warning (MSAW) system (*ASW*, 9/06, p. 9).

When installed in en route and terminal facilities, MSAW software processes air traffic control radar data to determine if an aircraft is below, or is predicted to descend below, a programmed minimum safe altitude. If so, the system generates an aural alarm, which typically lasts for about five seconds, and a visual alarm that consists of the flashing letters "LA" or "LowAlt" next to the aircraft's data block on the controller's radar display. When a controller detects an MSAW alarm, he or she is required to issue a safety alert to the flight crew or to inform the controller who is in radio contact with the crew.

NTSB found that the controllers involved in the CFIT accidents in which safety alerts were not issued or were issued too late were otherwise conscientious and attentive in performing their duties but did not understand how the MSAW system was configured and operated in their areas. For example, approach controllers were not aware that tower controllers do not receive aural alarms until aircraft are within a specific distance — typically 5 nm (9 km) — of the airport. This can create a critical gap between the time an arriving aircraft is handed off to a tower controller and the time the controller begins to receive an aural alarm for the aircraft.

"Aural alarms are particularly important in tower facilities because controller attention must mainly be focused on aircraft visible through the windows, rather than on a radar display, and the aural alarm is the primary method used to draw attention to the radar display," NTSB said. Two of the CFIT accidents illustrate these issues:

On Dec. 17, 2002, an Airbus A330 descended prematurely and more steeply than normal during a localizer approach to Agana, Guam, in instrument meteorological conditions (IMC). The accident involved minor damage but no injuries to the 115 occupants when the airplane struck power lines atop a hill but remained airborne. A ground-proximity warning system (GPWS) warning then prompted the crew to conduct a missed approach. Investigators found that MSAW alarms had been generated for more than a minute at the approach control facility as the airplane descended from about 1,700 ft to 700 ft. The approach controller said that she heard the aural alarm but believed that a second aural alarm would sound if the situation was not resolved. Because of the gap between handoff and generation of aural alarms, an alarm sounded in the tower about the same time the A330 crew told the controller that they were conducting a missed approach.

In an Aug. 4, 2005, accident that was still being investigated at press time, a Mitsubishi MU-2B descended below the glideslope and struck terrain during an instrument landing system (ILS) approach in nighttime IMC to Centennial Airport near Denver, Colorado, U.S. The airplane was about 10 nm (19 km) from the airport when the approach controller handed off the flight to the tower controller. MSAW alarms began 65 seconds before impact, but only a visual alarm appeared on the tower controller's radar display until the airplane was about 5 nm from the airport. An aural alarm then sounded, and the tower controller immediately issued a safety alert to the pilot. There was no acknowledgement, and the airplane crashed a few seconds later, killing the pilot.

Because the system is based on minimum altitudes for instrument flight operations, MSAW service is provided to pilots operating under instrument flight rules but is available only on request to pilots operating under visual flight rules. The digital terrain maps used in MSAW data processing at terminal facilities comprise 2-nm (4-km) squares, each with an assigned minimum altitude. "The software provides alarms when an aircraft is presently within 500 ft of the depicted minimum altitude or is predicted to be within 300 ft of the minimum altitude within 30 seconds," NTSB said. "Different rules are applied to aircraft known to be executing an instrument approach procedure, recognizing that the flight is intentionally descending to ground level."

A problem that has plagued the system from the start is unwarranted, "nuisance," alarms. NTSB said that overexposure to nuisance alarms causes controllers to assume that MSAW alarms are invalid and to "tune them out." To reduce them, MSAW software parameters typically are modified so that alarms are not generated for aircraft that are flown below minimum instrument altitudes during visual approaches. However, this means that an alarm may not be generated until an aircraft is substantially below the expected instrument approach altitude in IMC. This was the case in the G-III accident: "The system provided only 11.5 seconds of warning before the aircraft struck the pole, which was not sufficient time for the controller handling the airplane to recognize the alarm and warn the crew," NTSB said.

Modifying software to apply different alarm parameters for aircraft on visual approaches and aircraft on instrument approaches could improve the effectiveness of the MSAW system while keeping nuisance alarms to a minimum, NTSB said.

The U.S. Federal Aviation Administration (FAA) has told NTSB that it modified some MSAW parameters to improve system accuracy and reduce nuisance alerts, and was gathering data under a safety alert assessment plan that will help determine if further changes are necessary. The FAA said that it also strengthened requirements for issuing safety alerts and was developing new computer-based training aids for controllers.

— ML

who had recently flown the airplane told investigators that the GPWS functioned normally during preflight tests. The company's director of training said that he had received a glideslope warning while flying below the glideslope during a visual approach.

"The only common failure that could prevent activation of the GPWS glideslope and altitude callouts is a radio altimeter failure," the report said. "However, a review of Business Jet Services' maintenance records and the CVR transcript found no evidence indicating any problems with the radio altimeter. The GPWS unit and the radio altimeter were destroyed during impact; therefore, [investigators] were unable to determine why the GPWS did not operate as expected."

One Altitude Warning

The MSAW system generated a warning 11.5 seconds before the crash occurred. "The [tower] controller began issuing a warning to the flight crew about 7.5 seconds after the alert activated, which was about three to four seconds before impact with the light pole," the report said.

The FAA told investigators that MSAW parameters are set so that a "nuisance alarm" is not generated when an aircraft descends below the glideslope during a visual approach. "Because the present MSAW design does not provide any way to alter system performance to treat aircraft flying visual approaches differently from aircraft flying instrument approaches, aircraft that deviate from instrument approach limits during IMC [instrument meteorological conditions] may not generate an MSAW alert until they are well below the expected instrument approach altitude," the report said.

NTSB made no new recommendations based on the findings of the investigation. However, the report made reference to recommendations issued in July 2006 to improve the effectiveness of the MSAW system (*ASW*, 9/06, p. 9).●

This article is based on U.S. National Transportation Safety Board Accident Brief NTSB/AAB-06/06, "Crash During Approach to Landing, Business Jet Services, Ltd., Gulfstream G-1159A (G-III), N85VT, Houston, Texas, November 22, 2004." The 27-page report contains illustrations.

Notes

1. U.S. Federal Aviation Administration Advisory Circular 25-11, *Transport Category Airplane Electronic Display Systems*.
2. The accident occurred before the March 29, 2005, regulatory deadline for installation of terrain awareness and warning systems (TAWS) in turbine airplanes with six or more passenger seats.