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Erroneous ILS Indications Pose Risk of Controlled Flight Into Terrain

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Flight Safety Foundation is an international membership organization dedicated to the continuous improvement of aviation safety. Nonprofit and independent, the Foundation was launched officially in 1947 in response to the aviation industry's need for a neutral clearinghouse to disseminate objective safety information, and for a credible and knowledgeable body that would identify threats to safety, analyze the problems and recommend practical solutions to them. Since its beginning, the Foundation has acted in the public interest to produce positive influence on aviation safety. Today, the Foundation provides leadership to more than 850 member organizations in more than 140 countries.

Erroneous ILS Indications Pose Risk of Controlled Flight Into Terrain

Several incidents involved flight crews who observed normal, on-course instrument landing system (ILS) indications although their aircraft were not established on the glideslope or on the localizer course.

FSF Editorial Staff

On May 11, 2001, the International Civil Aviation Organization (ICAO) sent a letter to the civil aviation authorities in its 187 contracting states advising that "a number of incidents … have occurred in recent years resulting from the operational use of instrument landing system (ILS) signals being radiated during ILS testing-and-maintenance procedures."[1]

The letter, signed by ICAO Secretary General R.C. Costa Pereira, said that ILS signals radiated during testing or maintenance of ground equipment can cause aircraft navigation instruments to display on-course indications and/or on-glideslope indications, with no warning flags, regardless of the actual position of the aircraft within the ILS service area.

"The use of ILS localizer and/or [glideslope] signals for approach guidance during these testing-and-maintenance procedures can therefore result in false indications to the flight crew and has the potential to cause a controlled-flight-into-terrain (CFIT) accident," the letter said.[2] (See "Recommendations for Protection Against Erroneous ILS Indications," page 2.)

One incident occurred the night of July 29, 2000, at Faleolo International Airport, which is near Apia on the northwest coast of Upolu Island, Samoa (formerly Western Samoa). The incident involved a Boeing 767-300 that was being operated as Air New Zealand Flight NZ 60, a scheduled flight to Faleolo from Auckland, New Zealand, with three flight crewmembers, eight cabin crewmembers and 165 passengers.

Air New Zealand said, in its report on the incident, that the flight crew discussed notices to airmen (NOTAMs) for Faleolo before departing from Auckland.[3]

One NOTAM said that the glideslope equipment for the Runway 08 ILS approach was operating without a functional standby transmitter. (The glideslope equipment included two transmitters; one of the transmitters was not functional because it had a faulty power amplifier. The report said that the ILS had been operating without a functional standby glideslope transmitter since late May 2000.)

Two other NOTAMs advised caution when using the glideslope and the distance-measuring equipment (DME) associated with the ILS approach because the glideslope and the DME were operating in an unmonitored status. (The approach procedure included the use of information from the DME collocated with the ILS, rather than marker beacons, because a portion of the final approach is over water.)

ICAO recommends monitoring of ILS components — including localizer transmitters, glideslope transmitters, marker beacons (or DME used in lieu of marker beacons) — both by automatic monitoring equipment installed near the ILS components and by air traffic specialists using remote-control-and-indicator equipment installed in the airport control tower, approach-control facility and/or flight service station (see "ICAO Annex 10 Sets Standards for ILS Equipment," page 4).

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Recommendations for Protection Against Erroneous ILS Indications

The following recommendations, from several sources, are intended to help flight crews avoid accidents involving erroneous instrument landing system (ILS) indications caused by instrument error or by reception of localizer signals or glideslope signals — generated during maintenance/testing of ILS ground equipment or because of maintenance error — that are not intended to be used for navigation. Included are recommendations that have resulted from Flight Safety Foundation's continuing worldwide campaign to help reduce approach-and-landing accidents, including those involving controlled flight into terrain (CFIT).[1,2,3]

- Be aware of the possibility of erroneous ILS indications, including the nonappearance of warning flags;
- Check notices to airmen (NOTAMs) prior to flight to determine the operational status of ILS components;
- Ensure that any reported discrepancies in the operation or functioning of ILS receivers and/or indicators have been addressed adequately by maintenance personnel according to provisions of the aircraft's minimum equipment list (MEL);
- Ten minutes before beginning descent from cruise altitude, conduct an interactive approach briefing that includes: the use of automatic flight control system (AFCS) modes; use of the radio altimeter; minimum safe altitudes; terrain features (e.g., location and elevation of hazardous terrain or man-made obstacles); and typical vertical speed at the expected final approach groundspeed;
- Conduct a stabilized approach (see Table 1);
- Maintain situational awareness throughout the approach;
- Be especially alert when conducting an approach at an uncontrolled airport, where ILS critical areas are not protected by air traffic control (ATC);
- Ensure that ILS receivers are properly tuned and confirm reception of the Morse code identifier or voice identifier;
- Use the radio altimeter during approach to enhance terrain awareness (i.e., knowing where you are, where you should be and where the terrain and obstacles are). Set the radio altimeter decision-height (DH) bug according to the aircraft manufacturer's standard operating procedures (SOPs) or the company's SOPs. The first pilot who observes radio-altimeter activation at 2,500 feet should call "radio altimeter alive," and the radio altimeter should be included in the instrument scan for the remainder of the approach. Synthesized-voice ("smart") call-outs should be activated — or the pilot not flying should announce — the following radio altitudes: 1,000 feet, 500 feet, decision height, 50 feet, 40 feet, 30 feet, 20 feet and 10 feet. Radio-altimeter indications below the following obstacle-clearance values should be cause for alarm: 1,000 feet during the initial approach, 500 feet during the intermediate approach, and 250 feet during the final (Category I ILS) approach;

Table 1
Recommended Elements Of a Stabilized Approach

All flights must be stabilized by 1,000 feet above airport elevation in instrument meteorological conditions (IMC) and by 500 feet above airport elevation in visual meteorological conditions (VMC). *An approach is stabilized when all of the following criteria are met:*

1. The aircraft is on the correct flight path;
2. Only small changes in heading/pitch are required to maintain the correct flight path;
3. The aircraft speed is not more than V_{REF} + 20 knots indicated airspeed and not less than V_{REF};
4. The aircraft is in the correct landing configuration;
5. Sink rate is no greater than 1,000 feet per minute; if an approach requires a sink rate greater than 1,000 feet per minute, a special briefing should be conducted;
6. Power setting is appropriate for the aircraft configuration and is not below the minimum power for approach as defined by the aircraft operating manual;
7. All briefings and checklists have been conducted;
8. Specific types of approaches are stabilized if they also fulfill the following: instrument landing system (ILS) approaches must be flown within one dot of the glideslope and localizer; a Category II or Category III ILS approach must be flown within the expanded localizer band; during a circling approach, wings should be level on final when the aircraft reaches 300 feet above airport elevation; and,
9. Unique approach procedures or abnormal conditions requiring a deviation from the above elements of a stabilized approach require a special briefing.

An approach that becomes unstabilized below 1,000 feet above airport elevation in IMC or below 500 feet above airport elevation in VMC requires an immediate go-around.

Source: Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force (V1.1 November 2000)

- Check the barometric altimeter against the published glideslope-crossing altitude at the final approach fix (FAF), and then conduct distance-height checks prior to reaching DH — for example, by multiplying DME (distance-measuring equipment), GPS (global positioning system) or FMS (flight management system) information about distance from the runway threshold in nautical miles by 300 (if distance information is derived from a source beyond the runway threshold, subtract 300 feet for every nautical mile between the runway threshold and the source; if distance information is derived from a source between the aircraft and the runway threshold, add 300 feet for every nautical mile between the source and the runway threshold);

- Cross-check indications provided by separate instruments;

- Use raw data[4] sources to ensure that the aircraft is on the correct localizer course prior to initiating a coupled approach;

- If an ILS component is identified as unusable or inoperative by a NOTAM, automatic terminal information service (ATIS) broadcast or by an air traffic specialist, disregard any navigation indication relating to that component, regardless of its apparent validity;

- When in doubt about the status of an ILS component or about an approach clearance, question ATC;

- Cross-check groundspeed and rate of descent;

- Operators should equip their aircraft with TAWS, establish SOPs for use of the equipment and train their crews accordingly, including the requirement for the pilot flying to respond immediately to a TAWS warning;[5]

- Be go-around prepared and go-around minded.♦

— FSF Editorial Staff

Notes

1. Controlled flight into terrain (CFIT) occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct an approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport.

2. Flight Safety Foundation. "Approach-and-landing Accident Reduction (ALAR) Briefing Notes." *Flight Safety Digest* Volume 19 (August–November 2000).

3. Flight Safety Foundation. "Killers in Aviation: FSF Task Force Presents Facts About Approach-and-landing and Controlled-flight-into-terrain Accidents." *Flight Safety Digest* Volume 17 (November–December 1998) and Volume 18 (January–February 1999).

4. The Society of Automotive Engineers' *SAE Dictionary of Aerospace Engineering*, edited by William H. Cubberly, defines *raw data* as "information that has not been processed or analyzed by the computer." The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Task Force defines *raw data* as "data received directly (not via the flight director or flight management computer) from basic navigation aids (e.g., ADF, VOR, DME, barometric altimeter)."

5. *Terrain awareness and warning system* (TAWS) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration (FAA) to describe equipment meeting International Civil Aviation Organization (ICAO) standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS and ground collision avoidance system* are other terms used to describe TAWS equipment.

The report said that "unmonitored," as used in the NOTAMs, meant that the ILS equipment at Faleolo was not being monitored by tower controllers because the remote-control-and-indicator equipment in the tower was out of service. The report said that because New Zealand civil aviation rules require all ILS monitoring equipment to be functioning,[4] the NOTAMs should have advised that the ILS system had been withdrawn from service. (This is not a requirement in all countries; the United States, for example, does not prohibit operation of an ILS if remote monitoring equipment is out of service.)

"With no glideslope status indication in the tower, there was no means for the tower [controllers] to be aware that there was a fault on the glideslope transmission system," the report said.

The captain was the pilot flying. Before beginning the descent from cruise altitude, he briefed the first officer and the supplementary pilot on the arrival procedures, the ILS/DME approach to Runway 08 and the VOR (very-high-frequency omnidirectional radio)/DME approach to the airport.

"Due to the unmonitored state of the navigation aids, the [captain] requested the [supplementary pilot] to continuously

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ICAO Annex 10 Sets Standards for ILS Equipment

International standards and recommended practices for the installation, operation and performance of instrument landing system (ILS) equipment are contained in International Civil Aviation Organization (ICAO) Annex 10.[1]

Annex 10 requires that an ILS ground installation comprise the following basic components:

- Very-high-frequency (VHF) localizer equipment;
- Ultra-high-frequency (UHF) glideslope equipment;
- VHF marker beacons or "suitably located" distance-measuring equipment (DME); and,
- Automatic monitors and remote-control-and-indicator equipment for the localizer, glideslope and marker beacons (or DME).

Localizer radio frequencies range from 108.0 MHz to 111.975 MHz, and glideslope radio frequencies range from 328.6 MHz to 335.4 MHz. For each ILS installation, a glideslope frequency is paired with a localizer frequency. When a pilot selects a localizer frequency of 110.35 MHz, for example, the paired glideslope frequency — 334.85 MHz in this example — also is tuned by the onboard ILS receiver.

The localizer frequency includes a voice identification of the ILS or, more commonly, a Morse code identification signal consisting of two letters or three letters preceded by the letter "I" to identify the facility as an ILS. Annex 10 requires that the identification signal be transmitted at least six times per minute when the ILS (or the localizer, only, when the glideslope is out of service) is available for use. *The identification signal or the voice identification should be suppressed when the ILS is being operated for maintenance or testing and is not intended to be used*.

The localizer antenna is located on or near the extended runway centerline beyond the departure end of the runway. The localizer antenna radiates signals directly into space. The glideslope antennas are located off the side of the runway. A typical ILS installation comprises two or three glideslope antennas, which radiate signals directly into space and radiate signals downward where they are reflected by a prepared surface into space.

Although an ILS commonly is perceived as transmitting a tightly focused localizer beam and glideslope beam that form a narrow electronic funnel leading to the runway touchdown zone, in reality, an ILS transmits several different signals that create a complex "radiated field" in a relatively large area beyond the approach end of the runway.

The localizer antenna and the glideslope antennas in a standard "null reference" ILS installation transmit both a combined carrier and sideband (CSB) signal and a sideband only (SBO) signal. The CSB signal comprises the carrier frequency modulated with a 90 hertz (Hz; i.e., cycles per second) tone and a 150 Hz tone. The SBO signal comprises similar 90 Hz and 150 Hz tones; the carrier is suppressed.

Modulation and transmission of the signals are precisely adjusted according to specifications in Annex 10 to produce an SBO null along the desired localizer course line, which typically coincides with the extended runway centerline, and an SBO null along the desired glideslope angle (glide path), which typically is three degrees.

When an aircraft is left of the localizer course line, the onboard ILS equipment measures mostly 90 Hz modulation and causes a fly-right indication to appear on the course-deviation indicator (CDI). When the aircraft is right of the localizer course line, the receiver measures mostly 150 Hz modulation and causes a fly-left indication. When the aircraft is on the localizer course line (i.e., in the SBO null), the receiver measures an equal amount of 90 Hz and 150 Hz modulation and causes an on-course indication.

Similarly, when an aircraft is above the glide path, the onboard ILS equipment measures mostly 90 Hz modulation and causes a fly-down indication to appear on the CDI. When the aircraft is below the glide path, the receiver measures mostly 150 Hz modulation and causes a fly-up indication to appear. When an aircraft is on the glide path (i.e., in the SBO null), the receiver measures an equal amount of 90 Hz and 150 Hz modulation and causes an on-course indication.

The localizer "coverage area" (service area for the front course and the back course, if applicable) extends seven degrees above the horizontal plane and 35 degrees left and right of the runway centerline to 18.5 kilometers (10.0 nautical miles) from the localizer antenna and 10 degrees left and right of the centerline to 46.3 kilometers (25 nautical miles) from the antenna. Annex 10 says that the outer limit of the localizer service area may be reduced to 33.3 kilometers (18 nautical miles) when necessary because of terrain.

The glideslope service area extends typically from 1.4 degrees to 5.3 degrees above the horizontal plane and eight degrees left and right of the glide path centerline to at least 18.5 kilometers from the glideslope antenna.

The U.S. Federal Aviation Administration (FAA) says, in the *Aeronautical Information Manual* (*AIM*), that "false glideslope signals may exist in the area of the localizer back-course approach which can cause the glideslope flag alarm to disappear and present unreliable glideslope information. [Pilots should] disregard all glideslope signal indications when making a localizer back-course approach unless a glideslope is specified on the approach-and-landing chart." (Very few localizer back-course approach procedures include glideslope guidance.)

Kjell Haug, senior engineer at the Norwegian Civil Aviation Authority, said that "false courses" are created by ILS ground equipment outside the ILS service area.[2] Haug said that the false courses are normal byproducts of ILS signal generation. Depending on the type of ILS installation, localizer false courses are created at various angles outside the localizer service area — for example, at 41 degrees left and right of the localizer course line, and at 50 degrees or 60 degrees left and right of the course line of one particular localizer antenna system. A glide path false course typically is at nine degrees.

Nelson Spohnheimer, an FAA national resource engineer for navigation, said that when an aircraft is established on a false course, onboard indications will include centered needles and no warning flag.[3] He said that one method that pilots can use to detect a false localizer course is to check the aircraft's heading against the localizer course published on the approach chart.

"I cannot imagine a pilot being fooled by a glideslope false course; the descent rate to maintain a nine-degree glide path would be outrageous — something in the order of 2,000 feet per minute," he said.

Spohnheimer said that glideslope antennas also produce "null courses" at six degrees and at 12 degrees. When an aircraft is established on a glideslope null course, onboard indications will include centered glideslope needles and glideslope warning flags.

Both the CSB signals and the SBO signals are required for accurate navigation within the ILS service area. Reception of only a CSB signal will cause an on-course indication regardless of the aircraft's position in relation to the localizer course line or the glide path. For example, if only the glideslope CSB signal is being transmitted for calibration by maintenance personnel — and there is no SBO signal to provide steering information — the aircraft's ILS receiver will measure an equal amount of 90 Hz modulation and 150 Hz modulation and cause the glideslope indicator to center and the warning flags to retract (in electromechanical instruments) or not to be displayed (on electronic flight instruments).

FAA uses the term *hazardously misleading information* (HMI) to describe situations such as the radiation of a CSB signal without an SBO signal. Spohnheimer said that among the actions currently being considered by the FAA to reduce the possibility of an accident involving erroneous ILS indications because of HMI is a requirement that the localizer be shut down when specific types of glideslope maintenance/testing are being performed.

ICAO requires that air traffic controllers, flight service specialists and pilots be notified "without delay" when the performance of any navigational aid is changed because of equipment maintenance, testing or inspection.

"Day-to-day changes in the status of facilities are to be promptly and efficiently advertised," ICAO said. "A change in the status of a commissioned facility as a direct result of ground [inspection] or flight inspection procedures … should be advertised immediately by [air traffic control (ATC)] personnel and promptly by NOTAM [notice to airmen]."[4] ATC typically includes such information on automatic terminal information service (ATIS) broadcasts.

Automatic monitors — also called local monitors, integrity monitors or executive monitors — are installed near the ILS ground equipment. Annex 10 requires that when an automatic monitor detects a malfunction — for example, a reduction of power produced by a signal amplifier or a beyond-tolerances shift in the localizer course line or the glide path — the automatic monitor must stop the transmission of the affected signals and generate a failure warning on the remote-control-and-indicator equipment — also called the remote monitor or status monitor. Remote monitors usually are installed in the airport control tower, the ATC facility that controls aircraft on final approach and/or a flight service station.

FAA's Spohnheimer said that remote monitors typically provide "red light/green light" indications of ILS operation.

"Fundamentally, this remote status function only tells ATC whether the navaid is available," he said. "A few more details may be provided, such as whether a standby transmitter (if equipped) is available, whether the site is operating on battery power, etc.

"Many ATC towers can turn an ILS on or off … and switch between main and standby transmitters, if equipped."

Spohnheimer said that some Category I installations in the United States do not have remote monitors. *Airports that do not have remote monitors for approach navaids, or that have remote monitors that are out of service, cannot be filed as alternate airports on instrument flight rules (IFR) flight plans.*

"We do not want people flying a missed approach at a primary destination and then using up fuel flying to an alternate airport for which the approach is not *known* to be available," Spohnheimer said.

Examples of ILS signal-tolerance limits specified in Annex 10 are a 50 percent decrease in amplifier power and localizer course-line shifts — measured at the runway threshold — of more than 10.5 meters (35 feet) for a Category I installation, 7.5 meters (25 feet) for a Category II installation or six meters (20 feet) for a Category III installation.[5]

Under specific circumstances, the automatic monitor will restore an ILS to service after a component malfunctions. For example, at an ILS installation with two glideslope transmitters, if one transmitter malfunctions, the automatic monitor will automatically switch to the second (standby) transmitter. The automatic monitor also may cause a Category II ILS or a Category III ILS to revert to a lower-category ILS by activating standby equipment. If the automatic monitor detects that the standby equipment is not functioning properly, it will shut down the system.

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The automatic monitor also will shut down the system if it detects that faulty ILS signals are being radiated — because of an antenna-phasing problem, damage to power cables or environmental factors such as icing on the antennas, for example.

The period in which out-of-tolerance signals are radiated must be "as short as practicable" before an ILS is either shut down or restored to service by an automatic monitor. The maximum periods for radiation of faulty localizer signals are 10 seconds for a Category I ILS, five seconds for a Category II ILS and two seconds for a Category III ILS. The maximum periods for radiation of faulty glideslope signals are six seconds for a Category I ILS and two seconds for a Category II ILS or a Category III ILS.

Annex 10 says that these periods are "never-to-be-exceeded limits and are intended to protect aircraft in the final stages of approach against prolonged or repeated periods of localizer [or glideslope] guidance outside the monitor limits." Recommended maximum limits on radiation of out-of-tolerance signals are two seconds for a Category II ILS and one second for a Category III ILS.

If an automatic monitor fails, transmission of the ILS signals is terminated and a warning is generated on the remote monitors; loss of the ILS signals would cause warning flags to appear on aircraft instruments.

Performance objectives for ILS equipment are presented by Annex 10 as mean times between outages (MTBOs). The performance objectives include 1,000 hours between outages for a Category I ILS and 2,000 hours between outages for a Category II ILS. For a Category III ILS, the MTBOs are 2,000 hours for the glideslope equipment and 4,000 hours for the localizer equipment.

Annex 10 prescribes limitations on localizer course line "bends" and glide path bends caused by surface objects and terrain. A bend is defined as an "aberration of the localizer course line [or glide path] with respect to its nominal position." The limits on Category I ILS bends, for example, are designed to prevent an aircraft from being displaced more than 10 meters/30 feet from the localizer course line and more than three meters (10 feet) from the glide path.

In addition, Annex 10 says that bends generally are "unacceptable when they preclude an aircraft under normal conditions from reaching the decision height in a stable attitude and at a position … from which a safe landing can be effected."

In specifying performance objectives for ILS ground equipment, Annex 10 uses the term *ILS integrity*, which is defined as "that quality which relates to the trust which can be placed in the correctness of information supplied by the facility."

Levels of ILS integrity are expressed as probabilities of radiating false guidance signals during any aircraft landing. The performance objective for a Category I ILS installation is expressed as a probability of $1 - 10^{-7}$ (0.9999999 [i.e., nearly 100 percent]) that a landing aircraft will not receive false guidance signals. The performance objective for Category II and Category III installations is expressed as a probability of $1 - 0.5 \times 10^{-9}$ (0.9999999995) that a landing aircraft will not receive false guidance signals.♦

— FSF Editorial Staff

Notes

1. International Civil Aviation Organization (ICAO). Annex 10, *Aeronautical Telecommunications*; Volume I, "Radio Navigation Aids"; Chapter 3, "Specifications for Radio Navigation Aids," 3.1, "Specifications for ILS"; and Attachment C, Section 2.
2. Haug, Kjell. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 3, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.
3. Spohnheimer, Nelson. Email communication and telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 11, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.
4. ICAO. Document 8071: *Manual on Testing of Radio Navigation Aids*; Volume 1, "Testing of Ground-based Navigation Systems"; Chapter 1, "General"; paragraph 1.8, "Notification of Change of Status."
5. Annex 10 says that for Category I operations, the decision height (DH) must not be lower than 60 meters/200 feet, the minimum visibility is 800 meters/one-half statute mile and the minimum runway visual range (RVR) is 550 meters/1,800 feet. For Category II operations, the DH is lower than 60 meters but not lower than 30 meters/100 feet and minimum RVR is 350 meters/1,200 feet. For Category IIIA operations, the DH is lower than 30 meters, or there is no DH, and minimum RVR is 200 meters/700 feet. For Category IIIB operations, the DH is lower than 15 meters/50 feet, or there is no DH, and RVR is less than 200 meters but not less than 50 meters/150 feet. Category IIIC operations have no DH and no RVR limitation.

monitor the ILS identification (ident) during the approach," the report said. "The [supplementary pilot] individually identified the ILS on … all three receivers, which he continued to monitor throughout the approach."

The captain said that he would maintain 240 knots indicated airspeed (KIAS) while flying the 15-nautical-mile (28-kilometer) VOR DME arc that intercepts the localizer from the south and that, after intercepting the localizer, he would maintain180 KIAS until intercepting the glideslope.

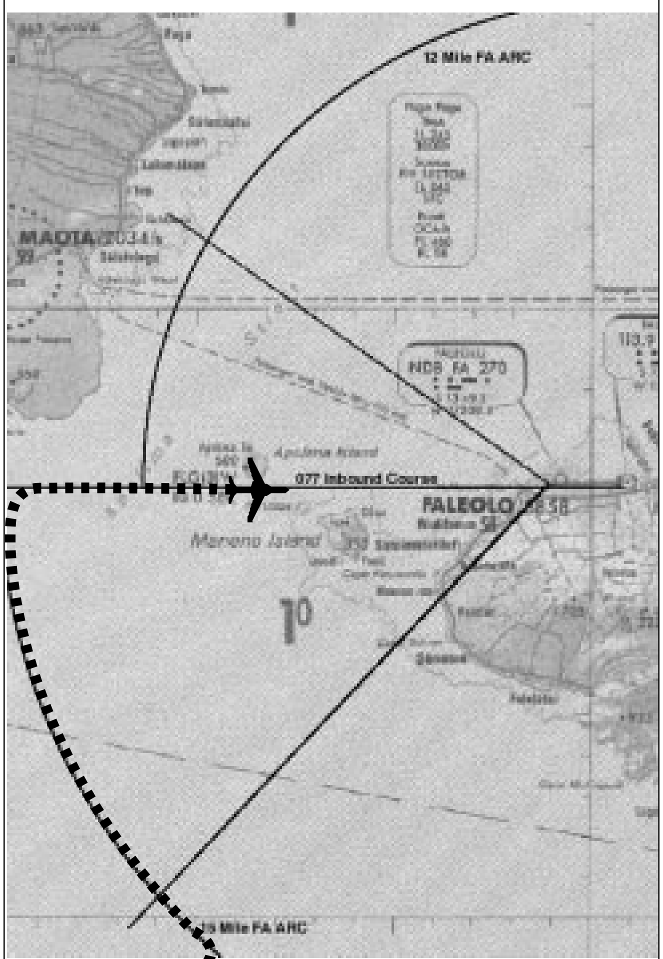
"The decision to fly 240 KIAS on the DME arc was made on the expectation that a level segment would be flown prior to glideslope capture, [during which] the aircraft would be appropriately configured to fly the glideslope," the report said.

The Faleolo airport did not have radar approach control service. The B-767 crew conducted the approach on a clear, dark night with no moonlight to assist with external vision.

"Approaches into Faleolo are typical of many into Pacific airports, being over water and prone to the 'black hole' effect at night," the report said.[5]

The captain flew the aircraft with the automatic flight control system (AFCS [i.e., autopilot and autothrottles]) engaged. The first officer observed runway lights before the aircraft intercepted the localizer at 2,800 feet and about 13 nautical miles (24 kilometers) from the runway threshold (see Figure 1). The report said that when the captain armed the AFCS approach mode, the autopilot "almost immediately" captured the glideslope. Airspeed increased as the aircraft began to descend on what later was determined to have been a 3.5-degree glide path.

Air New Zealand Flight NZ 60; Initial Instrument Landing System Approach; Faleola, Samoa; July 29, 2000



FA = Faleolo VOR (very-high-frequency omnidirectional radio)

Source: Air New Zealand

Figure 1

"The crew was surprised at the speed and rate of glideslope capture," the report said. "All [three pilots] reported that all ILS indications on the flight deck were normal."

The captain momentarily used the speed brakes to slow the aircraft to flap-extension speed and told the first officer to extend the landing gear. The crew completed the "Before Landing" checklist about the time the aircraft descended through 900 feet.

"The [captain] reported that he looked up on completion of the landing checks and saw a mishmash [variety] of lights but did not see the airfield runway lights," the report said. "He considered that the possible reason for not sighting the runway was due to patches of cloud between the aircraft and the airfield."

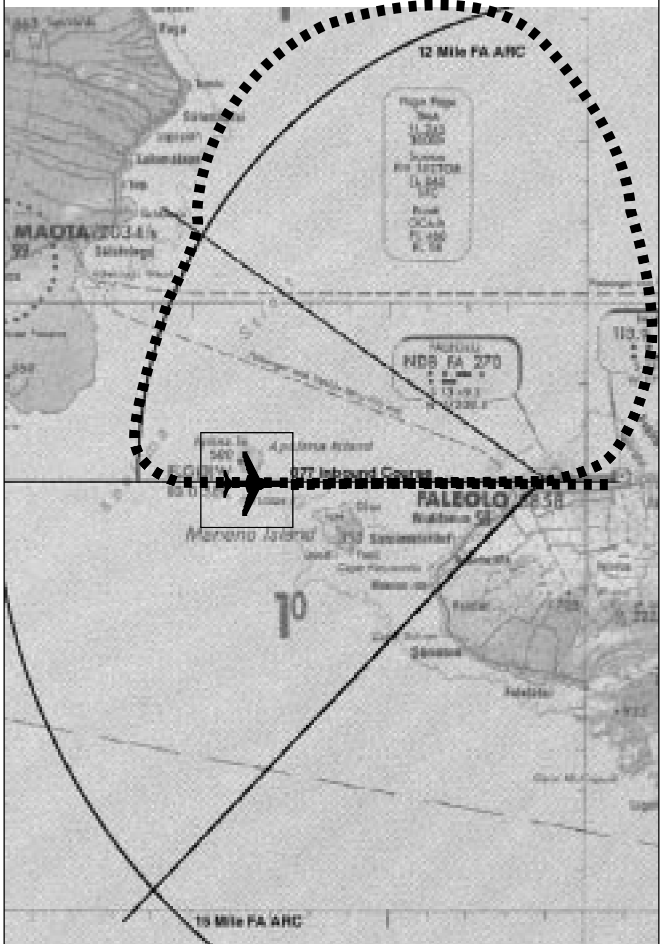
The captain then observed that the DME readout was "inappropriate" in relation to the on-glideslope indication and began a missed approach. At the same time, both the first officer and the supplementary pilot, who also had detected anomalies, called for a go-around.

The first officer had observed that the localizer pointers and glideslope pointers in the electronic attitude director indicators (EADIs) and electronic horizontal situation indicators (EHSIs) were centered and that the instruments displayed no "flags" (red boxes labeled "LOC" [localizer] or "G/S" [glideslope]). When he looked outside, however, he observed that the lights on a nearby small island appeared "much higher" than normal. He looked back at the instrument panel and observed the altimeter indicating about 600 feet. He said "go around" and moved his left hand to the throttle levers but found that the captain already was advancing the throttle levers.

The supplementary pilot had looked up after completing the "Before Landing" checklist, expecting to see the runway end identifier lights (REILs) but observed only the dim glow of two red lights. The report said that he then performed a distance-height check by multiplying the DME indication — seven nautical miles — by 300 and then subtracting 500 feet, which resulted in 1,600 feet. (Five hundred feet was subtracted to account for the distance from the runway threshold [1.5 miles] of the source of the DME information: the VOR.) He observed, however, that the altimeter indicated 700 feet. About this time, he heard the first officer say "those lights are close." He looked outside the aircraft, observed the lights and called for a go-around. He observed the first officer's hand come up behind the throttle levers, which the captain already was advancing.

The aircraft was about 5.5 nautical miles (10.2 kilometers) from the runway threshold when the captain began the missed approach (see Figure 2, page 8). The report said that the

Air New Zealand Flight NZ 60; Missed Approach, Localizer Approach and Landing; Faleola, Samoa; July 29, 2000



FA = Faleolo VOR (very-high-frequency omnidirectional radio)

Source: Air New Zealand

Figure 2

aircraft's minimum height above the ground during the go-around was 384 feet (see Figure 3, page 9).

The captain hand-flew the aircraft with reference to raw data during the go-around.[6]

"He deliberately climbed initially straight ahead to mimic a GPWS [ground-proximity warning system] escape maneuver, his priority being to ensure a maximum rate of climb away from whatever terrain was in the vicinity," the report said.

The crew then conducted the published missed approach procedure and intercepted the localizer course from the north.

"As the aircraft turned inbound onto the localizer, an erroneous glideslope indication was seen, which was ignored," the report said. "The strobes [REILs] and runway lights were visible throughout the second approach. The aircraft [was] landed uneventfully."

After landing, the crew prepared an operations occurrence report for the airline and told the airport control tower that a NOTAM should be issued immediately to remove the ILS from service. An airline service engineer at Faleolo inspected the aircraft for on-board electronic problems.

"The aircraft maintenance history was researched; no defects were noted that might have contributed to the occurrence," the report said. "Following the occurrence, the aircraft was carefully monitored; no discrepancy was noted that corresponded with the event at Faleolo."

Flight data recorder (FDR) data indicated that the aircraft's instruments had displayed "on-glideslope" indications near the airport, regardless of the aircraft's position in relation to the glideslope.

"Assessment of the FDR data revealed that during the arrival, the ILS glideslope receiver information changed from 'no valid data' to an 'on-glideslope' value at 5,240 feet pressure altitude and at approximately 40 degrees of arc to the south of the localizer front course," the report said. "The ILS glideslope receiver information remained at an 'on-glideslope' value throughout this approach and until abeam the runway threshold on the missed approach, where the glideslope receiver information value changed back to 'no valid data.'

"As the aircraft flew around the northerly 12-mile [22-kilometer] arc for a second approach, the FDR again recorded an 'on-glideslope' value at a point approximately 40 degrees of arc from the localizer front course."

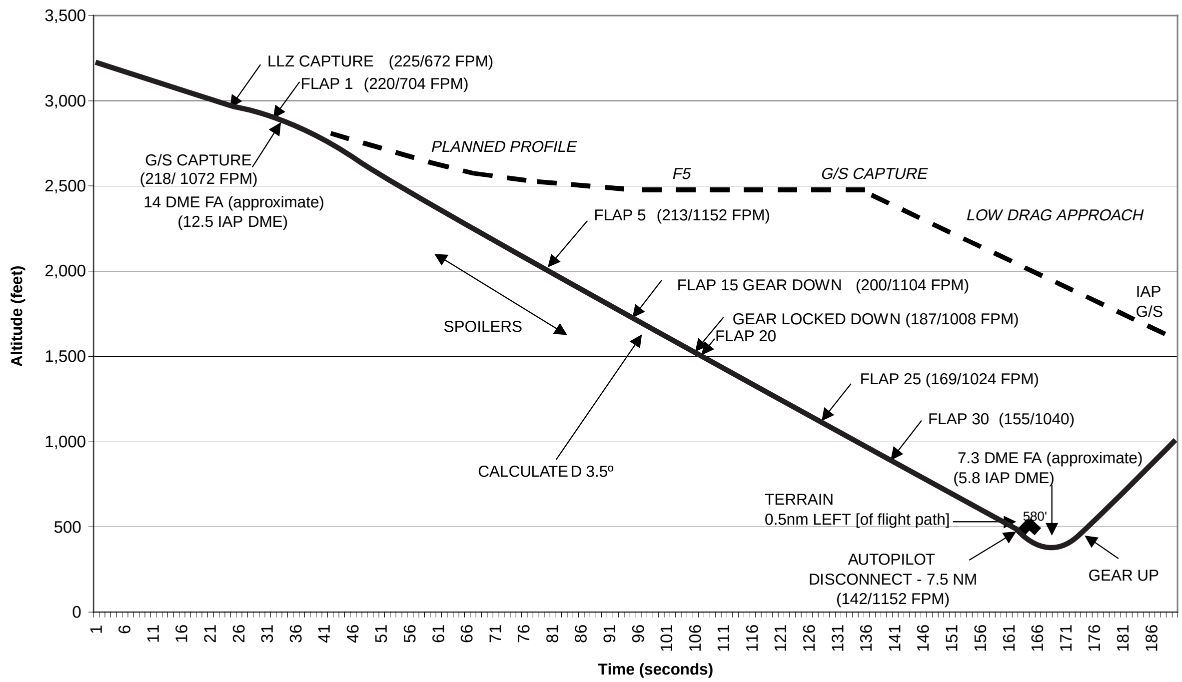
The report said that Samoan authorities told Air New Zealand that on the night of the incident, the ILS glideslope equipment "had been left transmitting with no SBO [sideband only] amplifier." The ILS receivers aboard the incident aircraft, therefore, received only the CSB (carrier with sidebands) signals transmitted by the glideslope equipment.

The presence of the CSB signals (which cause course deviation indicator [CDI] glideslope indicators/pointers to center and warning flags to retract or to not be displayed) without the SBO signals (which are required to provide steering information) caused the erroneous on-glideslope indications.

The Air New Zealand report said that the erroneous glideslope indications observed by the B-767 crew resulted from errors by a maintenance technician who returned the ILS system to service after repairs were performed on localizer power-supply cables that had been severed during construction at the Faleolo airport:

- The maintenance technician returned the ILS system to service with the malfunctioning standby glideslope transmitter selected as the operating transmitter; and,

Flight Path of Air New Zealand Flight NZ 60; Faleolo, Samoa; July 29, 2000



LLZ = Localizer G/S = Glideslope FPM = Feet per minute DME = Distance-measuring equipment
FA = Faleolo VOR (very-high-frequency omnidirectional radio) IAP = Faleolo instrument landing system

Source: Air New Zealand

Figure 3

- The maintenance technician left the system in the "control-bypass" mode, which prevented the automatic monitoring equipment from deactivating the malfunctioning glideslope transmitter and automatically switching to the other — serviceable — transmitter.

"There cannot have been any adequate safety checks carried out by the technician prior to leaving the installation to ensure [that] the faulty transmitter was not the transmitter selected to service," the report said. "With the tower 'monitor' unserviceable, the controller was unable to determine the status of the glideslope; therefore, this vital safety measure to detect maintenance error was unavailable."

About two weeks after the incident at Faleolo, Air New Zealand used a B-767 to conduct test flights in Auckland that included five ILS approaches in various aircraft configurations. The glideslope SBO transmission was disabled for the tests; only the CSB signals were radiated. (Information that the ILS would be out of service during the tests was provided in a NOTAM and by the automatic terminal information system [ATIS] at the airport.)

"During each approach, as the aircraft [was] established inbound, the glideslope indication 'materialized' on the EADI indicating 'on glideslope' and throughout the approach remained indicating 'on glideslope,' regardless of the [aircraft's] position relative to the true glideslope," the report said. "Glideslope capture consistently occurred very shortly after 'APP' [the autopilot approach mode] was armed."

During the investigation of the Faleolo incident, Air New Zealand examined what might have happened if the crew had continued the approach. The report said that the GPWS aboard the incident aircraft might not have provided adequate warning of an impending CFIT accident, but an "enhanced GPWS" (i.e., terrain awareness and warning system [TAWS]) would have.[7]

"If the [incident] flight profile had continued unchecked, a [GPWS] Mode 1 'sink rate' warning would probably have sounded at approximately 200 feet AGL [above ground level]," the report said. "It is unlikely, unless the [rate of descent] increased to above 1,400–1,500 feet per minute, that a 'pull up' warning would have sounded. A GPWS 'sink rate' warning at 200 feet AGL may have been too late to allow recovery of the aircraft if there had been terrain in the flight path of the aircraft."

The report said that a current-generation TAWS system would have announced "terrain, terrain, pull up" at about 400 feet AGL.

Based on the investigation, Air New Zealand made several recommendations to the New Zealand Civil Aviation Authority (CAA). Among the recommendations was that current navaid maintenance-and-testing procedures be reviewed with respect to the following:

- “Recommended meteorological conditions under which planned maintenance should take place;
- “Ensuring ATC [air traffic control] receipt of notification of maintenance prior to undertaking that maintenance;
- “Any additional procedures that may be required to ensure system safety during unplanned maintenance;
- “Ensuring positive ATC/flight crew communication if a navigation aid may be radiating erroneous information;
- “If maintenance is planned on the localizer [or glideslope] that has the potential to cause the radiation of erroneous information, then both the localizer [and glideslope] should be removed from service or, as a minimum, remove [the ident] or change the ident [e.g., to “TST” for test]; and,
- “Instituting an acceptable quality-assurance check that will, at a minimum, verify the [automatic] equipment monitor is in control prior to releasing the navigation aid back to service and note the importance of the tower ‘monitor’ [ILS status-indication system] in detecting systemic failure.”

Michael A. Carrelli, a safety investigator for the New Zealand CAA, said that the CAA has taken action or is investigating all the airline’s recommendations and is preparing a report on the incident for publication.[8]

A draft summary of the CAA incident report said, “The investigation has shown that this phenomenon [i.e., erroneous on-glideslope indications with no warning flags] was virtually unknown among pilots and air traffic controllers. In addition, navigation aid maintenance technicians assumed the aircraft would display appropriate warning flags.”

The Air New Zealand report said that recurrence of maintenance error leading to an incident similar to that at Faleolo is unlikely and that erroneous ILS indications are more likely to occur during maintenance or testing of ILS ground equipment.

“Although the probability of the reoccurrence of a chain of events similar to that experienced at Faleolo is remote, there is a great risk of crew using a glideslope that is radiating erroneous information during maintenance or test,” the report said. “For the operator, the only defenses available at present appear to be issuing instructions regarding the use of unmonitored equipment or equipment on test or maintenance, raising crew awareness, crew education regarding CFIT and seeking methods of raising crew situational awareness during the approach phase.”

ICAO recommends prompt notification of controllers and pilots of any change in the operational status of a navaid. The ICAO *Manual on Testing of Radio Navigation Aids* says, “A change in the status of a commissioned facility as a direct result of ground [inspection] or flight inspection procedures … should be advertised immediately by [ATC] personnel and promptly by NOTAM.”[9]

The ICAO letter said that despite this recommendation, “there have been occurrences when the facility status notification has not reached the flight crew or the [ATC] unit concerned, or this notification has not been complied with due to shortcomings in the notification procedures or [due to] human error.”

An incident in which tower controllers apparently were not informed about maintenance of ILS equipment was discussed in a paper prepared by Capt. Bertrand de Courville and Capt. J.M. Jud of Air France.[10]

The paper said that in February 1999, the crew of an Air France Boeing 777 was cleared to conduct an ILS approach to Runway 10 at Rio de Janeiro (Brazil) International Airport. The weather conditions were described as “misty, and horizontal visibility was reduced by the morning sun.” Interception of the localizer course and the glideslope was indicated by centered flight director command bars and by a green “G/S” display on the flight-mode annunciator (FMA).

“Around 2,500 feet AGL, the crew had the ground in sight,” the paper said. “After a while, the first officer was looking for visual contact with the runway when he noticed a small hill [ahead on the extended runway centerline] at an abnormally low angle of sight.

“Surprised to find himself in such a situation, the captain was going to level off, when the EGPWS [enhanced GPWS] ‘pull up, terrain ahead’ alarm sounded. He leveled off at approximately 800 feet AGL and noticed that the glideslope indication remained centered.”

The flight crew established visual contact with the runway and landed the aircraft without further incident.

“The crew immediately alerted ATC and filed an air safety report,” the paper said. “The crew was interviewed, and the recorded parameters from the QAR [quick-access recorder] were analyzed with the crew. It was confirmed that:

- “The approach was stabilized until the level-off (speed, configuration and flight path);

- "[The localizer and glideslope command bars] were centered all along the final [approach];
- "The minimum radio altitude was 300 feet; [and,]
- "No outer marker signal was received."

The paper said, "A verbal report from the ATC [controller] explained that this scenario resulted from calibration operations initiated by ground technical staff while the plane was on final without [the] knowledge [of] the ATC controller."

The paper also provided the following information about similar events observed by Air France flight crews at Madrid, Spain; Rabat, Morocco; and La Reunion Airport in France (the dates were not specified):

- Traffic at the Madrid airport and controller workload were described as heavy when an Airbus A320 crew received radar vectors from ATC for an ILS approach to Runway 36. The landing runway was changed "at the last minute" to Runway 18 because of a change in the surface wind. During the final approach, with the localizer indicator and glideslope indicator centered, the captain observed "an abnormal DME/altitude combination and decided [to] go around; after a check with the ATC [controller], the ILS appeared to be under calibration." Information about testing of the ILS Runway 18 equipment had been published in a NOTAM, "but the crew prepared [for] and briefed an approach on the other runway and disregarded the information on the non-active runway. Neither ATIS nor [the] ATC controller mentioned the ILS status."
- A Boeing 737 crew was cleared to conduct an ILS approach to Runway 22 at Rabat. The crew questioned the clearance because a NOTAM said that the ILS was out of service. "The ATC controller confirmed that the ILS was operating normally. This was heard in another plane by pilots flying approaches for training. They advised our crew that during the previous final approach, the [localizer indicator and glideslope indicator] remained centered for any position of the aircraft. Some minutes later, the ATC controller advised our crew that the ILS was not usable."
- A Boeing 747 crew was cleared to conduct an ILS approach to the La Reunion airport. "On base leg, several miles before reaching the runway centerline on final, the crew observed a steady, centered ILS localizer [indication] and [glideslope] indication. As weather was fine, there was no consequence. After a complaint sent by our company and investigation by the local authorities, the reason given was a lack of communication and coordination between the technician in charge of ILS maintenance and the controller."

Capt. de Courville said that the information about these events was obtained during research conducted by Air France after the incidents in Rio de Janeiro.[11]

"After Rio, we looked for similar events," he said. "If we launched research with other airlines that have good reporting systems, we most likely would find other events of this kind."

The Air France paper recommended the following methods for detecting an erroneous glideslope indication:

- "Cross-check altitude and DME distance;
- "Cross-check altitude and FMS [flight management system] threshold distance;
- "Cross-check altitude and OM [outer marker] (or locator or VOR or FMS fix) crossing altitude;
- "Cross-check radio altitude and barometric altitude;
- "Cross-check groundspeed and rate of descent; [and,]
- "Question ATC."

An incident in which information about ILS maintenance was not provided to a flight crew was reported in March 1991 to the U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS).[12]

The report, filed by the first officer of an air carrier aircraft, said that during an ILS approach to Runway 28R at San Francisco (California, U.S.) International Airport in daylight visual meteorological conditions (VMC), glideslope flags appeared in the ADIs and HSIs.[13]

"After approximately 30 seconds, the flags disappeared and reception of the glideslope signal appeared normal," the report said.

The glideslope indicators showed the aircraft to be slightly above the glideslope, however, and the crew corrected the flight path.

"At 500 feet AGL, the aircraft appeared quite low visually but still showed on-glideslope on all cockpit indications," the report said. "The flight path was adjusted higher to produce a normal visual 'picture,' [and the] landing was normal."

When the crew reported the incident to the tower controller, they were told that maintenance was in progress on the glideslope.

"This was our first report of the signal being out of service," the ASRS report said. "No NOTAM was published, nor was there any [notice] on the ATIS, which was recently updated."

Based on the reports of incidents involving erroneous ILS indication, the ICAO letter recommended the following "minimum protective measures" during testing and maintenance of ILS equipment:

- "NOTAM phraseology that is specific about the possibility of false indications to the flight crew from the radiated test signals and [that] clearly prohibits their use (suggested NOTAM wording — 'Runway XYZ ILS not available due to maintenance (or testing); do not use; false indications possible';
- "Confirmation by maintenance personnel that such a NOTAM has been issued by the aeronautical information services before the testing procedures begin;
- "Prior to beginning the tests, suspension or alteration to an unusual tone/sequence of the transmission of the unique Morse code facility identification on the localizer, if the localizer should radiate solely for testing purposes; and,
- "A requirement that ATC advise, by [ATIS] and/or by a voice advisory, each pilot on an approach to the affected runway, emphasizing the possibility of false indications."

The ICAO letter said that the *Manual on Testing of Radio Navigation Aids* will be revised to "emphasize the need for coordination of [ILS testing-and-maintenance] procedures with [ATC] and for the timely promulgation and distribution of relevant information by a NOTAM before the procedures commence."

The letter recommended the following procedures during ILS testing and maintenance:

- "When [phasing and modulation balance] tests are being performed on the localizer, remove the [glideslope] from service by turning the signals off (to provide a [glideslope] flag indication to the pilot); and,
- "When the tests are being performed on the [glideslope], remove the localizer from service by turning the signals off (to provide a localizer flag indication to the pilot)."

The letter recommended that ILS-status-indication equipment be installed where it can be observed by air traffic controllers who issue approach clearances to flight crews.

"It is imperative that all personnel directly engaged in flight inspection, maintenance or installation of aeronautical navigation aids should be adequately qualified, trained and experienced for their job functions," the letter said "Accordingly, management systems should include written procedures for ensuring the continued competence of such personnel through regular assessment.

"Initial [training programs] and recurrent training programs for aeronautical navigation aid specialists should include a detailed explanation of maintenance procedures and their effect on the integrity of the radiated signal."

The ICAO letter also recommended specific measures to prevent pilots from using a navaid identified by ATC or by a NOTAM as out of service.

"Aircraft operating manuals should strictly prohibit the use of a radio navigation facility which is notified to be out of service even though its cockpit indications might appear to be normal," the letter said.

A flight crew's confusion about glideslope indications that appeared during a localizer approach was cited by the U.S. National Transportation Safety Board (NTSB) in its final report on the Aug. 6, 1997, accident involving a Korean Air Boeing 747 at Guam.[14]

The aircraft struck terrain on Nimitz Hill, about three nautical miles (six kilometers) southwest of A.B. Won Guam International Airport, in night instrument meteorological conditions (IMC). Of the 254 occupants, 228 were killed and 26 received serious injuries.

NTSB said that the probable cause of the accident was "the captain's failure to adequately brief and execute the nonprecision approach and the first officer's and [the] flight engineer's failure[s] to effectively monitor and cross-check the captain's execution of the approach."

The accident report said that a NOTAM and the ATIS indicated that the glideslope for the ILS approach to Runway 06L at Guam was out of service. The ATIS also indicated that VMC prevailed at the airport.

The captain (the pilot flying) briefed the crew for a visual approach. During the briefing, he said, "The localizer glideslope is out, MDA [published minimum descent altitude for the localizer approach] is five hundred sixty feet."

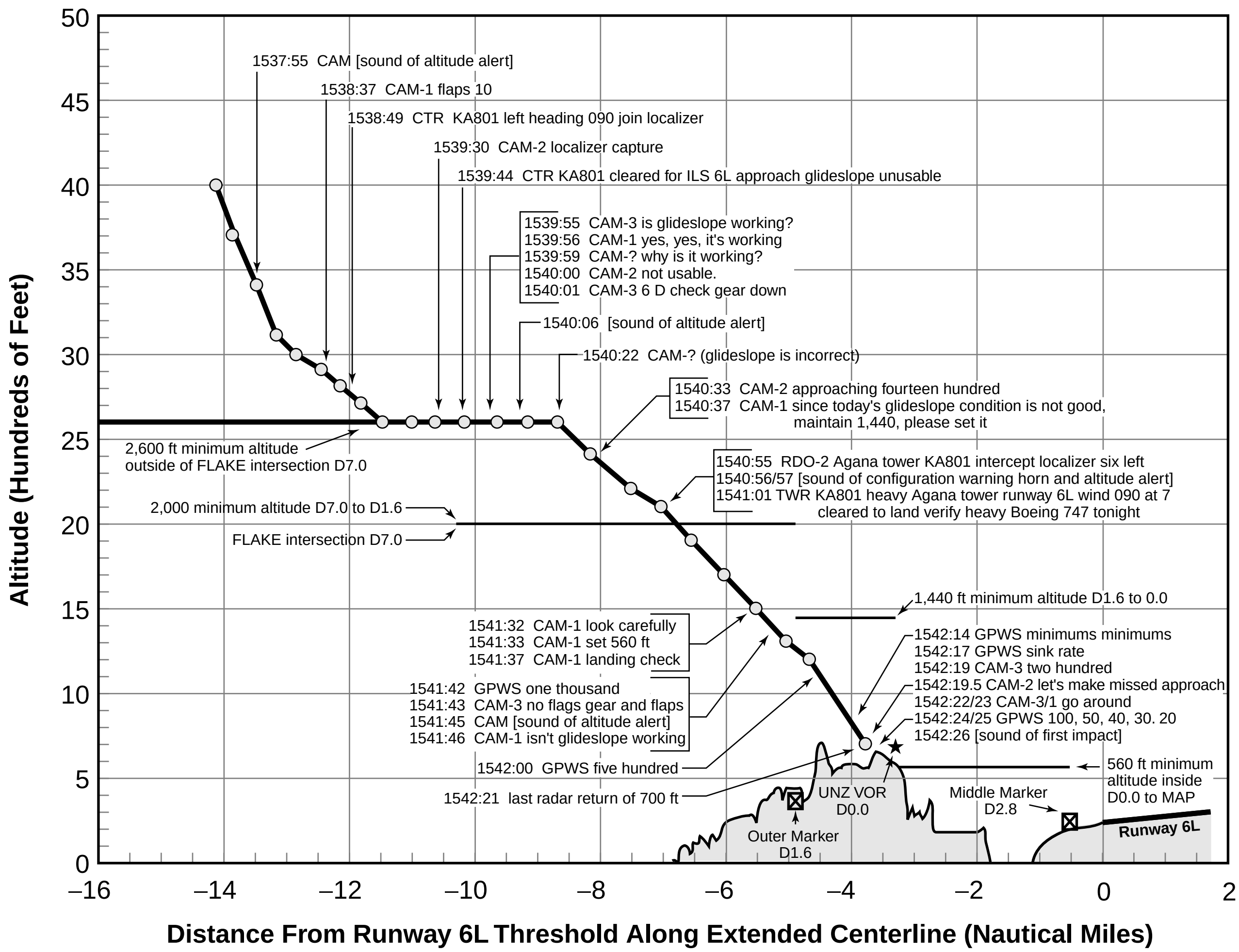
The crew flew the aircraft around thunderstorms near the airport and were given radar vectors by ATC (see Figure 4, page 13). The controller told the crew that they were cleared to conduct "the ILS runway six left approach … glideslope unusable."

The first officer read back "cleared ILS runway six left" but did not acknowledge that the glideslope was unusable.

The report said that the aircraft likely entered clouds and increasingly heavier precipitation during the approach, and that the captain apparently became confused about — and preoccupied with — the status of the glideslope.

"Despite several indications that the flight crew was aware that the glideslope was inoperative, in the last 2 1/2 minutes of the

Flight Path and Excerpts From Cockpit Voice Recorder Transcript; Korean Air Flight 801; Nimitz Hill, Guam; Aug. 6, 1997



CAM = Recording by cockpit area microphone CAM-1 = Captain CAM-2 = First officer CAM-3 = Flight engineer
CAM-? = Unidentified voice CTR = Guam center controller ft = Feet D = Distance from UNZ (Nimitz)
VOR (very-high-frequency omnidirectional radio) RDO-2 = Radio transmission by first officer TWR = Guam tower controller
MAP = Missed approach point GPWS = Ground-proximity warning system

Source: U.S. National Transportation Safety Board

Figure 4

flight (beginning shortly after the airplane was established on the approach, the CVR [cockpit voice recorder] recorded a series of conflicting flight crew comments concerning the status of the glideslope," the report said.

The flight engineer said, "Is the glideslope working?"

The captain said, "Yes, yes, it's working."

An unidentified voice said, "Why is it working?"

The first officer said, "Not usable."

The aircraft was about eight nautical miles (15 kilometers) from the runway when the captain said, "Since today's glideslope condition is not good, we need to maintain one thousand four hundred forty [feet]." The captain then told the first officer to set the altitude selector to 1,400 feet, the published minimum altitude between the outer marker and the Nimitz VOR, a step-down fix from which descent to the MDA (560 feet) can be conducted.

Nevertheless, about one minute later, the captain said, "Look carefully. Set five hundred sixty feet."

The aircraft descended below 1,400 feet when it was 2.1 nautical miles (3.9 kilometers) from the VOR. About this time, the captain said, "No flags, gear and flaps."

The flight engineer said, "No flags, gear and flaps."

The captain said, "Isn't [the] glideslope working?"

The report said that the CVR recording indicated that neither the first officer nor the flight engineer responded to the captain's question.

The airplane was descending at 1,400 feet per minute through 840 feet (about 200 feet AGL) when the GPWS announced "minimums" and then generated a "sink rate" alert. The flight engineer called out 200 feet radio altitude, and the first officer said, "Let's make a missed approach. Not in sight." The crew was conducting a go-around when the aircraft struck terrain at 660 feet, about 2,000 feet (610 meters) southwest of the Nimitz VOR.

During the investigation, a U.S. Federal Aviation Administration (FAA) navigation specialist told NTSB investigators that brief and intermittent CDI needle activity and flag activity (commonly called "flag pops") are encountered frequently during ILS flight tests.

The report said that spurious radio signals could have caused erratic movement of the glideslope needles and flags on the accident crew's ADIs and HSIs but that continuous activation of the needles and continuous retraction of the flags were unlikely. The report said that the absence of glideslope-capture indications on the FMAs "should have been sufficient to convince the … flight crew to disregard the glideslope indications."

"Even if the flight crewmembers did see a continuous glideslope needle activation and flag retraction, it would not have been prudent or reasonable for them to rely on a glideslope signal of any sort when the glideslope had been reported to be unusable," the report said.

NTSB made several recommendations based on the findings of the Guam accident investigation. Among the recommendations was that FAA "disseminate information to pilots, through the *Aeronautical Information Manual* [*AIM*], about the possibility of momentary erroneous indications on cockpit displays when the primary signal generator for a ground-based navigational transmitter (for example, a glideslope, VOR or nondirectional beacon transmitter) is inoperative. Further, this information should reiterate to pilots that they should disregard any navigation indication, regardless of its apparent validity, if the particular transmitter was identified as unusable or inoperative."

FAA agreed with the recommendation and included the following note in the July 12, 2001, revision of the *AIM*:

> Pilots should be aware of the possibility of momentary erroneous indications on cockpit displays when the primary signal generator for a ground-based navigational transmitter (for example, a glideslope, VOR or nondirectional beacon) is inoperative. Pilots should disregard any navigation indication, regardless of its apparent validity, if the particular transmitter was identified by NOTAM or otherwise as unusable or inoperative.[15]

An incident in which a flight crew was not aware of ILS maintenance and followed erroneous localizer indications occurred Oct. 19, 1994, in Cranbrook, British Columbia, Canada. The incident involved the crew of an Air BC de Havilland Dash 8 that descended below clouds during an ILS/DME approach to find that they were six nautical miles (11 kilometers) east of the extended runway centerline and about 0.5 nautical mile (0.9 kilometer) from high terrain.

The Transportation Safety Board of Canada (TSB) said, in its final report on the incident, that a NOTAM indicating that the ILS equipment for Runway 16 would be out of service until 1800 local time on the day of the incident was not included in the crew's preflight briefing package.[16]

The report said, however, that the airline's flight operations manual (FOM) requires the pilot-in-command (PIC) to ensure that he has all relevant information for the planned flight.

"Had there not been any current NOTAMs for Cranbrook, the information [i.e., the preflight briefing package] provided by dispatch would have so stated," the report said.

En route from Vancouver, the Dash 8 crew was cleared by Vancouver Area Control Centre about 1650 local time to conduct an approach to the Cranbrook airport, which is uncontrolled. The crew did not tell the controller that they would conduct the ILS/DME approach.

The report said that the Canadian *Aeronautical Information Publication* (*AIP*) recommends that as soon as practicable after receiving an approach clearance that does not specify a particular approach procedure, the crew should advise ATC of the approach procedure they intend to conduct.

"ATC is not obligated to elicit from the pilot what approach he or she intends to fly," the report said.

The report said that if the crew had told the center controller that they intended to conduct the ILS approach, the controller might have told them about the NOTAM advising that the ILS was out of service.

The crew received an airport advisory from the Cranbrook Flight Service Station (FSS), but the FSS specialist did not tell the crew about the NOTAM. The report said that FSS specialists are required to include supplemental information, such as NOTAMs, in airport advisories.

"The FSS specialist did, however, advise the crew that a Transport Canada (TC) aircraft was conducting a flight check of the ILS, but this information did not alert the crew to the possibility of ILS signal unreliability."

The report did not indicate whether the crew checked the Morse code identification for the ILS. (ICAO requires that the identification, which begins with the letter "I" and includes two additional letters or three additional letters to identify the ILS, be removed from the frequency during maintenance or testing.)

During the initial segment of the approach, the first officer and a TC inspector, who was aboard the aircraft to conduct a flight inspection of the operation, observed a discrepancy between indications provided by the CDIs and the automatic direction finder (ADF); the localizer indicators were centered but the ADF indicated that the aircraft was passing to the east of the localizer course.

"The PIC did not make a correction because he considered the ADF indications to be less accurate than the CDI," the report said. "[The first officer] was about to recommend following the missed approach procedure when the aircraft descended out of cloud [at about 4,000 feet AGL]."

The crew then conducted a visual approach and landed the aircraft.

The report said that the ILS had transmitted for one minute a localizer test signal that caused the erroneous on-course indications on the incident aircraft's CDIs.

The report said that the ILS had transmitted for one minute a localizer test signal that caused the erroneous on-course indications on the incident aircraft's CDIs.

"During this period, the CDI would have indicated that the aircraft was on course, regardless of its actual position," the report said. "No facility identification signal would have been transmitted from the localizer unit, and the localizer warning flag on the cockpit CDI instrument would have become momentarily visible three times. At the end of this test phase, the CDI would have gone to full deflection, indicating that the aircraft was off course."

The Canadian *AIP* recommends that pilots do the following before using any navigational aid:[17]

- "Check NOTAMs prior to flight for information on navaid outages. … For remote [airports] or [airports] with community aerodrome radio stations (CARS), … contact the CARS observer/communicator or the [airport] operator prior to flight to determine the … status of navaids;
- "Ensure that onboard navigation receivers are properly tuned and that the navaid identifier is aurally confirmed; and,
- "Visually confirm that the appropriate indicator displays are presented."

Besides faulty signals transmitted by ground equipment during maintenance and testing, erroneous ILS indications can result from problems with equipment aboard the aircraft.

For example, the NTSB report on the Korean Air accident at Guam said that the crew of a Boeing 727 observed erroneous ILS indications while conducting flight tests of newly installed global positioning system (GPS) equipment the day before the accident. The captain told investigators that while conducting a localizer approach to Runway 06L at the Guam airport, the navigation displays showed the aircraft centered on the glideslope, with no flags, even though the aircraft was above the normal glide path. The crew ignored the glideslope indication because they knew that the glideslope was inoperative.

The B-727 captain believed that the erroneous ILS indications might have resulted from problems with the GPS wiring installation. In the weeks following the incident, several navigation displays, including both ADIs and HSIs, were replaced repeatedly because of reported anomalies.

"The maintenance documents indicated that the cockpit-display problems were the result of integrating the new GPS with the existing cockpit displays," the NTSB report said.

Failure of an amplifier that controlled the glideslope indicators on the first officer's panel in a Gates Learjet 25B was cited in NTSB's final report on a fatal accident that occurred on Jan. 13, 1998, in Houston, Texas, U.S.[18]

The crew was conducting a positioning flight to George Bush Intercontinental Airport when the Learjet struck terrain about two nautical miles (four kilometers) from Runway 26 during an ILS approach in IMC. The pilots were killed.

The crew had conducted a missed approach when the captain had difficulty tracking the localizer course because of a problem with the compass card in his HSI. During the second ILS approach, the captain again had difficulty tracking the localizer and transferred control of the aircraft to the first officer during final approach.

Both pilots used the first officer's ADI and HSI, which were displaying erroneous fly-down indications because of the failed amplifier. (The warning flags operated erratically during postaccident tests.) The report said that the captain's ADI and HSI likely provided proper fly-up indications but the crew "failed to cross-check their glideslope indications."

The report said that the probable cause of the accident was "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"; a contributing factor was the captain's "improper decision to continue the approach by transferring control to the first officer, instead of executing a missed approach."

The report said that the Learjet's maintenance records indicated that two months before the accident, another flight crew reported a malfunction of the glideslope indicators in the first officer's ADI and HSI. The malfunction was diagnosed incorrectly as "sticking pointers." The maintenance records said, "Advised customer, repairs deferred until such time available to send unit out to mfr [manufacturer]."

The report said, however, that the provisions of the aircraft's minimum equipment list (MEL) required repair of the first officer's ADI and HSI within 10 days. The Learjet operator's "failure to provide an airworthy airplane to the flight crew following maintenance" was cited by NTSB as a contributing factor to the accident.

Water trapped between chafe tape and the VHF antennas was cited in a NASA ASRS report about erratic localizer indications observed during an ILS approach to Richmond, Virginia, U.S.[19] The report said that the glideslope indication was normal but that the localizer needle "moved randomly from stop to stop." The crew of the Embraer EMB-145 conducted a missed approach.

"ATC and other aircraft reported no problems with the localizer," the report said. "Also, [we] had a good localizer ident."

The crew began to conduct a VOR approach to Richmond but again observed the course-deviation indicators moving from stop to stop. The crew conducted a missed approach, declared minimum fuel and diverted to Norfolk, Virginia, which had VMC.

"En route [to Norfolk], we spoke with maintenance and requested assistance," the report said. "They said this problem had been reported earlier, but they could not duplicate it."

After the aircraft was landed in Norfolk, maintenance technicians removed chafe tape and released the trapped water from the VHF navigation antennas, which "fixed the problem." The report said that the chafe tape "is apparently used to prevent wear on the leading edge of the antenna."

In another ASRS report, the first officer of an air carrier aircraft said that during an ILS approach to Boston (Massachusetts, U.S.) Logan International Airport in daylight VMC, he was looking for another aircraft when the captain asked him if he had a glideslope indication on his HSI.[20]

The first officer observed a full fly-up indication and told the captain to climb. At the same time, the controller issued a low-altitude alert and told the crew to climb immediately.

"We proceeded on the approach with no further problems," the report said. "I asked the captain why he descended prior to glideslope interception, and he said [that] he was following his glideslope indicator on his ADI, which we then discovered was stuck at the bottom of the [display]," the report said.

After landing, the pilots discussed "the importance of cross-checking other instruments when flying an approach [and] the importance of cross-checking glideslope altitude at the FAF [final approach fix]," the report said.

Erroneous ILS indications in the form of indicators that "stick" in electromechanical instruments usually are caused by friction as the instruments wear and become tarnished, said Rick Ochs, president of Spirit Avionics (formerly Capital Aircraft Electronics) in Columbus, Ohio, U.S.[21]

"Instruments wear out; they need to be inspected at certain intervals to make sure they are working correctly," Ochs said. "An instrument or radio can fail even though it appears to be working correctly.

"An operational check of an aircraft's avionics equipment is required during annual inspections, but most A&Ps [airframe and powerplant mechanics] do not have the test equipment or the training to do the check properly."

Ochs recommends that a thorough inspection of an aircraft's avionics equipment be performed by a qualified facility every two years, in conjunction with required tests of the altimeter system and transponder.[22]

Tom Rogers, president of Avionics West in Santa Maria, California, U.S., agrees with this recommendation.[23] He said that another frequent cause of erroneous ILS indications in electromechanical equipment is electrical resistance resulting from corrosion that accumulates on relays.

"Only 150 microamps of current is required to drive a needle in an HSI," Rogers said. "A lot of 'keep-alive' circuits in computers and in automobiles are in that range; so, you can see that it doesn't take much resistance to [reduce the electrical current and] cause poor deflection or no deflection of an HSI needle."

Rogers said that one method of monitoring indicators for proper movement is to use both navigation receivers and CDIs during the initial approach.

"If possible, keep both radios tuned to the localizer frequency and make sure the indicators are showing the same thing," he said. "Then, at the [FAF], set up the no. 2 radio and CDI for the missed approach."

Both Rogers and Ochs said that indications provided by electronic flight instrument system (EFIS) equipment generally are more reliable than indications provided by electromechanical instruments. Ochs said that EFIS systems are less prone to wear but are more susceptible to interference from other equipment.

"Older EFIS systems generate a lot of heat and have CRTs [cathode-ray tubes] that are highly susceptible to voltage problems," Ochs said. "The newer flat-panel displays generally are more reliable than CRTs."

In the mid-1990s, Transport Canada investigated several incidents of "localizer false captures" by the AFCS systems in Airbus A320 and Boeing 747, 757 and 767 aircraft.[24] The agency defines a localizer false capture as a situation in which "the aircraft [AFCS] initiates a turn prematurely onto the localizer centerline when it is well outside the proportional guidance region of the localizer signal area."

The investigations revealed that false captures are most likely to occur approximately eight degrees to 10 degrees from the localizer centerline — an area of high modulation of the localizer signals (see "ICAO Annex 10 Sets Standards for ILS Equipment") — in aircraft with AFCS systems designed to use course-deviation output to initiate localizer capture.

The Canadian *AIP* says that false localizer captures may occur when a pilot prematurely changes the AFCS mode from either "HDG" (heading) or "LNAV" (lateral navigation) to "APP" (approach).[25]

"Some ILS receivers produce lower-than-expected course-deviation outputs in the presence of high modulation levels of the localizer radiated signal," the *AIP* said. "This can occur even when both the ground transmitter and the airborne receiver meet their respective performance requirements. This reduced course deviation can, in turn, trigger a false course capture [by the AFCS]."

The *AIP* says that the possibility of localizer false capture can be minimized by using "raw data sources to ensure that the aircraft is on the correct localizer course prior to initiating a coupled approach."

Information about another potential cause of erroneous ILS indications — distortion of signal transmissions by aircraft or vehicles that are operated near the localizer antenna or the glideslope antennas — has been disseminated by regulatory authorities and training organizations.

ICAO recommends that, when ILS operations are being conducted at an airport, ATC should prevent aircraft and vehicles from being operated in areas (termed *critical areas*) where they can disturb ILS signals when aircraft are on final approach.[26]

In the United States, when the reported ceiling is lower than 800 feet and/or the visibility is less than two statute miles (three kilometers), airport traffic controllers are required to prevent aircraft/vehicles from operating in critical areas when an arriving aircraft is on final approach, unless the crew has reported the runway in sight or is circling to land on another runway.[27]

The *AIM* advises pilots to be "especially alert" when conducting ILS approaches at uncontrolled airports, where critical areas are not protected by ATC. The manual also advises pilots to notify ATC of their intentions to conduct coupled approaches or autoland operations at controlled airports when weather conditions are such that controllers are not required to protect critical areas. (In this situation, controllers are required to tell pilots if the critical areas are not being protected.)

Two incidents reported to NASA ASRS involved distortion of ILS signals by aircraft in critical areas.

Two incidents reported to NASA ASRS involved distortion of ILS signals by aircraft in critical areas.

An ASRS report filed by a tower controller at the William B. Hartsfield Atlanta (Georgia, U.S.) International Airport said that the crew of a McDonnell Douglas DC-9 had been told to hold short of Runway 27L in a position that was approximately 300 feet (92 meters) from the glideslope antenna.[28]

"Since the ceiling was greater than 800 feet, this was legal," the report said. "However, interference caused numerous aircraft to descend well below the glideslope. One aircraft was down to 1,000 [feet] AGL 10 miles [19 kilometers] from the airport. The DC-9 was moved, [and the glideslope] returned to normal."

An ASRS report filed by the captain of an air carrier aircraft said that he observed the aircraft's rate of descent begin to increase near the outer marker during an ILS approach to Runway 27L at Chicago (Illinois, U.S.) O'Hare International Airport in daylight IMC with a 750-foot ceiling and two statute miles visibility. The descent rate increased from 700–800 feet per minute to 1,000–1,500 feet per minute.[29]

"[The first officer] and I reacted about the same time, questioning the descent rate," the report said. "I stopped the descent rate and started back toward the marker altitude about the same time [the controller] called us to check [our] altitude. I estimate the altitude deviation at the marker to be about 300 feet to 400 feet low."

The captain then heard the pilot of another aircraft question the status of the glideslope.

"About the same time, [the controller] again questioned our altitude and then said something like 'I see what's happening,'" the report said.

The controller told the crew to go around. The crew conducted a missed approach and then conducted a normal approach and landing.

"After landing, I contacted approach [control] by phone to find out that an aircraft on the ground had entered the [critical] area and disrupted the glideslope signal for Runway 27L," the report said. "Three aircraft had to [go around]."♦

Notes

1. Costa Pereira, R.C. "Incidents caused by operational use of ILS signals radiated during testing and maintenance procedures." International Civil Aviation Organization (ICAO) AN 7/5-01/52. May 11, 2001.

2. Controlled flight into terrain (CFIT) occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew.

3. Air New Zealand. *Investigation Report: Go-around at Faleolo due to erroneous on-glideslope indication*. Occurrence Investigation 00/SI/91, March 1, 2001.

4. New Zealand Civil Aviation Rules Part 171.113, "Limitations on [telecommunication service] certificate holder," states, in part, that except during testing or during an emergency, an aeronautical facility may not be operated unless "any integrity-monitoring system for the aeronautical facility is fully functional."

5. The *black-hole effect* typically occurs during a visual approach conducted on a moonless or overcast night, over water or over dark and featureless terrain where the only visual stimuli are lights on and/or near the airport. The absence of visual references in the pilot's near vision affects depth perception and causes the illusion that the airport is closer than it actually is and, thus, that the aircraft is too high. The pilot may respond to this illusion by conducting an approach below the correct flight path (i.e., a low approach).

6. The Society of Automotive Engineers' *SAE Dictionary of Aerospace Engineering*, edited by William H. Cubberly, defines *raw data* as "information that has not been processed or analyzed by the computer." The Flight Safety Foundation (FSF) Approach-and-landing Accident Reduction (ALAR) Task Force defines *raw data* as "data received directly (not via the flight director or flight management computer) from basic navigation aids (e.g., ADF , VOR, DME, barometric altimeter)."

7. *Terrain awareness and warning system* (TAWS) is the term used by the European Joint Aviation Authorities and the U.S. Federal Aviation Administration (FAA) to describe equipment meeting ICAO standards and recommendations for ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS* and *ground collision avoidance system* are other terms used to describe TAWS equipment.

8. Carrelli, Michael. E-mail communication with Lacagnina, Mark. Alexandria, Virginia, U.S. June 23, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S. Carrelli said that the New Zealand Civil Aviation Authority (CAA) report on the Air New Zealand incident at Faleolo, Samoa, July 29, 2000, will be published on the CAA's Internet site, <www.caa.govt.nz>.

9. ICAO. Document 8071: *Manual on Testing of Radio Navigation Aids*; Volume 1, "Testing of Ground-based Navigation Systems"; Chapter 1, "General"; 1.8, "Notification of Change of Status."

10. De Courville, B.; Jud, J.M. "ILS Calibration During Final Approach: A Potential CFIT Scenario."

11. De Courville, Bertrand. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. July 17, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

12. The U.S. National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (ASRS) is a confidential incident-reporting system. The ASRS Program Overview said, "Pilots, air traffic controllers, flight attendants, mechanics, ground personnel and others involved in aviation operations submit reports to the ASRS when they are involved in, or observe, an incident or situation in which aviation safety was compromised. … ASRS de-identifies reports before entering them into the incident database. All personal and organizational names are removed. Dates, times, and related information, which could be used to infer an identity, are either generalized or eliminated."

    ASRS acknowledges that its data have certain limitations. ASRS *Directline* (December 1998) said, "Reporters to ASRS may introduce biases that result from a greater

tendency to report serious events than minor ones; from organizational and geographic influences; and from many other factors. All of these potential influences reduce the confidence that can be attached to statistical findings based on ASRS data. However, the proportions of consistently reported incidents to ASRS, such as altitude deviations, have been remarkably stable over many years. Therefore, users of ASRS may presume that incident reports drawn from a time interval of several or more years will reflect patterns that are broadly representative of the total universe of aviation-safety incidents of that type."

13. NASA ASRS. Report no. 173399. March 1991.

14. U.S. National Transportation Safety Board (NTSB). *Aircraft Accident Report: Controlled Flight Into Terrain; Korean Air Flight 801; Boeing 757-300, HL7468; Nimitz Hill, Guam; August 6, 1997*. NTSB/AAR-00/01. See also: Flight Safety Foundation. *Flight Safety Digest* Volume 19 (May–July 2000).

15. FAA. *Aeronautical Information Manual*; Chapter 1, "Navigation Aids"; 1-1-1(b). Feb. 21, 2002.

16. Transportation Safety Board of Canada. *Aviation Occurrence Report: Instrument Approach Using Unserviceable Localizer; Air BC Limited de Havilland DHC-8, C-GABH; Cranbrook, British Columbia, 19 October 1994*. Report no. A94P0269.

17. Transport Canada. *Aeronautical Information Publication*. "Communications"; 3.3, "Accuracy, Availability and Integrity of Navigational Aids."

18. NTSB report no. FTW98MA096. See also: FSF Editorial Staff. "Learjet Strikes Terrain When Crew Tracks False Glideslope Indication and Continues Descent Below Published Decision Height." *Accident Prevention* Volume 56 (June 1999).

19. NASA ASRS. Report no. 506938. March 2001.

20. NASA ASRS. Report no. 162286. November 1990.

21. Ochs, Rick. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. June 25, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

22. U.S. Federal Aviation Regulations (FARs) Part 91.411 requires tests and inspections every 24 calendar months of static pressure systems, altimeters and automatic pressure-altitude-reporting systems aboard aircraft that are operated in controlled airspace under instrument flight rules. FARs Part 91.413 requires tests and inspections every 24 calendar months of transponders.

23. Rogers, Tom. Telephone interview by Lacagnina, Mark. Alexandria, Virginia, U.S. June 28, 2002. Flight Safety Foundation, Alexandria, Virginia, U.S.

24. Beaudoin, Dennis. "Localizer False Capture — the Root Cause and the Implications on Flight Inspection." In *The Impact of Technology on Flight Inspection: Proceedings of the Eighth International Flight Inspection Symposium*, Denver, Colorado, United States: FAA, 1994.

25. Transport Canada. *Aeronautical Information Publication*. "Communications"; 3.13.1, "Caution — Use of ILS Localizers."

26. ICAO. Annex 10, Volume I, Attachment G, 2.1.10.

27. FAA. *Air Traffic Control*. Order 7110.65N; 3-7-5, "Precision Approach Critical Area."

28. NASA ASRS. Report no. 505535. March 2001.

29. NASA ASRS. Report no. 157805. September 1990.

Further Reading From FSF Publications

FSF Editorial Staff. "Pitch Oscillations, High Descent Rate Precede B-727 Runway Undershoot." *Accident Prevention* Volume 58 (September 2001).

Flight Safety Foundation. "Approach-and-landing Accident Reduction (ALAR) Briefing Notes." *Flight Safety Digest* Volume 19 (August–November 2000).

Flight Safety Foundation. "Killers in Aviation: FSF Task Force Presents Facts About Approach-and-landing and Controlled-flight-into-terrain Accidents." *Flight Safety Digest* Volume 17 (November–December 1998) and Volume 18 (January–February 1999).

Flight Safety Foundation. "Airport Safety: A Study of Accidents and Available Approach-and-landing Aids." *Flight Safety Digest* Volume 15 (March 1996).

Lawton, Russell. "Captain Stops First Officer's Go-around, DC-9 Becomes Controlled-flight-into-terrain (CFIT) Accident." *Accident Prevention* Volume 51 (February 1994).

FSF Editorial Staff. "Rapid Emergence of New Technologies Spurs Debate About Precision Landing System Priorities." *Airport Operations* Volume 19 (May–June 1993).

Aviation Statistics

U.S. Corporate, Business and On-demand Operations Show Reduced Accident Rates for 2001

General aviation as a whole posted higher accident rates for the year compared to 2000 based on a recent analysis.

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FSF Editorial Staff

General aviation aircraft operated under U.S. Federal Aviation Regulations (FARs) Part 91 (general operating and flight rules) in 2001 recorded more accidents and fatalities compared to 2000, based on data for worldwide accidents involving U.S.-registered aircraft. Nevertheless, accident rates improved in corporate operations (business aircraft flown by professional pilots), business operations (business aircraft flown by nonprofessional pilots) and FARs Part 135 on-demand operations, said William Garvey, editor-in-chief of *Business & Commercial Aviation*, presenting a paper by Richard N. Aarons, the magazine's editor-at-large/safety, with data from Robert E. Breiling Associates.

Garvey presented the data during the 47th Corporate Aviation Safety Seminar, presented by Flight Safety Foundation (FSF) with the National Business Aviation Association (NBAA) May 7–9, 2002, in Phoenix, Arizona, U.S.

Among the findings of the analysis, 17 percent of turboprop aircraft accidents occurred during approach (Figure 1, page 21) — nearly six times the percentage for turbojet aircraft operations (3 percent, Figure 2, page 21), he said. Similarly, the percentage of turboprop aircraft taxi accidents (17 percent) was nearly twice the percentage for turbojet aircraft operations (9 percent).

Garvey said that Part 135 (commuter and on-demand) operators flew 3.4 million hours in 2001 compared to 2.4 million hours in 2000; despite the significant increase in activity, they had fewer accidents, fewer total accidents, fewer fatal accidents and fewer fatalities.

Garvey presented the following data and comparisons (all rates are accidents per 100,000 hours):

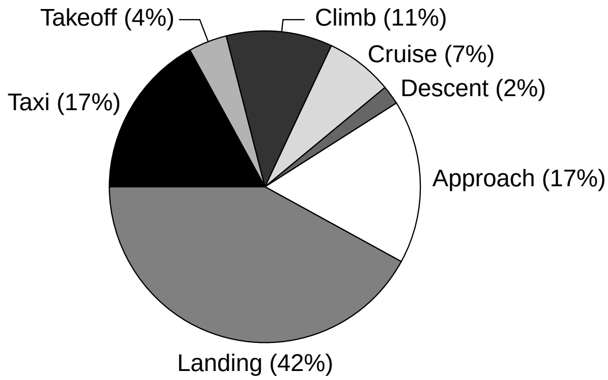
- The 2001 accident rate in Part 91 operations (including business operations, corporate operations and all aircraft types) was 6.56 accidents (Figure 3, page 22) and 1.22 fatal accidents (Figure 4, page 23), which compared to a rate of 5.96 accidents and a rate of 1.11 fatal accidents in 2000;

- In 2001, 1,721 accidents occurred in Part 91 operations compared to 1,835 accidents in 2000; 321 fatal accidents in this category of operations involved 556 fatalities compared to 341 fatal accidents involving 592 fatalities in 2000;

- From 1992 through 2001 in Part 91 operations (including corporate operations and business operations), the lowest accident rate was 5.96 in 2000 and the highest accident rate was 9.08 in 1994; the lowest fatal accident rate was 1.11 in 2000 and the highest fatal accident rate was 1.82 in 1992;

- The 2001 accident rate in business operations (all aircraft types) was 1.06 accidents and 0.23 fatal

U.S.-registered Turboprop Aircraft Accidents By Phase of Flight, 2001[1]

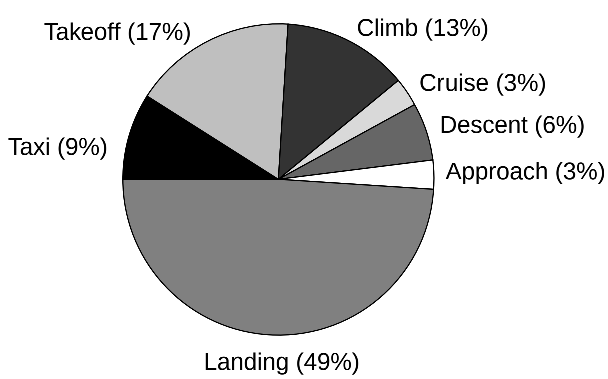


[1]Accidents include those involving professional flight crews and nonprofessional flight crews, and all types of turboprop aircraft operations except U.S. Federal Aviation Regulations Part 121 (air carrier) operations.

Source: *Business & Commercial Aviation* with data from Robert E. Breiling Associates

Figure 1

U.S.-registered Turbojet Aircraft Accidents By Phase of Flight, 2001[1]



[1]Accidents include those involving professional flight crews and nonprofessional flight crews, and all types of turbojet aircraft operations except U.S. Federal Aviation Regulations Part 121 (air carrier) operations.

Source: *Business & Commercial Aviation* with data from Robert E. Breiling Associates

Figure 2

accidents, which compared to a rate of 1.27 accidents and a rate of 0.37 fatal accidents in 2000;

- In 2001, 68 accidents occurred in business operations compared to 83 accidents in 2000; 15 fatal accidents in this category of operations involved 38 fatalities compared to 24 fatal accidents involving 48 fatalities in 2000;

- From 1992 through 2001 among business operations, the lowest accident rate was 1.06 in 2001 and the highest accident rate was 2.2 in 1992; the lowest fatal accident rate was 0.23 in 2001 and the highest fatal accident rate was 0.68 in 1992;

- In corporate operations (all aircraft types) in 2001, the rates were 0.11 accidents and 0.03 fatal accidents, which compared to rates of 0.13 accidents and 0.06 fatal accidents in 2000. Seven accidents and eight fatalities were recorded in this category of operations in 2001 compared to nine accidents and 13 fatalities in 2000;

- From 1992 through 2001, among all corporate operations, the lowest accident rate was 0.09 in 1998 and the highest accident rate was 0.25 in 1995; the lowest fatal accident rate was 0.03 in 2001 and the highest fatal accident rate was 0.11 in 1995;

- In all Part 121 operations (air carrier, scheduled and unscheduled) in 2001, the rates were 0.24 accidents and 0.04 fatal accidents, which compared to rates of 0.32 accidents and 0.02 fatal accidents in 2000. Forty accidents and 542 fatalities were recorded in this category of operations in 2001 compared to 57 accidents and 92 fatalities in 2000;

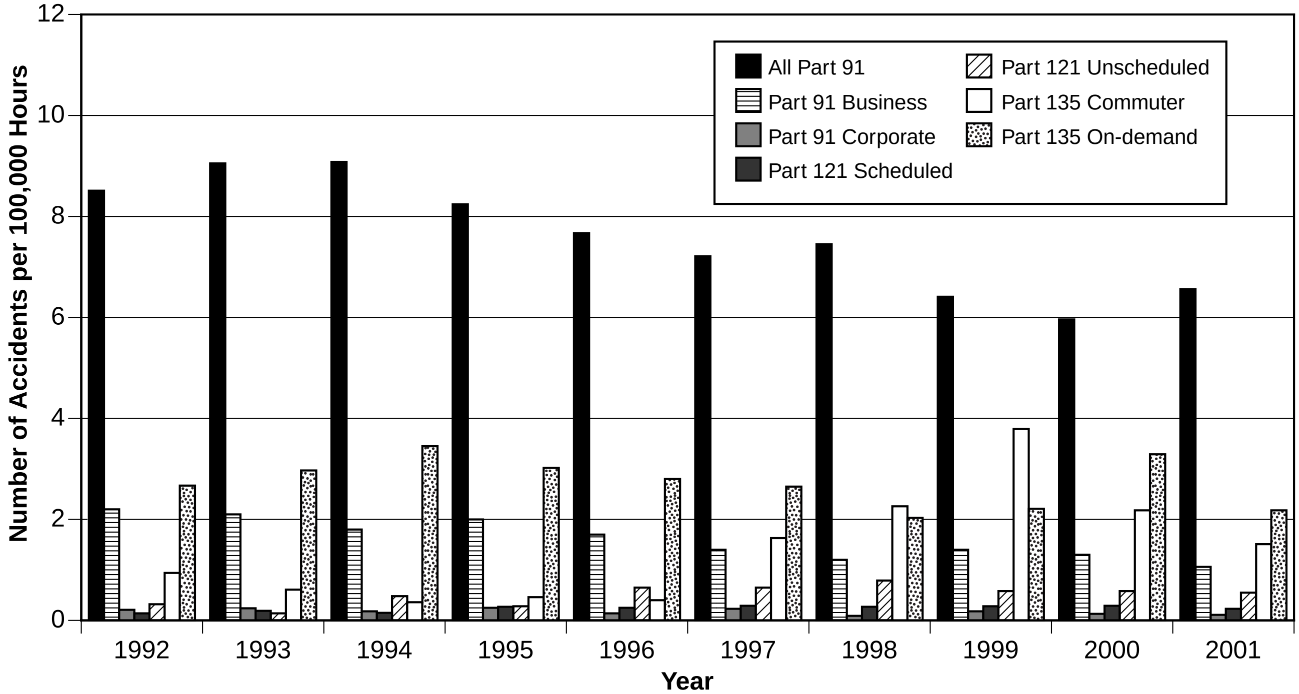
- In Part 121 scheduled operations in 2001, the rates were 0.23 accidents and 0.04 fatal accidents, which compared to rates of 0.29 accidents and 0.02 fatal accidents in 2000. Thirty-six accidents and 542 fatalities were recorded in this category of operations in 2001 compared to 49 accidents and 92 fatalities in 2000;

- From 1992 through 2001, among Part 121 scheduled operations, the lowest accident rate was 0.14 in 1992 and the highest accident rate was 0.29 in 1997 and 2000; the lowest fatal accident rate was 0.01 in 1993, 1998 and 1999, and the highest fatal accident rate was 0.03 in 1992 and 1994;

- In Part 121 unscheduled operations in 2001, the rates were 0.55 accidents and zero fatal accidents, which compared to rates of 0.58 accidents and zero fatal accidents in 2000. Four accidents and zero fatalities were recorded in this category of operations in 2001 compared to five accidents and zero fatalities in 2000;

- From 1992 through 2001, among Part 121 unscheduled operations, the lowest accident rate was 0.14 in 1993 and the highest accident rate was 0.78 in 1998; the lowest fatal accident rate was zero in 1992, 1993, 1994, 1998, 1999, 2000 and 2001, and the highest fatal accident rate was 0.26 in 1996;

Accident Rates, U.S.-registered Aircraft by Category of Operation, 1992–2001



Rates = Number of accidents per 100,000 hours

Part 91 = U.S. Federal Aviation Regulations (FARs) Part 91 (general operating and flight rules)

Part 121 = FARs Part 121 (air carrier)

Part 135 = FARs Part 135 (commuter and on-demand)

Source: *Business & Commercial Aviation* with data from Robert E. Breiling Associates

Figure 3

- In Part 135 commuter operations in 2001, the rates were 1.51 accidents and 0.61 fatal accidents, which compared to rates of 2.18 accidents and 0.18 fatal accidents in 2000. Five accidents and 13 fatalities were recorded in this category of operations in 2001 compared to 12 accidents and five fatalities in 2000;

- From 1992 through 2001, among Part 135 commuter operations, the lowest accident rate was 0.36 in 1994 and the highest accident rate was 3.79 in 1999; the lowest fatal accident rate was zero in 1998 and the highest fatal accident rate was 1.46 in 1999;

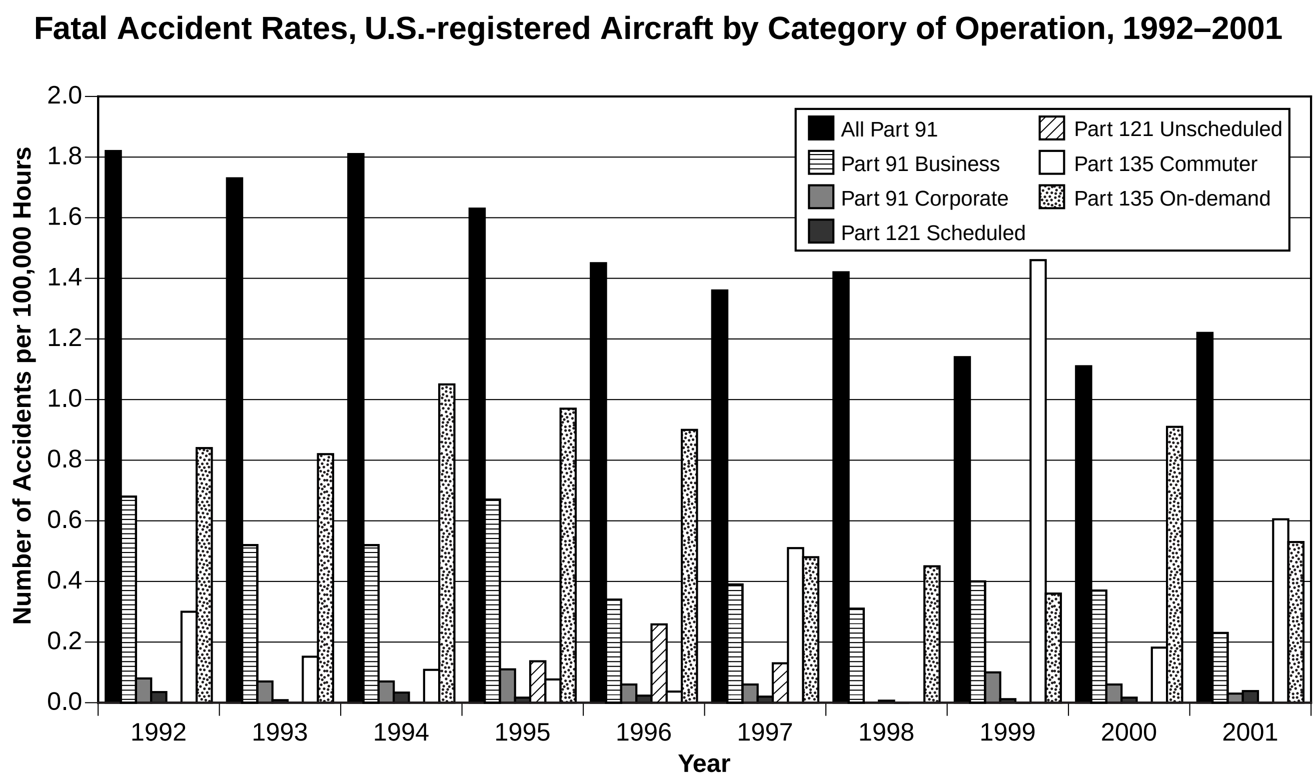
- In Part 135 on-demand operations (all aircraft types) in 2001, the rates were 2.18 accidents and 0.53 fatal accidents, which compared to rates of 3.29 accidents and 0.91 fatal accidents in 2000. Seventy-four accidents and 60 fatalities were recorded in this category of operations in 2001 compared to 80 accidents and 71 fatalities in 2000;

- From 1992 through 2001, among all Part 135 on-demand operations, the lowest accident rate was 2.03 in 1998 and the highest accident rate was 3.45 in 1994; the lowest fatal accident rate was 0.36 in 1999 and the highest fatal accident rate was 1.05 in 1994;

- Figure 5 (page 23) shows the distribution of turbojet aircraft accidents (excluding operations under FARs Part 121) in 2001 by categories of probable cause; and,

- Figure 6 (page 23) shows the distribution of turboprop aircraft accidents (excluding operations under FARs Part 121) in 2001 by categories of probable cause.

In the analysis, probable cause categories were identified for each accident based on the analysts' judgment of available information in accident reports, whether or not an official determination of probable cause was included in the source report. Landing accidents were defined as those in which the aircraft wheels were on the ground; takeoff accidents were defined as occurring from the takeoff roll until the landing gear was retracted.♦



Rates = Number of accidents per 100,000 hours

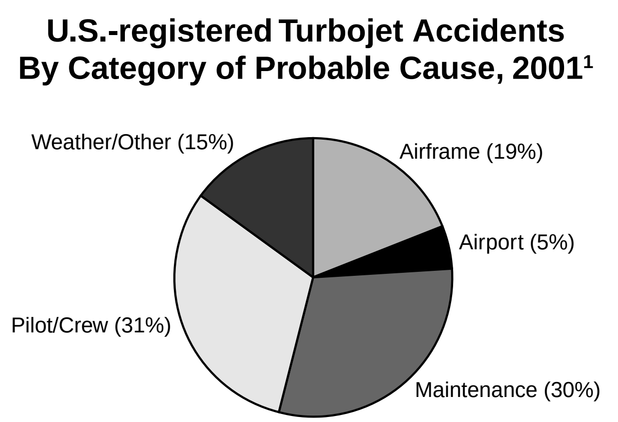
Part 91 = U.S. Federal Aviation Regulations (FARs) Part 91 (general operating and flight rules)

Part 121 = FARs Part 121 (air carrier)

Part 135 = FARs Part 135 (commuter and on-demand)

Source: *Business & Commercial Aviation* with data from Robert E. Breiling Associates

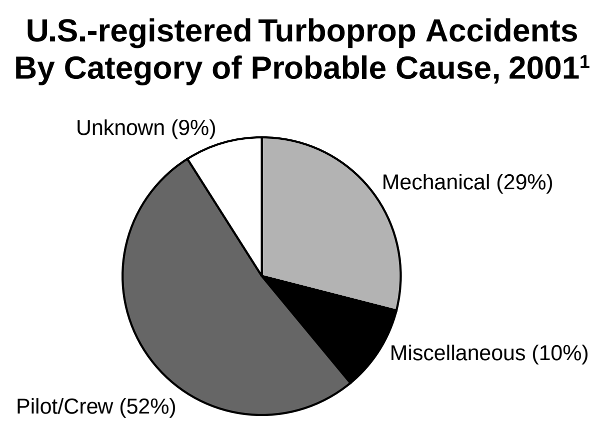
Figure 4



[1]Probable cause categories were identified based on the analysts' judgment of available information in the accident report. U.S. Federal Aviation Regulations Part 121 (air carrier) operations were excluded.

Source: *Business & Commercial Aviation* with data from Robert E. Breiling Associates

Figure 5



[1]Probable cause categories were identified based on the analysts' judgment of available information in the accident report. U.S. Federal Aviation Regulations Part 121 (air carrier) operations were excluded.

Business & Commercial Aviation with data from Robert E. Breiling Associates

Figure 6

Publications Received at FSF Jerry Lederer Aviation Safety Library

Report Provides Safety Data for Use in Accident Prevention

The report by the International Air Transport Association, which is part of a safety information package, identifies areas of concern and high risk and recommends methods of improvement.

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FSF Library Staff

Reports

Safety Report 2001. International Air Transport Association. Ref. no. 9049-02. Montreal, Canada: March 2002. 158 pp. Figures, tables, appendixes, compact disc. Available through IATA.*

In the introduction, the International Air Transport Association (IATA) says that safety (including security) is "the no. 1 corporate objective of IATA" and that the *Safety Report* is intended to help in "maintaining safety vigilance by identifying the areas of greatest risk apparent from the experience of aircraft accidents."

The *Safety Report*, which presents data in numerous graphs, figures, tables and textual analysis, is a consolidated source of diverse safety-performance data that can be used to enhance safety awareness and accident prevention. The report focuses on commercial air transportation operations and presents the results of IATA's monitoring of airline operations and analysis of accident data. This new edition of the *Safety Report* presents jet accident statistics and turboprop accident statistics and provides information on IATA safety initiatives, such as the safety alliance with Flight Safety Foundation (FSF).

The report identifies areas of concern and high risk and includes 22 recommendations to the industry. The following are the top three recommendations, each of which involves approach-and-landing accident reduction (ALAR):

- Because the approach-and-landing phase of flight presents the greatest risk, airlines should incorporate the FSF *ALAR Tool Kit* into their training programs. The *ALAR Tool Kit* is a unique set of pilot briefing notes, videos, presentations, risk-awareness checklists and other products designed to prevent approach-and-landing accidents, including those involving controlled flight into terrain (CFIT). CFIT occurs when an airworthy aircraft under the control of the flight crew is flown unintentionally into terrain, obstacles or water, usually with no prior awareness by the crew. This type of accident can occur during most phases of flight, but CFIT is more common during the approach-and-landing phase, which begins when an airworthy aircraft under the control of the flight crew descends below 5,000 feet above ground level (AGL) with the intention to conduct and approach and ends when the landing is complete or the flight crew flies the aircraft above 5,000 feet AGL en route to another airport;

- Both Airbus and Boeing are expected to distribute training videos in 2002 about various aspects of landing techniques. Operators should obtain and incorporate this training material to improve crew proficiency; and,

- Airlines should optimize their flight-data-monitoring systems to examine undershoots, low-level go-arounds and long landings. Animated analysis tools should be used to assist with timely counseling of flight crewmembers.

The report says that the IATA Safety Committee's Classification Working Group identified 83 operational accidents in 2001 involving Western-built jet aircraft and turboprop aircraft, compared with 84 accidents in 2000. Of the 83 accidents, 20 were jet hull loss accidents, 16 were turboprop hull loss accidents, 36 were jets that were damaged substantially, and 11 were turboprops that were damaged substantially.

The report said that, although the data show that 2001 "had a better-than-average safety performance, there is still room for further improvement."

The report is part of a safety information package that includes a graphical report, a compact disc containing additional information for airline safety managers, the FSF *ALAR Tool Kit* and the *IATA Directory of Airline Safety Representatives*.

Essays on Aviation: A Reconnaissance Flight for Policy Renewal. Directorate-General of Civil Aviation. The Hague, Netherlands: Ministry of Transport, Public Works and Water Management, 2002. 180 pp. Figures, tables. Available through DGCA.**

As part of the annual budget process, F.L. Bussink, the director-general of civil aviation in the Netherlands, reviews factors that influence aviation policy. In the foreword, Bussink said, "A constant factor in aviation policy concerns the need to strike the right balance between the benefits and burdens of aviation." To encourage discussion of what constitutes the right balance, he asked aviation specialists to submit essays about specific aspects of aviation policy. This report is a compilation of 14 essays — including one by Flight Safety Foundation President and CEO Stuart Matthews — that describe developments, trends and problem areas, and recommend solutions. The essays are included in the following four policy areas:

- Safety — the promotion of aviation safety;

- Capacity — the availability of an aviation network (including airports and airspace) that is demand-adjusted, effective and efficient;

- Market regulation — the provision of an effective civil aviation system by contributing to the development and sustainability of a smoothly functioning aviation market; and,

- Environment — the realization and maintenance of sustainable aviation.

Findings and comments resulting from discussions of the essays are included in the introductory text. Some essays discuss the development of aviation policy in the Netherlands. Others have generic themes that could be applied elsewhere in the industry.

A Review of Situation Awareness Literature Relevant to Pilot Surveillance Functions. Uhlarik, J.; Comerford, D.A. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine (OAM). DOT/FAA/AM-02/3. March 2002. 24 pp. Figures, tables, references. Available through NTIS.***

In aviation, the concept of situational awareness involves the controlled operation of a complicated system in a dynamic environment. The human operating the system should integrate disparate and possibly inconsistent sensory information (visual, auditory, tactile, vestibular and other information) with sophisticated, cognitive machinery and operating environments to control the movement of an aircraft.

Situational awareness appears to have parallels with mental workload. For example, cockpit task demands may draw upon pilots' mental resources, and this could correlate with pilot performance. As with mental workload and physical tasking, situational awareness has human factors considerations and limitations.

The report focuses on situational awareness and surveillance activities in commercial air carriers. The authors reviewed and critiqued many definitions and diverse concepts of situational awareness in research literature.

Rather than define situational awareness, the authors used approaches and models to discuss the concept. The authors summarized situational awareness in the following ways:

- Use of information-processing models — In these models, situational awareness refers to traditional psychological factors, such as attention, long-term memory, perception and automaticity (the automatic, mechanical and apparently undirected behavior that is beyond conscious control);

- Use of perception-action cycles — This approach refers to the cyclical and dynamic process of perceiving an object or information in the environment and applying knowledge gained from training and experience to further explore the environment;

- Decision-making models — These models attempt to fuse situational awareness with judgment and decision making, resulting in expert-level performance based upon assessment of a given situation; and,

- Phenomenon description — These models categorize situations and events according to cause and effect, by degrees of complexity.

The report says that situational awareness is a term used indiscriminately to describe a psychological state and “an implied quality of avionics displays.” The report says that if situational awareness is to become “an enduring and useful concept, a commonly accepted definition and adequate operational definitions must be developed in the near future.”

Contact Lens Use in the Civil Airman Population. Nakagawara, V.B.; Wood, K.J.; Montgomery, R.W. U.S. Federal Aviation Administration (FAA) Office of Aerospace Medicine (OAM). DOT/FAA/AM-02/6. May 2002. 14 pp. Figures, tables, references. Available through NTIS.***

Statistically, more than 80 percent of all information that a pilot requires to operate an aircraft safely is obtained with the eyes, making vision the most important sense used by pilots when operating aircraft.

Since 1976, FAA (which is responsible for medical certification of all civilian airmen in the United States) has permitted civilian pilots to use contact lenses to correct distant vision problems. FAA has conducted several studies to investigate possible relationships between contact lens use and aviation accidents. For this study, the authors examined contact lens use within the civil airman population from 1967 through 1997. Data were extracted from the U.S. National Transportation Safety Board accident/incident database, the FAA medical database and the FAA incident database.

The report said that study findings showed that contact lens use was a contributing factor in a small number of aviation accidents. Discussions of five aviation accidents and one incident are included in the report.

Other findings show that the number of pilots using contact lenses has increased considerably but not at the same rapid rate found among the general population. Such increases suggest that pilots have determined that contact lenses are beneficial in a cockpit environment. The report said that, because of advances in contact lens technology and aviation technology (including the glass cockpit, in which electronic displays have replaced traditional equipment), contact lens use should be monitored to ensure that pilots operate in a safe environment.

Books

Human Factors in the Training of Pilots. Koonce, J.M. London, England: Taylor & Francis Books, 2002. 302 pp. Figures, tables, references.

The book is written for pilots, instructors and student pilots and explains how to apply human factors principles to training methods and flying. The author’s focus is on safety and good practices, not on accident reports and incident reports.

The author discusses the principles of human learning, perceptual capabilities and limitations of human senses, such as sight, hearing and smell. The author includes elements that influence pilots, such as touch, balance, motion, disorientation and standardization of cockpit controls. Chapters discuss various human factors and their influences on the decision making, skills and performance of pilots.

Terrorism and Business: The Impact of September 11, 2001. Alexander, D.C.; Alexander, Y. Ardsley, New York, U.S.: Transnational Publishers, 2002. 265 pp. Bibliography.

This book discusses the effects on the U.S. government, U.S. labor forces, U.S. business and the aviation industry of the terrorist attacks against the United States on Sept. 11, 2001. The opening chapter describes acts of terrorism from ancient times to modern times and says that there is no universal consensus on the definition of terrorism. Subsequent chapters describe economic costs and management costs of terrorism and the multi-faceted responses by corporate America and the U.S. government to the Sept. 11 attacks. The book concludes with a discussion of lessons learned that could be applied to future terrorist threats. A lengthy bibliography of books, articles, reports, proceedings and Internet sites is provided.♦

Sources

* International Air Transport Association (IATA)
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** Directorate-General of Civil Aviation
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*** National Technical Information Service (NTIS)
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Accident/Incident Briefs

Precautionary Landing of B-767 Prompted by Fumes, Smoke-detector Alert

Inspections by maintenance personnel revealed that the fumes were caused by the release of chemical compounds in the protective coating on the airplane's secondary heat exchanger.

FSF Editorial Staff

The following information provides an awareness of problems through which such occurrences may be prevented in the future. Accident/incident briefs are based on preliminary information from government agencies, aviation organizations, press information and other sources. This information may not be entirely accurate.

Incident Prompts Changes In Overhaul Process

Boeing 767. No damage. No injuries.

The airplane was being flown at Flight Level (FL) 410 (approximately 41,000 feet) on a domestic flight in Australia when fumes were detected on the flight deck and a smoky haze in the cabin activated a lavatory smoke detector. The report said that the crew conducted "appropriate non-normal procedures" and landed the airplane at an en route airport. During the descent, with the engines at idle thrust, the fumes decreased in intensity.

Maintenance personnel found no defects, and the aircraft was flown to another airport for further maintenance checks. No fumes were detected during the flight or during subsequent ground tests.

The airplane was returned to service. Two days later, fumes again were detected when the airplane climbed through FL 410. The flight crew conducted the "Smoke or Fumes Air Conditioning" checklist and returned the airplane to the departure airport. Maintenance inspections revealed no oil contamination of the pneumatic system; maintenance personnel replaced hydraulic-reservoir pressurization modules and recirculation filters. During an assessment flight, as the airplane was leveled at about 41,600 feet, an "acrid odor became apparent" in the cabin and on the flight deck, the report said. Maintenance personnel determined that the sources of the odor were the right pneumatic distribution system and the right air-conditioning system; as a result, the right engine was replaced.

During a second assessment flight, when the airplane was flown above 41,900 feet, the odor again was detected. Examination determined that the source was the right air-conditioning pack system and that the pneumatic ducting was not contaminated. When components of the right air-conditioning system were removed and replaced, a black deposit was found on the air-cycle-machine (ACM) compressor, a brown fluid was found in the right secondary heat exchanger, and the right secondary heat exchanger and downstream components were found to emit the same odor that was detected during the assessment flights. The report said that the secondary heat exchanger had been overhauled about two months earlier and that records showed that protective coating was baked onto the secondary heat exchanger at “a significantly lower temperature than if the exchanger had been completely re-cored.”

During a third assessment flight, no odors were detected.

The report said that the fumes probably resulted from the heating of chemical compounds contained in the secondary heat exchanger.

After the incidents, the contractor changed the secondary heat exchanger overhaul process to increase the temperature used when baking on the protective coating and to use forced ventilation during the baking process to ensure that fumes are removed from the exchangers.

Airplane Damaged During Training-flight Landing In Gusty Crosswinds

Airbus A300B4. Minor damage. No injuries.

The airplane was being flown on a night training flight in England, and the pilot flying was a captain under training who had accumulated more than 3,000 flight hours on A300 airplanes.

The airplane was flown on an instrument landing system (ILS) approach to Runway 26L, and crewmembers said that conditions were turbulent, with an inertial-reference-system wind speed indication of 70 knots at 1,000 feet and surface winds from 210 degrees at 18 knots and gusts to 30 knots.

The report said, “The pilot flying began to flare the aircraft but then experienced a left wing drop. He attempted to correct this by application of right aileron and additional power. However, the aircraft touched down heavily, first on the left-main [landing] gear, followed by the right-main [landing] gear. The aircraft rebounded into the air and, following a nose-down elevator input, touched down in a nose-down pitch attitude with right roll.”

The right-main landing gear, the nose landing gear and the right engine touched the runway surface. The airplane bounced two more times.

The report said that the manufacturer’s maximum computed and demonstrated crosswind for the aircraft (assuming a “steady-state” crosswind) is 32 knots and that 32 knots is the company’s A300 crosswind limit.

The report said that the U.K. *Aeronautical Information Publication* entry for the airport contained a warning to pilots of “the possibility of building-induced turbulence and wind shear effects” when strong southerly/south-westerly winds occurred during landing on the runway.

Right-main Landing Gear Fails During Landing

Douglas DC-9. Substantial damage. No injuries.

Visual meteorological conditions prevailed and an instrument flight rules flight plan was filed for the domestic flight in the United States.

The airplane was flown on an instrument landing system (ILS) approach until about 1,000 feet above ground level, when the airplane was flown below an overcast cloud layer. The first officer hand-flew the remainder of the approach, and the airplane touched down about 1,000 feet (305 meters) from the approach end of the runway. As the airplane decelerated to about 60 knots, the thrust reversers were retracted.

“The brakes gave an initial release, followed by a hard tilt to the right with a continuous warning horn,” a preliminary accident report said.

The airplane slid about 1,500 feet (458 meters), then stopped on the centerline. Passengers and crewmembers exited the airplane using a portable stairway at the forward galley left-side entrance.

The outer cylinder of the right-main-landing-gear strut had fractured into two sections. The fracture point was about two inches (5.1 centimeters) above the designed fuse section of the strut assembly. The report said that the lower portion of the right-main landing gear, including the wheels, brakes and hub assembly, “was impacted up into the right-inboard flap assembly” and that the outboard half of the right wing — including the lower wing skin, the main spar and the surrounding wing structure — was scraped.

The fractured outer cylinder had accumulated 71,665 flight hours and 67,467 cycles, including 21,546 flight hours and 17,886 cycles since the last component overhaul. The outer cylinder was sent to a laboratory for further examination.

Air Taxi Commuter

Paint on Nut Assembly Blamed for Landing Gear’s Failure to Extend

Beech 200 Super King Air. Minor damage. No injuries.

Visual meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the midday flight from an airport in the United States.

The pilot said that when the landing gear was retracted after takeoff, he heard an unusual noise, "like a chain popping or slipping around a sprocket." He then observed the left-main tire and inboard gear doors beneath the engine nacelle. His attempts to manually extend the landing gear were unsuccessful. He diverted the flight to an en route airport, where he conducted a wheels-up landing.

An inspection of the nose-landing-gear actuator by the aircraft manufacturer revealed that the nut assembly had been painted while the landing gear was extended. The manufacturer's report said that the nut assembly "is a chromed metal shaft that is not to be painted."

The accident report said that the cause of the accident was the "jamming of the nose-landing-gear actuator due to improper painting procedures by other maintenance personnel which resulted in a wheels-up landing."

Overweight Airplane Strikes Terrain During Takeoff

Reims F-406 Caravan. Destroyed. Three fatalities.

Visual meteorological conditions prevailed for the cargo flight's night departure for Namibia from an airport in South Africa. The airplane was loaded with the heaviest boxes in the front of the cabin area, lighter boxes in the center and rear of the cabin area and two three-meter-long (9.8-feet-long) steel bars on top of the boxes on the left side of the aircraft. The cargo was not secured by a cargo net, as required by South African Civil Aviation Regulations. A passenger — a pilot with an airline transport pilot license who had accumulated more than 12,000 flight hours and who also was a designated examiner — was seated on the cabin floor with no seat belt.

A witness observed the airplane flying just above the runway when it pitched up, rolled left and struck the ground. The accident occurred 106 seconds after the beginning of the takeoff roll.

An investigation revealed that, in addition to the cargo, the passenger and two pilots, the airplane was fueled to capacity before takeoff with about 1,452 kilograms (3,200 pounds) of Jet A1 fuel. The airplane's takeoff weight was 5,079 kilograms (11,198 pounds); maximum certified takeoff weight is 4,245 kilograms (9,359 pounds).

A preliminary accident report said that investigators could not determine whether the airplane was loaded to conform with center-of-gravity (CG) requirements.

"This is [because] there is no known record of the weight and location of cargo loaded in the aircraft and the fact that a large discrepancy exists between the empty-weight CG position of [the accident airplane] and other South African-registered F-406 aircraft when compared to the empty-weight CG position data given by the manufacturer," the report said.

The report said that the South African Civil Aviation Authority had been told that an individual had been fired for "improperly supervising the loading of the aircraft on the night of the fatal flight."

Stone Lodged in Pulley Restricts Aileron Movement

De Havilland DHC-6-200 Twin Otter. Minor damage. No injuries.

During descent to an airport in Canada, the airplane was flown into moderate turbulence and rolled left. The captain tried to correct the airplane's attitude, but the control column could not be moved past the neutral position to the right. The flight crew flew the airplane back to the departure airport, where they conducted a landing that did not require right-aileron control.

An inspection revealed that a small stone was lodged in an aileron-control-cable pulley. As a result of the incident, maintenance personnel installed pulley covers on the company's Twin Otters.

Corporate
Business

Tape on Vent Cited in Fuel Tank's Collapse

British Aerospace HS 125 Series 700A. Substantial damage. No injuries.

Visual meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the morning flight from an airport in the United States. The captain said that the airplane was being flown at 4,000 feet when the flight crew heard a bang and believed that the airplane had struck a bird. They conducted a normal landing at the destination airport.

An inspection revealed that the left-wing fuel tank was compressed, the left wing was distorted and the left-wing fuel vent was blocked with duct tape. The left-wing fuel-tank stringers and the left-wing ribs also were damaged. The captain said that the fuel tanks had been repaired and pressure-tested before the flight. After the pressure test, the maintenance technician removed duct tape from the right-wing fuel vent, but the maintenance technician and the flight crew did not observe the duct tape covering the left-wing fuel vent. Because the fuel vent was blocked by tape, air could not enter the fuel tank as the fuel pump began pumping fuel out. The resulting low pressure inside the fuel tank led to the collapse.

The final report said that the probable cause of the accident was "the pilot-in-command's inadequate preflight inspection, which resulted in a flight with a blocked fuel-tank vent." The report said that a contributing factor was the failure of maintenance personnel to remove the duct tape.

Citation's TCAS Alerts Crew to Smaller Airplane

Cessna 560 Citation. No damage. No injuries.
Cessna 172. No damage. No injuries.

The crew of the Cessna Citation had received air traffic control (ATC) clearance for takeoff from an airport in Canada on an afternoon instrument flight rules flight. The clearance required them to conduct the takeoff on Runway 15 and to fly the airplane to 3,000 feet.

They were not told about the Cessna 172, which was being flown at 2,000 feet, two nautical miles to three nautical miles (3.7 kilometers to 5.6 kilometers) from the departure end of the runway. The pilot of the C-172 had received ATC clearance to descend to join a left downwind for runway 21.

During the Citation's climb, as the airplane approached 2,000 feet, the crew received a traffic-alert and collision avoidance system (TCAS) resolution advisory to maintain the climb. As they applied maximum power and increased the rate of climb, they observed the C-172, which was crossing from right to left, 0.5 nautical mile (0.9 kilometer) ahead. Both flights were continued as planned; an investigation was being conducted.

Other General Aviation

Flight Instructor Injured in Attempt to Swing Propeller

Gulfstream American AA-5A. No damage. One injury.

The airplane was parked on a grass area near a flight-training school in England. After the airplane's engine could not be started using the airplane battery, one flight instructor took the controls while another flight instructor swung the propeller in an attempt to start the engine so that the airplane could be taxied to the maintenance area.

The engine controls, the parking brake and the magnetos were set correctly, and the flight instructor swung the propeller.

"The engine did not start; therefore, a second attempt was made," the report said. "As soon as the propeller moved, the engine started. The first down-going blade of the propeller struck the head of the instructor, and the second blade struck his arm. The aircraft commander immediately closed the throttle and selected the magnetos to "OFF."

The injured flight instructor was cut on the head and had a broken arm. After the incident, the flight school ended its policy of allowing flight instructors to start airplane engines by swinging the propeller.

Landing Gear Collapses After Electrical Failure

Cessna P-210N Centurion. Substantial damage. No injuries.

Visual meteorological conditions prevailed and an international instrument flight rules flight plan had been filed for the midday flight in the Bahamas. After departure, as the pilot attempted to fly the airplane to 14,000 feet, he observed that the airplane had begun to descend, that the autopilot had disengaged and that the flight instruments "had gone dark," the report said.

The pilot conducted the electrical-failure checklist procedures, but electrical power was not restored to the instrument panel. The pilot conducted a precautionary landing at the nearest airport. The pilot and the passengers could see that the landing gear had extended, but after touchdown, the right-main landing gear collapsed.

An inspection revealed that the left-main landing gear and the nose landing gear were locked in the extended position. The investigation was continuing.

Incorrect Aileron Installation Blamed for Takeoff Accident

Piper PA-28-140. Substantial damage. Two minor injuries.

Visual meteorological conditions prevailed for the flight from an airport in Canada. The pilot flying had 200 flight hours and had not flown for more than three months. He was accompanied by a more experienced pilot with a commercial pilot certificate.

After takeoff, about 25 feet above ground level, the airplane rolled left. The pilot applied right aileron, but the airplane continued to turn left. The other pilot applied full right aileron. The airplane's left wing tip struck a snow bank, and the left wing separated.

An investigation revealed that the aileron bell cranks were installed backward. The accident report said that the aileron bell crank brackets had been replaced during the airplane's annual inspection.

"Most aircraft maintenance shops use a microfiche reader system for aircraft maintenance," the report said. "Microfiche systems take less space and cost less than maintenance manuals, but the reader cannot be used near the aircraft. … This particular [microfiche] reader did not have a print feature. Consequently, the AME [aviation maintenance engineer] elected to perform the work from memory instead of using the microfiches. As a result, he interchanged the bell cranks when reinstalling them, thereby reversing the aileron controls."

The report said that the procedures described in the manufacturer's maintenance manual for installing aileron bell cranks were not followed, that the independent licensed AME who recorded the inspection in the aircraft technical log did not observe that the controls were reversed and that, during pre-flight checks, the two pilots failed to observe that the controls were reversed.

Engine Failure Ends Airplane's First Flight

Rutan VariEze. Substantial damage. No injuries.

Visual meteorological conditions prevailed for the first flight of the newly constructed airplane from an airport in England. The pilot conducted extensive checks of the airplane on the ground and while flying 50 feet above the runway, then increased power for a climb.

The engine lost power. The pilot applied carburetor heat and power was restored; the climb continued to about 400 feet or 500 feet, when the pilot conducted a left turn and the engine again lost power. The pilot selected carburetor heat "OFF," and the engine stopped.

The pilot declared an emergency and turned downwind toward the runway to conduct an emergency landing. The airplane landed 30 meters (98 feet) before the runway threshold. The wheels sank into soft ground, and the nose landing gear failed.

An investigation revealed a small amount of debris in the engine fuel-filter drain, but the report said that the pilot believed that the power loss had been caused by carburetor ice.

The temperature at the time of the accident was seven degrees Celsius (C; 45 degrees Fahrenheit [F]) and the dew point was zero degrees C (32 degrees F). The report said, "This equated to 61 percent relative humidity and placed the environmental conditions within the 'serious icing at any power' envelope [on a chart published by the U.K. Civil Aviation Administration]."

Rotorcraft

Pilot in Wire-strike Accident Faults Absence of Markers

Aerospatiale AS 350B Ecureuil/AStar. Minor damage. No injuries.

After an overhead reconnaissance flight, the pilot flew the helicopter to about 200 feet above ground level to allow a passenger to film along the sides of a heavily wooded valley in England. Visual meteorological conditions prevailed.

After one minute of filming, the pilot banked the helicopter to the left to avoid a house. During the maneuver, the front of the left skid struck and severed a power cable. The pilot conducted a precautionary landing. Maintenance personnel inspected the helicopter and authorized a flight back to the base for more detailed inspections and repairs.

The pilot said that the cable did not contain visibility markers and that the supporting poles, which were in wooded areas, were not visible from the air.

Report Cites Improper Inspection of Landing Site

McDonnell Douglas 369E. Substantial damage. One minor injury.

The pilot, who had been hired to use his helicopter to drive a herd of reindeer in Sweden, flew the helicopter to a reindeer research station to meet the owner of the herd before sunrise. The pilot had not landed a helicopter at the research station before, and the herd owner and the pilot had not discussed the landing site.

When the pilot arrived at the research station, he observed a car and a flatbed trailer in an open area. He believed that the vehicles had been parked there because this was the site where the helicopter would be refueled from a tank on the flatbed trailer.

"He did not see any obstacles in the area and judged the site to be suitable for landing," the report said. "There was no radio contact between the pilot and the herd owner."

At about 33 feet above ground level, the pilot observed a power line.

"He attempted to turn away and avoid making contact but was unable to keep the tail boom from hitting the power line," the report said. "After the collision, the helicopter entered an uncontrolled rotation, and the pilot reduced the engine power, causing the aircraft to sink and hit the ground and the car."

The report said that the pilot had not asked the herd owner about conditions at the planned landing site and that he did not know what experience the herd owner had in determining the suitability of a landing site. (The herd owner had planned for the helicopter to be landed on a plowed surface between two buildings that typically was used as a helicopter landing site.)

The report said that the accident was caused by "the pilot failing to properly inspect the planned landing site with regard to obstacle clearance."

Helicopter Strikes Power Line During Inspection

Bell 206B. Destroyed. Two fatalities; one serious injury.

The helicopter was being flown on a power-line inspection for an electric power company in Australia. After about 10 hours in flight, with breaks for refueling and lunch, one passenger — a power company observer — saw what he believed was an anomaly in an insulator device. The pilot banked the helicopter for a 180-degree left turn over the main power line and hovered the helicopter on the western side of the main power line for an inspection of the insulator device. The inspection revealed no problem with the device, and the pilot transitioned the helicopter from the hover to forward flight to continue the inspection flight.

The power line inspector said that the helicopter's engine "began sounding as though it was laboring, as if the helicopter was struggling under a heavy load."

The power line inspector "looked out of the left side of the helicopter and saw the first pole of the spur line," the report said. The helicopter struck the spur line and then struck the ground.

The report said that neither the power line inspector nor the power line observer had undergone formal training "to enable them to carry out their in-flight roles in helicopter power line inspections," although the operator's operations manual said that such training was required. The division of the electric power company that hired the helicopter operator did not have a published requirement for the training.

The report said, "When the pilot turned the helicopter left across the power line, he was turning 'blind' and probably could not see the main power line or the poles during execution of the turn.

"The long distance between the spur-line support poles, in conjunction with the ambient light conditions and almost featureless surrounding terrain, would have made the spur line difficult to see from the air. … The pilot was probably unaware of the spur line's existence."

The report also said that the helicopter was not flown at an altitude that would have ensured obstacle clearance and that, "although the operator and the pilot had operated in accordance with the existing aviation regulatory requirements, the training that the pilot received to meet those requirements was inadequate for the task of power line inspections."

The report also said that the operator's training procedures and operational procedures for power line inspections were inadequate, that there were no hazard markers to indicate a hazard in the helicopter's flight path and that the "organizational process" in the division of the power company "did not adequately equip its employees to undertake crewmember roles for helicopter power line inspections."

After the accident, the helicopter operator and the electric power company began a formal training program for power company employees who participate in aerial power line inspections, and the electric power company developed a reference document on guidelines for power line inspections by helicopter.

Helicopter Destroyed by Fire in Grassy Landing Site

Robinson R44. Destroyed. No injuries.

Visual meteorological conditions prevailed for the on-demand flight in the United States to pick up two passengers who had been conducting a ground survey. The pilot landed the helicopter in an area of brush and grass, reduced engine revolutions per minute (rpm) to 70 percent and remained in the helicopter while the surveyors loaded their equipment into external baskets.

The pilot smelled smoke, and the surveyors observed flames under the helicopter. The pilot tried to increase engine rpm to 100 percent, but the engine stopped. The pilot deplaned and worked with ground personnel to extinguish the flames, which continued to burn. The pilot then tried unsuccessfully to restart the engine. The fire destroyed the helicopter and burned about 60 acres of brush and grass.

A preliminary report said that the pilot/operator manual for the helicopter includes a safety advisory that says, "Never land in tall dry grass. The exhaust is low to the ground and very hot; a grass fire may be ignited."♦

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The original Bendix Trophy was awarded yearly from 1931 until 1962 (except during World War II and in 1951–52) to winners of the trans-North America Bendix Air Race, sponsored by Vincent Bendix of The Bendix Corp. The original Bendix Trophy was donated in 1985 to the Smithsonian Institution by the estate of Bendix Air Race founder Cliff Henderson. The trophy is displayed at the National Air and Space Museum in Washington, D.C., U.S.

The nominating deadline is Sept. 5, 2002; the award is presented at the FSF International Air Safety Seminar (IASS).

Submit your nomination(s) via our Internet site.
Go to <www.flightsafety.org/bendix_trophy.html>.

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