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ICP Flight - Central Flying School

How an ILS can Kill You

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June 2004

The Instrument Landing System (ILS) approach has been a mainstay within the IFR environment for decades. It is the bread and butter approach for cracking low ceilings and poor visibility. But an ILS is a complicated piece of equipment and it doesn't always work the way we want it to. Certain malfunctions of the ILS and its associated equipment can lead an unsuspecting pilot to a fiery death. An encounter with a false glide path, a false localizer capture, or, worst of all, an erroneous glide slope doesn't happen often, but it happens often enough that you should know about it.

How an ILS Works

An ILS approach utilizes two transmitters to deliver the signals necessary to bring an aircraft down toward the runway on a specified course and glide slope. The localizer signal is transmitted over the VHF frequency that is shown on the approach plate and on the front of the VOR/ILS control head in the cockpit. There are 40 different localizer channels in the frequency range of 108.10 MHz to 111.95 MHz. The localizer signal is usable and accurate to a range of 18 NM from the localizer antenna unless otherwise depicted on the approach plate.

The glide slope signal is carried over a paired UHF frequency (in the range of 329.30 MHz to 335.00 MHz—not that you would ever need to know). When you select the appropriate VHF ILS frequency listed on the approach plate, the paired UHF glide slope frequency is also selected by the ILS receiver. The glide slope signal transmits two overlapping beams modulated at 90 Hz and 150 Hz (as does the localizer signal). When an aircraft is above the glide path, the 90 Hz beam is received stronger by degree than the 150 Hz beam and the aircraft instruments display "above glide path" indications. Conversely, if the aircraft is below glide path, the 150 Hz beam will be stronger, resulting in a display of "below glide path." When both signals are received equally, the aircraft instruments will indicate that the aircraft is precisely on the glide path. From full scale above glide path to full scale below glide path is 1.4º wide. Thus, the glide path is approximately 1,500 feet thick at 10 nautical miles from the antenna, about 100 feet thick at decision height, and less than one foot thick at touchdown.

To transmit the glide slope signal, there is a transmitter building, a glide slope antenna, some monitor antennas, and a clear zone. The glide slope antenna and the transmitter building are about 500 feet from the runway centerline and about 1,000 feet from the approach end of the runway.

To properly transmit the glide slope with a single antenna would require an antenna 50 to 100 feet tall. Since tall antennae next to runways is not a good idea, a satisfactory result can be obtained by bouncing the signal off the ground directly in front of the antenna (called the glide slope reflecting area). This reduces the height of the antenna mast to about 30 feet.

ILS Critical Area

Any obstruction directly in front of or to the side of the glide slope transmitter might block the transmission of the signal, thereby corrupting it. To prevent this, the area directly in front of the glide slope antenna is designated the glide slope critical area. It is crucial that when aircraft are conducting ILS approaches this area be kept clear of aircraft, vehicles, deep snow, or anything that may interfere with the operation of the glide slope transmitter.

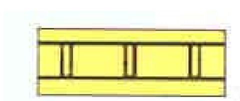
Furthermore, it is critically important that the glide slope reflecting area bounces the glide slope signal at the proper angle and with the proper amount of reflectivity. Many factors can temporarily change the reflectivity of this zone. Water-soaked ground, excessive snow, or extremely long grass can all cause the glide slope to reflect at the wrong angle. To ensure proper glide slope operation, glide slope monitors are located within the clear zone. If these monitors detect that the glide slope radiation pattern is no longer within established tolerances, the glide slope transmitter is automatically shut down and ATC is electronically notified.

Rules

According to the AIP, holding position signs and markings normally indicate the boundaries of electronically sensitive areas. Pilots are further instructed that when an airport is operating under Category II or Category III ILS weather (when the weather is less than 200'/ ½), they are to observe the CAT II or CAT III mandatory holding position signs. Otherwise, pilots are expected to taxi to the CAT I taxiway holding position markings, unless advised otherwise by ATC (AIP RAC 4.2.7).

ILS Category II Hold Line Marker (Canada)

In the US, the normal hold lines do not protect the ILS critical area. There are separate ILS critical area hold lines that are used under certain weather conditions. When the weather is less than 800' ceiling and 2 miles visibility, vehicles and aircraft are not authorized in the ILS critical area when an arriving aircraft is between the ILS FAF and the airport, unless the aircraft has reported the airport in sight and is circling or side stepping to land on a runway other than the ILS runway. When the weather is at or above 800/2, no critical area protection is provided. A flight crew should advise the tower if it intends to conduct an autoland or coupled approach to ensure that the ILS critical areas are protected when the aircraft is inside the ILS middle marker. Critical areas are not protected at uncontrolled airports. (AIM 1-1-9k)



ILS Critical Area Hold Line (US)

ILS Critical Area Hold Line Marker (US)

False Glide Slope

False signals may be generated along the glide slope in multiples of the glide path angle, the first at approximately 6º above horizontal (double the published glide slope angle.) This false signal will be a reciprocal signal, meaning that the fly up and fly down commands will be reversed. The next false signal will be at triple the published glide slope angle. The false signal at around 9º will be "right side up," the 12º signal will be a reciprocal signal and so on. There are no false signals below the actual slope. Normally, an aircraft flying the published procedure or getting vectors to final will not encounter these false signals. But, an aircraft that is much higher than the normal 3º glide path during a lengthy en route descent may find itself trying to intercept the glide path from above, and may lock onto a false glide path signal by mistake. A false glide path is a normal by-product of the ILS transmission and provides a distinct, but incorrect, glide slope.

What to Do About It

To ensure that you use the right glide path when shooting an ILS, it is imperative that you plan and fly your descent so that you intercept the glide path from below it. As there are no false glide paths below the proper one, if you intercept from below, you know you've got the right one.

Additionally, a basic crosscheck of pitch, power setting, and descent rate with known and planned values should help you to quickly discern if the wrong glide path has been captured. The altitude and distance relationship can also clue you into your proximity to a false glide path. The aircraft altitude in hundreds of feet above airport elevation should be about 3 times the distance in nautical miles to fly. For example, at 10 NM to fly, the aircraft should be about 3000' above field elevation.

In my opinion, false glide paths are not a big flight safety risk. They tend to be pretty unstable and are difficult to stay on should you inadvertently catch one. If you should happen to find one and stay on it, the vertical velocity will be double the normal rate of about 600-700 fpm and the power setting needed to stay on glide path and airspeed will be excessively low. If you did manage to find a false glide path, either steepen the descent rate to intercept the true glide slope from below (altitude and distance permitting—and this should only be done if you are well back from the FAF, with careful respect paid to minimum safe altitudes and the like) or go around and re-establish from a lower altitude.

Erroneous Glide Slope

Of a far more serious safety concern, however, is what's called an erroneous glide path. An erroneous glide path occurs when something is not working properly. Perhaps the glide path signal has been corrupted in some way or the airplane's glide path receiver has not sent the signal properly to the pilot's instruments. An erroneous glide path occurs when the aircraft instruments display what appears to be a good, usable glide path without warning flags, but the display is neither accurate nor correct. This occurrence can be far more difficult for a pilot to detect. An autopilot is quite happy to follow an erroneous glide path all the way into the ground. A study of an Alitalia DC-9 crash will serve to illustrate.

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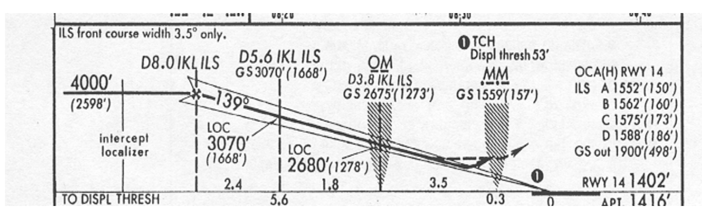
Alitalia DC-9 Crash

On 14 November 1990, Alitalia Flight AZ404, a DC-9, departed Milan for Zurich, Switzerland. The approach was made at night in conditions of 1500' scattered, 3000' broken, and 6 miles visibility. The crew shot an ILS to Runway 14, following the localizer centerline perfectly, but descending well below the glide path, resulting in impact with terrain 5 miles short of the runway. All 46 people on board the aircraft were killed. The Swiss Aircraft Accidents Inquiry Board concluded that the aircraft's No. 1 VHF navigation receiver malfunctioned, causing all four cockpit glide slope indicators to give incorrect "on glide path" indications with no glide slope warning flags appearing.

Like virtually all aircraft accidents, there were a number of links in the chain that could have been broken by the crew prior to the accident, preventing its occurrence. Their approach clearance was to "descend to 4000 feet, turn right heading 110, cleared ILS approach Runway 14." The crew initially had trouble receiving the glide slope and selected the No. 1 nav radio for the final approach, on which they believed they were receiving a good signal. The crew descended to 4000', intercepted the localizer, and the captain announced to the first officer "Capture loc, capture glide slope . . ." and began descent out of 4000'.

Although the ILS instrument indications must have appeared normal for course and glide path capture, the aircraft was at 11.5 DME. The profile view of the approach plate clearly indicates that glide path is to be captured from 4000' at 8.0 DME. As the aircraft was approaching 8 DME and descending through 1250' QFE (2676' QNH), the captain said "Outer marker check is at 1250' . . . 3.8 almost 4 miles." The 1250' altitude is a QFE altitude (QFE refers to the altimeter and altitude convention used in certain places in Europe—a QFE altimeter setting will make the altimeter show height above airfield during an approach) indicated on the approach plate in parentheses as 1273'. At this point, the marker beacon was still some 4 miles in front of them. Without a bearing pointer, it can be difficult to positively determine on which side of the marker the aircraft is, particularly if there have been a number of distractions in the cockpit or if attention has been focused elsewhere. In this case, the approach plate clearly indicates the location of the outer marker at 3.8 DME, as the captain had announced. The erroneous glide path could have been caught at this point, had either pilot recognized the disparity between the altitude and the DME (that they were at the glide path check altitude for the outer marker at 3.8 DME, but still out at 8 DME).



Shortly thereafter, some confusion arose in the cockpit about their relative position to the outer marker, although the thought process that occurred is not clear from the cockpit voice recorder. At about 7 DME, the first officer asks "Haven't we passed it?" Twelve seconds later, the FO again asks, "Haven't we passed the outer marker?" The altitude at the time was 670' QFE. The captain answered, "No, no it hasn't changed yet." At 6.6 DME, the captain said, "Oh, it shows seven." The crew now seems to have recognized their position, but still have not fully grasped the seriousness of their situation.

Last radio contact was from Zurich arrival reference some preceding traffic, "AZ404, speed now as convenient, four miles behind a DC-9, contact tower eighteen-one, good night." The captain acknowledged the call and said to the FO, "That doesn't make sense to me." The

FO replied, “Nor to me.” It would have seemed appropriate to have initiated an immediate overshoot at that point, but of course that is the luxury of being a Monday morning quarterback. Seconds later they impacted a ridge in a 3º angle of descent.

In the days following the accident, the ILS to Runway 14 was tested and found to be operating within parameters, as were all other navaids at the field. Both navigation receivers installed in the mishap aircraft were unmonitored, analog units. According to the accident report, a major disadvantage of their analog ILS systems is that when no output signal is produced by the navigation receiver, the same indication is given as “on course” or “on glide slope.” This situation could occur with a short circuit or signal break between the receiver output and the HSI.

When the crew first tuned in the ILS frequency, they initially believed there was a problem with the glide slope signal on the No. 2 nav radio, analyzed it as being unusable, and switched to Nav 1 for the approach. In reality, the No. 2 radio was probably fine, and it was the No. 1 nav radio that was malfunctioning, showing an “on glide path” indication. This rapid and incorrect diagnosis proved to be a fatal mistake. The crew then coupled the autopilot to the ILS, which accurately followed the localizer and was most probably following a centered “frozen” glide path signal all the way to impact.

The US National Transportation Safety Board got into the act and issued a report on the accident noting that there are newer, more advanced navigation receivers that are not able to detect a signal break or open circuit between the receiver output and the cockpit instruments. The NTSB report also added “that the basic avionics design concerning navigation receiver failure monitoring depend on the flight crew properly performing the checklist when differences are noted between receivers, regardless of the type of receiver installed in the aircraft.” Upon initial tune-up of the ILS signal, differences were noted between the displays generated from Nav 1 and Nav 2. Because the display from Nav 1 was showing a centered (though erroneous) glide slope, the crew wrongly assumed the Nav 2 receiver to be bad and switched both pilots’ displays to show data from Nav 1. In doing this, they bypassed the avionics’ comparator circuit and possibly also induced the ground proximity warning system to be fooled into thinking that they were indeed on glide path as they approached the ground.

In 1992, the NTSB recommended that the Federal Aviation Administration:

> “Issue an Air Carrier Operations Bulletin to Principal Operations Inspectors requiring that operators of airplanes equipped with the following navigation receivers include in their operating manuals procedures for detecting malfunctions that result in the display of disparate information: Collins model 51RV-1; Collins model 51-RV-4; Wilcox model 806; King model KNR 6030 [the receiver that had been installed in AZ404]; and some versions of Bendix model RNA 26C.”

It is critical for all pilots to understand that ILS instrument indications can be incorrect with no “off” flags showing AND that proper precautions must to taken to ensure that “on course, on glide path” indications are not, in fact, erroneous.

Air New Zealand Incident

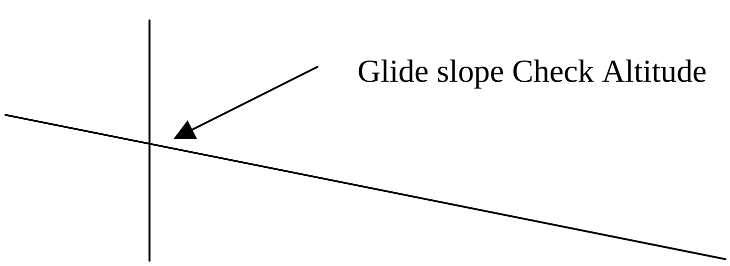
Events like the Alitalia crash in Zurich are not limited to antiquated equipment. An Air New Zealand 757 experienced a similar malfunction on an ILS approach into Faleolo International Airport in Western Samoa in July, 2000. This time, however, the results were different. This time, the crew recognized a disparity between altitude and distance to fly, followed by visual cues that did not match instrument indications. But, then again, they were 400' above the water descending, still 6 miles from the airport. They initiated an immediate go-around and returned for a localizer-only approach. The glide path indicator was centered throughout the entire first approach, overshoot, and second approach. Further investigation revealed that it was not the aircraft's systems that were at fault, but the ILS transmitter itself. The systems that monitored the field's navaids were undergoing maintenance and were NOTAM'd as such (VOR, ILS/GP, ILS/DME unmonitored). Additionally, the ILS glide path's standby transmitter was inoperative (and NOTAM'd). After some maintenance had been performed on the glide path monitor, the monitor had inadvertently been left in a test mode. This inhibited the automatic shutdown of the primary glide path transmitter when, as Murphy's Law would have it, it started emitting a faulty signal. Fortunately, this crew broke out with enough altitude and enough visual cues to keep from hitting the water. The next crew that is faced with this situation may not have the same luxury.

Glide Slope Check Altitude

We were all taught in pilot training to crosscheck our altitude with the published glide slope check altitude on an ILS approach. But the numbers seldom match exactly. Why not? And what are we supposed to do about that as pilots? The glide slope check altitude offers an opportunity to check both the altimeters AND that the glide slope you are about to intercept (or have already intercepted) is indeed a valid, properly transmitted signal. While you can tune, identify, and monitor a localizer signal, you have no capability to do the same with the glide slope signal. There is no way to tell if the signal is bad, except to crosscheck instrument indications, flight parameters, and published altitudes along the final approach path. The glide path check altitude is one of the only ways to ascertain if the glide path signal is good before descending through the clag toward the ground. Just relying on the absence of any "off" flags is not adequate.

But what if the glide slope check altitude does not match your altimeter? There are no published tolerances for the glide path check altitude. And, unfortunately, there are plenty of sources for error. Understanding the potential errors can help a pilot make a better decision about whether or not something is wrong before proceeding with the approach.

We normally think of the glide path check altitude as a single point in space where the glide path intercepts the final approach fix or other fixed point on an approach, like a DME fix or a marker beacon, as depicted below.



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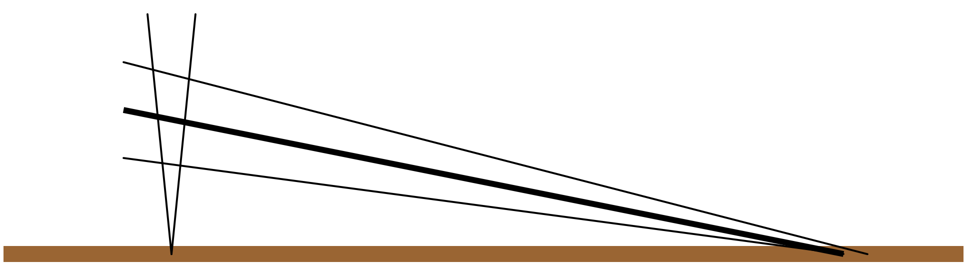
But the glide path check altitude should be thought of as a box (see diagram below) of varying dimensions, depending upon things like approach design and the weather. First, there can be a certain amount of ambiguity in exactly where the FAF is because of tolerances in the ground equipment that define the FAF plus tolerances in the aircraft's navigation equipment. That error is called fix displacement error and it can be significant—up to plus or minus 2 nm—depending upon the type of fix it is (see GPH 209 Section 8 for more detail). For normal approach designs, the fix displacement error along a 3^o glide path would induce about 150' of error in the published glide path check altitude. There are also tolerances for the glide path transmitter to be considered. If the approach depicts a 3^o glide path, the glide path transmitter is considered acceptable if it is within 7.5% of 3^o (that equates to +/- $.225^o$). This transmitter angular tolerance can induce an additional 190' of error into the glide path check altitude. Add to that 50' of allowable altimeter error in the aircraft instrument and +/- 200' for temperature error due to temperatures that are warmer or colder than the scientific definition of "standard day" and you can be off by as much as 590' with absolutely nothing wrong.



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The glide path check altitude is still important. Knowing the potential sources for error can help you understand what is happening. If you are high at the glide path check altitude, you will be low at decision height. If it's 25 below zero, then you should be about 200' high at the check altitude. If you're not, the hair on the back of your neck should stand up so that you at least consider the possibility that there might be something wrong. There might not be, but you should at least be vigilant. And if something doesn't seem right, execute an immediate overshoot and sort it out at a safe altitude.

There are other things that can be done to prevent getting tricked into flying into the ground by an erroneous glide path. Crosscheck your altitude against the distance to fly off DME or the FMS periodically. Your altitude above the aerodrome (in hundreds of feet) should be about 3 times your distance to fly (4 miles to fly should put you about 1200' AAE). Periodically crosscheck the radar altimeter with both distance to fly and barometric altitude (5 miles to fly, should put you at 1500' AAE, compare it to the radar altimeter—field elevation 700' so you should see 2200' on the altimeter, plus or minus depending on the temperature.) Then periodically check your rate of descent. Is it appropriate for an ILS? Strong headwinds or tailwinds will affect VVI on final. Remember that your autopilot is perfectly happy to follow an erroneous glide path all the way into the ground. If something seems wrong, query ATC because you might not be the first to report a problem and the problem might not be with your equipment at all, but with theirs. Don't be the guy with a secret who lands right before some younger, less experienced pilot crashes because he didn't have the full picture.

False Localizer Capture

The danger doesn't just end with the glide slope. There can be problems with the localizer signal as well. A Challenger crew was on radar vectors for an ILS to Runway 27 at Victoria Int'l Airport. When cleared for the approach, the aircraft was 10 miles from the airport and about 5 miles north of the localizer course. When the pilot selected the autopilot to approach mode, the aircraft turned to the right, away from the course, and the navigation equipment indicated that it had captured the localizer. The crew determined that the autopilot had taken a bad intercept and was directing their aircraft away from the localizer, which they knew to be about 5 miles south of their position. The crew visually confirmed the false localizer course capture when they broke out below a scattered layer of cloud and noted that the localizer intercept was heading their aircraft toward a mountain. The crew switched the autopilot to heading mode and re-established an intercept for the Runway 27 localizer and landed safely.

Transport Canada conducted a study that concluded that false localizer captures are caused by an incompatibility of ground and airborne instrument landing systems. The problem can occur even though both the ground transmitter and the airborne receiver meet their respective performance requirements.

False localizer course captures may occur when a pilot prematurely selects the approach mode on the autopilot. Although the problem can occur at azimuths of 8º to 35º from the localizer course, it is most likely to occur when the aircraft is in the vicinity of 8º to 12º from the localizer course. In the Victoria incident, the aircraft was 26º north of the localizer course when the false localizer course capture occurred.

Following the release of the Transport Canada study, the AIP was amended with the following verbiage (Com 3.13):

> To reduce the risk of false captures
>
> § approach mode should not be selected until the aircraft is within 18 nm of the threshold and positioned within 8º of the inbound ILS course
>
> § pilots should use raw data sources to ensure that the aircraft is on the correct localizer course before initiating a coupled approach.

Additionally, when crews note a false localizer course capture, they are required to report it to ATC.

Conclusion

The aviation world is fraught with hazards. The likelihood of encountering an erroneous glide path or a false localizer capture is probably pretty small. But it is not zero. And your own longevity will be improved if you know that the potential exists and if you know how to recognize it if it does occur. And you owe it to your squadron mates to teach them the same things.

Note: Source material from “Catch the False Glideslope,” by Eric Walton, IFR, Vol 19, No. 11, November 2003, pp. 18-20 and “Captain Stops First Officer’s Go-around, DC-9 Becomes Controlled-flight-into-terrain (CFIT) Accident,” by Russell Lawton, Flight Safety Foundation Accident Prevention, Vol 51, No. 2, Feb 1994.