Dangerous Approaches

Straying outside the protected areas can be fatal.

BY DICK MCKINNEY AND ERIK REED MOHN

While poring through rafts of reports on accidents and serious incidents in the course of our investigations as members of the Flight Safety Foundation (FSF) Approach and Landing Accident Reduction (ALAR) Task Force, the same questions occurred over and over: Why didn't the flight crew follow standard operating procedures? Why didn't they fly their instruments? Why didn't they hear and respond to the ground-proximity warning system (GPWS)?

Poor decision making in many cases was caused by stress overload that resulted in the narrowing of crew focus to the point that warnings were not heard, recognized or acted upon.

In the course of working with accidents similar to those in this article, we noted that many times the pilots seemed to lack knowledge of the design criteria for the instrument approach procedures that they were conducting.

In both the *U.S. Standard for Terminal Instrument Procedures* (TERPS) and the International Civil Aviation Organization (ICAO) equivalent, *Procedures for Air Navigation Services–Aircraft Operations* (PANS-OPS), there are strict — and different — limitations of which pilots must be aware. Without knowledge of the limitations, pilots may inadvertently stray outside the protected areas and place themselves and their aircraft in peril.

Unexpected Approach

We studied the Conviasa Boeing 737-200 accident report, attempting to identify the stressors that might have overloaded the crew to the point that they strayed from a protected area and failed to respond properly to GPWS warnings for the last 22 seconds of the flight.

The 737 was being ferried from Venezuela to its new owner in Latacunga, Ecuador, the night of Aug. 30, 2008. The crew expected, and briefed for, a published arrival procedure that leads almost straight in to the instrument landing system (ILS) approach to Runway 18. However, when they contacted Latacunga Tower, they were told to fly a different arrival procedure, which requires crossing the Latacunga VOR/DME (VHF omnidirectional radio/distance measuring equipment) station south of Runway 18 and turning to a heading of 004 degrees. This basically places the aircraft on a right downwind leg for Runway 18 (Figure 1).

The aircraft must track 004 degrees until reaching the ILS turn-in point, which is defined as 9 nm DME on the 340-degree radial of the VOR. For an aircraft with conventional navigation equipment, such as a 737-200, navigating to the turn-in point requires some dead reckoning skills. The area west of the airport is protected from obstacles only up to 4 nm from the runway centerline; beyond that lies high, rugged terrain.

Cockpit voice recorder (CVR) data indicated that as the 737 neared the VOR, the crew was "behind the aircraft" and attempting to navigate via both instrument and visual references. The arrival chart specifies a maximum speed of 200 kt, but recorded flight data indicated that the 737's calibrated airspeed was 210 kt as it crossed the VOR and began a shallow right turn to the north. Airspeed increased to 225 kt during the turn. The high speed, wind drift and 22-degree bank angle caused the aircraft to roll out on downwind 7 nm west of the runway centerline, outside the protected area. Shortly thereafter, Quito Radar lost radar contact with the aircraft.

One minute after crossing the VOR, the commander commented that the radial did not "look right" but that he could see the lights of the city. The first officer said that he did not see the lights of the city or the airport.

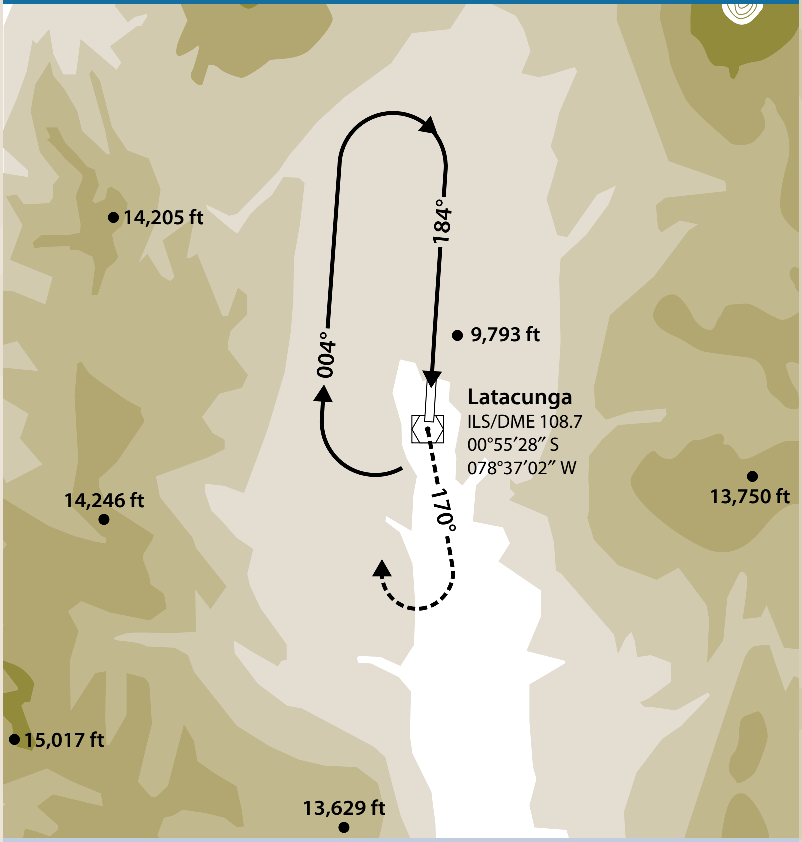
As the crew began configuring the aircraft for the approach 40 seconds later, the GPWS sounded: "Whoop, whoop, terrain." The commander voiced an expletive. The GPWS sounded again, and the first officer called for a go-around. The GPWS warnings continued for the next 22 seconds, until the aircraft struck a mountain at 13,100 ft. Both pilots and their passenger, a mechanic, were killed.

Investigators determined that the engines were operating at a high power setting and that the aircraft could have out-climbed the mountain if the commander had immediately and correctly reacted to the GPWS warning.

Risk Awareness

Among the products resulting from the Foundation's ALAR work is the *Approach and Landing Risk Awareness Tool* (Figure 2, p. 40).[1] Although it is intended to be used as a planning tool, to gain an awareness of risk before beginning an

Latacunga Arrival Procedure



Note: In 2008, a Boeing 737 crew strayed outside protected airspace after making the procedure turn onto the 004-degree heading, and the airplane struck a mountain west of the airport.

Sources: Dick McKinney, Erik Reed Mohn

Figure 1

Approach-and-Landing Risk Awareness Tool

Elements of this tool should be integrated, as appropriate, with the standard approach briefing prior to the beginning of descent to improve awareness of factors that can increase the risk of an accident during approach and landing. The number of warning symbols (⚠) that accompany each factor indicates a relative measure of risk. Generally, the greater the number of warning symbols that accompany a factor, the greater the risk presented by that factor. Flight crews should consider carefully the effects of multiple risk factors, exercise appropriate vigilance and be prepared to conduct a go-around or a missed approach.

Failure to recognize the need for a missed approach and to execute a missed approach is a major cause of approach-and-landing accidents.

Flight Crew	
Long duty period — reduced alertness	⚠⚠
Single-pilot operation	⚠⚠
Airport Services and Equipment	
No ATC approach service or airport tower service	⚠⚠⚠
No current local weather report	⚠⚠
Unfamiliar airport or unfamiliar procedures	⚠⚠
Minimal or no approach lights or runway lights	⚠
No visual landing aid (e.g., VASI/PAPI)	⚠
Foreign destination — possible communication/ language problems	⚠
Expected Approach	
Nonprecision approach — especially with step-down procedure or circling procedure	⚠⚠⚠
Visual approach in darkness	⚠⚠
Late runway change	⚠⚠
No published STAR, STAR/RNAV or STAR/FMSP	⚠

Environment	
Hilly terrain or mountainous terrain	⚠⚠
Visibility restrictions (e.g., darkness, fog, haze, IMC, low light, mist, smoke)	⚠⚠
Visual illusions (e.g., sloping terrain, wet runway, whiteout/snow)	⚠⚠
Wind conditions (e.g., crosswind, gusts, tail wind, wind shear)	⚠⚠
Runway conditions (e.g., ice, slush, snow, water)	⚠⚠
Cold-temperature effects — true altitude (actual height above mean sea level) lower than indicated altitude	⚠
Aircraft Equipment	
No GPWS/EGPWS/GCAS/TAWS with up-to-date database and current software version	⚠⚠⚠
No radio altimeter	⚠⚠⚠
No wind shear warning system	⚠
No TCAS II	⚠

Source: Flight Safety Foundation

Figure 2

approach, we'll use it to look back at the risks that the 737 crew faced during their approach to Latacunga.

The findings of the accident investigation show that the flight crew risk factor "long duty period — reduced alertness" likely was involved. The report said that about 20 minutes before the accident occurred at 2150 local time, the commander complained that he had been flying all day and was still at work.

The report also noted that the Latacunga airport is designated as a "special airport" that requires initial operating experience with a check pilot, followed by at least two approaches and landings per year to maintain currency. The 737 commander had flown only once to the airport, which is at an elevation of 9,205 ft and is flanked by mountains rising more than 5,000 ft higher. Thus, the approach conducted by the 737 crew involved the risk factor "unfamiliar airport or unfamiliar procedures."

The crew expected the straight-in arrival procedure but was assigned the more complex procedure, which is similar to the "late runway change" risk factor. In retrospect, the commander should have requested the straight-in procedure, rather than accepting the change. Apparently sharing a common trait among pilots in being mission-oriented, the crew likely was reluctant to ask for extra time or a change of plan. They might not have wanted to slow down someone behind them, or refuse a challenge.

There are three risk factors in the "environment" section that apply to this accident: the terrain was, indeed, mountainous; visibility was restricted by darkness; and the conditions were conducive to somatogyral and somatogravic illusions.

In conclusion, we found that six separate risk factors and 12 warning symbols applied to the approach at Latacunga, which indicates that this was a very dangerous approach.

A similar accident at Bardufoss Airport in northern Norway the night of Nov. 14, 1989, killed the pilots and the two passengers when their Cessna Citation 551 struck a mountain outside a protected area for a procedure turn onto the ILS approach to Runway 29. The accident investigation board concluded that the aircraft "was on the wrong track, and the speed was 100 kt too high" when the accident occurred.

The accidents at Latacunga and Bardufoss happened during the intermediate segments of approach procedures that were complex and workload-intensive. Common factors were flight outside protected areas and excess speed. It is noteworthy that on most approach charts, the underlying design speed is not printed. Pilots are supposed to know such things, but often they do not.

Circling Hazards

The last accident that we'll discuss happened in Busan, South Korea, on April 15, 2002. The crew of the Air China 767-200ER conducted the ILS/DME approach to Runway 36L down to Category C minimums and circled to land on Runway 18R. Visibility was 2 mi (3,200 m) in rain and fog, and surface winds were from 210 degrees at 17 kt.

The approach was a TERPS-based procedure that required a Category C aircraft to remain within 1.7 nm of the runway threshold. The accident report said that the crew descended too low, too soon, lost sight of the runway and hit a 670-ft hill approximately 2.5 nm (4.6 km) north of the airport.[2] The 767 was destroyed; 129 occupants were killed, and 37 survived.

This accident illustrates a serious problem with circling approaches: It is not enough to know what boundaries to stay within; it is of paramount importance to have the runway and the terrain within the prescribed circling area in sight at all times. If you lose sight of the airport and the terrain for even a fraction of a second, it's time to go around.

The U.S. Federal Aviation Administration *Aeronautical Information Manual* states the following about circling minimums:

> *Published circling minimums provide obstacle clearance when pilots remain within the appropriate area of protection. Pilots should remain at or above the circling altitude until the aircraft is continuously in a position from which a descent to a landing on the intended runway can be made at a normal rate of descent using normal maneuvers. Circling may require maneuvers at low altitude, at low airspeed and in marginal weather conditions. Pilots must use sound*

Terrain rises precipitously near the airport in Bardufoss, Norway, where an approach accident occurred in 1989.

© Kjell Arild Bersaas/Jetphotos.net

> *judgment, have an in-depth knowledge of their capabilities and fully understand the aircraft performance to determine the exact circling maneuver since weather, unique airport design and the aircraft position, altitude and airspeed must all be considered.*

Circling approaches are the most dangerous of all approaches.

ICAO provides the following information in Doc 8168, *Aircraft Operations*:

> *A circling approach is a visual flight maneuver. … After initial visual contact, the basic assumption is that the runway environment (i.e., the runway threshold or approach lighting aids or other markings identifiable with the runway) should be kept in sight while at MDA/H [minimum descent altitude/height] for circling. If visual reference is lost while circling to land from an instrument approach, the missed approach specified for that particular procedure must be followed.*

No Room for Error

Circling approaches are the most dangerous of all approaches, especially when the procedure is a TERPS design. TERPS circling approaches leave no room for error. For example, the protected area for Category C aircraft could provide only 300 ft of obstacle clearance within 1.7 nm of the thresholds of the runways suitable for use (Table 1). Thus, a tower or a mountain bluff 1,000 ft higher than field elevation can be located 1.75 nm off the end of the landing runway.

PANS-OPS provides a minimum of 394 ft of obstacle clearance within 4.2 nm of the runway thresholds.

The issue of TERPS vs. PANS-OPS is very serious for a pilot flying a TERPS approach using PANS-OPS techniques. How do you know whether a procedure is TERPS or PANS-OPS? Look on the left side of the approach chart for “PANS-OPS” or “TERPS” printed vertically. If there is no label, use every means at your disposal to determine the design basis for the approach. Ask air traffic control; the controller might not know, but he or she may be able to find out.

Do not assume that all airports in the same country use the same design criteria. Some states use PANS-OPS procedures for civil airports and TERPS for airports that are used, or have been used, by the U.S. military. It is the responsibility of the operator’s operations department to convey this kind of information to pilots; unfortunately, not all departments do. Moreover, not all chart providers publish the information on their charts — a serious omission, in our opinion.

Circling Approach Obstacle Protection

	TERPS			PANS-OPS		
Aircraft Category	Airspeed[1]	Radius of Protected Area[2]	Minimum Obstruction Clearance	Maximum Airspeed[3]	Radius of Protected Area[2]	Minimum Obstruction Clearance
A	< 91 kt	1.3 nm	300 ft	100 kt	1.68 nm	295 ft
B	91–120 kt	1.5 nm	300 ft	135 kt	2.66 nm	295 ft
C	121–140 kt	1.7 nm	300 ft	180 kt	4.20 nm	394 ft
D	141–165 kt	2.3 nm	300 ft	205 kt	5.28 nm	394 ft
E	> 165 ft	4.5 nm	300 ft	NA	NA	NA

TERPS = *U.S. Standard for Terminal Instrument Procedures*; PANS-OPS = International Civil Aviation Organization *Procedures for Air Navigation Services–Aircraft Operations*; NA = not applicable

Notes

1. Based on 1.3 times the stall speed in landing configuration and at maximum landing weight.
2. Extends from the runway threshold to the arc defining the circling area.
3. Based on maneuvering speed during circling approach.

Sources: U.S. Federal Aviation Administration, International Civil Aviation Organization

Table 1

Training Gap

It is, of course, impossible to say what the pilots who ended up in these accidents knew or did not know about the design criteria governing the procedures they flew. What can be said with certainty is that they busted the design criteria and paid the ultimate price.

In principle, both TERPS and PANS-OPS obstacle-protection areas must be considered funnels that pilots must stay within. There might be rocks just outside the funnels.

There are differences between TERPS and PANS-OPS that pilots who fly in both environments need to know, and the unfortunate fact is that very few airlines teach their pilots about them. The philosophy seems to be that as long as pilots follow the approach procedures, they will be all right.

The problem is that many pilots do not have the necessary knowledge to stay safe while following an approach procedure. We believe that the airlines should consider this knowledge gap more seriously and incorporate TERPS and PANS-OPS briefings in their initial and recurrent training programs. Money is always tight, but what we are advocating is an awareness program. If pilots are aware that these problems exist, they could access the appropriate documentation when necessary. Pilots who mainly operate in one design environment — TERPS or PANS-OPS — cannot be expected to know the intricacies of unfamiliar procedures in the other design environment.

Our review of training material from Airbus for the A330 and A340, from Boeing for the 737 and MD-80, and from Canadair for the CRJ900 showed that only Boeing includes the TERPS and PANS-OPS circling area limitations. However, the Boeing material does not connect these limitations to aircraft category (i.e., A, B, C or D) or to aircraft speed. The other manufacturers provide only vague general guidelines. A common suggestion, for example, is to make an initial, 45-degree turn away from the approach track for 45 seconds. This, however, will put you outside the 1.7-nm protected area specified by TERPS in 65 seconds at 140 kt, or in 50 seconds at 180 kt.

What we, as an industry, teach our pilots is not sufficient. The manufacturers, in cooperation with the operators of their equipment, should easily be able to do a lot better. In addition, we believe that it is time for aviation regulatory authorities to tighten the requirements for training on the design criteria for circling approaches. We also would like to see new regulations mandating proper labeling of approach charts.


© Ian Moy/Airliners.net

This 767 struck a hill in South Korea in 2002 when the crew descended too low during a circling approach

Moreover, after having looked at many different types of approach charts during our careers, a good case could be made for simplifying them.

Flying will never be risk free, but it is every pilot's duty to mitigate the risk as well as he or she can. It is every flight department manager's duty to do the same. The areas we have covered here have not received the attention they deserve. We hope this will change.

Dick McKinney is a former U.S. Air Force fighter pilot and American Airlines captain. He recently retired as an International Air Transport Association flight operations auditor. McKinney was an FSF ALAR Task Force core team member and served on several working groups.

Erik Reed Mohn, a fellow of the Royal Aeronautical Society and a former Norwegian air force pilot, is a Boeing 737 captain for SAS. He was co-chair of the FSF ALAR Operations and Training Working Group.

Notes

1. The *Approach and Landing Risk Awareness Tool* is part of the FSF *ALAR Tool Kit*, which provides on compact disc a unique set of pilot briefing notes, videos, presentations, risk-awareness checklist and other tools designed to help prevent approach and landing accidents. More information about the tool kit is available on the Foundation's Web site, <flightsafety.org>.
2. The official report is available at <www.skybrary.aero/bookshelf/books/549.pdf>.