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Learning From Experience

Incident No. 3

Delayed

Pull-Up

Third in a series focusing on approach-and-landing incidents that might have resulted in controlled flight into terrain but for timely warnings by TAWS.

BY DAN GURNEY

Anomalies in the depiction of the nonprecision approach procedure are among several factors that might have played a role in the premature descent conducted by the flight crew of a widebody glass-cockpit aircraft in this incident. The hazard was exacerbated by the failure of the crew to respond appropriately to a terrain awareness and warning system (TAWS) warning.[1] A second warning was required to motivate the crew to extract the aircraft and themselves from a close call with terrain.

The chart for the VOR/DME (VHF omnidirectional radio/distance measuring equipment) approach, which the crew apparently was conducting in nighttime visual meteorological conditions (VMC) with visibility restricted by haze, shows that a minimum altitude of 4,600 ft should have been maintained until reaching the final approach fix (FAF), 7.0 nm DME from the station. However, the crew began the descent for the final segment of the approach two nm before reaching the FAF, from there flying a three-degree descent path (Figure 1).

The aircraft was about 1,300 ft too low when it crossed the FAF. The descent was continued below the minimum descent altitude (MDA) for the VOR/DME approach, 3,300 ft, likely because the flight crew had the ground environment in sight and was continuing the flight by reference to external visual cues. The crew received a "TERRAIN, PULL UP" warning from the TAWS when the aircraft was 250 ft above ground level — a city in this case — and 6.7 nm from the station (about 6.0 nm from the runway threshold). The crew stopped the descent and began a climb, but leveled the aircraft at the MDA. Not having reached the charted step-down fix for descent to the MDA, 4.0 nm, the aircraft was 380 ft below the appropriate minimum altitude and about 100 ft below the top of a nearby obstacle.

The aircraft was in level flight at the MDA for about 1.5 nm before the TAWS generated a "TOO LOW, TERRAIN" warning, which apparently prompted the crew to conduct a missed approach.

Several factors that might have contributed to the premature descent at 9.0 nm were considered

Approach Profile View and Aircraft Flight Path

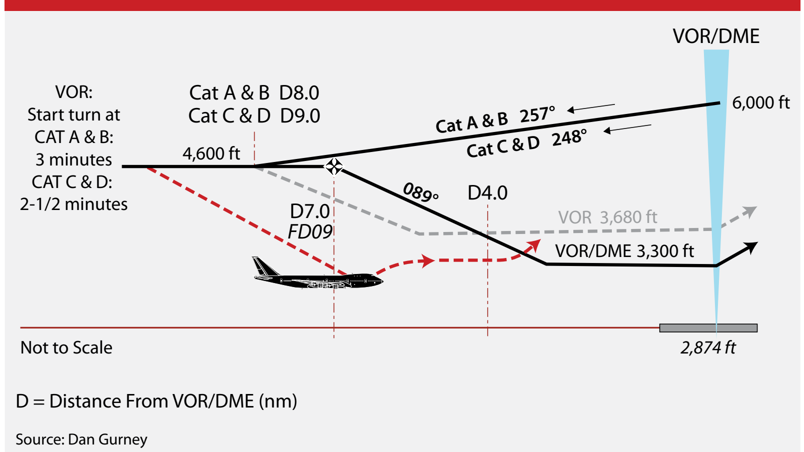
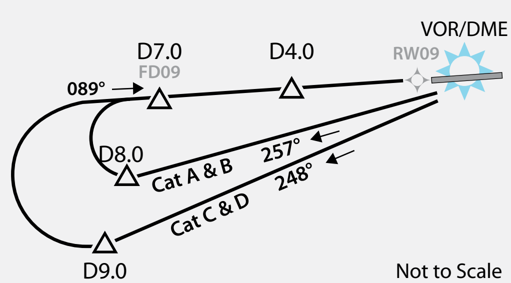


Figure 1

in the author's analysis of the incident, which was reviewed by a select group of aviation safety professionals and airline pilots. Chief among the likely factors was confusion caused by anomalies in the charted approach procedure. Among the anomalies are the following:

- The chart includes information for a VOR approach as well as the VOR/DME approach to Runway 09. In the charted profile view, a dashed line depicting the glide path for the final segment of the VOR approach indicates that the descent from 4,600 ft is initiated *before* reaching the FAF. Furthermore, this pre-FAF descent point is identified on the chart by a listing of the turn-in points for the procedure turn — 8.0 nm for Category A and B aircraft and 9.0 nm for Category C and D aircraft (Figure 1 and Figure 2). Thus, the crew might have mistakenly identified the descent point for the VOR/DME approach as the 9.0 nm turn-in point rather than the required 7.0 nm.

Approach Plan View



D = Distance From VOR/DME (nm)

Source: Dan Gurney

Figure 2

- The chart includes area navigation (RNAV) waypoints for flight management system (FMS) programming and other uses. The FAF is identified by the RNAV waypoint "FD09," as well as by "D7.0" (7.0 nm DME), which provides an additional opportunity for misidentification of the FAF as 9.0 nm.

- Another anomaly, which likely was not a factor in the incident but nevertheless presents a source of confusion, is the inclusion in the chart's profile view — but not in the plan view — of information on turn-in points defined by timing for crews conducting the VOR procedure in aircraft not equipped with DME — three minutes for Category A and B aircraft, and 2.5 minutes for Category C and D aircraft.

Besides misidentification of the FAF from the information on the approach chart, the following are possible explanations for the premature descent and low approach:

- The crew deliberately descended early, in a "duck-under, dive-and-drive" procedure.

- Having abandoned the published approach procedure to conduct a visual approach, the crew experienced the "black-hole effect." The existing conditions were conducive to this effect: a dark night and featureless terrain beyond the city with lights on or near the airport as the only visual stimuli. The crew's depth perception was affected, resulting in the illusion that the airport was closer than it actually was or that the aircraft was too high, causing them to conduct the visual approach below the correct flight path.

- While programming the FMS, the crew entered waypoints at 9.0 nm DME on both the outbound and inbound courses of the procedure turn to facilitate a continuous turn to the inbound course. Subsequently, they mistook the electronic flight information system (EFIS) display of the 9.0 nm waypoint on the inbound course for the FAF.

- The runway position either was not displayed by the EFIS or was not referred to by the crew. Thus, the crew likely had little or no awareness of the aircraft's position relative to the runway.

The crew apparently did not effectively use two terrain-avoidance tools at their disposal: the altitude/range table provided on the approach chart (Table 1) and the aircraft's radio altimeter. A cross-check of the altitude/range table would have shown clearly that the aircraft was too low. The radio altimeter, properly set and monitored, likely would have provided an early warning that the aircraft was too low.[2]

The crew did not climb to a safe altitude after the first TAWS warning. This might have resulted from mental reversion to outdated advice applying to early generation ground-proximity warning systems (GPWS). Crews were advised to pull up and climb to a safe altitude *or*, if in daytime VMC, to continue flight if the aircraft was verified to be clear of terrain and obstacles.

In the author's opinion, the crew should have continued the climb to 6,000 ft, the sector safe altitude — also called minimum safe altitude — shown on the approach chart.

Lessons to Be Learned

A thorough approach briefing at a time of relatively low workload in the cockpit is important to ensure that the flight crew understands a charted procedure and agrees on how it will be conducted. The crew also should cross-check an FMS-generated routing and its display on the EFIS to ensure that it corresponds with the charted procedure.

The standard operating procedure (SOP) for crew action in the event of a TAWS warning must require, unconditionally, an immediate climb to a safe altitude. The determination of what constitutes a safe altitude should not be left to the crew's judgment; SOPs must define safe altitudes for the various phases of flight. Only after reaching the safe altitude should the crew re-evaluate the situation.

Flight crews should use all terrain-avoidance tools at their disposal, including altitude/range tables and radio altimeters. Requirements and guidance for effective use of these tools should be included in company SOPs.

Flight crews also should recall that MDA is not always a safe altitude, particularly at relatively long distances from the runway.●

Altitude/Range

DME	7.0 nm	6.0 nm	5.0 nm	4.0 nm	3.0 nm
Altitude	4,600 ft	4,300 ft	3,990 ft	3,680 ft	3,370 ft

Source: Dan Gurney

Table 1

[This series, which began in the July issue of *Aviation Safety World*, is adapted from the author's presentation, "Celebrating TAWS Saves, But Lessons Still to Be Learned," at the 2006 European Aviation Safety Seminar and the 2006 Corporate Aviation Safety Seminar.]

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Notes

1. *Terrain awareness and warning system* (*TAWS*) is the term used by the International Civil Aviation Organization to describe ground-proximity warning system (GPWS) equipment that provides predictive terrain-hazard warnings; *enhanced GPWS* (*EGPWS*) and *ground collision avoidance system* (*GCAS*) are other terms used to describe TAWS equipment.

2. The Flight Safety Foundation Approach-and-landing Accident Reduction (ALAR) Task Force recommends that during a straight-in nonprecision approach, the radio altimeter be set at 1,000 ft for the initial segment, 500 ft for the intermediate segment and 250 ft for the final segment. The settings correspond to obstacle-clearance requirements for the design of approach procedures. FSF ALAR Task Force; FSF Editorial Staff. "ALAR Briefing Notes." *Flight Safety Digest* Volume 19 (August–November 2000).