Tim de Groot, AirTeam Images

Learning From Experience

Night VMC

First 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

Throughout the history of aviation, controlled flight into terrain (CFIT) has been a major cause of fatal accidents. In response to this hazard, the industry developed and implemented the ground-proximity warning system (GPWS) and the more capable and reliable terrain awareness and warning system (TAWS).[1] To date, no aircraft equipped with TAWS has been involved in a CFIT accident.

Nevertheless, there have been some close calls. The industry has recorded an increasing number of "saves" in which TAWS provided flight crews with timely warnings of threatening situations. Some events were sufficiently serious that investigations by national authorities were required; official reports on at least two of these events have been published.[2] Other TAWS saves have been investigated by the aircraft operators and manufacturers to gain an understanding of how the flights were exposed to terrain or obstacle hazards and to identify the circumstances that prevented the crews from detecting the threats before TAWS provided timely warnings.

This report is the first in a series that will discuss six TAWS saves after premature final descent for landing. TAWS data provided information on each aircraft's location, altitude and airspeed; approach charts were used to determine the expected flight path of each aircraft in normal operations. The author's analyses of the incidents were reviewed by a select group of aviation safety professionals and a few airline pilots. Many factors identified as likely to have been involved in these incidents correlated with the well-documented factors identified in studies of CFIT accidents by the Approach-and-landing Accident Reduction Task Force.[3]

The incidents involved different operators and regions of the world, but there were several interesting similarities. Each incident involved a modern aircraft equipped with a flight management system (FMS) and an electronic flight instrument system (EFIS). All but one incident involved a large commercial aircraft. All occurred during nonprecision approaches.

Night Visual Approach

Incident no. 1 involved a widebody aircraft capable of FMS vertical navigation (VNAV) that was being flown on a visual approach in nighttime visual meteorological conditions to a major airport in a geographically remote area.

The crew likely had a charted VOR/DME (VHF omnidirectional radio/distance measuring equipment) approach procedure for reference. Figure 1 shows the vertical profile of the approach procedure and the flight path of the aircraft. The final approach fix (FAF) is 5.0 nm (9.3 km) from the VOR/DME location and 5.4 nm (10.0 km) from the runway threshold.

After crossing the FAF, the aircraft was flown below the expected flight path. A TAWS "TERRAIN, PULL UP" warning was generated when the aircraft was 250 ft above ground level — 124 ft above airport level — and at 1.5 nm DME. The crew recovered from the 300 feet-per-minute descent and conducted an uneventful landing.

The following features of the approach procedure were considered as having contributed to the incident:

- The three-degree glide path begins at 4.3 DME, *not* at the FAF. If a crew misinterprets this point, a descent begun at the FAF could result in a low flight path.

- Similar problems might occur if the crew entered the DME information into the FMS for a VNAV approach without cross-checking the threshold crossing altitude.

- The approach chart does not have an altitude/range table to aid the crew in monitoring the descent. The crew might not have prepared their own table or programmed a correct VNAV approach profile. Thus, they might have had to rely on mental calculations of altitude/range to monitor the approach.

- The VOR/DME station is not colocated with the runway threshold. Thus, a descent below the three-degree glide path might be conducted if the crew were to use DME for altitude/range checks, believing zero to be at the threshold. Without the mental manipulation of adding 0.4 nm to all DME indications, an altitude error of 120 ft below the proper glide path would result from using the typical altitude/range check of 300 ft per nm.[4] In addition, the approach chart's depiction of the DME offset is not to scale. The actual distance, 0.4 nm (0.3 km), is scaled as approximately 1.5 nm (2.8 km), which could add confusion and an opportunity for error in mental calculations; it could also increase mental workload.

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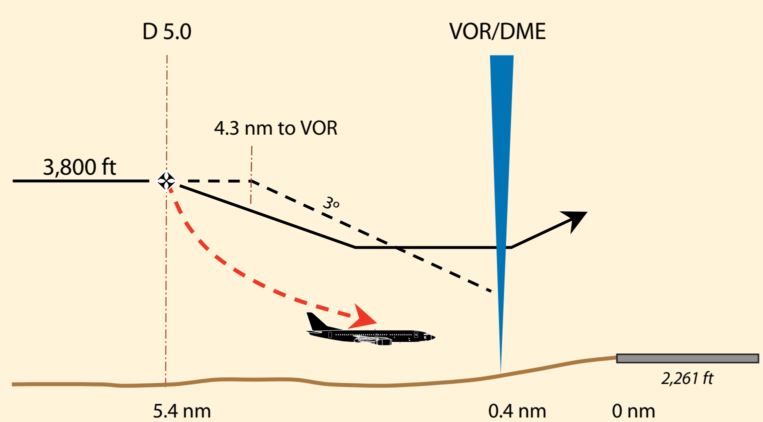
Aircraft Flight Path



D = distance from VOR/DME

Source: Dan Gurney

Figure 1

Although the crew apparently did make that location mistake and began the descent at the FAF, none of the scenarios discussed above matched the incident aircraft's recorded flight path. Nevertheless, each can be considered a potential threat to flight safety.

Black Hole Approach

As Figure 1 shows, the flight path of the incident aircraft had a noticeable bow shape consisting of an initial steep descent that slowly flattened out, resulting in a low vertical speed. This is typical of a flight path flown by a pilot following a false visual cue — and conducting a classic "black hole approach."

A black hole approach typically occurs during a visual approach conducted on a moonless or overcast night, over water or over dark, 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). In the extreme, a black hole approach can result in ground contact short of the runway.

The preconditions for a black hole approach were present:

- A night visual approach.
- A long, straight-in final approach.
- A runway in a remote location with few lights in the local area but with a town in the distance beyond or to the side of the airport.
- Up-sloping terrain before the runway.

Conditions conducive to a black hole approach are a pre-existing threat that can be identified or avoided, or at least the effects mitigated, by the crew prior to an approach. Threat information can be gained from the chart and discussed during the approach briefing, and from an airport briefing guide prepared by the operator from a survey or audit. When a black hole threat is identified, additional awareness and monitoring defenses must be implemented.

Without cross-monitoring or intervention alerting the pilot flying of any flight path deviation, a threat condition can quickly become a significant safety hazard. In black hole conditions, there is no point in the pilot not flying (pilot monitoring) using the same visual references as the pilot flying, because both pilots could encounter the same visual illusion. An altitude/range table or an electronically defined VNAV flight path would provide the basis for independent monitoring, and altitude checks should be made every 300 ft/one nm.

The runway always should be shown on the EFIS map display. If the EFIS is capable of displaying a vertical profile, it must be monitored during final approach.

In this incident, if the pilot flying did indeed fly the aircraft below the optimum glide path because of a visual illusion, it is likely that the crew's cross-monitoring was inappropriate or nonexistent. The safety resources either were unavailable or not used; but, primarily, the crew's mental picture of where the aircraft was in relation to the runway apparently deteriorated to a low level. TAWS saved the flight from the combination of threats, an error-provoking situation and the apparent false perception encountered during this approach. ●

[This article was 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.]

Dan Gurney served in the Royal Air Force as a fighter pilot, instructor and experimental test pilot. He is a co-author of several research papers on all-weather landings. Gurney joined BAE Systems in 1980 and was involved in the development and production of the HS125 and BAe 146, and was the project test pilot for the Avro RJ. In 1998, he was appointed head of flight safety for BAE Systems. Gurney is a member of the FSF CFIT/ALAR Action Group, the FSF European Advisory Committee and the FSF steering team developing the "Operators Guide to Human Factors in Aviation."

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. Australian Transport Safety Bureau (ATSB) Aviation Safety Investigation Report 200402747 discusses a Boeing 737 flight crew's misinterpretation of an approach chart and incorrect programming of an FMS for a nighttime instrument approach in July 2004. U.K. Air Accidents Investigation Branch (AAIB) Bulletin 9/2005 discusses a premature descent conducted during a visual approach by the crew of a de Havilland Dash 8 and the crew's delayed response to a TAWS warning in March 2005.
3. FSF Approach-and-landing Accident Reduction (ALAR) Task Force. "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. Although 300 ft per nm facilitates mental calculation of altitude vs. range, an aircraft actually descends 318 ft per nm on a three-degree glide path.