Indispensable Upgrades

BY DON BATEMAN

Only the latest TAWS software and databases, plus GPS positioning, can optimize terrain/obstacle warnings with hardly any unwanted alerts.

I applaud U.S. airlines, their pilots, the U.S. Federal Aviation Administration (FAA) and the MITRE Corp. for working in concert toward the use of data from flight operational quality assurance (FOQA) programs with other sources to improve the safety of all who travel by air (*ASW*, 5/08, p. 25). Real world operational data, including the knowledge gained from accidents, help improve not only the design but the performance of flight safety equipment and operations. However, I have some concerns.

The industry needs to be careful about how we use digital flight data recorders while examining complex issues such as unwanted alerts from a terrain awareness and warning system (TAWS) because the parameters recorded often lack the necessary detail about critically important factors. This can end up distorting and hurting a well-intentioned study. Further, we need to wisely invest precious public funds by using the work that others in the industry already have accomplished.

As described in the May 2008 *AeroSafety World,* the limited method used in the FAA-industry study of unwanted TAWS alerts was not a wise choice. A key variable, the technical characteristics of each TAWS unit, was mentioned but apparently not considered. As a result, the flight data from FOQA programs provided no information about a TAWS unit's manufacturer, model, software version, database version or whether the aircraft position data sent to the unit was from a flight management system (FMS) or a global positioning system (GPS) receiver/sensor.

This omission is significant. Ongoing research on the Honeywell enhanced ground-proximity warning system (EGPWS) shows that a large number of unwanted alerts are caused by the failure of many operators to periodically update the software. The updates improve the alerting algorithms and expand the database of terrain, obstacles and airports. Many airlines have never updated their EGPWS database since they installed or received the equipment.

Similarly, unwanted alerts also can be traced to a failure to use GPS to provide a direct source of aircraft three-dimensional (3D) position to the EGPWS — latitude, longitude and geometric altitude. In aircraft equipped as recommended, however, unwanted alerts from the EGPWS unit have been reduced to less than one per 20,000 flights (*ASW,* 6/08, p. 21). The remaining unwanted alerts have been caused mostly by some characteristics of unstabilized approaches that should not cause a TAWS alert.

Despite the widely hailed adoption of this technology, an aircraft equipped with EGPWS or other TAWS equipment still could experience a controlled flight into terrain (CFIT) accident because of the factors involved in unwanted TAWS alerts. In such a CFIT scenario, the impaired TAWS equipment would not provide a timely warning to the flight crew (Figure 1, p. 20). In one serious incident in 2006, the EGPWS-equipped aircraft struck power lines some 1,200 m (3,937 ft) short of the runway. There was *no* EGPWS warning because the unit's software had not been updated and there was no GPS data direct to the EGPWS. With the latest software and GPS data direct to EGPWS, that flight crew would have had more than 30 seconds of warning prior to colliding with the power lines.

Such scenarios underscore the importance of updating the database at least once a year to help provide timely alerts and reduce the probability of an unwanted warning. Keeping the system fully operational requires sound avionics maintenance practices. It is also important for operators to provide a standard operating procedure in which one terrain display is enabled on every departure or arrival to enhance pilot situational awareness of terrain and obstacles.

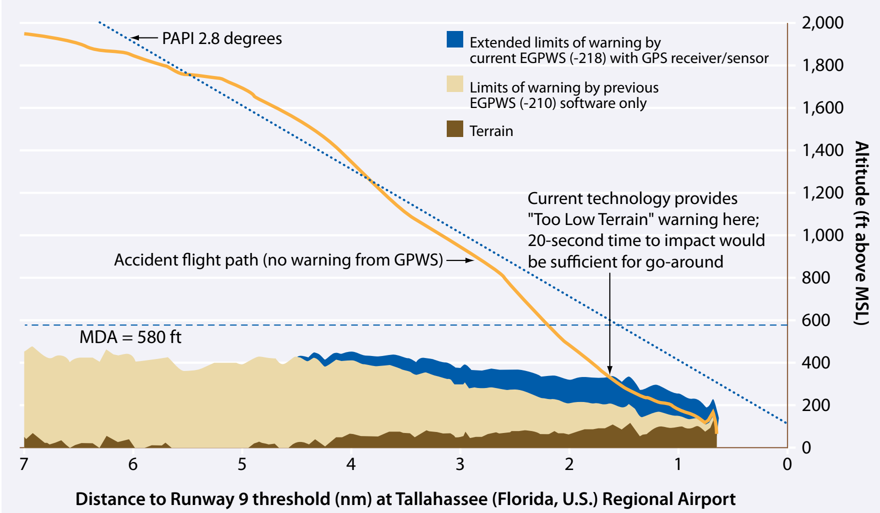
An EGPWS unit that uses only the FMS and barometric altimeter as its data sources for aircraft position can have limitations such as map shift, faulty updating of aircraft position while navigating to ground coordinates; a mismatch between the geographic coordinates issued in a nation's aeronautical information publication and the World Geodetic System 1984 reference frame (WGS-84) coordinates used by TAWS for terrain, obstacles and runway-end positions; and altimetry errors.

When an EGPWS-equipped aircraft has the latest software and terrain-obstacle-airport database installed — and also uses GPS as an aircraft position source — current research shows that it will have virtually no unwanted TAWS alerts in the United States and will be compatible with most air traffic control (ATC) vectoring.

A GPS receiver/sensor, with geometric altitude enabled in the EGPWS example, is especially important because it provides earlier terrain/obstacle warnings when needed near the runway, creates less risk of unwanted alerts, provides compatibility with QFE operations[1] and provides independence from barometric altimeter-setting errors and altimeter errors. Unfortunately, more than half of the 18,000 large commercial jet aircraft currently equipped with EGPWS operate without the benefits of aircraft 3D position from GPS direct to EGPWS.

When updated as recommended, EGPWS and other TAWS units also may add proprietary functions that help reduce the risk of loss of control, a premature descent or a collision with an obstacle during a go-around. The "peaks" function of EGPWS, for example, helps the pilot to detect a possible premature ATC descent clearance over mountainous terrain and provides a descent aid during an off-course weather deviation or a descent required by engine shutdown or an explosive decompression of the cabin. This can be enabled on any EGPWS unit by changing a jumper wire on the unit to enable display of the highest terrain value ahead of the aircraft, display obstacles and provide aural and visual warnings for a possible flight path into a tower or obstacle higher than 30 m (98 ft) above terrain. An estimated 60 percent of airliners equipped with EGPWS do not have these functions enabled.

Go-Around Opportunity With Current TAWS Technology



EGPWS = Honeywell enhanced ground-proximity warning system; GPS = global positioning system; GPWS = ground-proximity warning system; MDA = minimum descent altitude (unused nonprecision radar approach); MSL = mean sea level; PAPI = precision approach path indicator; TAWS = terrain awareness and warning system

Note: Federal Express Flight 1478, a Boeing 727, struck trees on short final approach and crashed short of Runway 9 on July 26, 2002. During this night visual approach to landing, the crew did not respond to the too-low indication of the PAPI. The onboard GPWS, which met existing requirements, was not designed to provide terrain alerts in this landing scenario. EGPWS also does not provide terrain alerts in this scenario unless the software and terrain-obstacles-airport database are current and the unit receives aircraft latitude, longitude and geometric altitude from a GPS receiver or internal GPS sensor.

Source: Don Bateman and U.S. National Transportation Safety Board

Figure 1

Various methods of identifying sources of unwanted TAWS alerts have evolved. As an analytical tool, a nonvolatile flash-memory device was designed into EGPWS units in 1995 to automatically store flight path data whenever a terrain caution or warning alert occurs. Conditions such as wind shear and excessive bank angle also activate recording. The memory retains a flight history from 20 seconds prior to each alert to 10 seconds after the alert. An airline can download this deidentified data with a memory card for its own analysis and/or contribute the data to the Honeywell research database.

The flight history comprises the aircraft groundspeed, ground track, airspeed, heading, altitude, vertical speed, geographic position during the event, runway track and location, flap/gear configuration, EGPWS software version, EGPWS terrain/runway database version and the aircraft type. In accordance with agreements reached in 1995 with the initial airlines that installed EGPWS and their pilot associations, the flight history has no time/date stamp or aircraft registration number.

To date, more than 11 million departures — counting flight legs/sectors — have been audited from a total of some 300 million departures of Western-built large commercial jets around the world without compromising the privacy of the pilots or the airlines. Contributions of downloaded flight histories to this research database during the last 10 years have led to EGPWS software upgrades and the improvement and validation of databases. Specifically, the audits have helped validate that runway locations match their WGS-84 coordinates. They also have helped to improve algorithms in the software to increase the predictive terrain warning time in case of an inadvertent flight path into the ground or into water short of the runway.

Today, an industry goal should be to systematically prioritize all types of unwanted warnings in the cockpit, isolate the systemic causes and reduce those warnings through improvements in the total system architecture. In my opinion, the minimum operational standards for the traffic-alert and collision avoidance system (TCAS) and ATC practices need to be revisited (*ASW*, 6/08, p. 17). For example, the smart use of automatic dependent surveillance–broadcast (ADS-B), including flight path intent information from the FMS of the other aircraft to improve the integrity of TCAS could help greatly to reduce unwanted resolution advisories and help both the pilot and the air traffic controller.

Thus, if U.S. airlines, the FAA and industry partners combine forces to collect actual warning data that give sufficient detail on the equipment in use, analyzing these data will allow us all to make improvements to complete aircraft systems and the traffic environment.

Don Bateman, corporate fellow-chief engineer, flight safety technologies, at Honeywell Aerospace, received awards for research and development of EGPWS in the 1990s and GPWS in the 1970s.

Note

1. In the QFE method, the pilot adjusts the altimeter with a setting provided by the airport so that it will read zero at touchdown on the runway.