Enhanced Ground Proximity Warning Systems Evolve, Provide Greater Safety

B Y K I M W I O L L A N D

In 1978, the FAA extended the ground proximity warning system (GPWS) requirement to Part 135 operators with 10 or more passenger seats. Based on subsequent National Transportation Safety Board (NTSB) reports since then, further amendments were made in 1992 to FAR 135.153, which required GPWS equipment to be installed on all turbine-powered aircraft with 10 or more passenger seats.

Following a Learjet controlled flight into terrain (CFIT) accident in 1994, the NTSB made further recommendations that all turbojet-powered, U.S.-registered airplanes equipped with six or more passenger seats have an operating GPWS. There has been a consistent push for these safety systems based on specific CFIT accident history, and for good reason. The system advancements were many during these early years, and soon the enhanced ground proximity warning system (EGPWS) evolved.

One would think the geometric altitude provided by the GPS alone would be sufficiently accurate, but it is blended with other air-data signals to confirm its real-time accuracy.

The enhanced version features digital terrain mapping techniques (nearly a form of terrain navigation) paired with three-dimensional GPS information, which gives this system a "look-ahead" capability as well as advanced aural and visual warnings. These advancements resulted in conflict predictability and improved the crew's warning time, by 20 seconds in some cases, over earlier scenarios. The EGPWS was a substantial improvement over the earlier GPWS technology.

As stated in Advisory Circular 23-18, the FAA adopted a broader term

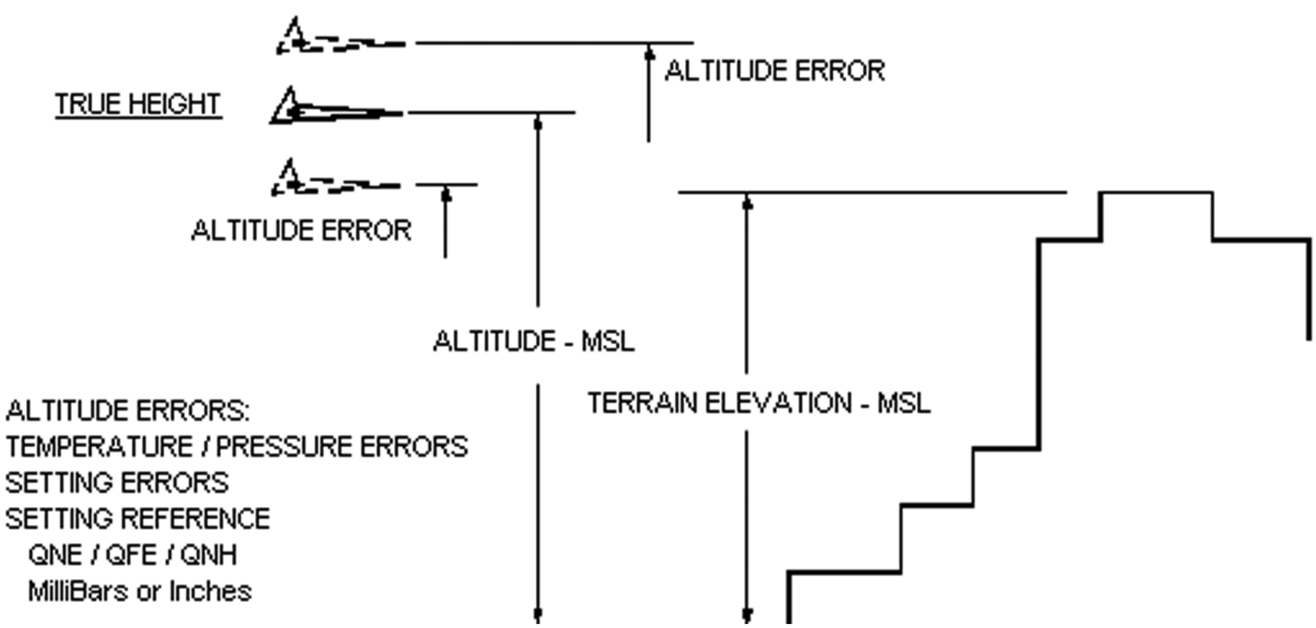

Figure 1

for this safety system, "terrain awareness and warning system"(TAWS), in anticipation of broader follow-on systems. In 1998, the FAA issued a notice proposing all turbine-powered, U.S.-registered type-certificated airplanes with six or more seats be equipped with a TAWS system (mandated by March 2005).

The TAWS is available as Class A or Class B; passenger-seating capacity dictates which version is installed. The advancements in systems technology and reduction in component sizes (less than 2 pounds in some cases) has facilitated the migration of these systems to even smaller aircraft types.

As a result of the system's enhancements, CFIT accidents have been reduced substantially for aircraft with these systems. In January 2007, the Flight Safety Foundation reported there were fewer commercial aviation accidents in 2006 than in the preceding year. None of the accidents involved a TAWS-equipped aircraft.

In 2005, commercial jets were involved in five CFIT accidents, and none of the five aircraft were TAWS-equipped. This is important to note as more aircraft are filling the skies each year. The situational awareness and safety margin this system provides can't be overestimated.

This safety-of-flight system has transferred information once again from the terrestrial domain onto the aircraft, thus offering less reliance on the systems and people below. The EGPWS computer must provide a situational awareness of the surrounding terrain and obstacles to alert the crew in a timely manner. The computer requires an accurate geometric altitude compatible with the elevation and terrain data in the database. This ensures confidence in the forward-looking capability and minimizes any nuisance warnings.

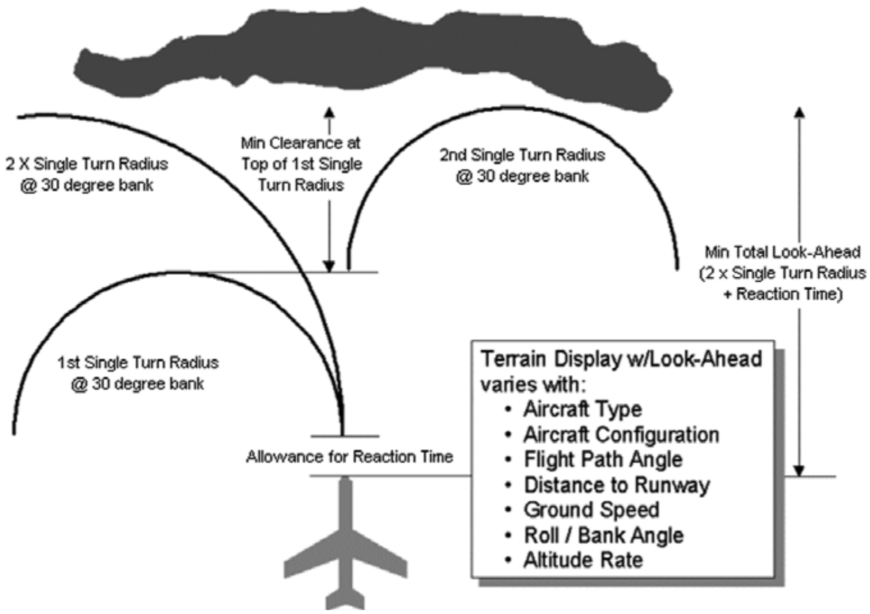

Figure 2

The geometric altitude uses a calculation based on pressure altitude, GPS altitude, radio altitude, groundspeed, roll angle and position, along with terrain and runway elevation data to reduce any errors induced by altimeter mis-sets and non-standard altitude conditions (the pressure gradient is not linear).

One would think the geometric altitude provided by the GPS alone would be sufficiently accurate, but it is blended with other air-data signals to confirm its real-time accuracy. With the geometric altitude computed, the system can operate through extreme temperature and pressure variations as is typical on long commercial legs.

This corrected true height is illustrated in Figure 1 as it relates to terrain elevation (msl). This extremely accurate, multi-sourced altitude determination, in concert with known airport elevation numbers from the database, produces a high level of confidence in the separation of the aircraft from an anticipated terrain conflict.

The terrain alerting algorithms, while monitoring aircraft position, groundspeed and altitude, must continuously look ahead of the aircraft to determine if there will be a conflict with the terrain elevation and the required clearance envelope protecting the aircraft.

If a conflict does arise, the EGPWS can be programmed to "pop-up" a terrain map on the compatible radar indicator or multi-function display. Depicted in Figure 2, we can see the Honeywell horizontal look-ahead mode and how it weighs decision-making.

There were two areas of concern EGPWS was focused specifically: "No Warning," a scenario in which the aircraft was configured to land but ended up landing short of the runway threshold; and "Late Warning" or "Improper Response," scenarios in which the crew gets behind the aircraft in a busy environment.

As a solution to resolve the "No Warning" scenario, EGPWS introduced the terrain clearance floor (TCF) function, as the Honeywell diagram

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EGPWS
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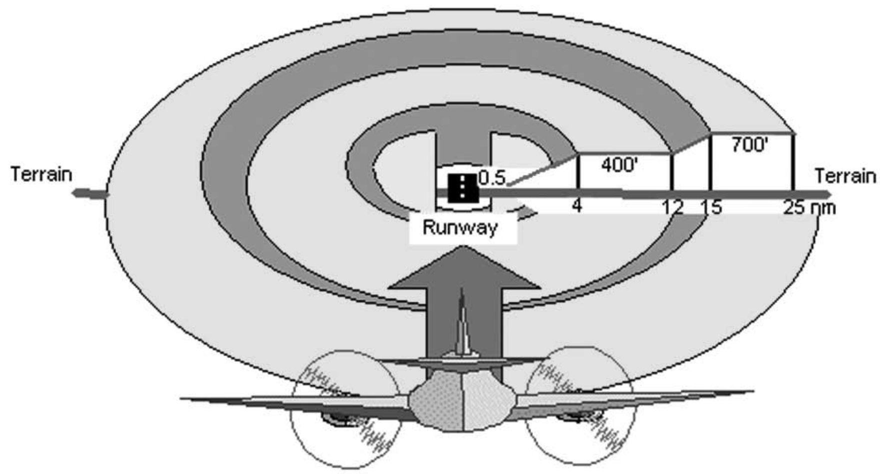

Figure 3

illustrates in Figure 3. This provides protection when the aircraft is in the landing configuration and might be landing short or under a no-runway scenario. This feature adds an increasing terrain clearance envelope around the destination runway to prevent premature descent rates (such as landing short). The envelope should provide adequate clearance for a typical three-degree glide path.

The system's database knows the exact runway location and elevation; therefore, it can predict a safe descent profile. If the aircraft were to penetrate the alert envelope shown, an aural warning and conflict alerts would be generated. Knowing exact location and elevation of the airports and runways through database sourcing, as well as latitude/longitude sensing, has substantially improved the level of safety this system provides over the earlier GPWS.

The TCF function will significantly reduce CFIT accidents, as data has shown the majority of these accidents have occurred near airports.

The advancements in predictability and the look-ahead feature of EGPWS have made great strides in the warning times given to the crew. The fact this system is predictive by design says it all — the capability for advanced warnings are there.

The extensive Kalman filtering of multiple sensor inputs provides for an accurate picture of any conflict with the terrain below and ahead of the aircraft. The aircraft's speed will determine the look-ahead distance the computer evaluates to permit timely warnings to the pilot. As the aircraft turns, so does the area scanned, and any subsequent loss of radar altimeter information will not degrade the system.

There is a second mode of operation, reactive ground proximity warning (RGPW). In this mode, the system relies more heavily on the radar altimeter and barometric altimeter readings, rather than the terrain database. This RGPW mode would be used only if the aircraft was flying outside the terrain database area or if the standard predictive mode was unable to provide a solution.

EGPWS can keep the crew and passengers safe from terrain conflict. As reports have confirmed, when EGPWS is onboard an aircraft, the chances of a CFIT accident are rare indeed. ❑