

► Terrain Awareness



A TAW for ROTORCRAFT

In aviation, the helicopter is a unique animal that operates in its own, distinct environment. Honeywell has taken that into account with a system specially developed for rotorcraft.

By Harry Kraemer



TERRAIN AWARENESS WARNING in every aircraft... Sounds nice. It certainly would enhance safety—which is why Honeywell has developed multiple versions of its enhanced ground proximity warning system (EGPWS).

Perhaps the latest version, the Mark XXII for helicopters, was the most challenging to develop. Unlike fixed-wing aircraft, which commonly are flown well above the terrain, rotorcraft often operate at low altitudes, where one could imagine a terrain awareness warning system (TAWS) issuing alerts constantly.

Officially announced in early 2000, the Mark XXII became the first EGPWS especially designed for helicopters. Honeywell officials emphasize that it is not a modified version of a fixed-wing EGPWS.

The system has, for example, distinct look-ahead algorithms. Because rotorcraft are more maneuverable and usually fly slower than fixed-wing aircraft, the Mark XXII for helicopters uses a 30-second look-ahead algorithm vs. the 60-second look-ahead algorithm in fixed-wing units. So, when the unit detects terrain or an obstruction 30 seconds ahead of the aircraft, the pilot will

receive a clear voice alert, saying "Caution Terrain, Caution Terrain" or "Caution Obstacle, Caution Obstacle." When the threat is within approximately 20 seconds ahead of the aircraft, the alert is changed to "Warning Terrain, Warning Terrain" or "Warning Obstacle" in a more urgent tone. The system



Among the helicopters in which the Honeywell Mark XXII is certified is the Sikorsky S-76B. The EGPWS displays (top of page) show the use of multiple colors to depict the threat of controlled flight into terrain (CFIT).

even looks into a turn.

The look-ahead feature is part of what makes the Mark XXII an enhanced GPWS. Honeywell's traditional ground proximity warning systems (GPWS) could look only straight down. A pilot might be 1,000 feet above the ground and heading for a steep

mountain ridge but receive no warning. EGPWS, with its terrain data base, can see the mountain ridge, and this is particularly beneficial, since helicopters often fly below ridge lines.

The Mark XXII also can eliminate accidents caused by altimeter errors that are pilot-induced or caused by temperature or pressure extremes. It does so by using geometric altitude, which is based on three independent altitude sources: radio altitude with terrain data base, barometric altitude, and GPS altitude.

If a helicopter takes off into rising terrain, the Mark XXII calculates whether the aircraft will clear the terrain. If the system calculates insufficient terrain clearance, it will give the warning "Too Low Terrain." This feature works off of the terrain data-base and radio altimeter. It is based on a minimum terrain clearance (a floor) that increases with the radio altitude. The value is 75 percent of the aircraft's radio altitude. In other words, if the helicopter climbs to 100 feet but then loses 25 feet of altitude, the pilot will receive an alert. This mode is active up to 150 feet above ground level (AGL). The warning comes when there is a decrease of radio altitude below the safe

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zone (warning area) with the gear up or at airspeeds greater than 40 knots.

The Mark XXII's data base—compiled from various sources, including the National Oceanic and Atmospheric Administration (NOAA)—stores more than 70,000 obstacles in North America. In addition to its audio warning, the system's crisp, easy-to-understand display provides a real-time picture of the surrounding terrain and known obstacles in relation to the aircraft's flight path in multiple colors: red (2 densities), yellow (3 densities), green (2 densities), black and blue.

One hundred percent red complements the audio "Warning Terrain" or "Warning Obstacle" and appears when the aircraft will not safely clear the terrain/obstacle, which is about 20 seconds from the aircraft. One hundred percent yellow accompanies the audio "Caution Terrain" or "Caution Obstacle," meaning the terrain/obstacle is about 30 seconds ahead of the aircraft, and the current altitude may not allow safe clearance. And green or black means the terrain or obstacles are below the aircraft, allowing clearance at the current altitude.

As soon as Honeywell can gather and verify all information, the Mark XXII will warn against one of the most dreaded obstacles to helicopter pilots: power lines. The company is developing a data base with information from power companies throughout the United States. Honeywell also is seeking assistance in obtaining power line data from its customers. The power line warning feature has been tested successfully in the Appalachian region surrounding Asheville, N.C.

Honeywell will add the power line information to the data base. The company adds that some upgrades may be required to accompany the power line data.

Seeing in 3-D

The Mark XXII has other tricks up its sleeve. In my many years of flying, I have found that using multifunction displays (MFDs) to determine distances from the aircraft to a threat can be difficult, especially when the range on the display is set at greater than 10 nautical miles. This is largely due to the diminutive size of the threat in relation to the terrain as depicted on the display.

But Honeywell says it has solved this problem on the Mark XXII with its "cell

expansion" mode, which increases the size of the grids containing the threat. This feature enlarges the obstacle or obstruction (displayed on the MFD), thereby giving the pilot a more vivid picture of the closeness of the threat. Honeywell plans to make the picture even more realistic to the pilot by developing a three-dimensional presentation of the threat's relationship to the aircraft.

The Mark XXII also incorporates a "bank angle" alert. Roll the aircraft into a steep bank and—upon calculating the radio altitude, roll attitude and roll rate—the system will give a warning two times. (With the Sikorsky S-76B, a steep bank would be 30 to 55 degrees, depending on altitude and roll rate.) Roll the aircraft an additional 20 percent, and it gives another warning. A graph in the operations hand-

Honeywell's EGPWS Lineup

Bendix/King KGP 560	For piston and other light aircraft; requires two inputs: GPS and barometric altitude
Mark VI	For business and regional airline turboprop aircraft
Mark VIII	For light to medium business jets
Mark V	For large, air transport jets and large business jets
Mark VII	Identical to the Mk V but interfaces with analog avionics
Mark XXII	For helicopters with radar altimeters
Mark XXI	For helicopters without radar altimeters

book shows how steep the bank angle has to be for the warning.

The Mark XXII for helicopters also includes a "sink" alert. This unique feature for rotorcraft can be triggered when the aircraft settles while ascending after liftoff or when it descends at a rate that is too great for its altitude. During an ascent, the voice alert will say, "Don't Sink." If the aircraft continues to lose altitude, the pilot will receive a "Pull Up" warning. To avoid nuisance alerts, this feature is enabled only when the gear is up or the altitude is above 40 feet and airspeed is greater than 50 knots. After the pilot has reestablished a positive rate of climb, the aural warning will cease.

Not unique to the helicopter version of Mark XXII is the "Below Glideslope" alert made during instrument approaches. The first alert comes when the helicopter's descent is more than 1.3 dots below the glideslope on the cockpit display. "Glideslope" is called out as an aural alert. If the pilot continues with more than two dots

below the glideslope display, he receives a louder "Glideslope" alert at a faster repetition rate. Fly the glideslope, and the unit calls out "Minimums, Minimums," telling the pilot that he is at his minimum descent altitude (MDA) for the approach. These and other altitude call outs are selected and set when the EGPWS is installed.

If it appears the helicopter is flared at too great an angle during a landing, the Mark XXII provides a tail strike warning. The voice alert, "Tail Too Low," is triggered by the calculations of the radio altitude, pitch attitude, pitch rate and barometric altitude rate, which is the rate at which the altimeter is changing.

For wheel-equipped helicopters (as opposed to the skid-equipped variants), the Mark XXII also can include a "terrain clearance - gear up" mode. If the aircraft penetrates an envelope (based on radio altitude of 150 feet) with the gear up and at less than 100 knots airspeed, the alert will be "Too Low Gear." Above 100 knots the alert will be "Too Low Terrain."

The Mark XXII even will serve as a co-pilot, should the sole pilot of a helicopter face an urgent need to execute an autorotation. Supplanting the co-pilot, the system will call out altitudes and remind the pilot to put the gear down. At 400 feet AGL, if the gear is not down, the pilot will hear "Too Low Gear." It also gives altitude call outs at 200 and 100 feet AGL.

What about nuisance alerts? Honeywell has developed various modes in the system, which correspond to different flight profiles. When the EGPWS is automatically made aware of the different profiles the aircraft enters, it makes adjustments to thwart false alerts.

The Mark XXII received Federal Aviation Administration approval Jan. 26, 2001. It has been installed and certified in the Bell 430, MD 900/902 Explorer, and variants of the Sikorsky S-76. Additional certifications are expected soon. Honeywell is having the Mark XXII installed in the company's Eurocopter Astar for use as a demonstration aircraft.

Honeywell had several purposes in mind when it developed the Mark XXII: to provide pilots with situational awareness of terrain and obstacles, to issue timely warnings of impending impact with terrain and obstacles, while minimizing nuisance alerts, and to end, or at least greatly reduce controlled flight into terrain. Those goals seem to have been met. A