

# Terrain Awareness and Warning Systems—TAWS

## Buyer's Guide

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**See TAWS COMPARISONS CHART on pages 36, 37 & 39**

**C**ontrolled Flight Into Terrain (CFIT) describes an accident where a completely airworthy aircraft is flown into the terrain. These accidents only occur during poor visual conditions; but other factors besides visibility usually contribute, such as a cockpit distraction, malfunctioning equipment, an ATC error or a pilot/controller miscommunication. To reduce the occurrence of Controlled Flight Into Terrain accidents, Terrain Awareness and Warning Systems (TAWS) were developed to provide a warning of a possible terrain conflict. The purpose of a TAWS is to provide a warning with enough time for the flight crew to take appropriate action.

There are various types of TAWS systems, whether they fall into the definition of TAWS or not. The three general categories provide increasing levels of protection—from the basic Terrain Map to TAWS-B through the highest level of protection—TAWS-A. Many moving maps contain databases of terrain elevations gained from government charts.

These “terrain depiction” systems show the terrain in color codes just as sectional charts. The colors depict elevations above sea level and it's up to the pilot to determine if sufficient clearance exists. A little bit of mental gymnastics are required to correctly interpret these moving maps. The terrain mapping systems are only capable of giving the pilot the general awareness of the terrain, no audio or visual warnings are given.

A true TAWS system on the other hand, can look ahead of the aircraft and warn the pilot of impending impact with the ground; thus monitoring the pilot's actions and providing an audible and visual alert if the aircraft is about to have a date with the ground. Hopefully, the pilot of a TAWS-equipped aircraft will never hear a terrain or obstacle warning, but the safety margins are there just in case.

The TAWS computer receives position information from a GPS receiver, and compares that position with the internal terrain or obstacle database. The

TAWS computer also receives aircraft configuration and air-data information to then create a 4-D position of latitude, longitude, altitude and time. It then compares this position with the on-board database of terrain, obstacles and runways to determine any conflicts. If the TAWS computer detects a possible conflict between the future flight path of the aircraft and terrain, visual and audible warnings are given to the pilot.

### **Class-A TAWS**

For those airplanes that require Class-A TAWS, the systems include a minimum of five basic functions:

#### **1. Forward looking terrain avoidance**

This function looks ahead and below the aircraft flight path to provide a suitable alert if a potential threat exists.

#### **2. Premature descent alert**

This function uses the predicted flight path information (determined from an approach navigation source) and its own airport database to determine if the aircraft is below the normal (typically 3 degree) approach path for the nearest runway. If a conflict is detected, a warning is given.

#### **3. Attention alerts**

The system provides appropriate visual and audio alerts for

### **Federal Aviation Regulations Require:**

**TAWS Class-A** equipment is required for turbine-powered airplanes operated under part 121 (airline) and part 135 (charter) of 10 or more passenger seats.

**TAWS Class-B** equipment is required for turbine-powered airplanes operated under part 91 with six or more passenger seats and for turbine-powered airplanes operated under part 135 with six to nine passenger seats.

both cautions and warnings.

#### **4. Terrain awareness display**

The TAWS equipment provides terrain information to a suitable display system—radar or multi-function display.

#### **5. Indications of imminent contact with the ground**

The TAWS equipment provides indications of possible terrain conflicts for the following conditions:

- Excessive rates of descent
- Excessive closure rate to terrain
- Negative climb rate or altitude loss after takeoff
- Flight into terrain when not in landing configuration
- Excessive downward deviation from an ILS glideslope
- Voice callout “five hundred,” when the aircraft descends to 500 feet above the terrain or nearest runway elevation

### **Class-B TAWS**

For those aircraft that require Class-B TAWS, the systems include a minimum of four basic functions:

#### **1. Forward looking terrain avoidance**

This function looks ahead and below the aircraft flight path to provide a suitable alert if a potential threat exists.

#### **2. Premature descent alert**

This function uses the predicted flight path information (determined from an approach navigation source) and its own airport database to determine if the aircraft is below the normal (typically 3 degree) approach path for the nearest runway. If a conflict is detected, a warning is given to the pilot.

#### **3. Attention alerts**

The system provides appropriate visual and audio alerts for both cautions and warnings.

#### **4. Indications of imminent contact with the ground**

The TAWS equipment provides indications of possible terrain conflicts for the following conditions:

- Excessive rates of descent
- Negative climb rate or altitude loss after takeoff
- Voice callout “five hundred” when the aircraft descends to 500 feet above the terrain or nearest runway elevation

NOTE: A Class-B TAWS installation does not require a terrain display (as does Class-A), but the awareness of terrain around the aircraft is severely lacking.

The TAWS equipment is either contained in a remote avionics box that feeds a multi-function display, or contained entirely in the display unit. The larger aircraft generally use the remote box configuration, while the smaller aircraft use combined units. The following are short descriptions of each TAWS manufacturer. The comparison chart that accompanies this article lists the particulars of each TAWS unit.

### **Honeywell**

Honeywell’s EGPWS, or Enhanced Ground Proximity Warning System, was the pioneer TAWS system that combined an exhaustive terrain and obstacle database with the traditional Ground-Prox systems to offer look-ahead alerting. There are 10 EGPWS systems currently available from Honeywell that can be installed as remote computers in over 250 types of aircraft. Since the EGPWS was first introduced, 30,000 have been installed in aircraft ranging in size from small general avia-

tion airplanes to the largest air transports. They even have two models specifically designed for the special needs of helicopters, who routinely fly eye-level with the obstacles they’re trying to avoid.

The TAWS-A Mark series (Mark V-VIII) of EGPWS are intended for corporate jet and air transport installations. As an option, they contain software to detect windshear conditions and alert the flight crew when to take evasive maneuvers to escape a microburst. A recent addition to the Mark series is the software upgrade for RAAS, Honeywell’s Runway Awareness and Advisory System. The field-updatable software enhancement uses GPS position data and the EGPWS database to provide audio advisories that supplement flight crew awareness of position during ground operations and on approach to landing. Honeywell is the only TAWS manufacturer offering this enhanced safety feature.

The Mark XXI (TAWS-B) and Mark XXII (TAWS-A) offer terrain awareness functions tailored uniquely to helicopter flight profiles. For the light jet, turboprop and piston crowd, Honeywell’s general aviation line of EGPWS offer TAWS-B awareness and alerting of potential terrain or obstacles. The EGPWS is even bundled with traffic alerting sensors, either TAS or TCAS-I, to provide total awareness of ground-based and air-based threats.


Even though the mandated TAWS-B installations don’t require a cockpit display, the graphic depiction of terrain surrounding the aircraft greatly

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# TAWS COMPARISONS

TAWS REMOTE COMPUTERS			
	Model	Description	Price
<b>Honeywell</b> <a href="http://www.egpws.com">www.egpws.com</a> , <a href="http://www.bendixking.com">www.bendixking.com</a>			
	EGPWS – Mark V	TAWS-A, w/windshear detection, vertical situation display (VSD), radar AutoTilt T, worldwide Terrain/Obstacle/Airport database, optional RAAS. Remote Computer - Digital Interface	\$74,710 without internal GPS \$77,630 w/internal GPS RAAS add \$18,932
	EGPWS – Mark VII	TAWS-A, w/windshear detection, vertical situation display (VSD), radar AutoTilt T, worldwide database, optional RAAS. Remote Computer - Analog Interface	\$74,710 without internal GPS \$77,630 w/internal GPS RAAS add \$18,932
	EGPWS– Mark VI	TAWS-A, regional Terrain/Obstacle/Airport databases. Remote Computer designed for Turboprop aircraft - Limited Analog/Digital Interfaces	\$26,168 without internal GPS \$28,358 w/internal GPS
	EGPWS – Mark VIII	TAWS-A, worldwide Terrain/Obstacle/Airport database. Remote Computer designed for Turbofan and Turboprop aircraft - Limited Analog/Digital Interfaces	\$39,358 without internal GPS \$40,402 w/internal GPS
	EGPWS – Mark XXI Helicopter	TAWS-A, w/internal GPS, regional Terrain/Obstacle/Airport/Oil Rig databases. Remote Computer - All Displays	\$41,614
	KGP-560 EGPWS	TAWS-B, w/internal GPS, regional Terrain/Obstacle/Airport databases. Remote Computer - Limited Displays	\$10,090
	KGP-860 EGPWS	TAWS-B, w/internal GPS, enhanced alerting, regional Terrain/Obstacle/Airport databases. Remote Computer - All Displays	\$13,090
	EGPWS - Mark XXI Helicopter	TAWS-B, w/internal GPS, regional Terrain/Obstacle/Airport databases. Remote Computer - All Displays	\$12,900
	KMH-880	TAWS-B & TAS (traffic). Remote TAWS Computer / Traffic Sensor	\$29,990 Includes Install kit and antenna
KMH-980	TAWS-B & TCAS-I (traffic). Remote TAWS Computer / Traffic Sensor	\$38,280 Includes Install kit and antenna	
<b>L-3 Avionics Systems</b> <a href="http://www.as.l-3com.com/products/taws.asp">www.as.l-3com.com/products/taws.asp</a>			
	LandMark 8000	TAWS-B, worldwide database. Remote Computer	\$11,550
	LandMark 8100	TAWS-B w/internal WAAS-GPS, worldwide database, enhanced positioning. Remote Computer	\$13,925
<b>Universal Avionics</b> <a href="http://www.universalavionics.com">www.universalavionics.com</a>			
	TAWS-A	TAWS-A. Remote Computer	\$36,500
	TAWS-B	TAWS-B. Remote Computer	\$22,000

## TAWS REMOTE COMPUTERS continued...

	Model	Description	Price
<b>ACSS (L-3/Thales)</b> <a href="http://www.acssonboard.com/">www.acssonboard.com/</a>			
	TW-950/951 TAWS+	TAWS-A, optional GPS. Remote Computer	\$77,500 no/GPS \$89,250 w/GPS
	TT-950/951/ 952	TAWS-A with TCAS II, windshear, optional GPS. Remote TAWS Computer / Traffic Sensor	TT 950/951 - \$217,385 TT 952 (w/GPS) - \$230,135

## TERRAIN DISPLAYS

	Model	Description	Price
<b>Honeywell</b> <a href="http://www.bendixking.com">www.bendixking.com</a>			
	Skymap IIIC	Rudimentary Terrain Moving Map— Panel or pedestal-mount	\$2,470
	KMD-150	Terrain Map - Combination moving map display with GPS navigation	\$3,870 no/GPS \$4,570 w/GPS
	KMD-250	Terrain Map with Relative Elevation mode. Combination moving map display with GPS navigation, traffic & weather	\$4,140 no/GPS \$4,630 w/GPS
	KMD-550	Display only for Honeywell EGPWS. Multi- Function Display – TAWS, Traffic, Datalink & Stormscope	Additional circuit board to in- terface with EGPWS - \$2,100
	KMD-850	Display only for Honeywell EGPWS. Multi- Function Display – TAWS, Traffic, Datalink, Storm- scope & Radar	Additional circuit board to in- terface with EGPWS - \$2,100
	MFRD	Primarily Radar Indicator. Display for any Honeywell EGPWS. Multi-Function Display— radar, TAWS, traffic, FMS & checklist	\$42,590
	TRA-45	Radio Altitude and EGPWS. Display for any Honeywell EGPWS. Replaces existing 3 inch Radio Altimeter	\$14,500
<b>Avidyne</b> <a href="http://www.avidyne.com">www.avidyne.com</a>			
	FlightMax EX500	Dedicated page for EGPWS display. Multi- Function Display—TAWS, Traffic, Datalink, Storm- scope & Radar	Additional software to inter- face with EGPWS - \$2000
	FlightMax EX5000	Dedicated page for EGPWS display. Multi- Function Display – TAWS, Traffic, Datalink, Storm- scope & Radar	Additional software to inter- face with EGPWS - \$2000

All prices are subject to change. Please contact the individual manufacturer or authorized dealer for current pricing.

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enhances the pilot's ability to plan escape maneuvers when a turn may be more appropriate than just a pull-up. Honeywell offers many options to display TAWS, as well as offering a few moving-map displays that just depict a colored terrain map.

### **L-3 Avionics Systems**

L-3 Communications recently bought the entire BFGoodrich line of avionics, including the Stormscope and LandMark TAWS products. The LandMark 8000 and 8100 are Class-B TAWS remote-mounted units that display terrain information on a variety of Multi-Function Displays. The LandMark 8100 is the first stand-alone Class-B TAWS to offer an optional WAAS-GPS sensor. Thus eliminating the need for multiple inputs from other aircraft sensors, and simplifying the installation process. By operating autonomously, the LandMark 8100 provides terrain data without complicated GPS, air-data or temperature inputs. In addition, the LandMark system offers greater terrain resolution, providing an accurate lay of the land with crisper imaging, and more distinct runway and obstacle depictions. Whether depicting terrain on an MFD, EFIS or Radar Indicator, the LandMark TAWS easily integrates with existing cockpits.

### **Universal Avionics**

Universal Avionics is generally known for their excellent FMS line, and just recently received approval for their TAWS Class-A and Class-B remote-mounted units. Their system is unique in that besides displaying the terrain in a plan view (looking down

or "God's eye" view) it can also display a complete profile (side view) of the terrain in relation to the entire flight plan, even before the aircraft is airborne. It differs from EGPWS in that it uses inputs from an FMS to project an aircraft's flight path onto the terrain display. The resulting unprecedented "look-ahead" capability can provide warnings and alerts well in advance of potential hazards, allowing time for the pilot to make the necessary maneuvers or waypoint corrections for terrain avoidance.

If that isn't enough, the Universal system also depicts a 3-D perspective view on video-capable devices such as Universal's Flat Panel Integrated Display, FMS Display Control Unit and Cockpit Display. On the display, a blinking star-shaped symbol shows the position of the hazard based on the aircraft's predicted flight path. This graphic is colored white, yellow or red corresponding to Advisory, Caution and Warning alert levels respectively.

### **ACSS**

The TAWS+ Terrain Awareness Warning System from ACSS brings advanced terrain prediction and avoidance technology to the cockpit with their capable line of remote-mount units. TAWS+ has the patented Terrain Advisory Line (TAL), "Avoid Terrain" and Engine Out features. These advanced functions encompass terrain and airport databases. Available with standard aircraft climb rate, TAWS+ offers a unique set of enhanced features in a line-replaceable unit (LRU). An optional GPS card can be installed in the same unit, providing even greater situational awareness capability. Building

on the TAWS+ capabilities, the TAWS+Performance package is a step beyond conventional TAWS offering the higher level of safety afforded by basing alerts on the actual ability to climb. Sophisticated modeling of aircraft climb capabilities provides the most complete picture for improved situational awareness.

In addition to audio and visual alerts, TAWS+ provides enhanced situational awareness with the unique Terrain Advisory Line (TAL) feature. Extending the conventional TAWS cautionary terrain segment, the TAL reaches out to 30 degrees on either side of the aircraft flight path and out as far as two minutes in front of the aircraft, providing the crew with an enhanced indication of potential hazards in the current flight path. ACSS can supply the TAWS+ or TAWS+Performance capability in a single remote-mounted box or combined with a TCAS-II traffic sensor. The combined T2CAS is a form fit for the TCAS-2000 remote sensor and adds TAWS capability without the addition of a second box.

### **Avidyne**

Avidyne offers two multi-function displays that interface to any Honeywell EGPWS, either Class-A or Class-B. Their FlightMax EX-500 is a six-inch display intended to be mounted within the existing radio rack of small aircraft or in place of the radar display in larger aircraft. The multi-function display (MFD) comes standard with a database of terrain elevations, obstacles and waterways, which then requires the pilot to interpret any terrain threats. The addition of a remote-mounted EGPWS computer provides full TAWS

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## TERRAIN DISPLAYS continued...

TERRAIN DISPLAYS continued...			
	Model	Description	Price
<b>Garmin</b> <a href="http://www.garmin.com">www.garmin.com</a>			
	GNS-400	TAWS-like, Terrain Map. GPS Navigator	Software & hardware (factory) upgrade—\$500
	GNS-420	TAWS-like, Terrain Map. GPS Navigator / Moving Map	Software & hardware (factory) upgrade—\$500
	GNS-430	TAWS-like, Terrain Map. GPS Navigator / Moving Map / Nav/Com	Software & hardware (factory) upgrade—\$500
	GNS-500	TAWS-B. GPS Navigator / Moving Map	Software & hardware (factory) upgrade—\$8,000
	GNS 530	TAWS-B. GPS Navigator / Moving Map / Nav/Com	Software & hardware (factory) upgrade—\$8,000
	MX20	MFD moving map with optional traffic and weather interface capability, radar and TAWS-B	\$7,295 w/ I/O Traffic: \$8,495 w/ I/O Traffic & Radar (TAWS-B): \$14,495
<b>Chelton</b> <a href="http://www.cheltonflightsystems.com">www.cheltonflightsystems.com</a>			
	FlightLogic EFIS	TAWS-A, B or C. Complete PFD/MFD EFIS with Synthetic Vision, TAWS-C included TAWS-B or A optional	TAWS-C – included TAWS-B – additional \$10,000 TAWS-A – additional \$25,000
<b>Sandel</b> <a href="http://www.sandel.com">www.sandel.com</a>			
	ST3400	TAWS and RMI. TAWS-A or B. TAWS Computer and Display – can replace existing 3 inch RMI	TAWS-A – \$34,500 TAWS-B – \$20,950
<b>Aspen Avionics</b> <a href="http://www.aspenavionics.com">www.aspenavionics.com</a>			
	AT-300	TAWS & Vertical Speed Indicator. Terrain Map. Combination moving map display with GPS navigation – can replace existing 3 inch VSI (certification mid-2005)	\$3,995 – certified \$3,495 – non certified
PANEL-MOUNTED SWITCH / ANNUNCIATOR UNITS			
	Model	Description	Price
<b>Mid-Continent Instruments</b> <a href="http://www.mcico.com">www.mcico.com</a>			
	MD-41	Terrain Awareness Control Unit. Panel-mounted, Mode Switch and Alert Lights	\$984 - \$1,140

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capability including visual and audible alerting. If the EGPWS detects a terrain conflict, a message is posted that directs the pilot to access the TAWS page, but the audio callout and remote annunciators are always active. Avidyne's bigger brother MFD, the FlightMax EX-5000, is 10 inches wide and part of the Entegra system being installed in many factory aircraft (Cirrus, Lancair, Piper, etc.), although it is also available for retrofit into existing aircraft.

### Garmin

Garmin offers three options of terrain awareness, software upgrades for their popular GNS-430 and 530, and a terrain display with their MX20 moving map display. Customers of existing GNS-530s or GPS-500s can have the units upgraded by the Garmin factory for TAWS Class-B capability for \$8,000, which doesn't include the aircraft modifications necessary for remote warning annunciators or audio interface. This is most likely the easiest upgrade path for the FAA TAWS-B mandate in those aircraft that already have the GNS-530, although a separate and continuous display of terrain (MFD) is much better when flying in mountainous terrain.

For those aircraft that have the Garmin 400 series navigators (400, 420 & 430) a TAWS-like software field upgrade is available for \$500. The addition enables the depiction of surrounding terrain and obstacles in bright yellow and red, relative to the current altitude, but is not certified for full TAWS-B capability and does not satisfy the FAA TAWS mandate.

Garmin purchased the entire line of avionics from UPS Aviation Technologies, including the MX20 moving map. This fully-capable moving map/MFD comes standard with a database of terrain elevations and obstacles displayed in much the same manner as a sectional chart. It is not a true TAWS and therefore does not qualify for the FAA TAWS mandate, but it does offer a unique relative terrain mode that color codes any terrain near the aircraft altitude. As an option, the MX20 can interface to the Honeywell or LandMark Class-B TAWS computers.

### Chelton

The FlightLogic Synthetic Vision EFIS is a complete flight/navigation instrumentation system that provides information to a pilot via computer-generated screen displays on panel-mounted hardware. The hardware is comprised of a high-brightness LCD screen, menu buttons, control knob and slip indicator, all of which are backlit. The FlightLogic EFIS system uses terrain, airport and runway databases to warn of hazardous terrain within the search envelope in front of the aircraft. The FlightLogic system comes standard with a Class-C TAWS, which may be upgraded to Class-B or Class-A TAWS. A unique feature of the FlightLogic Primary Flight Display (PFD) is a color-coded, wireframe, 3-D Synthetic Vision display that depicts terrain ahead of the aircraft.

### Sandel

The Sandel ST-3400 TAWS/RMI was the first self-contained Class-A or Class-B TAWS system that includes an integrated full-color, multi-screen, edge-to-

edge display with a built-in RMI function. The ST-3400 is a self-contained TAWS that replaces an existing RMI, therefore saving substantial costs because new panels do not need to be fabricated. Sandel's patented edge-to-edge display technology provides a large viewing area equal in size to a 4 inch display.

### Aspen Avionics

The AT-300 display combines moving terrain mapping functions with GPS navigation depictions. This 3 inches display also contains a graphical indication of aircraft vertical speeds, up to 2,000 feet per minute. The unit uses the same mechanical mounting as a standard 3 inches VSI, allowing it to easily replace that instrument. It is compatible with virtually all panel mounted GPS navigation systems, providing an easy upgrade to add color moving map technology to older GPS systems. The unit offers a high-resolution sunlight readable color LCD moving map display that includes both top-view and side-view terrain presentations. Instantaneous height above ground is also displayed whenever the aircraft is below 10,000 feet AGL. Aspen Avionics projects FAA certification in mid-2005.

### SWITCH / ANNUNCIATOR UNITS

Some installations require external switching to disable certain functions or initiate the built-in testing functions. Many of the corporate jet and air transport installations use individual switch/annunciators. The specific STC will list the required switches and their placement in front of the pilots. To simplify the instal-

lation, two units are available that combine the necessary switching and pilot alert functions into a simple panel-mounted unit.

### **Mid-Continent Instruments**

Mid-Continent Instruments' MD-41 Terrain Awareness Control Units provide annunciation, mode selection and automatic dimming capability. The fully integrated, compact control units do away with the need for a myriad of switches, relays and annunciators making installation fast and easy. Both the MD41-1308 and the more compact MD41-1208 present primary or secondary visual alert of TAWS/EGPWS within the pilot's direct field-of-view. Mounted through a single cutout in the panel, the MD-41 reduces typical installation costs. ■