Promech Air
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NATIONAL TRANSPORTATION SAFETY BOARD
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ATTACHMENT 12

Chelton User's Manual Excerpts

42 Pages

Section 2

System Overview

General Description

The FlightLogic synthetic vision EFIS is a complete flight/navigation instrumentation system that intuitively provides information to a pilot via computer generated screens shown on panel-mounted hardware.

The panel-mounted hardware consists of an integrated display unit (IDU) that can be either a Primary Flight Display (that only shows the PFD screen) or a multifunction display (MFD) capable of showing a variety of screens. The MFD can be configured by the pilot as a reversionary PFD or navigation display (ND) at the touch of a button. The ND can be further configured as a moving map, electronic HSI, a dedicated traffic display, or a dedicated weather display.

PFD

MFD

The displays are comprised of a high-brightness backlit LCD screen, eight buttons, two control knobs, and an optional slip indicator. The buttons and slip indicator are also backlit and their brightness can be adjusted independently of the screen. All lighting is night-vision goggle compatible.

Remote-mounted equipment consists of an AHRS (Attitude/ Heading Reference System), an ADC (Air Data Computer), a GPS WAAS receiver, and an optional AIU (Analog Interface Unit). In some installations, the ADC and AHRS may be combined in a single unit called an ADAHRS (Air Data / Attitude Heading Reference Unit).

The fixed-wing FlightLogic EFIS includes integral Class C TAWS (Terrain Awareness Warning System) or, optionally, may include Class B or Class A TAWS. For a detailed description of TAWS functions, refer to the TAWS section in the appendix.

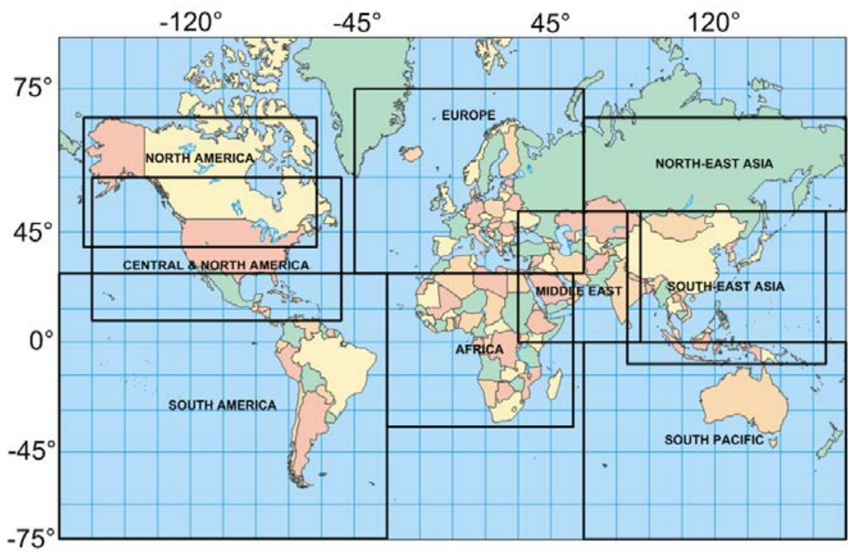
Rotorcraft systems include Class B rotorcraft TAWS. Class A rotorcraft TAWS is available as an option.

The EFIS complies with Advisory Circular AC 90-100A based on compliance with TSO-C146a Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).

Terrain

The terrain ahead of the aircraft is shown conformally with the artificial horizon and in the correct scale and perspective for the aircraft's current position and altitude.

Worldwide terrain coverage is provided and is grouped into regions as follows:



Each of the above regions is stored on a single terrain data card, which is installed in each display. Each system comes loaded with one terrain region. Terrain cards may be changed in minutes by your Chelton FlightLogic dealer or A&P Mechanic.

Terrain is shown with a resolution of 24 arc seconds, which represents about 2,400 feet.

Terrain is displayed ahead of the aircraft using a grid and simulates"atmospheric perspective," meaning that the terrain lines fade into the background "ground" color as they recede into the distance. This enhances the three-dimensional effect, improves distance judging, and minimizes foreground occlusion (objects in the foreground that cannot be seen against a similar background). Furthermore, an actual horizon is depicted based on aircraft altitude, like the real horizon. Distance varies to create a realistic depiction of the horizon.

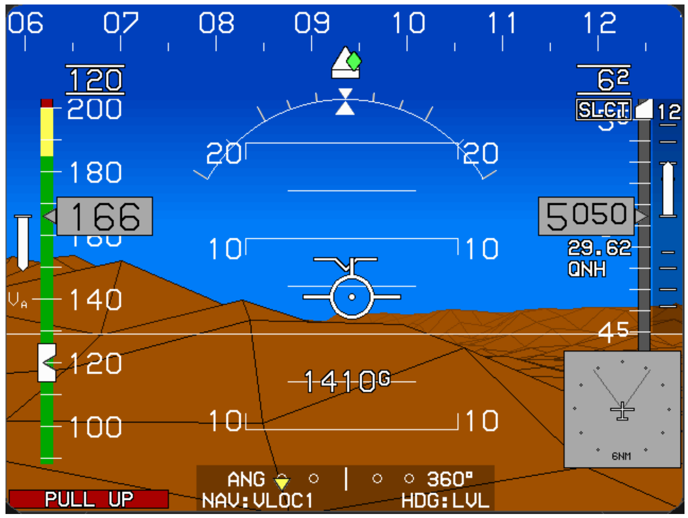
Threatening terrain will cause a “pop-up” condition on the PFD and MFDs in a system meaning that, even if it has been manually decluttered by the pilot, terrain will automatically be shown on the displays when it becomes threatening.

A blended-tone sky is displayed in conjunction with terrain. The sky fades from light blue at the horizon to dark blue at the top of the display to simulate atmospheric perspective and enhance the 3-D presentation. Additionally, the blended sky increases contrast of the directional scale, emphasizes the horizon, and provides a compelling visual cue to a nose-high attitude.

If a runway or the “**x**” at the bottom of the waypoint symbol is obscured, then there is terrain between the aircraft and the runway or waypoint at ground level.

NOTE:
This is an important point; if the aircraft is descending and the active waypoint becomes obscured or partially obscured, the aircraft could impact terrain.

WARNING!
DO NOT USE THIS SYSTEM FOR TERRAIN-FOLLOWING FLIGHT. DO NOT ATTEMPT TO NAVIGATE USING THE TERRAIN DEPICTION. ALWAYS ADHERE TO PUBLISHED INSTRUMENT APPROACH PROCEDURES IN INSTRUMENT CONDITIONS.

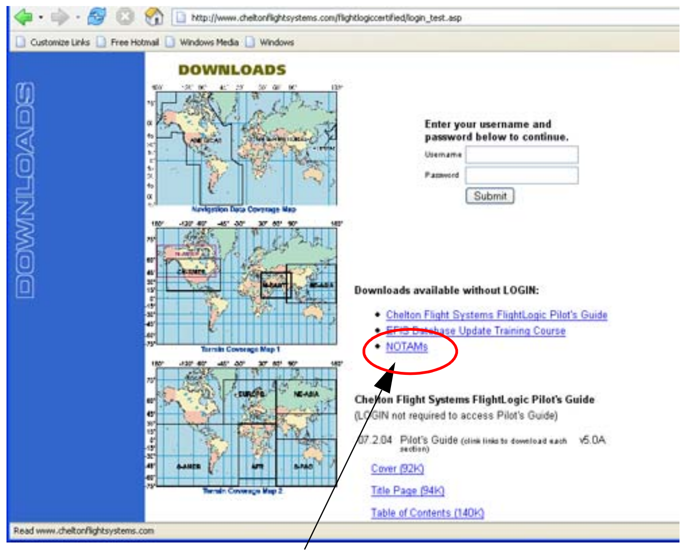


Terrain in this example is approximately 10° above the horizon. Position of flight path marker indicates that terrain will be cleared if the current climb angle is maintained.

While the grid uses the highest points for terrain depiction, terrain between datapoints is not displayed. This results in a “simplification” of the terrain that will be most noticeable near ground level in areas of rugged terrain.

The FlightLogic EFIS for airplanes includes integral Class C TAWS (Terrain Awareness Warning System) and, optionally, may include Class B or Class A TAWS. Rotorcraft systems include Class B HTAWS or, optionally, Class A HTAWS. For a detailed description of TAWS functions, refer to **TAWS (Terrain Awareness and Warning System) Functions, page 9-12**).

While the Chelton EFIS uses the same terrain source as the enhanced ground proximity warning systems in airliners and is quite accurate, certain geographic areas exhibit greater errors than others.

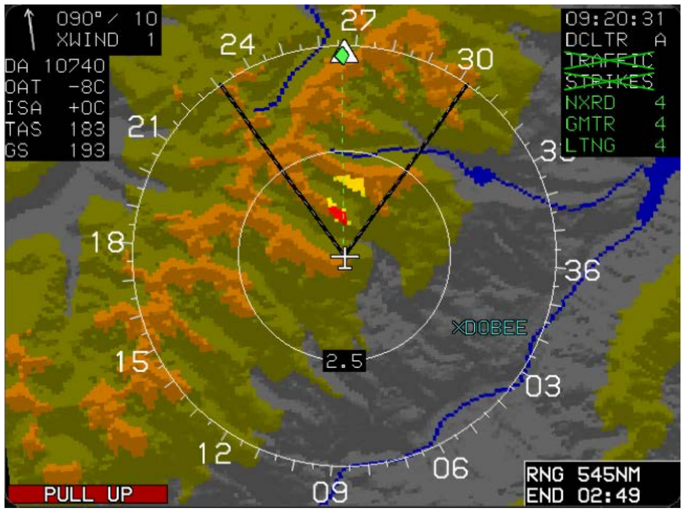


Please see the Terrain NOTAM at www.cheltonflightsystems.com (Certified Downloads section) which is posted whenever a new terrain database is compiled. This NOTAM identifies airports in mountainous regions of the United States near which terrain database errors in excess of 100 ft. have been detected due to exceptionally rugged geography. Pilots operating near these airports should use extra vigilance.

NOTE:
*To avoid unwanted alerts, the Terrain Awareness System must be inhibited by pushing the **TAWS INHIBIT** switch (located near the display) when approaching or departing a landing site that is not included in the airport database, or when a user waypoint approach has not been selected.*

Terrain

Terrain is displayed around the aircraft and is color-coded as **threatening** and **non-threatening** terrain.



Terrain alert MFD

Non-Threatening Terrain

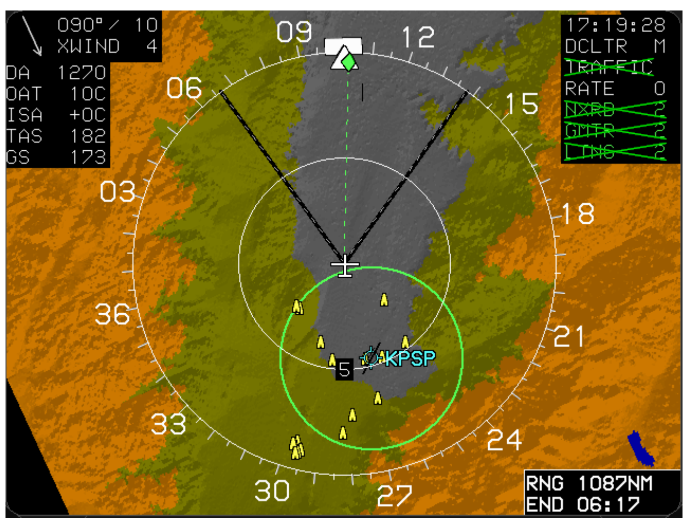
Terrain is displayed on the MFD in its correct relationship to the ownship symbol. Terrain is be shown using color to show relationship to aircraft altitude as follows:

1. Terrain is colored shades of gray when more than 2000 feet below aircraft altitude. The shade used is determined by the slope between adjacent terrain pixels in an increasing longitude direction.

2. Terrain is colored shades of olive when within 2000 feet but below aircraft altitude. The shade used is determined by the slope between adjacent terrain pixels in an increasing longitude direction.

3. Terrain is colored shades of brown when at or above aircraft altitude. The shade used is determined by the slope between adjacent terrain pixels in an increasing longitude direction.

4. Deep blue denotes areas of water and takes precedence over other colors.



Threatening Terrain

Threatening terrain, as determined by the requirements for TAWS, is colored in red and yellow. The red and yellow colors are shown with a “transparency” that allows the underlying contours to be distinguished to aid a terrain avoidance maneuver.

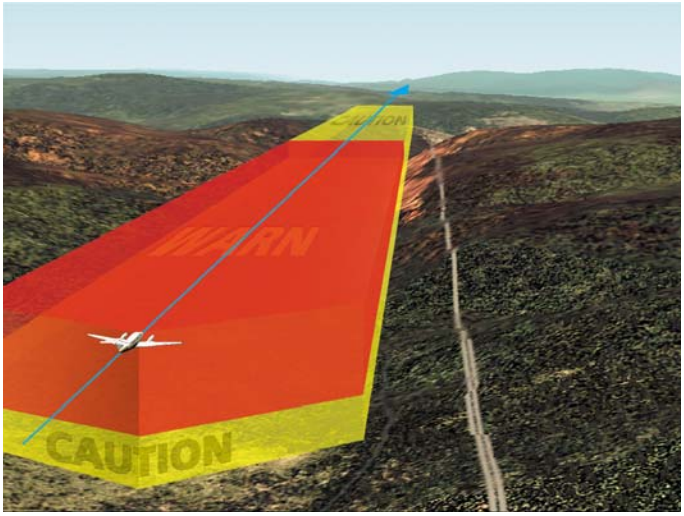
Threatening terrain will cause a “pop-up” condition on both the PFD and first MFD in a system meaning, even if it has been manually decluttered by the pilot, terrain will automatically be shown on the displays. On the moving map, the scale will be set automatically to highlight the threatening terrain. The pilot is then free to reconfigure the displays as desired. A **RESET** menu botton will appear in the upper left corner of the MFD for 20 seconds to return to the previous scale.

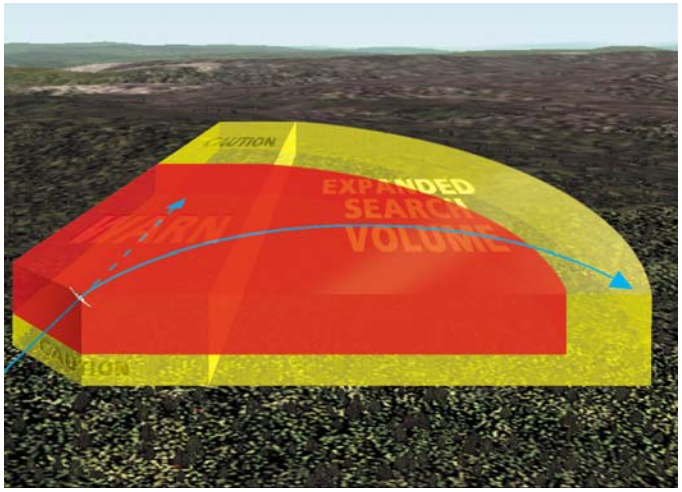
TAWS

The FlightLogic EFIS features integrated Class C TAWS or, optionally, Class A or B TAWS or Class A or B Helicopter TAWS (HTAWS).

Class B and C TAWS provide the following terrain alerting functions:

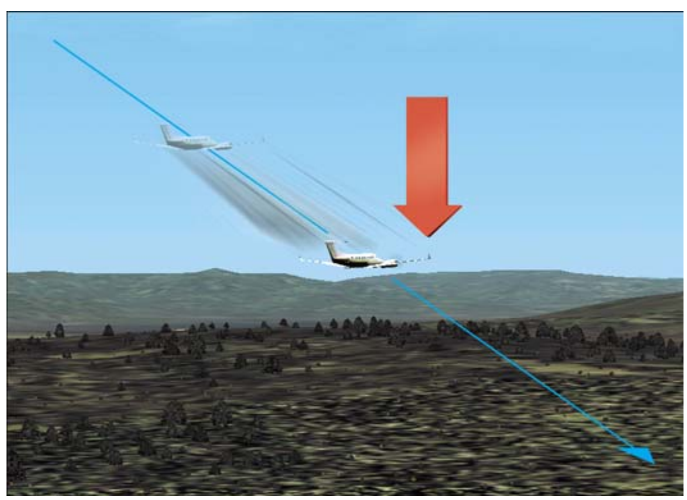
1. Forward Looking Terrain Awareness ("FLTA"): A warning function that uses a terrain database to alert the pilot to hazardous terrain in front of the aircraft, automatically adjusting for climbs, descents, and turns (see preceding graphic).



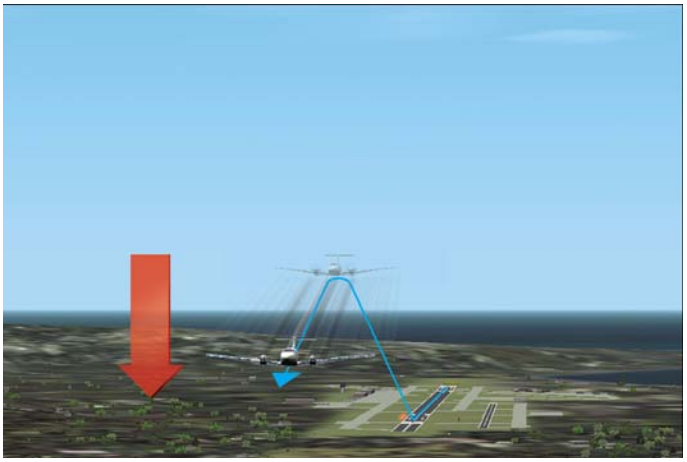


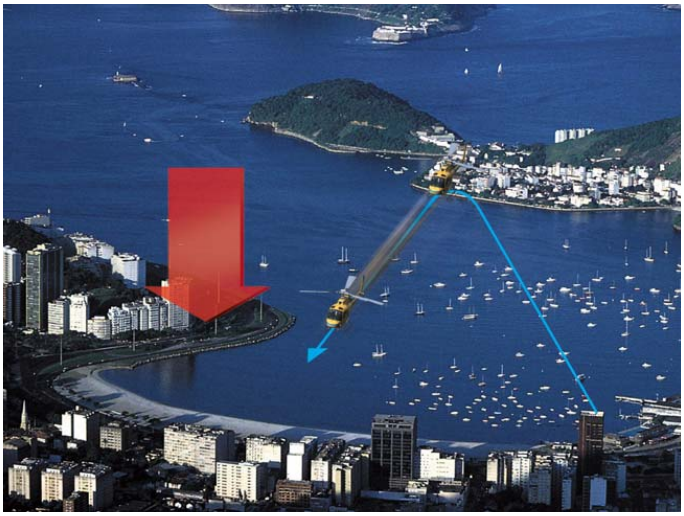
2. Premature Descent Alert (“PDA”): A warning function that alerts the pilot when descending well below a normal approach glide path on the final approach segment of an instrument approach procedure.

3. Excessive Rate of Descent (GPWS Mode 1): A warning function that alerts the pilot when the rate of descent is hazardously high as compared to height above terrain (i.e., descending into terrain).

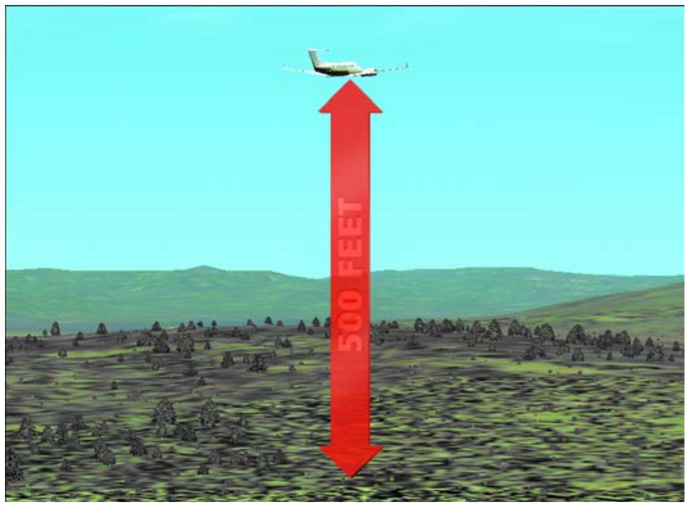


4. Sink Rate after Takeoff or Missed Approach (GPWS Mode 3): A warning function that alerts the pilot when a sink rate is detected immediately after takeoff or during initiation of a missed approach.





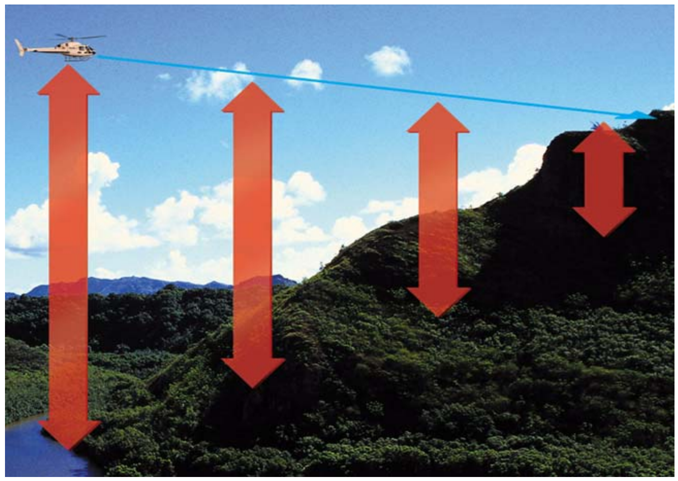
5. 500 foot Wake-up Call: A single voice callout when descending through 500 feet AGL.



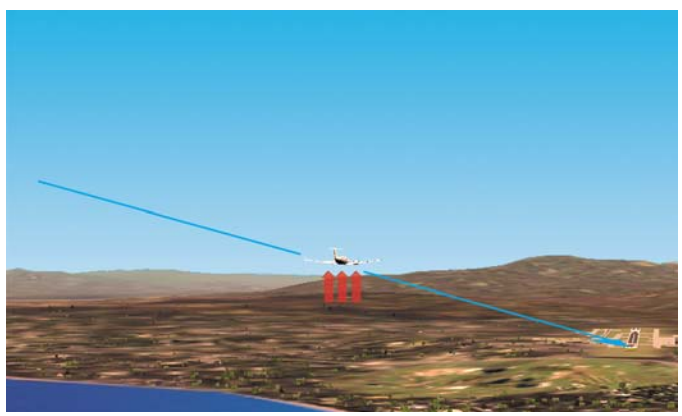
Class A TAWS incorporates gear and flap position, radar altitude, and ILS signal and adds the following functions:

1. Excessive Closure Rate to Terrain (GPWS Mode 2): This function uses AGL rate of change and AGL altitude to alert the pilot when the rate of change of height above terrain is

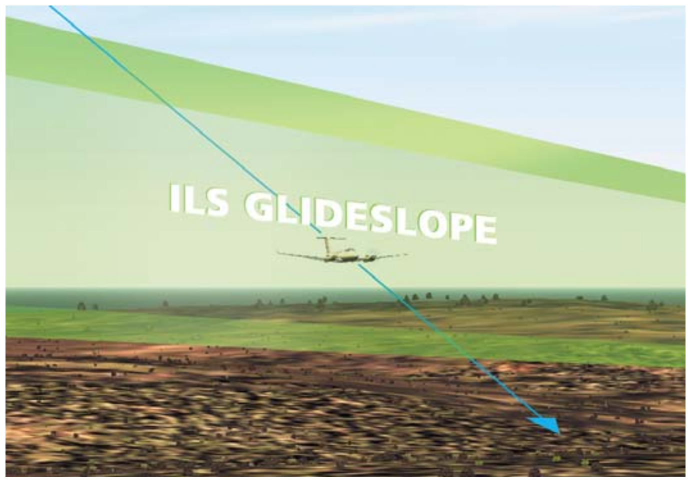
hazardously high as compared to height above terrain (i.e., flying level over rising terrain).



2. Flight into Terrain when not in Landing Configuration (GPWS Mode 4): This function uses aircraft speed and AGL altitude to alert the pilot when descending into terrain without properly configuring the aircraft for landing.



3. Excessive Downward Deviation from an ILS Glideslope (GPWS Mode 5): This function uses ILS glideslope deviation information and AGL altitude to alert the pilot when an excessive downward glideslope deviation is detected on the final approach segment of an ILS approach.



Each of the above TAWS conditions is accompanied by a voice annunciation and, except for the 500 foot callout, a CWA flag color-coded yellow for caution and red for warning.

A TAWS INHIBIT switch near the PFD mutes the voice warning and removes the caution and warning flags but the terrain is still colored for caution and warning conditions.

HELICOPTER TAWS

When installed in rotorcraft, the EFIS provides Class A or B Helicopter TAWS (HTAWS) functions which allow for operation closer to the ground without generating nuisance alerts.

Rotorcraft Class B includes only FLTA and altitude loss on climb-out functions (GPWS Mode-3).

Rotorcraft Class A includes all TAWS functions except premature descent alert (PDA) and the 500-foot callout.

Refer to the preceding TAWS section for explanation of these functions.

A low-altitude mode desensitizes the system to allow for very-low altitude operations. The low altitude mode is activated with a switch that reduces the terrain clearance requirements in the protection envelopes provided. See the extended TAWS description in the Appendix for more information.

See **Caution/Warning/Advisory System, page 2-16** of System Overview section for details of the auditory annunciations associated with terrain.

"The bottom line on terrain and TAWS:
If you see red or yellow on the moving map, accompanied by a voice alert, take action immediately. Use extreme caution and be suspect of yellow terrain. Add power, climb, and turn away from red terrain. You have two very effective terrain displays, the moving map and primary flight display; use them both to your advantage."

NOTE: *Please see the Terrain NOTAM at www.cheltonflightsystems.com (Certified Downloads section) which is posted whenever a new terrain database is compiled. This NOTAM identifies airports in mountainous regions of the United States near which terrain database errors in excess of 100 ft. have been detected due to exceptionally rugged geography. Pilots operating near these airports should use extra vigilance.*

NOTE:
In order to be considered valid for use by the TAWS, the horizontal figure of merit must be less than or equal to the greater of 0.3NM or the horizontal alert limit ("HAL") for the mode of flight.
In order for GPS/WAAS geodetic height to be considered valid for use as MSL altitude, the vertical figure of merit must be less than or equal to 75 feet. The secondary source of MSL altitude will be barometric altitude from an air data computer

TAWS (Terrain Awareness and Warning System) Functions

The IDU provides TSO-C151b TAWS functionality. Depending upon aircraft configuration settings and external sensors/switches, the system is configurable as a Class A, B or C TAWS or a Class A or B HTAWS. Functions provided by TAWS are:

1. Terrain Display: Display of terrain and obstacles on the PFD and ND.
2. Forward Looking Terrain Awareness (“FLTA”): A warning function that uses a terrain database and an obstruction database to alert the pilot to hazardous terrain or obstructions in front of the aircraft.
3. Premature Descent Alert (“PDA”): A warning function that alerts the pilot when descending well below a normal approach glidepath on the final approach segment of an instrument approach procedure.
4. Excessive Rate of Descent (GPWS Mode 1): A warning function that alerts the pilot when the rate of descent is hazardously high as compared to height above terrain (i.e., descending into terrain).
5. Excessive Closure Rate to Terrain (GPWS Mode 2): A warning function that alerts the pilot when the rate of change of height above terrain is hazardously high as compared to height above terrain (i.e., flying level over rising terrain).
6. Sink Rate after Takeoff or Missed Approach (GPWS Mode 3): A warning function that alerts the pilot when a sink rate is detected immediately after takeoff or initiation of a missed approach.
7. Flight into Terrain when not in Landing Configuration (GPWS Mode 4): A warning function that alerts the pilot when descending into terrain without properly configuring the aircraft for landing.

8. Excessive Downward Deviation from an ILS Glideslope (GPWS Mode 5): A warning function that alerts the pilot when an excessive downward glideslope deviation is detected on the final approach segment of an ILS approach

9. 500 foot Wake-up Call: A single voice callout when descending through 500 feet AGL

TAWS functions provided by the EFIS as compared to TAWS / HTAWS class and aircraft type is as follows:

Aircraft Type	TAWS Class	Terrain Display	FLTA	PDA	GPWS Mode 1	GPWS Mode 2	GPWS Mode 3	GPWS Mode 4	GPWS Mode 5	500' Call
Airplane RG + F	A	X	X	X	X	X	X	X	X	X
Airplane RG	A	X	X	X	X	X	X	X	X	X
Airplane FG + F	A	X	X	X	X	X	X	X	X	X
Airplane FG	A	X	X	X	X	X	X		X	X
Rotorcraft RG	A	X	X		X	X	X	X	X	
Rotorcraft FG	A	X	X		X	X	X		X	
Airplane	B or C	X	X	X	X		X			X
Rotorcraft	B	X	X				X			

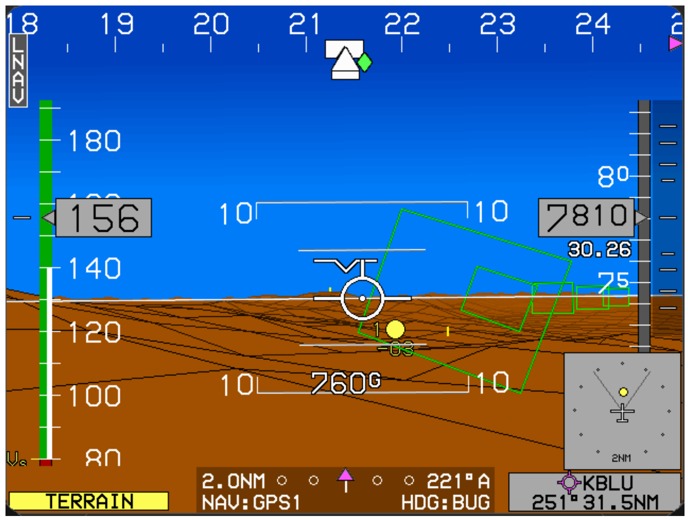
Notes: RG + F = Retractable Gear with Defined Landing Flaps Position
RG = Retractable Gear
FG + F = Fixed Gear with Defined Landing Flaps Position
FG = Fixed Gear

Detailed operations of the TAWS functions are described in the following sections.

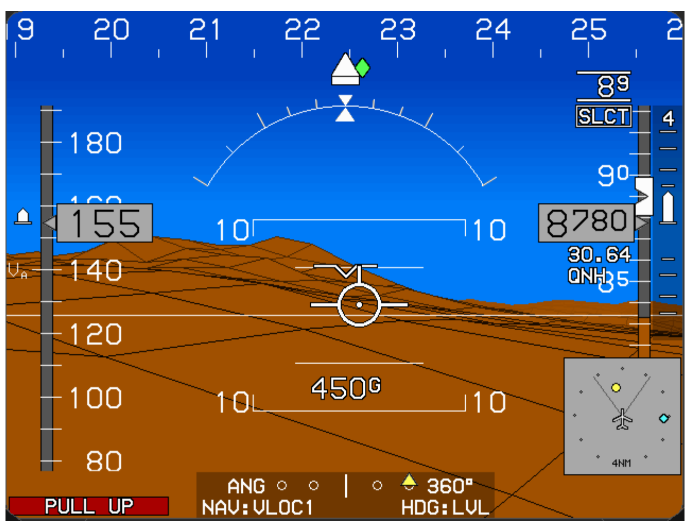
Terrain Display:

This function is present in all systems. The Terrain Display function uses a terrain database, aircraft position, aircraft heading or track, aircraft attitude, and aircraft altitude to render a display of surrounding terrain and obstacles on the primary flight display and navigation display.

Terrain is displayed on the primary flight display using a perspective fishnet style rendering. Terrain color is brown with the fishnet color fading from black to brown to impart atmospheric perspective. In addition, the sky color changes from a light blue at the horizon to a darker blue above the horizon for additional atmospheric perspective effect. The relative elevation of terrain with respect to aircraft altitude and performance is naturally observed by reference to the primary flight display pitch ladder and flight path marker. Obstacles are shown on the primary flight display as simple yellow lines, and look very much like radio towers. The following screen captures show terrain and obstacles on the primary flight display:

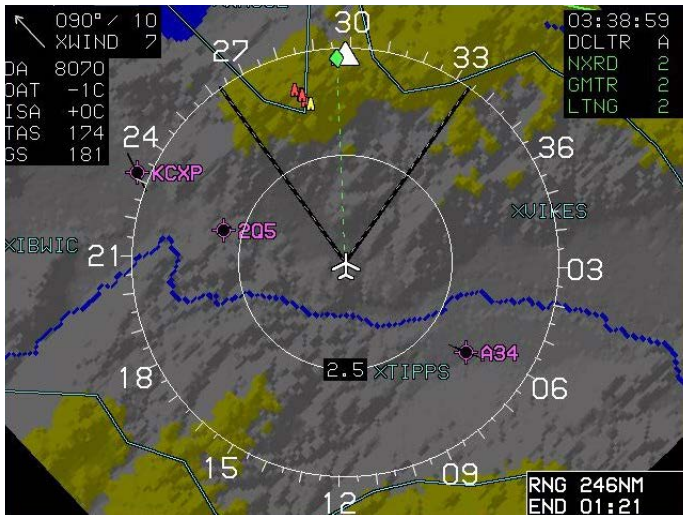


Above: TAWS Caution on PFD.

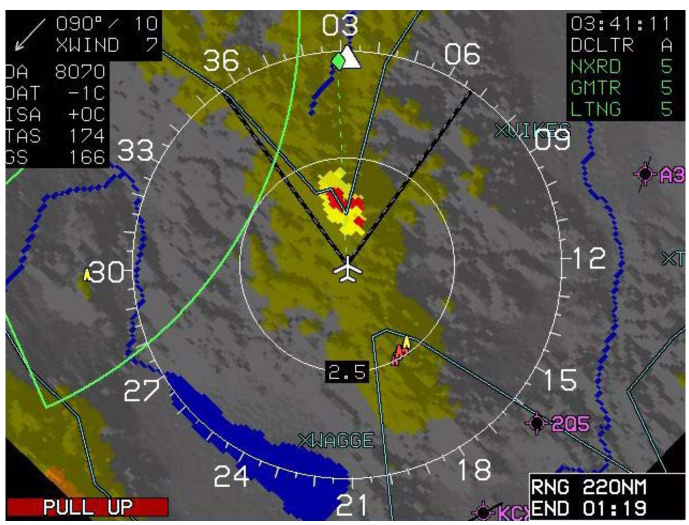


Above: TAWS warning on PFD.

Terrain and obstacles are displayed on the navigation display using colors to show relationship to aircraft altitude. Terrain areas are colored black when more than 2000 feet below aircraft altitude; dark olive when within 2000 feet but more than 500 feet below aircraft altitude; dark brown when within 500 feet but below aircraft altitude; and light brown when at or above aircraft altitude. Deep blue denotes areas of water and takes precedence over other colors. Obstruction symbols are colored yellow when within 2000 feet but more than 500 feet below aircraft altitude; light red when within 500 feet but below aircraft altitude; and deep red when at or above aircraft altitude. The colors green, yellow and red are not used for normal display of terrain because: (1) such usage would conflict with the meanings attributed to these colors by the FAR's; and (2) these are customarily used on electronic displays to show weather and could lead to pilot confusion when both terrain and weather are shown on the navigation display. Yellow and red are used to show terrain areas causing an FLTA alert as further described in the FLTA section below. Such coloration complies with the requirement that terrain elements causing an FLTA alert be distinguishable from those that do not. The following screen capture shows terrain and obstructions on the navigation display:



Above: Obstructions and non-threatening terrain on the moving map; no TAWS warning.



Above: Threatening terrain on the moving map generating a TAWS warning.

The Terrain Display function can be manually inhibited by the pilot for decluttering. In addition, under certain failure conditions, the Terrain Display function is automatically inhibited. When the Terrain Display function is inhibited, the primary flight display background changes to a solid blue over brown presentation without a fishnet or atmospheric perspective. This makes it clear to the pilot that terrain is not being displayed and obviates the need for an annunciation on the primary flight display. On the navigation display, the word TERRAIN with an X over the top is displayed in the upper right hand corner. If the Terrain Display function is manually disabled, the X will be green. If the Terrain Display function is automatically disabled due to an abnormal condition, the X will be red.

Forward Looking Terrain Alert Function:

The EFIS FLTA mode is either slaved to the GPS/WAAS navigation mode or set automatically based upon default mode logic. Mode selection is described as follows:

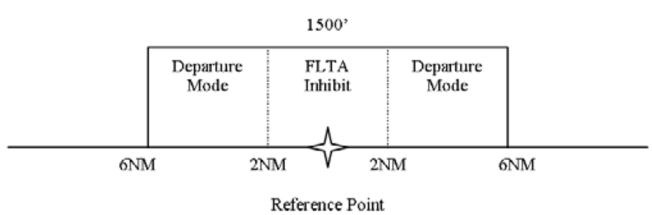
GPS/WAAS Navigation Mode Slaving

The EFIS performs TSO-C146a GPS/WAAS system functions in addition to the TAWS functions. As a result, GPS/WAAS navigation mode is available as an input to the TAWS. In accordance with RTCA/DO-229C, the user can select an IFR procedure (Approach, DP, or STAR) that automatically changes the GPS/WAAS navigation mode to Enroute, Terminal, Departure, or IFR Approach as appropriate. In addition, the EFIS allows the user to select a VFR approach to any runway or user waypoint with a defined approach path. Selection of a VFR approach causes automatic GPS/WAAS navigation mode changes to Enroute, Terminal or VFR Approach as appropriate. If the GPS/WAAS navigation mode is higher in precedence than the default FLTA mode, the FLTA mode is slaved to the GPS/WAAS navigation mode. The order of precedence is: (1) Departure Mode; (2) Approach Mode (IFR or VFR); (3) Terminal Mode; and (4) Enroute Mode. When slaved, the GPS/WAAS active runway threshold or user waypoint will be the reference point for automatic FLTA inhibiting. The advantage of this methodology is that the GPS/WAAS navigation modes are a direct indication to the FLTA function of pilot intent. Thus, it provides a mechanism for rotorcraft or bush pilots to desensitize the TAWS when conducting normal off-runway operations.

Default FLTA Mode

If the default FLTA navigation mode is higher in precedence than the GPS/WAAS navigation mode, the FLTA mode will be slaved to the default FLTA navigation mode. The order of precedence is: (1) Departure Mode; (2) Approach Mode; (3) Terminal Mode; and (4) Enroute Mode. These modes are as follows:

1. Departure Mode. This mode is enabled when on the ground (defined as indicated airspeed less than or equal to Vs. AND AGL altitude less than 75 feet). The reference point for automatic FLTA inhibiting and mode envelope definition is the last point at which the ground definition was satisfied (this will be near the liftoff point). The Departure Mode will end upon climbing through 1,500 feet above or traveling more than 6NM from the reference point.

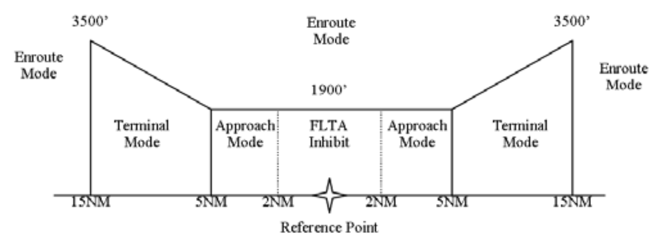


2. Other Modes. For other default FLTA modes, the reference point for automatic FLTA inhibiting and mode envelope definition will be the nearest runway threshold. The TAWS continuously searches all runway thresholds at the nearest airport to determine the nearest runway. The TAWS performs a search for the nearest airport every 3NM of distance traveled. Modes are as follows:

a. Approach Mode. This mode exists when within 1,900 feet and 5.0NM of the reference point.

b. Terminal Mode. This mode exists from 5NM to 15NM from the reference point when below an altitude that varies from 1,900 feet (at 5NM) to 3,500 feet (at 15NM) above the reference point.

c. Enroute Mode. This mode exists when not in any other mode.



FLTA Search Envelope:

The FLTA search envelope is an area in front of and below the aircraft. If terrain or an obstruction is found within the FLTA search envelope, a caution or warning is given to the pilot. The dimensions of the search envelope depend TAWS type, FLTA mode (described above), aircraft groundspeed, aircraft bank angle and aircraft vertical speed. Basic envelope parameters are as follows:

1. TAWS Type: The TAWS type determines the value of several parameters used to calculate the search envelope. These parameters are described below:

   a. Level-Off Rule: This parameter is the value, in percent of vertical speed, used to determine level-off leading for the descending flight Reduced Required Terrain Clearance (RTC) calculation. For airplanes, this value is set to 20% for Class A and B TAWS, and 10% for Class C TAWS. For rotorcraft, this value is set to 10%.

   b. Range: This parameter is the forward range of the search envelope in seconds. For airplanes, this value is set to 60 seconds. For rotorcraft, this value is set to 30 seconds and is reduced to 20 seconds when Low Altitude Mode is engaged.

c. Enroute Mode Level / Climbing Flight RTC: This parameter is the Enroute Mode level or climbing flight RTC in feet. For airplanes, this value is set to 700 feet for Class A and B TAWS, and 250 feet for Class C TAWS. For rotorcraft, this value is set to 150 feet and is reduced to 100 feet when Low Altitude Mode is engaged.

d. Terminal Mode Level / Climbing Flight RTC: This parameter is the Terminal Mode level or climbing flight RTC in feet. For airplanes, this value is set to 350 feet for Class A and B TAWS, and 250 feet for Class C TAWS. For rotorcraft, this value is set to 150 feet and is reduced to 100 feet when Low Altitude Mode is engaged.

e. Approach Mode Level / Climbing Flight RTC: This parameter is the Approach Mode level or climbing flight RTC in feet. For airplanes, this value is set to 150 feet. For rotorcraft, this value is set to 150 feet and is reduced to 100 feet when Low Altitude Mode is engaged.

f. Departure Mode Level / Climbing Flight RTC: This parameter is the Departure Mode level or climbing flight RTC in feet. This value is set to 100 feet for all TAWS classes for both airplanes and rotorcraft.

g. Enroute Mode Descending RTC: This parameter is the Enroute Mode descending flight RTC in feet. For airplanes, this value is set to 500 feet for Class A and B TAWS, and 200 feet for Class C TAWS. For rotorcraft, this value is set to 100 feet.

h. Terminal Mode Descending RTC: This parameter is the Terminal Mode descending flight RTC in feet. For airplanes, this value is set to 300 feet for Class A and B TAWS, and 200 feet for Class C TAWS. For rotorcraft, this value is set to 100 feet.

i. Approach Mode Descending RTC: This parameter is the Approach Mode descending flight RTC in feet. This value is set to 100 feet for all TAWS classes for both airplanes and rotorcraft.

j. Departure Mode Descending RTC: This parameter is the Departure Mode descending flight RTC in feet. This value is set to 100 feet for all TAWS classes for both airplanes and rotorcraft.

TAWS type parameters are summarized in the following table:

Aircraft Type	TAWS Class	Level-Off Rule	Range	Level RTC				Descending RTC			
				Enroute	Terminal	Approach	Departure	Enroute	Terminal	Approach	Departure
Airplane	A & B	20%	60sec	700'	350'	150'	100'	500'	300'	100'	100'
	C	10%		250'	250'			200'	200'		
Rotorcraft	A & B	10%	30sec	150'	150'	150'	100'	100'	100'	100'	100'
Rotorcraft (Low Alt)	A & B	10%	20sec	100'	100'	100'	100'	100'	100'	100'	100'

2. Aircraft Track: The terrain search envelope is aligned with aircraft track.

3. Aircraft Groundspeed: Aircraft groundspeed is used in conjunction with the range parameter to determine the look-ahead distance. In addition, aircraft groundspeed is used in conjunction with FLTA mode to determine the search volume width as follows:

   a. Enroute Mode: Search volume width is based upon a 30° change in track followed by 30 seconds of flight at aircraft groundspeed. Maximum width is 0.5NM either side of track.

   b. Terminal Mode: Search volume width is based upon a 15° change in track followed by 30 seconds of flight at aircraft groundspeed. Maximum width is 0.4NM either side of track.

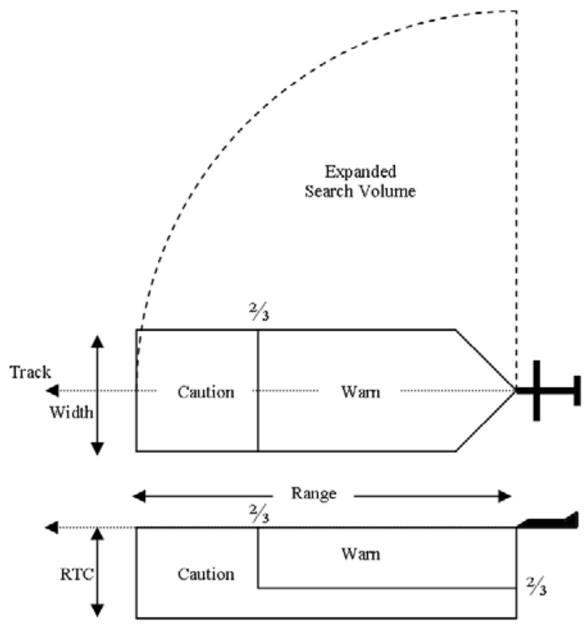
   c. Approach Mode: Search volume width is based upon a 10° change in track followed by 30 seconds of flight at aircraft groundspeed. Maximum width is 0.3NM either side of track.

   d. Departure Mode: Search volume width is based upon a 10° change in track followed by 30 seconds of flight at aircraft groundspeed. Maximum width is 0.3NM either side of track.

4. Aircraft Bank Angle: Aircraft bank angle is used to expand the search volume in the direction of a turn. Search volume expansion requires at least 10 degrees of bank. In addition, search volume expansion is debounced such that at 10° of bank, the bank angle must be continuously held for 3.25 seconds. The amount of debouncing is reduced linearly with increased bank angle such that at 30° of bank, there is no debounce time. Debouncing is intended to reduce nuisance search volume expansions when experiencing bank angle excursions due to turbulence.

5. Aircraft Vertical Speed: Aircraft vertical speed is used to determine which RTC values should be used. At vertical speeds above -500fpm, level and climbing flight RTC values are used. At vertical speeds less than or equal to -500fpm, descending flight RTC values are used. In addition, vertical speed is used to increase the descending flight RTC value used by the system. The increase in descending flight RTC is based upon a 3 second pilot reaction time and VSI leading according to the level-off rule parameter.

FLTA search volume is depicted below:



FLTA Alerts and Automatic Popup:

When terrain falls within the FLTA search envelope an FLTA warning is generated as described in **Caution/Warning/ Advisory System, page 2-16**. In addition, an automatic popup mode will be engaged as follows:

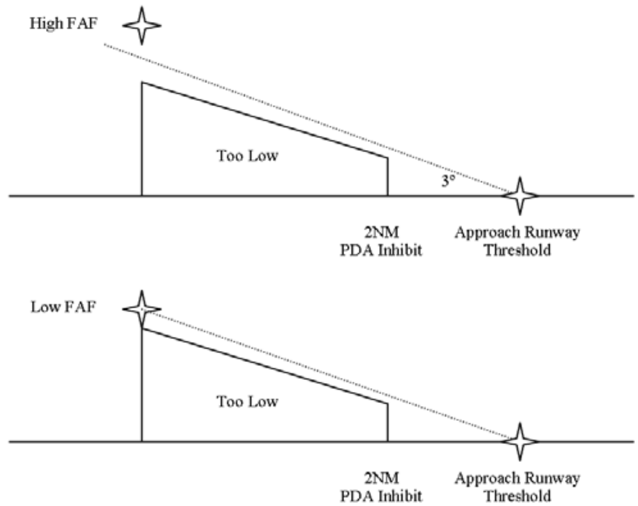
Primary Flight Display	Multi-Function Display
Terrain rendering enabled.	1. Display switched to navigation display. 2. Terrain rendering enabled. 3. Display switched to aircraft centered and heading up. 4. Scale set to 5NM (groundspeed < 200 knots) or 10NM (groundspeed > 200 knots). 5. Terrain elements generating cautions are colored amber. 6. Terrain elements generating warnings are colored red.

After the popup mode is engaged, the pilot is able to manually change any setting that was automatically changed by the popup mode. In addition, a "RESET" button appears for 20 seconds to allow the pilot to reset the previous screen configuration with one button press. The following screen capture shows the ND in popup mode.

Premature Descent Alert Function:

This function applies to airplane TAWS systems. The PDA function uses the GPS/WAAS navigation database, GPS/WAAS navigation mode, aircraft position, and aircraft altitude to alert the pilot when descending well below a normal approach glide path on the final approach segment of an instrument approach procedure.

The PDA function is armed when on the final approach segment of an IFR approach procedure and below the FAF crossing altitude. The alerting threshold for the PDA function is 0.5° less than the lower of: (1) a straight line from the FAF to the approach runway threshold; or (2) 3°. When the aircraft descends below the threshold, a yellow TOO LOW caution flag is presented in conjunction with a single Too Low Terrain voice alert. The PDA alert threshold is depicted below:



Excessive Rate of Descent (GPWS Mode 1):

This function is present in all airplane TAWS systems and rotorcraft Class A HTAWS. The GPWS Mode 1 function uses aircraft vertical speed information and AGL altitude to alert the pilot when the rate of descent is hazardously high as compared to height above terrain.

GPWS Mode 1 has a caution threshold and a warning threshold. When below the warning threshold, a red PULL UP warning flag is presented in conjunction with a repeating Pull Up, Pull Up voice alert. When above the warning threshold but below the caution threshold, a yellow SINK RATE caution flag is presented in conjunction with a single Sink Rate voice alert. The system uses RTCA/DO-161A Mode 1, Envelope 1 for TAWS systems, and a similar curve modified for rotorcraft operations for HTAWS systems.

Excessive Closure Rate to Terrain (GPWS Mode 2):

This function is present in Class A TAWS and HTAWS systems. The GPWS Mode 2 function uses filtered AGL rate and AGL altitude to alert the pilot when the rate of change of height above terrain is hazardously high as compared to height above terrain (i.e., flying level over rising terrain). AGL rate filtering is based upon a sampling distance that varies with AGL altitude. Sampling distance varies from 0.5NM at 0'AGL to 0.2NM at 2,500'AGL.

There are two Mode 2 envelopes: Mode 2A which is active when not in landing configuration; and Mode 2B which is active when in landing configuration. Envelope selection is determined as follows:

Aircraft Type	Mode 2A	Mode 2B
Airplane RG + F	Flaps NOT in landing configuration.	Flaps in landing configuration.
Airplane RG	Landing Gear UP	Landing Gear DOWN
Airplane FG + F	Flaps NOT in landing configuration	Flaps in landing configuration
Airplane FG	AGL Altitude > 500' OR IAS > Note 1	AGL Altitude < 500' AND IAS < Note 1
Rotorcraft RG	Landing Gear UP	Landing Gear DOWN
Rotorcraft FG	AGL Altitude > 200' OR IAS > 80KIAS	AGL Altitude < 200' AND IAS < 80KIAS

Notes: RG + F = Retractable Gear with Defined Landing Flaps Position
RG = Retractable Gear
FG + F = Fixed Gear with Defined Landing Flaps Position
FG = Fixed Gear
1. Normal Landing Pattern Speed + 15KIAS

When the GPWS Mode 2 envelope is pierced, a GPWS Mode 2 warning is generated as described in **Caution/Warning/ Advisory System, page 2-16**. Envelopes are defined below:

Mode 2A (NOT in Landing Configuration):

The system uses the RTCA/DO-161A Mode 2A envelope for TAWS systems, and a similar curve modified for rotorcraft operations for HTAWS. The upper limit of the curves includes an airspeed expansion function.

Mode 2B (Landing Configuration):

The system uses the RTCA/DO-161A Mode 2B envelope for TAWS systems, and a similar curve modified for rotorcraft operations for HTAWS systems.

Sink Rate after Takeoff or Missed Approach (GPWS Mode 3):

This function is present in all TAWS and HTAWS classes. The GPWS Mode 3 function uses aircraft vertical speed information and AGL altitude to alert the pilot when a sink rate is detected immediately after takeoff or initiation of a missed approach.

GPWS Mode 3 is armed by either being on the ground (defined as indicated airspeed less than V_S (airplanes) / 40KIAS (rotorcraft) AND AGL altitude less than 75 feet) or by being on the first leg of a missed approach procedure (as determined by the EFIS FMS) with distance to the active runway threshold increasing. GPWS Mode 3 is disarmed upon climbing through 700 feet AGL, traveling more than 6NM from the last point at which the ground definition was satisfied (this will be near the liftoff point), or transitioning to the second leg of a missed approach procedure. GPWS Mode 3 has a caution threshold based upon height above terrain and vertical speed. When below the caution threshold, a GPWS Mode 3 warning is generated as described in **Caution/Warning/Advisory System, page 2-16**

Flight into Terrain when not in Landing Configuration (GPWS Mode 4):

This function is present in Class A TAWS and HTAWS. The GPWS Mode 4 function uses aircraft speed information and AGL altitude to alert the pilot when descending into terrain without properly configuring the aircraft for landing. There are two Mode 4 envelopes: Mode 4A which gives cautions when landing gear is in other than landing configuration; and Mode 4B which gives cautions when landing gear or flaps are in other than landing configuration. Applicability of Mode 4 envelopes to aircraft types is as follows:

Aircraft Type	Mode 4A	Mode 4B
Airplane RG + F	Landing Gear UP	Landing Gear UP OR Flaps not in landing configuration.
Airplane RG	Landing Gear UP	Landing Gear UP
Airplane FG + F	Not Applicable	Flaps not in landing configuration
Airplane FG	Not Applicable	Not Applicable
Rotorcraft RG	Landing Gear UP	Not Applicable
Rotorcraft FG	Not Applicable	Not Applicable

Notes: RG + F = Retractable Gear with Defined Landing Flaps Position
RG = Retractable Gear
FG + F = Fixed Gear with Defined Landing Flaps Position
FG = Fixed Gear

Mode 4 alerting criteria require that the Mode 4 envelope be entered from above. Changing aircraft configuration while within a Mode 4 envelope will not generate an alert.

Airplane Mode 4 envelopes consist of a low-speed region and a high-speed region. When Mode 4A alerting criteria is met in the low-speed region, a yellow TOO LOW caution flag is presented in conjunction with a single Too Low Gear voice alert. When Mode 4B alerting criteria is met in the low-speed region, a yellow TOO LOW caution flag is presented in conjunction with either a single Too Low Gear voice alert (if landing gear is UP) or a single Too Low Flaps voice alert (if landing gear is DOWN). When either Mode 4 alerting criteria is met in the high-speed region, a yellow TOO LOW caution flag is presented in conjunction with a single Too Low Terrain voice alert.

The rotorcraft Mode 4 envelope also consists of a low-speed region and a high-speed region. In the low-speed region, a yellow TOO LOW caution flag is presented in conjunction with a single Too Low Gear voice alert. In the high-speed region, a yellow TOO LOW caution flag is presented in conjunction with a single Too Low Terrain voice alert. In addition, the rotorcraft Mode 4 features autorotation expansion. When autorotation expansion is engaged, the voice alert is Too Low Gear regardless of speed.

The system uses RTCA/DO-161A Mode 4 Envelope 3 for TAWS systems, and a similar curve modified for rotorcraft operations for HTAWS systems.

Excessive Downward Deviation from an ILS Glideslope (GPWS Mode 5):

This function is present in Class A TAWS and HTAWS systems. The GPWS Mode 5 function uses ILS glideslope deviation information and AGL altitude to alert the pilot when an excessive downward glideslope deviation is detected on the final approach segment of an ILS approach. GPWS Mode 5 is armed when a valid glideslope signal is being received AND the aircraft's 5 second filtered descending glide path is greater than 1° AND the aircraft is below 1,000' AGL.

GPWS Mode 5 has a caution threshold and a warning threshold. When below the warning threshold, a red GLIDESLOPE warning flag is presented in conjunction with a repeating Glideslope voice alert. When above the warning threshold but below the caution threshold, a yellow GLIDESLOPE caution flag is presented in conjunction with a single Glideslope voice alert. The system uses RTCA/DO-161A Mode 5 for TAWS and HTAWS.

500-Foot Wake-Up Call:

This function is present in all TAWS classes. The 500-Foot function includes an arming deadband of 500 feet to prevent nuisance warnings during low altitude operations. Thus, the aircraft must climb above 1,000 feet AGL to arm the 500-Foot function. Once armed, the 500-Foot function works by simply issuing a "Five Hundred" voice alert when descending through 500 feet AGL.

External Sensors and Switches:

The EFIS TAWS system requires a variety of inputs from external sensors and switches to perform its functions. These inputs are summarized below:

1. GPS/WAAS receiver. The GPS/WAAS receiver is the source of aircraft position, geodetic height, horizontal

figure of merit, vertical figure of merit, loss of integrity and loss of navigation inputs for the TAWS. The GPS/WAAS receiver connects directly to the EFIS IDU.

2. Air Data Computer. The air data computer is the source of barometric altitude, outside air temperature, and vertical speed for the TAWS. The air data computer connects directly to the EFIS IDU.
3. ILS Receiver. An ILS receiver is the source of glideslope deviation for the TAWS. The glideslope receiver connects to an external signal conversion box that communicates digitally with the EFIS IDU.
4. Radar Altimeter. A radar altimeter is the source for radar altitude for the TAWS. The radar altimeter connects to an external signal conversion box that communicates digitally with the EFIS IDU.
5. Gear Position Sensors. Three individual landing gear position discretes are the source of landing gear position for the TAWS. The landing gear position discretes are of the pull-to-ground type and connect directly to the EFIS IDU. Each discrete is grounded when the landing gear to which it is connected is down and locked.
6. Flap Position Sensor. A flap position discrete is the source of flap position for the TAWS. The flap position discrete is of the pull-to-ground type and connects to an external signal conversion box that communicates digitally with the EFIS IDU. The flap position discrete is grounded when the flaps are in the landing configuration.
7. TAWS Inhibit Switch. A TAWS Inhibit Switch is used for manual inhibiting of TAWS alerting functions. The TAWS Inhibit Switch is of the latching type and gives an obvious indication of actuation (i.e., toggle / rocker or pushbutton with indicator light). The TAWS Inhibit Switch is connected directly to the EFIS IDU. The TAWS Inhibit Switch is activated when manual inhibiting of TAWS alerting functions is desired.

8. Low Altitude Mode Switch. A Low Altitude Mode Switch is used for inhibiting and modifying HTAWS alerting functions to allow normal operation at low altitudes. The Low Altitude Mode Switch is of the latching type and gives an obvious indication of actuation (i.e., toggle / rocker or pushbutton with indicator light). The Low Altitude Mode Switch is connected directly to the EFIS IDU. The Low Altitude Mode Switch is activated when operation in Low Altitude Mode is desired.

9. Audio Cancel Switch (MUTE button). An Audio Cancel Switch is used for silencing active voice alerts. The Audio Cancel Switch is of the momentary type. The Audio Cancel Switch is connected directly to the EFIS IDU. The Audio Cancel Switch is momentarily depressed when silencing of active voice alerts is desired.

10. Glideslope Deactivate Switch. A Glideslope Deactivate Switch is used for inhibiting the GPWS Mode 5 function. The Glideslope Deactivate Switch is of the momentary type. The Glideslope Deactivate Switch connects to an external signal conversion box that communicates digitally with the EFIS IDU. The Glideslope Deactivate Switch is momentarily depressed when inhibition of the GPWS Mode 5 function is desired.

11. Low Torque Sensor. A low torque discrete is used for inhibiting and modifying HTAWS alerting functions during an autorotation. The low torque discrete is of the pull-to-ground type and connects to an external signal conversion box that communicates digitally with the EFIS IDU. The low torque discrete detects when engine torque is less than 7.5%.

The following tables list the applicability of external sensors and switches for various aircraft and TAWS system types:

Sensors/Switches Connected Directly to IDU							
Aircraft Type	TAWS/ HTAWS Class	GPS/WAAS	ADC	Gear Position Sensor	TAWS Inhibit Switch	Audio Cancel Switch	Low Altitude Mode Switch
Airplane RG + F	A	X	X	X	X	X	
Airplane RG	A	X	X	X	X	X	
Airplane FG + F	A	X	X		X	X	
Airplane FG	A	X	X		X	X	
Rotorcraft RG	A	X	X	X	X	X	X
Rotorcraft FG	A	X	X		X	X	X
Airplane	B or C	X	X		X	X	
Rotorcraft	B	X	X		X	X	X

Sensors/Switches Connected to External Signal Conversion Box						
Aircraft Type	TAWS/ HTAWS Class	ILS	Radar Altimeter	Flap Position Sensor	Glideslope Deactivate Switch	Low Torque Sensor
Airplane RG + F	A	X	X	X	X	
Airplane RG	A	X	X		X	
Airplane FG + F	A	X	X	X	X	
Airplane FG	A	X	X		X	
Rotorcraft RG	A	X	X		X	X
Rotorcraft FG	A	X	X		X	X
Airplane	B or C					
Rotorcraft	B					

Notes:
RG + F = Retractable Gear with Defined Landing Flaps Position
RG = Retractable Gear
FG + F = Fixed Gear with Defined Landing Flaps Position
FG = Fixed Gear

TAWS Basic Parameter Determination:

The fundamental parameters used for TAWS system functions are: (a) aircraft position, groundspeed, and track; (b) MSL altitude; (c) terrain data; (d) obstacle data; (e) AGL altitude; (f) vertical speed; (g) terrain closure rate; and (h) runway/ reference point location. There are redundant sources for some of these parameters. These parameters are acquired for use by the EFIS as follows:

1. Aircraft position, groundspeed and track. Aircraft position, groundspeed and track come solely from the GPS/WAAS. In order to be considered valid for use by the TAWS, the following conditions must be met:

    a. There is no GPS/WAAS loss of integrity caution;

    b. There is no GPS/WAAS loss of navigation caution; and

c. GPS/WAAS horizontal figure of merit (HFOM) is less than or equal to 0.3NM.

2. MSL altitude. The primary source for MSL altitude is GPS/WAAS geodetic height. In order for GPS/WAAS geodetic height to be considered valid for use as MSL altitude, the following conditions must be met:

   a. There is no GPS/WAAS loss of integrity caution;

   b. There is no GPS/WAAS loss of navigation caution; and

   c. GPS/WAAS vertical figure of merit (VFOM) is less than or equal to 75 feet.

   The secondary source of MSL altitude is temperature corrected barometric altitude from an air data computer.

3. Terrain data. The sole source for terrain data is a terrain database. In order for terrain data to be considered valid for use by the TAWS, the following conditions must be met:

   a. Aircraft position is valid;

   b. Aircraft position is within the boundaries of the terrain database; and

   c. The terrain database is not corrupt as determined by a CRC check at system initialization.

4. Obstacle data. The sole source for obstacle data is an obstacle database. In order for obstacle data to be considered valid for use by the TAWS, the following conditions must be met:

   a. Aircraft position is valid;

   b. Aircraft position is within the boundaries of the obstacle database; and

   c. The obstacle database is not corrupt as determined by a CRC check at system initialization.

Note that obstacle data is only used for depicting obstacles.

5. AGL altitude. The primary source for AGL altitude is radar altitude. The secondary source for AGL altitude is MSL altitude less terrain altitude.

6. Vertical speed. The primary source for vertical speed is barometric vertical speed from an air data computer. The secondary source for vertical speed is GPS/WAAS vertical speed. In order for GPS/WAAS vertical speed to be considered valid, the following conditions must be met:

   a. There is no GPS/WAAS loss of integrity caution;

   b. There is no GPS/WAAS loss of navigation caution; and

   c. GPS/WAAS vertical figure of merit is less than or equal to 75 feet.

7. Terrain closure rate. The source for terrain closure rate is the smoothed first derivative of AGL altitude. As there are multiple sources for AGL altitude, there are multiple sources for terrain closure rate. The smoothing algorithm is described in the GPWS Mode 2 section.

8. Runway/reference point location. The runway or reference point location used by the TAWS algorithms is determined from the EFIS navigation database. In order to be considered valid for use, the following conditions must be met:

   a. Aircraft position is valid;

   b. Aircraft position is within the boundaries of the navigation database; and

   c. The navigation database is not corrupt as determined by a CRC check at system initialization.

TAWS Automatic Inhibit Functions (Normal Operation):

The following automatic inhibit functions occur during normal TAWS operation to prevent nuisance warnings:

1. The FLTA function is automatically inhibited when in the Terminal, Departure, IFR Approach or VFR Approach Modes and within 2NM of the reference point.
2. The PDA function is automatically inhibited when within 2NM of the approach runway threshold.
3. GPWS Modes 1 through 5 are automatically inhibited when below 50 feet AGL (radar altimeter AGL altitude) or below 100 feet AGL (terrain database AGL altitude).
4. GPWS Mode 4 is inhibited while Mode 3 is armed.

As these inhibit modes are part of normal TAWS operation, no annunciation is given when they are engaged.

5. The FLTA function is automatically inhibited in HTAWS applications when the airspeed is below 50 knots to prevent spurious warnings when hovering or landing off-airport.

TAWS Automatic Inhibit Functions (Abnormal Operation):

The following automatic inhibit functions occur during the specified abnormal operations:

1. Autorotation detection. When engine torque drops below 7.5%, a Class A HTAWS system enters Autorotation Mode. In this mode:
   a. GPWS Mode 1 is inhibited;
   b. GPWS Mode 2 is inhibited; and
   c. GPWS Mode 4 uses a modified envelope (see GPWS Mode 4 description above).

2. System Sensor/Database Failures. System sensor failures, non-installation of optional sensors, database failures and combinations thereof affect the TAWS system as follows:

Sensor	Parameters Lost	Terr. Displ.	FLTA	PDA	GPWS Mode 1	GPWS Mode 2	GPWS Mode 3	GPWS Mode 4	GPWS Mode 5	500' Wake-Up
GPS (H)	AC Position	Inhibit	Inhibit	Inhibit						
TD	Terrain Elevation	Inhibit	Inhibit							
ILS	Glideslope Deviation								Inhibit	
GPS (H) + Radalt	AC Position, AGL Altitude	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit
GPS (V) + ADC	MSL Altitude, VSI	Inhibit	Inhibit	Inhibit	Inhibit		Inhibit			
TD + Radalt	Terrain Elevation, AGL Altitude	Inhibit	Inhibit		Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit
GPS (V) + ADC + Radalt	MSL Altitude, VSI, AGL Altitude	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit	Inhibit
GPS (V) + ADC + ILS	MSL Altitude, VSI, Glideslope Deviation	Inhibit	Inhibit	Inhibit	Inhibit		Inhibit		Inhibit	

Notes:

1. The combinations listed give the minimum combinations with the worst consequences. Many other combinations are possible, but their effects are subsumed within the combinations listed.
2. GPS (H) = HFOM > 0.3NM or loss of integrity or loss of navigation. Indication is "NO GPS" flag for loss of integrity or loss of navigation.
3. GPS (V) = VFOM > 75' or loss of integrity or loss of navigation. Indication is "NO GPS" flag for loss of integrity or loss of navigation.
4. GPS = GPS (H) + GPS (V). Indication is "NO GPS" flag for loss of integrity or loss of navigation.
5. TD = Terrain Data invalid. This would be due to being beyond the database boundaries, as the system will not initialize if database errors are detected on system start.
6. ADC = Air Data Computer. Indication is "NO AIR DATA" flag.
7. Radalt = Radar Altimeter. Indication is lack of radar altimeter source indication on radar altimeter display.
8. ILS = ILS Glideslope Deviation. Indication is lack of glideslope needles.

TAWS Functions:

The following manual inhibit functions can be selected by the pilot:

1. The Terrain Display function can be manually inhibited using the EFIS declutter menu.
2. All TAWS alerting functions can be manually inhibited by actuation of the external TAWS Inhibit Switch. The Terrain Display function is not affected by the TAWS Inhibit Switch.
3. In HTAWS systems, the TAWS Inhibit Switch disables the pop-up function such that the map does not automatically change scaling.

4. In HTAWS systems, a Low Altitude Mode Switch can be actuated to inhibit or modify parameters for alerting functions. The purpose of this switch is to desensitize the HTAWS when purposefully flying VFR at low altitudes. Low Altitude Mode has the following effects:
    a. If source terrain data has a resolution lower than 6 arc-seconds, the FLTA function is inhibited. If source terrain data resolution is equal to or better than 6 arc-seconds, FLTA parameters are modified.
    b. GPWS Mode 1 is inhibited.
    c. GPWS Mode 2 in inhibited.
    d. GPWS Mode 3 is inhibited.
5. GPWS Mode 5 can be manually inhibited by actuation of the momentary Glideslope Cancel Switch when below 2000’ AGL. GPWS Mode 5 manual inhibit is automatically reset by ascending above 2000’AGL or descending below the automatic inhibit altitude (50 feet AGL with radar altimeter AGL source or 100 feet AGL with terrain database AGL source).