A SYNTHETIC VISION UPDATE

One powerful development of the glass revolution is synthetic vision with its computer-generated terrain images. Is it enhanced situational awareness or TMI?

by Fred Simonds

IFR pilots fly the three most dangerous profiles in general aviation: IMC, at night and in low visibility. Not surprisingly, those profiles represent the majority of GA fatal accidents.

Technology has precipitated a sea change in the way IFR is conducted. More than any development since Doolittle made the first "blind" flight, the "glass" revolution has offered situational awareness on a scale bordering on TMI: Too Much Information.

Now we have synthetic vision available in more and more GA flight decks.

What Is It?

The FAA has defined synthetic vision as "a computer-generated image of external scene topography from the perspective of the flight deck, derived from aircraft attitude, high-precision navigation and a database of terrain, obstacles and relevant cultural features." "Cultural features" means human-built things like towers, runways and obstacles.

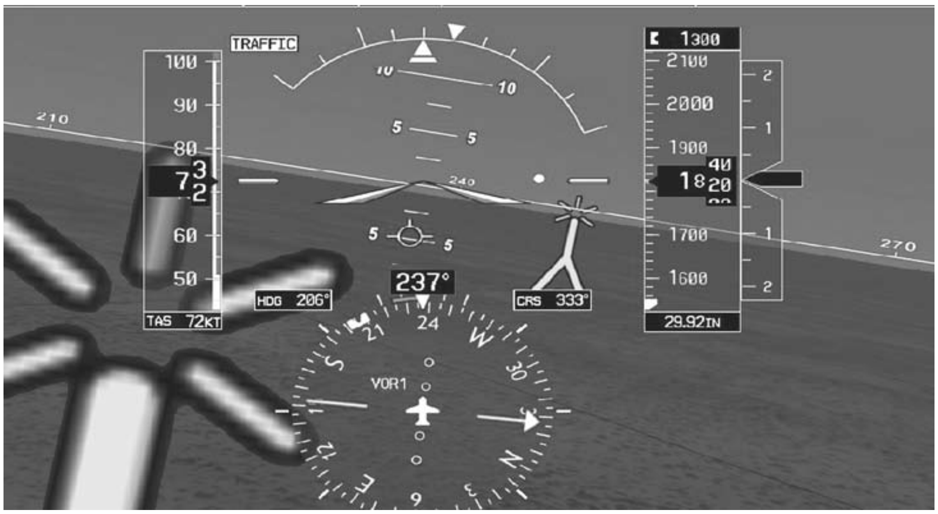
The question becomes, is synthetic vision (SV) a useful aid to awareness or just TMI?

The FAA clearly believes the former, but with many caveats as discussed in their thoughtful Aviation Circular 23-26.

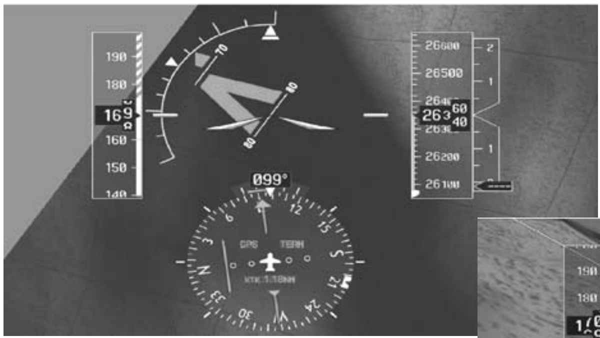
From '50s Head Up Displays

Synthetic vision originated in the 1950s in the military, an extension from head-up displays into SV as a head-down display. NASA has worked with SV since the late '80s. Years of research are in every SV device sold.

SV for general aviation began in 1994 with AGATE, a consortium of the FAA, NASA and private indus-



Synthetic vision's depiction of a tower (right of center) is nearly unmistakable.



try. Along with Highway In The Sky (HITS) pathway displays (more on this later), SV promised better situational and geographic awareness, lower pilot workload and quicker error detection.

AGATE saw SV as a way to artificially make IMC flying resemble clear, daytime weather, believing that mistakes made in IMC would decrease and the GA accident rate would fall.

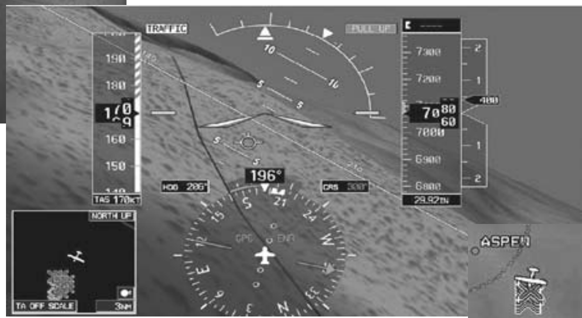
If safety was the first consideration, utility was close behind, coupled with peddling more airplanes.

SV and Terrain

Generally, SV installations in GA aircraft offer terrain awareness, not avoidance.

The display is not accurate enough to thread you through mountains, but is sufficient to help you avoid a CFIT accident or colliding with a tower. The display reasonably represents terrain but is limited in field of view and resolution.

FAA AC 23-26 compares this to the "compressed" image in your car's rearview mirror – useful if not entirely accurate.



Synthetic vision screen shots from the Garmin G1000 PC Trainer: Even at 80 degrees nose down the horizon is visibile (upper left); a CFIT in progress (above); and a CFIT as seen on the MFD (right).

Terrain images are drawn on the SV display from a *digital elevation model* database. Obstacles such as towers exceeding 200 ft. AGL, landmarks and the like are also drawn but derived from logically separate government databases.

This is because obstacles change and need updates whereas mountainous terrain is forever.

Manufacturers can apply Terrain Awareness Warning System (TAWS) specifications or develop their own system. If the latter, it must generate a visual and aural one-minute caution and 30-second warning if the current flight path will meet terrain or an obstacle.

A safety margin of at least 100 feet is mandated, but seems mighty thin to me.

Buyers of SV systems should assure themselves that the system includes terrain and obstacle data. TAWS-approved databases are okay for synthetic vision use. All the same, NOTAMs and ATIS remain the best real-time sources of obstacle information.

If TAWS is installed, it must not

SYNTHETIC VISION ON DISPLAY

The eye-friendly SV presentation is the product of much research. Since the SV background varies, the zero-pitch line is solid, bold and extends across the entire LCD panel. It helps pilots avoid using a deceptive terrain image such as downward sloping terrain which could look like a climb.

SV alone may not provide sufficient depth perception or field of view. A second top-down display should depict the same features, which could be shown as an inset.

Terrain coloring and shading help clarify the essential distinction between ground and sky. Bands of color as on our sectional charts help, but lighter colors can cause painful contrasts at night, and can wash out in direct sunlight. Shadowing can also help, but must not obscure terrain features in shadow.

One way SV avoids confusing large bodies of water with sky is by coloring water as dark blue or black against a lighter blue sky, and enhancing the distinction with shading and texturing.

Traditional symbols such as pitch "ladder" marks indicating degrees of pitch must always be on top, as must traffic and tower symbols.

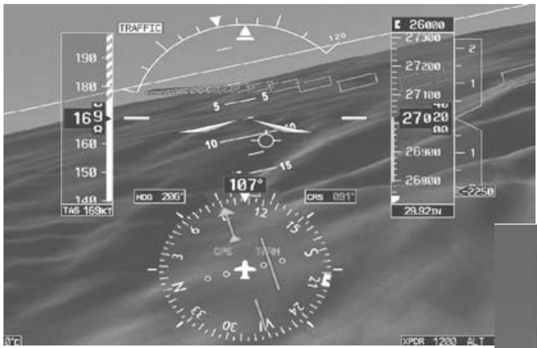
Neither must be washed out by background terrain.

Aural callouts remind pilots of approaching minimums, and may be pilot-selectable or automatic. This can prevent a pilot who "sees" the runway on the SV from going too low because they are fixating on course guidance, not minimums.

Synthetic vision's background can clutter the readability and interpretability of basic information on the PFD. SV systems typically allow levels of "decluttering" detail.

SVs are carefully designed to prevent or minimize misleading orientation and terrain cues.

The FAA's commonsense approach requires SV's level of safety to at least equal the conventional instruments it replaces.



conflict with SV, which would be confusing at the least. The FAA cautions that SV may be so compelling that pilots may be tempted to rely solely on it for terrain avoidance.

However, a potential accumulation of small errors dictates that additional flight and navigation information be consulted to avoid cumulogranite.

The SV display is designed to help pilots clearly distinguish terrain above and below the aircraft.

All's well if there is no terrain at or above the zero-pitch line and hopefully well below.

HITS symbols, also known as flight path markers, should appear above the terrain and not lead through a hillside. Good idea.

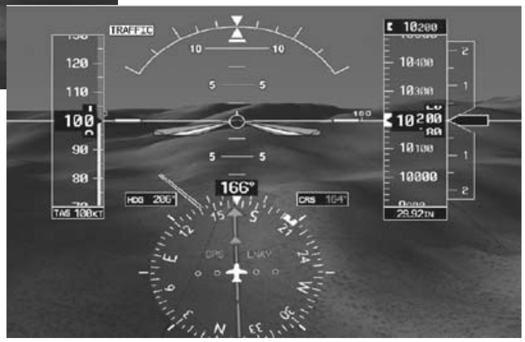
The bugaboo in GPS and SV navigation is HMI – hazardously misleading information. HMI is the stuff of nightmares where the flight management system sends you on an incorrect heading to nowhere or indicates a dangerous flight path. The avoidance and statistical calculation of the likelihood of HMI is utterly paramount in the world of silicon navigation.

No one suggests that SV replace approach plates. But an SV depiction of an approach should correlate with the plate. Secondary features like rail lines, roads and lakes are fine on MFDs, but discouraged on PFDs as TMI.

Highway In The Sky

HITS is often bundled with SV. HITS "provides a picture of the selected or programmed navigation path using a perspective view of the path. The three-dimensional pathway provides navigation position information to pilots."

A HITS pathway is a receding series of rectangular or oval-shaped flight path markers. If you fly through the center of each, you're on course. It's a flight director on steroids. The benefits are improved pilot performance and reduced workload.



Some of the abilities of synthetic vision: joining Highway In The Sky (upper left - the goal is to fly through the rectangles); top of descent for the GPS-C into Aspen, Co. (above), at the MAP for runway 15, Aspen (right).

Marker symbols are "damped" to appear smoothly, making them easy to fly.

A pathway is designed to be easily reacquired if it leaves the PFD's field of view. FAA pilots evaluate this and every other aspect of a synthetic vision system.

Pathway Fixation

Pilots may find flying the pathway so compelling that they fixate on flying through the hoops or boxes. It's necessary to train out of this.

On approach from FAF to MAP, HITS shows a vertical descent path including stepdown fixes even if the approach offers only lateral navigation.

It then shows the glidepath from MAP to runway. Should a pathway go behind or through terrain, it is HMI, is not presented and triggers a terrain conflict warning. A conflict is easily recognized as a break in path continuity in or near terrain.

On the miss, the pathway does not take the pilot below MDA nor down to MDA if the miss is begun early.

Should the airplane stray below MDA, the pathway shows vertical guidance to at least MDA.

If the pilot elects to miss early, the pathway goes to the MAP and then to the miss unless the pilot is so far off that going to the MAP is impractical.

In GA, approach pathway vertical navigation is GPS or ILS, and the system tells the pilot which is in use. This dual-sensor implementation serves up the pathway from GPS but raw ILS data is flown.

Pilots must comply with MDAs and DAs as usual. En route, barometric altitude for vertical guidance is required in order to be consistent with other airspace users.

Pilots can fly with SV, SV plus HITS or neither.

HITS shines when flying complex SIDs or STARs. With HITS you can meet altitude restrictions smoothly and precisely.

You don't need a fancy airplane to sample SV or HITS. The Garmin G1000 PC Trainer or a simulator incorporating a recent G1000 will do. Try it out. It's a blast.

Fred Simonds is a Gold Seal CFII and factory-certified G1000 instructor. See his web page at www.fredonflying.com.