L-3 Avionics Systems' IRIS long-wave system was introduced in 2006.

Envisioning What Lies Ahead

Synthetic and Enhanced Vision Point the Way to the Future

STORY BY JAMES WYNBRANDT

Visionaries always lead the way to the future, and perhaps nowhere more so than in today's aircraft cockpits where synthetic vision systems (SVS) and enhanced vision systems (EVS) are showing pilots the path to tomorrow. With their ability to reveal what lies ahead in any weather or light condition, SVS and EVS dramatically improve situational awareness and safety in all phases of operation — ground and air.

Different but complementary, SVS and EVS comprise an integral part of the FAA's Next Generation Air Transportation System. The systems' rapid appearance in the marketplace and breadth of products is enough to make one's eyes blur. So, let's catch our breath for a moment to assess the technologies and products, and see where they're taking us.

Synthetic and Enhanced Vision: The Big Picture

Synthetic vision is a computer-generated image of external topography and features, such as runways and obstacles as seen from the perspective of the flight deck, derived from a terrain database (also called a digital elevation model), the aircraft's state (heading, airspeed and attitude) and its position. It is "synthetic" in that it is not a real-time depiction of the world but a virtual recreation of it.

Enhanced vision is an image of external topography and features derived from sensors (usually infrared sensors) in real-time. Vision is "enhanced" in that it displays details invisible to the naked eye in fog, darkness or other occluded conditions.

Although relatively new to general aviation cockpits, the technologies have been in development for decades, dating in the case of synthetic vision to the Joint Army-Navy Instrumentation Research program of the 1950s, and for enhanced vision to the FAA's efforts to develop an infrared-based, low-visibility landing system under the Synthetic

Vision Flight Demonstration Program of the 1970s. General aviation got into the picture in 1994, with the introduction of the Advanced General Aviation Transport Experiment program involving the FAA, NASA and private industry.

Meanwhile, the high-tech revolution epitomized by computers and the Internet created the processors, display technology and other hardware that have made effective and affordable SVS and EVS a reality. But complementary as these technologies are, each needs to be understood on its own.

Synthetic Vision

Synthetic vision will provide the foundation for tomorrow's primary flight displays. Instead of an electronic six-pack or a widescreen attitude indicator, the PFD will show the ever-changing panorama ahead as it would appear on a clear day. Air data — airspeed, heading, attitude and other information formerly presented on individual instruments — is overlaid and integrated into the synthetic vision display.

To ensure SVS achieve their objectives of improving situational awareness and reducing the threat of CFIT (controlled flight into terrain), the FAA and avionics manufacturers developed common standards for system displays, published in Advisory Circular AC 23-26, "Synthetic Vision and Pathway Depictions on the Primary Flight Display." Unlike the different avionics suites driving them, if you can make sense of one SVS display, you can understand them all.

But for all its importance and the variety of branded synthetic vision solutions,

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consumers don't have much choice in selecting an SVS. That's because these aren't interchangeable, standalone products; avionics manufacturers develop their own proprietary SVS and bundle them into their glass-panel avionics suites or other display devices. And aircraft manufacturers typically tweak or revise the SVS to give it brand individuality. (The aircraft maker is, after all, responsible for getting the avionics in their airplanes certified for installation.)

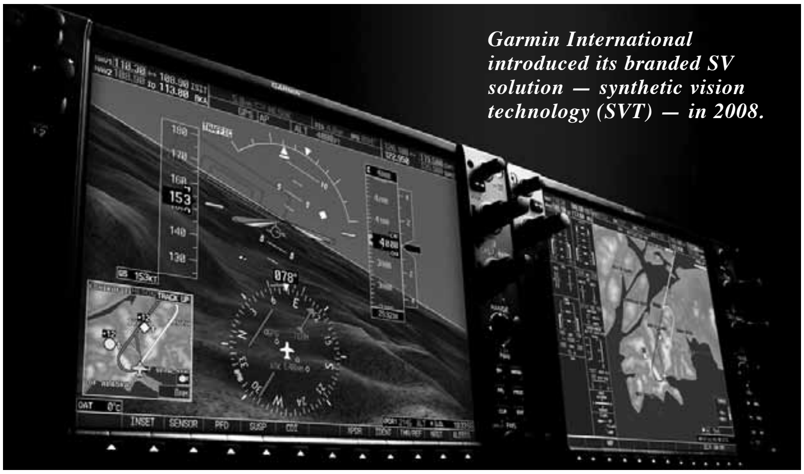
So, SVS might not be the deciding factor when making an aircraft purchase decision or when choosing a glass panel to install in a homebuilt or retrofit in a production aircraft. But buyers and flyers alike should understand the similarities and differences among SVS. Keep in mind, these are software-driven systems, which can be updated and upgraded.

SVS Similarities

The inclusion of primary flight information in the display is only one common element among SVS meeting AC 23-26 guidelines. All these systems also incorporate some form of terrain alerts, providing aural and/or visual warning if the system determines the flight path conflicts with an obstacle ahead. An aircraft's terrain awareness and warning system or enhanced ground proximity warning system database can drive these alerts.

Standards for terrain color and depiction also have been adopted to ensure pilots can quickly identify ground, water and sky from each other. The palette for the terrain resembles colors used on a sectional chart. However, the color of the terrain changes with its threat level, going to amber, then red as the vertical separation between aircraft and ground or obstacle ahead shrinks.

AC 23-26 also calls for a zero pitch line, a high-contrast horizon bar, so pilots can easily distinguish between terrain above and below the airplane.



Garmin International introduced its branded SV solution — synthetic vision technology (SVT) — in 2008.

SVS displays also include what is termed "cultural features," landmarks including airports, runways, waterways and obstacles, such as towers and tall buildings. Some features might be exaggerated in relative size as the aircraft nears them.

All conforming SVS allow pathway, or highway-in-the-sky (HITS) depictions, displaying the desired course with graphics, such as a series of cascading boxes. HITS depiction incorporates a flight path marker or velocity vector derived from head-up display symbology developed for military fighter pilots. The key to this capability is the system's ability to differentiate between where the airplane is pointed — its heading — and where it actually is going — its track.

Heading and track often are at odds because of wind drift, crab angle, or a climb or decent angle that does not match the aircraft's attitude relative to the horizon. Generating a flight path marker previously required heavy, expensive inertial systems, but the development of miniature accelerometers has brought this tool to the masses.

SVS Differences

Despite the similarities, there are substantial differences between SVS — some visible, others literally behind the scenes affecting performance and quality.

Among visible differences, display presentation is most obvious. Creating the moving picture and integrating air data in a useful and pleasing way on the PFD is both an art and a science. Each manufacturer, along with its designers, engineers and architects, has its own aesthetic sense, a unique approach to presenting data, and individual ideas about the preferences of its customers. This is reflected in the "look" of each SVS display, and it helps explain why the same view and data seen on two different SVS appear different.

Data resolution, the degree of fidelity of the SV image, is another differentiator. SVS resolution is based on the distance between survey points as measured in arc seconds. Processors fill in the spaces between the points to create

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synthetic vision — the higher the resolution, the more realistic the view. One arc second represents about 30 meters.

RTCA recommends SVS use one-second arc data in terminal areas and three-second arc data in en route environments. The FAA suggests 30 arc seconds as the minimum recommended resolution for an SVS. Apparent image detail does not always reflect the actual resolution; some lower-resolution systems buff the data with processors to give the images a higher-resolution appearance.

The databases SVS call upon to create their images differ as well. The raw data comes from two primary sources: shuttle radar topographic mission (SRTM) data from NASA, derived from a mapping mission conducted by the Space Shuttle, and digital terrain elevation data (DTED) from the National Geospatial Intelligence Agency.

The quality of the data is not uniform. The SRTM data is superior for most locations; the DTED data is superior in others. Data from Jeppesen and other private sources, such as commercial mapping companies, can be incorporated as well. The relative quality of the databases and how they're blended affects the accuracy of the topographical display.

The view on the PFD needs to be seamless and consistent with the aircraft's position, making the display update rate an important consideration. The

An exocentric view from Universal Avionics' Vision-1 SVS technology.

rate is particularly critical during instrument approaches when continual course corrections might be required. The faster the aircraft, the higher the rate should be. While no update rate requirements exist, discussions with designers and engineers suggest 15 frames per second as a reasonable minimum for advisory guidance in the approach environment.

Certification standards are another major difference separating SVS (and EVS). Systems certified for Part 23 (commuter) and Part 25 (transport category) aircraft must meet more stringent standards than systems certified for normal and utility category airplanes used in Part 91 operations.

Vendors and Products

Synthetic vision's path from research to development to implementation has been remarkably short. Just six years ago, in 2003, Chelton Flight Systems' FlightLogic EFIS (electronic flight information system) became the first certified SVS, approved for retrofit installations aboard air taxi and bush planes under the FAA's Capstone Project in Alaska, where the systems

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Chelton is now part of Cobham Avionics System Integration, and FlightLogic's SVS is a best-seller among light and medium helicopters.

Other significant developments are even more recent. In 2007, Universal Avionics' Vision 1 became the first SVS certified for a Part 25 aircraft (although only for MFDs, not PFDs) through its supplemental type certificate installation in a Challenger 601.

In 2008, using the SVS Honeywell designed for its Primus Epic avionics suite as a base, Gulfstream Aerospace of Savannah, Ga., became the first aircraft manufacturer to offer SVS for a Part 25 aircraft, with its proprietary synthetic vision/primary flight display, a system also incorporating a separate EVS display. Honeywell's own SVS for the Primus Epic suite has been chosen for business jets made by Cessna, Embraer, Falcon and Hawker Beechcraft, and rotorcraft manufacturer AgustaWestland. Honeywell will make its SVS available as a retrofit for aircraft with legacy Primus Epic systems.

Rockwell Collins' Pro Line Fusion, launched in 2007, combines synthetic vision and enhanced vision, hence the "fusion" name. It is certified for Bombardier Global 5000 and Global Express XRS, and it has been selected for the Cessna Citation Columbus, Learjet 85, Embraer Legacy and Gulfstream G250. Rockwell Collins has not reached a decision as to whether or not synthetic vision will be available as a retrofit on legacy Pro Line 21 panels.

Garmin International introduced its branded synthetic vision solution — synthetic vision technology (SVT) — in 2008. SVT can be retrofitted into any G1000 installation as long as the aircraft manufacturer has received FAA approval for an STC. Garmin's G600, G900X and G950 (for retrofit in production aircraft and experimentals, as well as for OEM installations) also support SVT.

Avidyne Corp. offers SVS on the next iteration of its Entegra

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glass panel. The SVS can be retrofitted in Release 9 versions of Entegra.

L-3 Avionics Systems has added synthetic vision capability to its SmartDeck as it seeks an OEM launch customer for the glass panel.

At this point, homebuilders are probably asking, “What took you so long?” In 2002, experimental aircraft glass-panel manufacturer Blue Mountain Avionics first offered SVS. The latest iteration runs on its EFIS/ One and other EFIS series displays.

MGL Avionics of South Africa, a glass-panel manufacturer for experimentals, has used free terrain data from the FAA and simple wireframe depictions to keep costs low for its SVS. Its upgraded Voyager and Odyssey panels, due in the second half of 2009, can incorporate shaded terrain depictions.

SVS has even migrated to portable devices. Honeywell has added synthetic vision capability to the Bendix/King AV8OR Horizon 3D.

Enhanced Vision

Enhanced vision systems distinguish themselves from synthetic vision systems the moment the display screen fires up. EVS show the real world and all the transient hazards that no database contains: people and aircraft on a dark apron at night; an unlit aircraft being towed across a taxiway; deer on the runway that otherwise would be invisible.

EVS has been available as an OEM option in an expanding number of business jets since 2002. In 2008, the technology first appeared as an OEM option for piston aircraft when Forward Vision’s EVS-100 was certified in Aviat Aircraft’s Husky. Since then, the system has been certified for OEM installation in other pistons, including Cirrus, Maule and Expedition aircraft, and as an STC retrofit for most Cessna pistons and Robinson helicopters.

Given the power of the technology, the relatively low cost of newer products and the simplicity of adding it to a pilot’s tool chest (an RS-170 video input, which most glass panels have, is all that is required to feed an EVS signal into an MFD), enhanced vision’s popularity likely will soar.

Although product choice is limited, educated consumers should understand how EVS work and some basic differences among them.

All objects emit infrared radiation (heat), a wavelength spectrum just above the length of visible light. Measured in microns, or millionths of a meter, IR waves can penetrate fog, haze, precipitation, smoke and darkness. EVS use onboard IR sensors — typically mounted in a small pod on the airframe — to “see” the IR, then process and translate the data into a picture comprehensible to the human eye, something akin to the picture you’d see on a black-and-white TV screen.

IR radiation can be detected easily only 0within three bandwidths: between 1 and 2 microns (shortwave band); three to five microns (medium); and eight

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to 14 microns (long). Various IR radiation sources are better seen in some frequencies than others. Approach and runway lights, for example, are best seen in the 1 to 2 micron band.

When enhanced vision was first certified — the enhanced flight vision system from Kollsman for Gulfstream — the primary objective was to enhance situational awareness during final approach in low-visibility situations. Because seeing approach and runway lights was the priority, systems relied on a single sensor spanning 1 to 5 microns.

These shortwave sensors required cryogenic cooling, making systems bulky, complicated and expensive, with prices well into the six figures. And the aircraft required an approved head-up display with which to view the image. Yet, it was well worth it for high-end business jets going into unfamiliar and remote airports around the world.

Subsequently, sensor technology employing microbolometers, which didn't need cooling, was developed, led by Max-Viz, and allowed for smaller, lighter and cheaper systems.

Max-Viz's uncooled EVS-1000 and its EVS-2000, the latter using a tandem short- and long-wave sensor and "sensor-fusing" technology, expanded the market. Max-Viz also makes the sensors used in Forward Vision's EVS-100 and EVS-600 units.

Other enhanced vision players include the FLIR System; Goodrich Corp. with its uncooled shortwave ISR-P indium gallium arsenide system; and L-3 Avionics Systems with its IRIS longwave system, introduced in 2006.

The next advance on the horizon is the integration of millimeter-wave radar to supplement infrared EVS. Although not as defined an image as infrared, millimeter-wave radar can see through clouds.

Into the Future

The majority of SVS and EVS are approved for advisory and situational awareness only; however, in the future, fused imagery of these two technologies might qualify an equipped aircraft for "operational credit," such as lower landing minima during instrument approaches. Currently, only EVS incorporating an approved HUD qualify for such credit.

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