AVIONICS NEWS IS A PUBLICATION OF THE AIRCRAFT ELECTRONICS ASSOCIATION.

AVIONICS NEWS

MAY 2019
avionicsnews.net

HEAD-UP FLYING

HUDs HELP KEEP PILOTS' EYES OUTSIDE THE COCKPIT

GARRY JOYCE

New AEA board chairman

AEA's international leadership reflects its global influence

Garmin's GHD 2100 HUD

HEAD-UP FLYING

HUDs HELP KEEP PILOTS' EYES OUTSIDE THE COCKPIT

STORY BY DAVE HIGDON

Eyes out the windows.

It's mantra preached by flight instructors since the advent of the enclosed-cabin airplane almost a century ago. But eyes-out flying risks missing critical flight information from the panel instruments.

Still, eyes-down ignores the risk of meeting other traffic. The solution developed through years of flying experience is the head-up display, or HUD.

According to a 2009 study by the Flight Safety Foundation, more than one-third of all accidents of glass-cockpit-equipped turbine aircraft might have been avoided if the flight crew had access to a HUD system. The same benefits accrue to smaller, slower aircraft using HUD systems.

Resolving the inherent conflict between the need to have eyes out for traffic and head-down for instruments spurred years of inventions, research, system evolution and market penetration leading to today's solution for aircraft ranging from light-sport to airliners and business-turbine aircraft.

Today, HUDs exist in a variety of sizes and applications usable in everything from light-experimental to piston singles to light business-turbine aircraft.

Collins Aerospace's HGS-3500

The evolution of HUDs

You could reasonably argue that today's head-up displays had their genesis more than a century ago, at the very dawn of the age of aviation. That first incarnation sought to help combat pilots shoot down enemy aircraft: the reflector sight.

After all, eyes outside is all well and good except when the pilot needs to evade enemy aircraft – or, in civilian aircraft, monitor instruments for takeoff, for landing and maneuvering. Resolving this conflict occupied the minds of some very sharp engineers, for years, many of them informed by their experiences flying combat aircraft during World War II and later.

That World War I reflector sight, a development of Germany, provided a parallax-free optical sight to help pilots aim. Pilots of Mustangs and Thunderbolts and Corsairs and the rest enjoyed the advantage of head-up gunsights, called the gyro gunsight.

This evolution of the reflector sight added gyro correction to the pilot's optical aiming device to help them point their machine guns where the enemy plane would be when the bullets got there. That's called leading the target, something any bird hunter, skeet or trap shooter knows.

Ditto for combat pilots – though when the gun platform and target both move at high speed and in three dimensions, the skill isn't the easiest to master. But master you must to survive air-to-air combat.

Those early air-combat pilots enjoyed the benefits of flying head-up during dogfights and by the mid-1930s the follow-on gyro gunsight. The gyro gunsight added a reticle that moved in reaction to the aircraft's speed and turn rate to solve the amount of lead necessary and show the solution to the pilot.

As aircraft performance advanced and the jet age produced higher speeds, aircraft makers and avionics engineers recognized the benefits of putting flight information where the pilot could see instruments with their head up.

Few flying situations beg more for head-up flying than aircraft carrier ops. The pilot must glance at the gauges between monitoring the landing signal officer's flag signals and the approach end of a flight deck moving away from the aircraft at 30-plus knots.

By the mid-1950s, the U.S. Navy's Office of Naval Research and Development developed a mock-up of a HUD concept, as well as a sidestick control hoping to ease the higher workload of pilots flying modern jet aircraft while simplifying the instrumentation. That research didn't make it into any cockpits of the day.

But that crude HUD mock-up used all the features of today's modern HUD units: a projector, combiner and video-generation computer processor.

With traditional HUD systems, the large projector unit mounted on the cockpit to shine its light on an optical combiner, a type of lens mounted ahead of the pilot and on the

Continued on following page

Continued from page 23

pilot's line of sight. The optical combiner typically stows away when not in use.

Until the past decade or so, the size of HUD components largely precluded their use in anything smaller than an airliner. But technologies change, and the revolutions in digital technologies helped these systems evolve both in capabilities and sizes.

What you see is what you need

At a minimum, a functional HUD projects an image on a screen that shows flight data ahead of the aircraft itself – so the pilot's eyes need not change focal point when scanning between the touchdown zone and the HUD imagery.

The basic information approaches that of a primary flight display, typically indicating attitude, compass indication, altitude, airspeed and vertical speed.

As HUDs and computing power improved, some HUDs incorporated more data such as navigation indication, radio frequencies, threat presentations, even terrain in recent years.

The appeal of a HUD advanced so much that automakers began incorporating relatively simple HUDs into their products. Most show at least a speedometer, but some add more relevant indications such as transmission-shifter position, fuel level, oil pressure and coolant temperature.

The benefits are common: More time looking ahead and less time looking down at the panel – dashboard, in this case.

As the capabilities of aircraft HUDs advanced, engineers added more indications. Today, HUDs on higher-performance systems include day and all weather flight symbology with details such as distance-measuring equipment distance, localizer and glideslope indications, radar altimeter, even the simulated outline of runways in the aircraft's database.

In the opinion of many pilots, a HUD most shows its worth at night and in instrument meteorological conditions, but others value them as much during daylight and visual meteorological conditions. The need to monitor traffic adds to the value of a HUD.

Some HUDs display traffic from various sensors. Another feature on some: An overlay of outside terrain features via an enhanced-vision-system sensor, an increasingly common feature on business jets.

ACCORDING TO A 2009 STUDY BY THE FLIGHT SAFETY FOUNDATION, MORE THAN ONE-THIRD OF ALL ACCIDENTS OF GLASS-COCKPIT-EQUIPPED TURBINE AIRCRAFT MIGHT HAVE BEEN AVOIDED IF THE FLIGHT CREW HAD ACCESS TO A HUD SYSTEM.

Options span the spectrum

Today, HUDs exist in varying sizes and capabilities with most sharing their basic abilities. Advances in HUD technology contributed to the development of smaller systems using different projection approaches and display plates.

These systems' smaller sizes make them suitable for installation in the cockpits of business-turbine aircraft down to light jets and turboprops. But these newer-technology systems provide benefits beyond being smaller, lighter and less power-hungry.

Rockwell Collins, now Collins Aerospace, led the way into use of the new technology when it unveiled its HGS-3500 back in 2011. The self-contained, lightweight HGS-3500 uses LED illumination and eliminates the typical overhead-mounted projector. Using substrate guided optics, the HGS-3500 projects the forward field of view through the head-up display by way of an optical waveguide.

First certification of the HGS-3500 – and a companion EVS-3000 EVS sensor – came in 2016 for launch customer Embraer in its Legacy 450 and Legacy 500.

Many folks might want to hit the pause button here. The 450 and larger 500 share an airframe, differing in length by only 4 feet, as well as range and capacity. But neither Legacy model is exactly a small jet.

Compared to other jets in its weight range – both in between 35,000 and 38,000 pounds at takeoff – the Brazilian airframes sport cockpits much smaller than their contemporaries from other OEMs.

The HGS-3500 answered Embraer's desire to give the two Legacies – and their follow-on Praetor 500 and Praetor 600 models – the most cutting-edge cockpit possible. The HGS and EVS sensor work together to fulfill that goal.

At its launch in 2011, Rockwell Collins noted its plans to continue shrinking the HGS-3500 to work in the cockpit of today's popular single-engine turboprops, such as the Daher TBM line – 700 through 940 models – Piper M600 and Pilatus PC-12 and its twin-jet stablemate, the PC-24.

Limitations for the HGS/EVS combination: It needs to mate with Collins' Pro Line Fusion integrated avionics package. Now at an estimated $150,000 installed, this enhanced flight vision system package is proving attractive to operators flying behind Pro Line Fusion panels, and other certifications will expand access to the HGS-3500.

In October 2018, Universal Avionics, an Elbit Systems Company, took HUD technology to another level when it introduced

In 2018, Universal Avionics, an Elbit Systems Company, introduced its head-up, head-down flight deck system with the integration of the InSight Display System and Elbit Systems' SkyLens wearable head-up display.

its head-up, head-down flight deck system at the NBAA Convention & Exhibition with the integration of the InSight Display System and Elbit Systems' SkyLens wearable head-up display. This product offers a wearable HUD to the retrofit market and, according to the company, reduces workload in critical flight phases by allowing the operator to program the FMS looking out the window while flying the aircraft.

"The integration of UA's InSight and Elbit Systems' SkyLens takes this technology into a new level of functionality which the market has never seen before," said Dror Yahav, Elbit Systems' vice president of commercial aviation, who was later named Universal's chief executive officer. "Leveraging the fact that these two systems are now owned by the same design house and company enables us to bring the augmented reality trend into the aviation world so operators can receive full flight management information generated by the FMS, superimposed on the real world."

For aircraft slower and lighter, systems are beginning to emerge to help spread the benefits of the modern HUD down into the realm of piston singles.

Options are growing

A number of avionics companies offer retrofit systems for light aircraft, systems rated highly enough that at least one airframe maker offers the system as an option for owners of its aircraft.

Here's a brief sample from a few AEA members. Other systems worth checking out are also available for retrofit in light-piston aircraft, both type certificated and experimental, amateur-built aircraft.

Garmin's GHD 2100 HUD

In May 2017, Garmin unveiled its launch into the HUD market, the Garmin Head-up Display 2100 – designated the GHD 2100.

Garmin's engineers designed the GHD 2100 for business-turbine aircraft in the light, midsize and super-midsize categories. The sole display unit integrates a self-contained projection system delivering a 30-degree-wide by 24-degree-vertical field of view.

One unusual feature in the GHD 2100 is a "simplistic control interface" with "intelligent dimming. This feature lets the GHD 2100 adjust automatically to ambient light to help the pilot focus on flying the aircraft." Garmin also gave the GHD 2100 a declutter mode to let the pilot choose how much data the HUD displays.

The information displayed by the GHD 2100 matches the symbology Garmin uses on its PFDs. Flight data available includes all the critical information shown on Garmin PFDs; conformal attitude and flight path overlaying the real-world view outside the windshield; flight plan and navigation information; autopilot modes; master warning/caution annunciations; and synthetic vision technology.

According to Garmin, since the synthetic vision image

Continued on following page

Continued from page 25

echoes the pilot view outside the cockpit, on a clear day, pilots have an easier time making the transition from flying with the GHD, to the flight display – or the outside view.

Garmin also integrated its SurfaceWatch ground-situation software into the GHD 2100. By employing takeoff performance data entered into Garmin avionics, the GHD 2100 also provides visual and aural cues to warn pilots about taking off or landing on a too-short runway, the wrong runway, or a taxiway.

The GHD 2100 also displays a flight path marker and flight path-based flight director. The flight path marker includes speed offset and velocity cue, according to Garmin's information, to help the flight crew employ precise energy management in-flight.

Garmin took a forward-looking approach to its first HUD product, equipping it with growth provisions built-in. Future enhancements include options such as external video cameras, multispectral enhanced vision systems and more.

Textron Aviation tapped the GHD 2100 for flight tests in the new Cessna Citation Longitude, a super-midsize business jet using Garmin's G5000 flight deck. Cessna installed the GHD in the Longitude prototype. The feature will be available in the future with another certification now that the Longitude has been type-certificated and entered service.

Estimated installed cost of the optional HUD/EVS package runs between $500,000 and $600,000. Textron plans to pursue approval for available lower approach minimums when using the HUD/EVS.

MyGoFlight's SkyDisplay HUD

This product came as something of a surprise when MyGoFlight, maker of all forms of cockpit conveniences (iPad mounts, screen protectors, clothing, flight bags, etc.) unveiled its new SkyDisplay HUD.

The SkyDisplay HUD uses flight information received from installed avionics that allows pilots to fly with their head up and eyes out, as with other HUD systems.

Compact and lightweight – about 2 pounds – the SkyDisplay is small enough and compact enough to fit into the cockpit of many piston singles – and larger general aviation aircraft.

The SkyDisplay, however, differs somewhat from most approved HUD systems.

First, the MyGoFlight HUD displays two colors on its combiner screen. While the display unit itself outputs in full color, MyGoFlight limited the colors used to two – green and magenta – the two colors that can safely be used in all light and background color situations, according to the company.

Also, its display is nonconformal, which means the HUD doesn't allow the pilot to use the flight-path marker as a flight-path vector. Additionally, the SkyDisplay's symbology doesn't overlay terrain graphics precisely.

Conversely, the SkyDisplay's $25,000 price, plus installation, is a fraction of the cost of other approved HUDs. Additionally, the SkyDisplay's combiner screen adjusts to match the pilots line of sight, not the other way around – making the pilot adjust the seat to find the sweet spot in the HUD's field of view.

The low cost and flexibility more than make up for the nonconformal display, in the view of those who've sampled the SkyDisplay's abilities.

Certification of the SkyDisplay should come by late spring, according to the company. The 35-day government shutdown delayed progress on this product, as it did for other aviation R&D activities. Since, MyGoFlight elected to pursue approval for SkyDisplay as a portable electronic device with certification for the installation provisions.

The first approvals sought cover Part 23 aircraft flown under Part 91. MyGoFlight plans to first STC the system for Avidyne-equipped Cirruses, with Cessna Caravans equipped with Garmin G600 displays next on the list before tackling the then later-model fleet with the Cirrus Perspective By Garmin avionics suite. After that, Pilatus' PC-12 propjet single is another strong prospect for the SkyDisplay.

Textron offers HUD option for pistons: Epic Optix portable HUD

Textron Aviation, maker of the Cessna and Beechcraft line of piston general aviation aircraft, began offering the Epic Optix Epic Eagle portable HUD about a year ago, and acceptance has been strong.

Epic Optix designed the Eagle HUD for light aircraft to help minimize distractions by equipping pilots with flight and navigation information on a full-color high-definition display. The Eagle HUD takes its power from the aircraft, its data via Wi-Fi from a pilot's iPad or portable tablet running either iOS or Android operating system.

Epic Optix bills the Eagle HUD as the first full-color HUD for light general aviation airplanes, and its price – about $2,000 – and flexibility are two keys to the success of the Epic Optix system.

Epic Optix designed the Eagle HUD with a simple clamp to mount the hardware to the leading edge of a glareshield or other firm mounting sources that puts the display in the pilot's line-of-sight.

The company programmed the Eagle firmware to work with Airplay or Screen Mirror to display the flight data of an EFB package running on one of the available mobile devices.

The company says the Eagle HUD works with any type of EFB software application, among them Avidyne's IFD100, Boeing's Foreflight, WingXPro, Garmin Pilot, Appareo Horizons for Stratus and others. ❑