Head-up display

A **head-up display**, or abbreviated as **HUD**, is any transparent display that presents data without requiring the user to look away from his or her usual viewpoint. The origin of the name stems from the user being able to view information with his head "up" and looking forward, instead of angled down looking at lower instruments.

Although they were initially developed for military aviation, HUDs are now used in commercial aircraft, automobiles, and other applications.

History

The first HUDs were essentially advancements of static gun sight technology for military fighter aircraft. Rudimentary HUDs simply projected a “pipper” to aid aircraft gun aiming. As HUDs advanced, more (and more complex) information was added. HUDs soon displayed computed gunnery solutions, using aircraft information such as airspeed and angle of attack, thus greatly increasing the accuracy pilots could achieve in air to air battles.

In June 1952 the Royal Navy released Naval Staff Requirement NA.39 calling for a carrier-borne strike aircraft with a large range capable of carrying a nuclear weapon under enemy radar cover and striking enemy shipping or ports. Blackburn Aircraft won the tender to produce their design which became the Buccaneer. The Buccaneer prototype first flew on 30th April 1958. The aircraft specification called for an Attack Sight giving navigation and weapon release information for the low level attack mode. There was a fierce competition between supporters of the new HUD design and the familiar electro-mechanical Gunsight with the HUD being cited as a radical even foolhardy option. The Air Arm branch of the Ministry sponsored the development of a Strike Sight. The Royal Aircraft Establishment designed the equipment and it was built by Cintel and the system was first integrated in 1958. The Cintel HUD business was taken over by Elliotts and the Buccaneer HUD was manufactured and further developed continuing up to a Mark III version with a total of 375 systems made; it was given a `fit and forget' title by the Royal Navy and it was still in service nearly 25 years

later. BAE Systems thus has a claim to the world's first Head Up Display in operational service.

In Great Britain, it was soon noted that pilots flying with new gun-sights were becoming better at piloting their aircraft. At this point, the HUD expanded its use beyond a weapon aiming instrument into a piloting tool. In the 1960s, French test-pilot Gilbert Klopfstein created the first modern HUD, and a standardized system of HUD symbols so that pilots would only have to learn one system and could more easily transition between aircraft. 1975 saw the development of the modern HUD to be used in instrument flight rules approaches to landing. Klopfstein pioneered HUD technology in military fighter jets and helicopters, aiming to centralize critical flight data within the pilot's field of vision. This approach sought to increase the pilot's scan efficiency and reduce "task saturation" and information overload.

In the 1970s, the HUD was introduced to commercial aviation. In 1988, the Oldsmobile Cutlass Supreme became the first production car with a head-up display.

Until a few years ago, the Embraer 190 and Boeing 737 New Generation Aircraft (737-600,700,800, and 900 series) were the only commercial passenger aircraft to come with an optional HUD. Now, however, the technology is becoming more common with aircraft such as the Canadair RJ, Airbus A318 and several business jets featuring the device. HUD has become standard equipment on the Boeing 787. Furthermore, the Airbus A320, A330, A340 and A380 families are currently undergoing the certification process for a HUD.

Displayed data

Typical aircraft HUDs display airspeed, altitude, a horizon line, heading, turn/bank and slip/skid indicators. These instruments are the minimum required by 14 CFR Part 91. Other symbols and data are also available in some HUDs.

boresight or **waterline** symbol - is fixed on the display and shows where the nose of the aircraft is actually pointing.

flight path vector (FPV) or **velocity vector** symbol - shows where the aircraft is actually going, the sum of all forces acting on the aircraft.[7] For example, if the aircraft is pitched up but is losing energy, then the FPV symbol will be below the horizon even though the boresight symbol is above the horizon. During approach and landing, a pilot can fly the approach by keeping the FPV symbol at the desired descent angle and touchdown point on the runway.

acceleration indicator or **energy cue** - typically to the left of the FPV symbol, it is above it if the aircraft is accelerating, and below the FPV symbol if decelerating.

Since being introduced on HUDs, both the FPV and acceleration symbols are becoming standard on head-down displays (HDD). The actual form of the FPV symbol on an HDD is not standardized but is usually a simple aircraft drawing, such as a circle with two short angled lines, (180 ± 30 degrees) and "wings" on the ends of the descending line. Keeping the FPV on the horizon allows the pilot to fly level turns in various angles of bank.

angle of attack indicator - shows the wing's angle relative to the airmass, often displayed as **"α"**.

navigation data and symbols - for approaches and landings, the flight guidance system can provide visual cues based on navigation aids such as an Instrument Landing System or augmented Global Positioning System such as the Wide Area Augmentation System. Typically this is a circle which fits inside the flight path vector symbol. By "flying to" the guidance cue, the pilot flies the aircraft along the correct flight path

Types

There are two types of HUD. Fixed HUDs require the user to look through a display element attached to the airframe or vehicle chassis. The system determines the image to be presented depending solely on the orientation of the vehicle. Most aircraft HUDs are fixed. Helmet mounted displays (HMD) are technically a form of HUD, the distinction being that they feature a display element that moves with the orientation of the user's *head* relative the airframe. Many modern fighters (such as F/A-18, F-22, Eurofighter) use both a HUD and an HMD concurrently. The F-35 Lightning II was designed without a HUD, relying solely on the HMD, making it the first modern military fighter not to have a fixed HUD.

Military aircraft specific applications
In addition to the generic information described above, military applications include weapons system and sensor data, such as:

target designation (TD) indicator - places a cue over an air or ground target (which is typically derived from radar or inertial navigation system data).

Vc - closing velocity with target.

Range - to target, waypoint, etc.

Launch Acceptability Region (LAR) - displays when an air-air or air-ground weapon can be successfully launched to reach a specified target.

weapon seeker or sensor line of sight - shows where a seeker or sensor is pointing.

weapon status - includes type and number of weapons selected, available, arming, etc.

V/STOL approaches and landings

During the 1980s, the military tested the use of HUDs in vertical take off and landings (VTOL) and short take off and landing (STOL) aircraft. A HUD format was developed at NASA Ames Research Center to provide pilots of V/STOL aircraft with complete flight guidance and control information for Category-IIIC terminal-area flight operations. These flight operations cover a large spectrum, from STOL operations on land-based runways to VTOL operations on aircraft carriers. The principal features of this display format are the integration of the flightpath and pursuit guidance information into a narrow field of view, easily assimilated by the pilot with a single glance, and the superposition of vertical and horizontal situation information. The display is a derivative of a successful design developed for conventional transport aircraft.