AIRCRAFT TECHNICAL BOOK COMPANY

B2

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

DIGITAL TECHNIQUES
ELECTRONIC INSTRUMENT SYSTEMS

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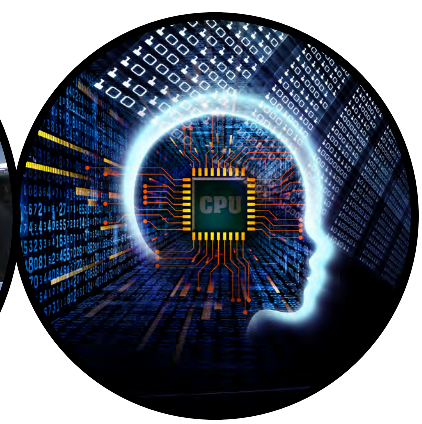

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REVISION LOG

Update notices for this book will be available online at www.actechbooks.com/revisions.html
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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2015.01	Module creation and release.
002	2017.02	Format updates and minor type corrections.
002.1	2019.11	Corrections to Figures: 3-5, 5-14, 8-4, 9-4.
002.2	2022.06	Inclusion of Measurement Standards for clarification, page iv. Minor appearance and format updates.
002.3	2023.04	Minor appearance and format updates.
003	2024.07	Regulatory update for EASA 2023-989 compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria.

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Submodule 1

Electronic Instrument Systems

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
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5.1	**Electronic Instrument Systems** Typical arrangements of systems and cockpit layout of electronic instrument systems.	2

5.1 ELECTRONIC INSTRUMENT SYSTEMS

TYPICAL ARRANGEMENT AND LAYOUT OF ELECTRONIC INSTRUMENT SYSTEMS

ANALOG INSTRUMENTS

Instruments that aid the pilot in controlling altitude, attitude, airspeed, and the heading of the aircraft are known as flight instruments. Since the early days of flight there have been four basic flight instruments that have formed the well-known "T" arrangement located in the center of the instrument panel, as shown in **Figure 1-1**. These four basic instruments are 1) the airspeed indicator, located on the top left, that measures the aircraft's speed in nautical miles per hour; 2) the attitude indicator, located on top center, that shows the aircraft's attitude relative to the earth's horizon; 3) the altimeter, on the top right, that displays the barometric altitude as measured in feet; and 4) the gyro-slaved heading indicator, in the bottom center, which shows which direction the aircraft is flying. These 4 basic flight instruments are typically augmented with a turn-and-bank indicator that displays the rate of turn in the roll axis and amount of bank in the yaw axis, and a vertical speed indicator that displays the rate of ascent or descent in feet per minute.

Assuming that the aircraft has radio navigation aids, it will also come equipped with a Radio Magnetic Indicator (RMI) coupled to an Automatic Direction Finder (ADF), and a Course Deviation Indicator (CDI) driven by VHF Omnidirectional Range (VOR) and Instrument Landing System (ILS) receivers. The ILS receiver drives the glide scope needle to set the glide path on an instrument approach and localizer needle provides lateral guidance to the center of the runway. A VHF Marker Beacon may be used in conjunction with the ILS to indicate position along the approach to the runway.

These early flight instruments were analog meaning that they contained either mechanical or electro-mechanical rotating mechanisms to drive the pointer dials on the instruments. For example, an analog airspeed indicator receives air pressure from the pitot tube, which expands a bellows that turns the dial on the indicator. With a digital system, the pitot air pressure enters an air data computer that converts the analog information into a digital data stream. Digital data is then sent to the airspeed indicator via an aircraft data bus where the data is converted back into analog signals to drive a pointer dial and/or is displayed digitally in numbers.

Figure 1-1. Basic analog cockpit flight instruments.

DIGITAL INSTRUMENTS

With the advent of digital electronics in the early 1970's, Electronic Instrument Systems, also known as "glass cockpits", evolved that were more much more reliable than mechanical or electro-mechanical analog instruments, and had the advantage of combining several flight and navigation functions into one display to provide the crew with greater situational awareness.

The first commercial transport aircraft to employ an Electronic Instrument System (EIS) was the McDonnell Douglas MD-80 in 1979. The EIS on the MD-80 used Cathode Ray Tube (CRT) technology. However, during the next 10 years, Liquid Crystal Display (LCD) technology matured thereby replacing CRTs. Flat-panel LCDs are lighter than CRT displays, require less volume, and consume less electrical power, thereby generating less cockpit heat. Glass cockpit configurations vary widely between

Figure 1-2. Airbus A380 EIS with 8 Large LCD Displays.

aircraft models from a single flight and navigation display in a small private aircraft to five or more LCD displays in a commercial transport aircraft. [**Figure 1-2**]

ELECTRONIC DISPLAYS

The early EIS displays mimicked the analog display formats for ease in pilot training as the crew transitioned from older analog displays to digital displays that were driven by aircraft data computers, known as display processors or symbol generators.

Figure 1-3 depicts an early model Boeing 737 instrument panel with an analog Attitude Direction Indicator (ADI) and analog Horizontal Situation Display (HSI) in the left picture, and a later model B737 instrument panel with electronic ADI (EADI) and electronic HSI (EHSI) displays shown in the right picture.

The ADI or EADI is an artificial horizon with lateral bars superimposed to display computer-generated pitch, roll and bank steering commands from the Flight Director computer. The HSI or EHSI is similar to a heading indicator, except that it combines navigation commands from the VHF Omni-Range (VOR) or Global Positioning System (GPS) receivers, which are used for en-route guidance, or from the Instrument Landing System (ILS), which is used for terminal guidance. Besides heading, the HSI/EHSI also provides actual track, desired track, track angle error, drift angle, cross-track deviation, and distance to destination information, from the Distance Measuring Equipment (DME) or Inertial Navigation System (INS). [**Figure 1-4**]

The pilot and the co-pilot not only have independent EADI and EHSI displays, but they also have independent Display Processor Units, also known as Symbol Generators, to drive their displays. [**Figure 1-5**]

Display formats are produced by the Symbol Generators that receive inputs from the crew and various on-board systems. The Flight Director Systems, Navigation Systems, Air Data Systems, and Weather Radar provide inputs to the Symbol Generators, along with commands from the each crewmember's display control panel. The Symbol Generators produce the graphics for the EADI, EHSI, and an optional Multi-Function Display (MFD) that is mounted in the center instrument panel. The MFD, which is physically identical to the EADI and EHSI, is typically used to display weather radar information; however, it can also be used to display either flight information or navigational information in the event of an EADI or EHSI failure. The following section will discuss the Boeing 777 EIS, which is a more advanced example of the one just covered.

ELECTRONIC FLIGHT INSTRUMENT SYSTEM

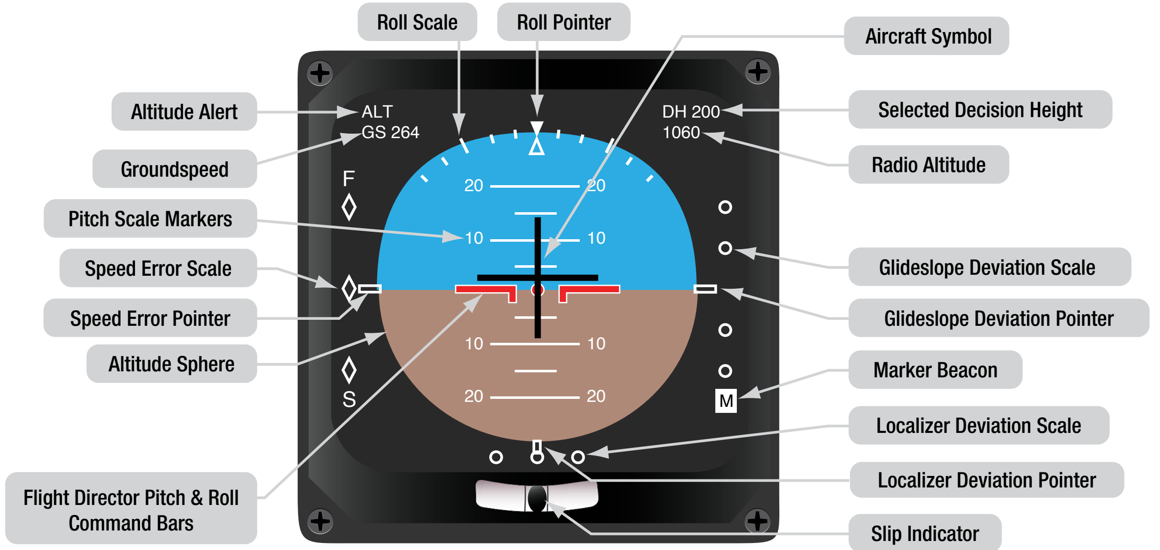
The Boeing 777, which first entered service in 1995, has six 8" × 8" multi-color LCD displays as shown in **Figure 1-6**. The B777 EIS consists of a dual-redundant Electronic Flight Instrument Systems (EFIS) and Engine Indication and Crew Alerting System (EICAS).

On the left side of the instrument panel is the Captain's EFIS, consisting of a Primary Flight Display (PFD) located outboard and a Navigation Display (ND) located inboard. The Co-Pilot's EFIS located on the right instrument panel has an identical PFD and ND, located outboard and inboard respectively. All the displays are interchangeable to reduce the number of required spares.

The information shown on each display, whether for flight or navigation, is determined by what each crew member selects on their individual display control panels.

The PFD takes the place of the EADI and displays all the information critical to flight, including attitude, airspeed, barometric altitude, vertical speed, heading, flight modes, radio altitude, ILS data, and Traffic Alert and Collision Avoidance System (TCAS) resolution advisory. The PFDs are designed to

Figure 1-3. Equivalent electromechanical flight and navigation instruments on the left.



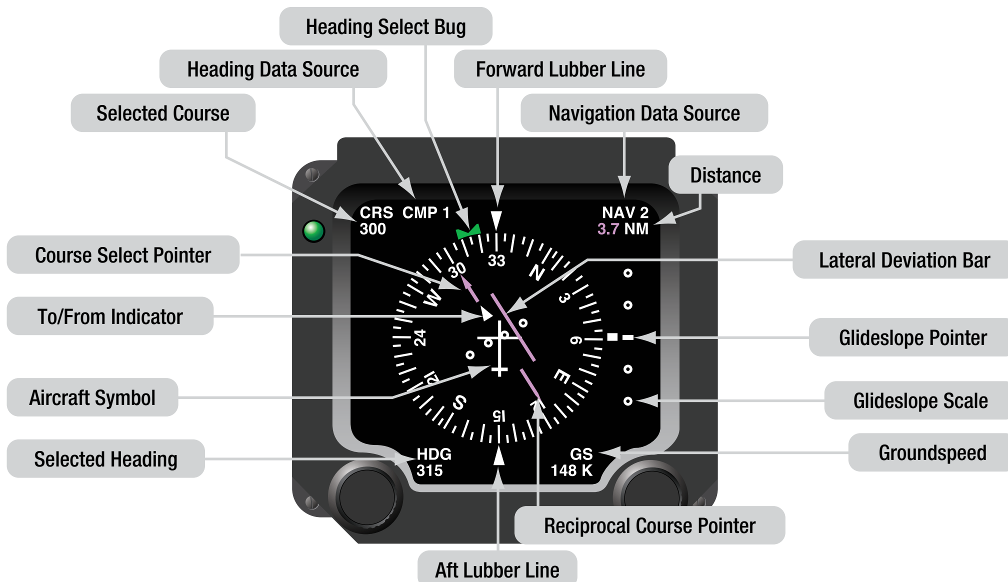


Figure 1-4. Typical EADI (top) and EHSI (bottom) Display Symbology.

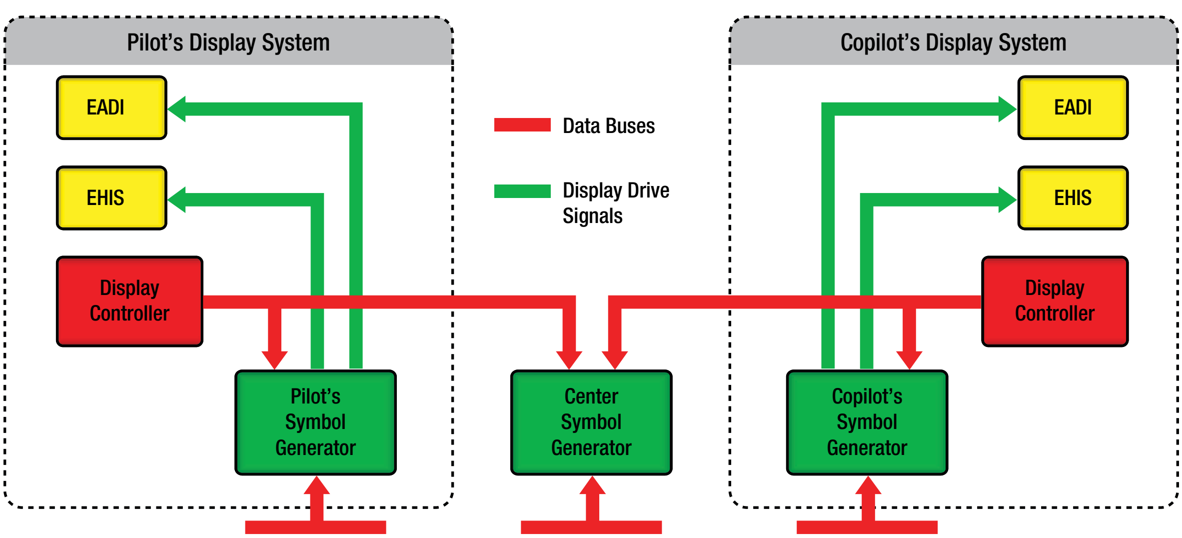


Figure 1-5. Electronic displays are driven by symbol generators.

Figure 1-6. Boeing 777 Electronic Instrument System has 6 LCD Displays.

increase the crew's situational awareness by integrating all of this information into a single composite display instead of the crew having to monitor several independent analog instruments. Also, the colors on the display change to alert the crew to potentially hazardous flight conditions, such as low airspeed, high rate of descent, etc.

Figure 1-7 is a typical Primary Flight Display format showing the artificial horizon in the center of the display, airspeed on the left side, altitude on the right side, heading on the bottom, and flight modes on the top of the display. Notice how the moving ladder format used for altitude and airspeed provide both absolute and relative information so the crew knows not only the exact numeric value, but also the rate that the altitude and airspeed is changing.

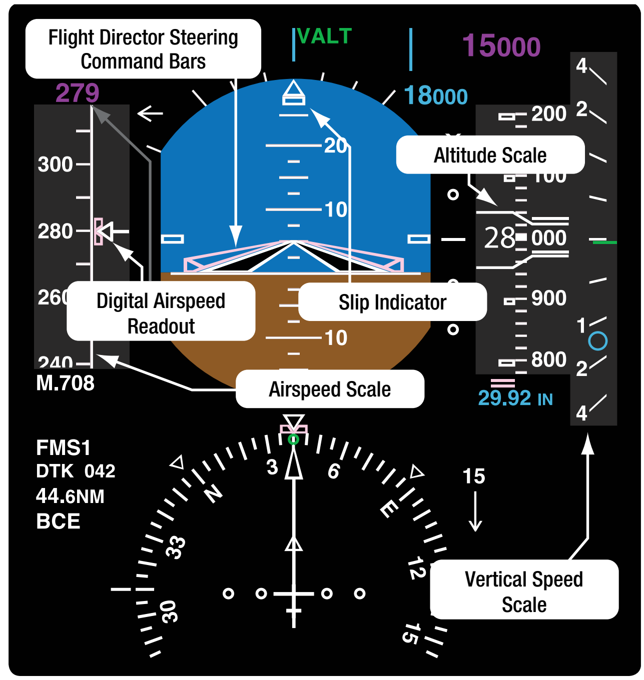


Figure 1-7. Primary Flight Display format.

The Navigation Display, shown in **Figure 1-8**, takes the place of the EHSI display to show the requisite information to navigate the aircraft, including heading, VOR, GPS, and ILS guidance. The ND has the ability to overlay additional information on the navigation page to eliminate the need for separate dedicated

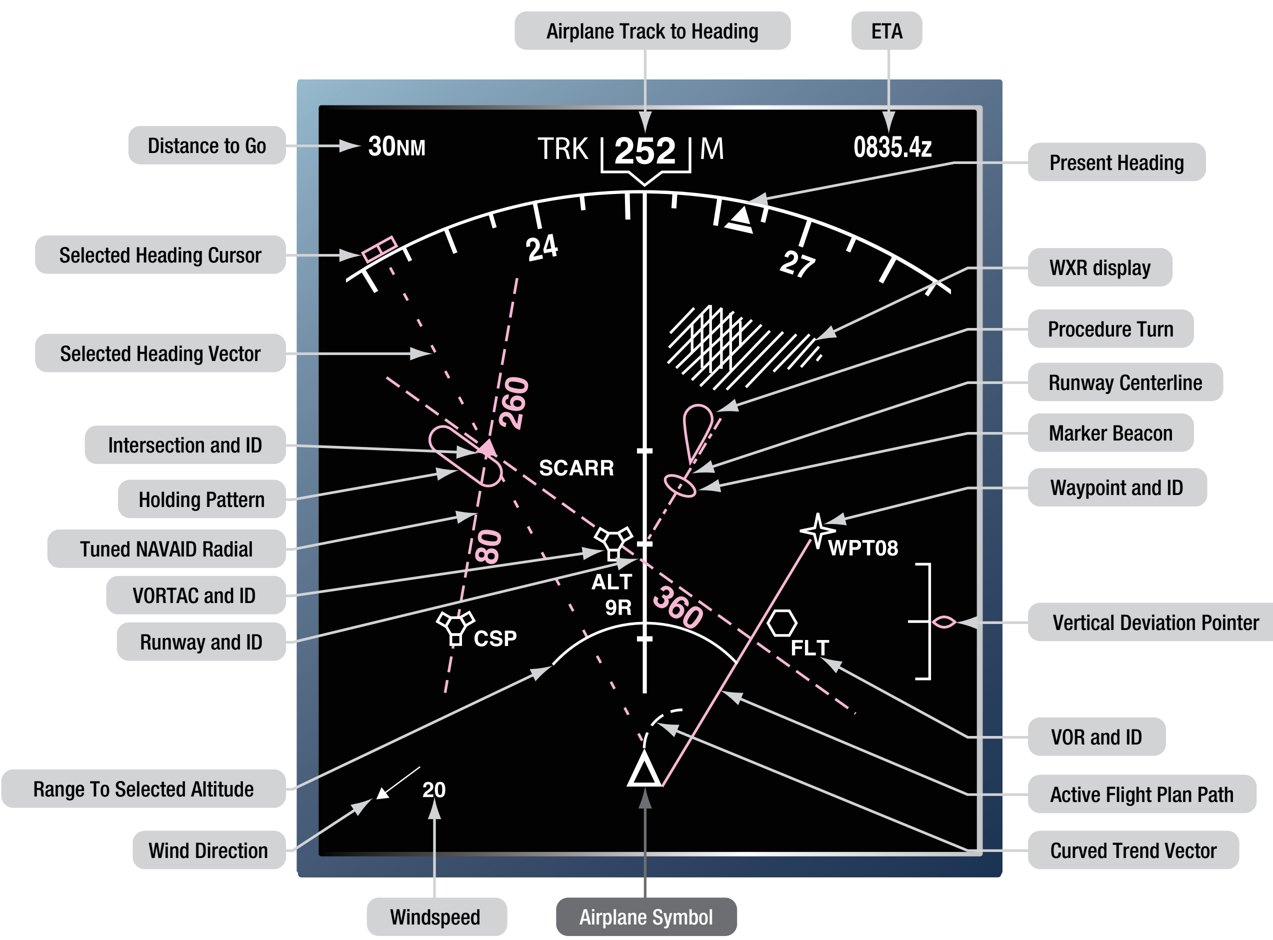


Figure 1-8. Navigation map display format.