

DIGITAL TECHNIQUES ELECTRONIC INSTRUMENT SYSTEMS

Aviation Maintenance Technician Certification Series



**AIRCRAFT
TECHNICAL**
Book Company

72413 U.S. Hwy 40
Tabernash, CO 80478-0270 USA

www.actechbooks.com

+1 970 726-5111
+1 970 726-5115 FAX

REVISION LOG

VERSION	ISSUE DATE	DESCRIPTION OF CHANGE	MODIFICATION DATE
001	2015 10	Module Creation and Release	
002	2016 01	Module Revisions and Release	2016.01.01

ACKNOWLEDGMENTS

Special thanks to and acknowledgment of:

Mike Stitt, Electronics Engineer, ADA, MI.

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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" x 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.



Figure 1-3. Equivalent Electromechanical Flight and Navigation Instruments on the left.

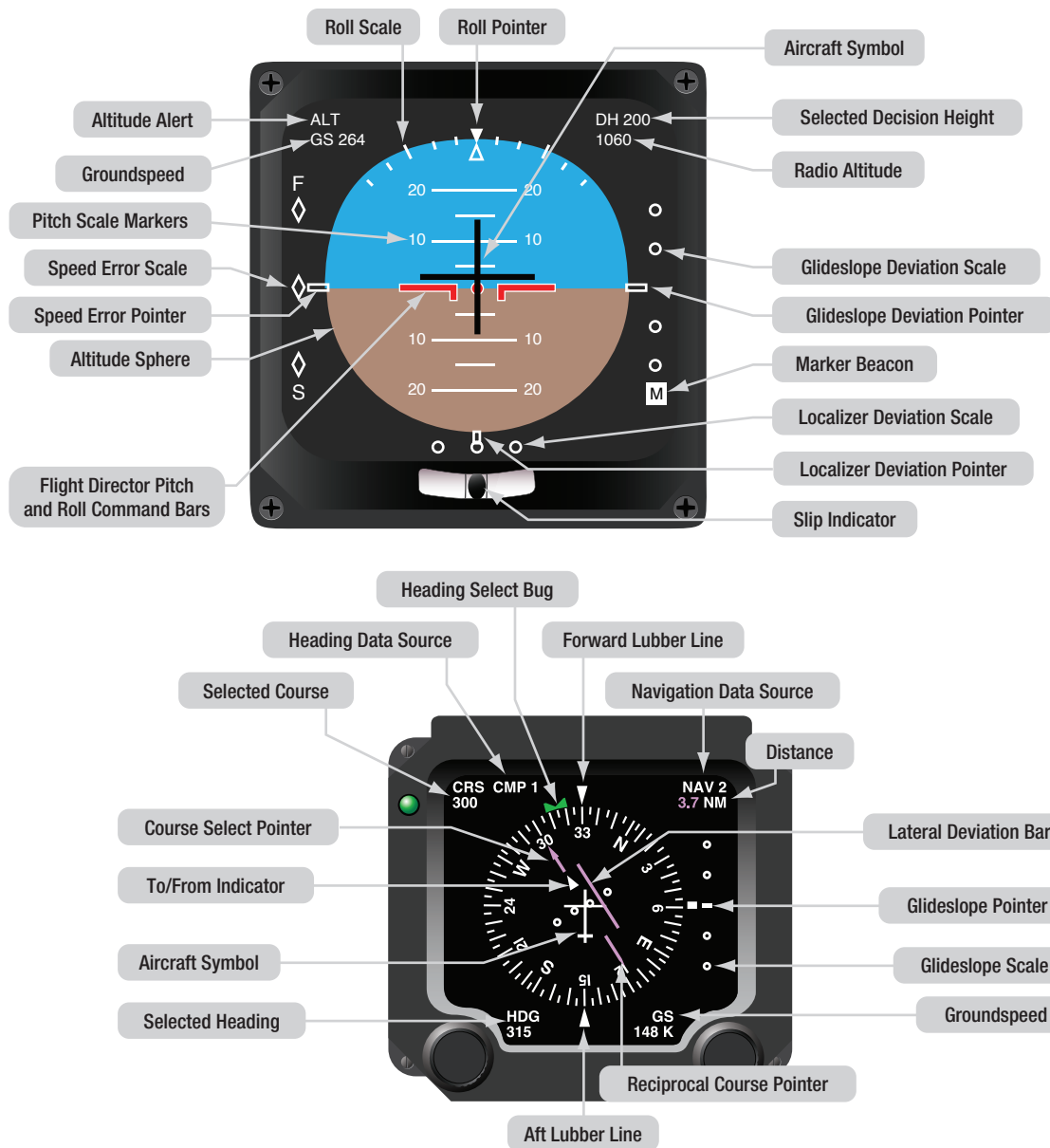


Figure 1-4. Typical EADI (top) and EHSI (bottom) Display Symbolology.

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 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.

The Navigation Display, shown in **Figure 1-8**, takes the place of the EHSI display to show the requisite

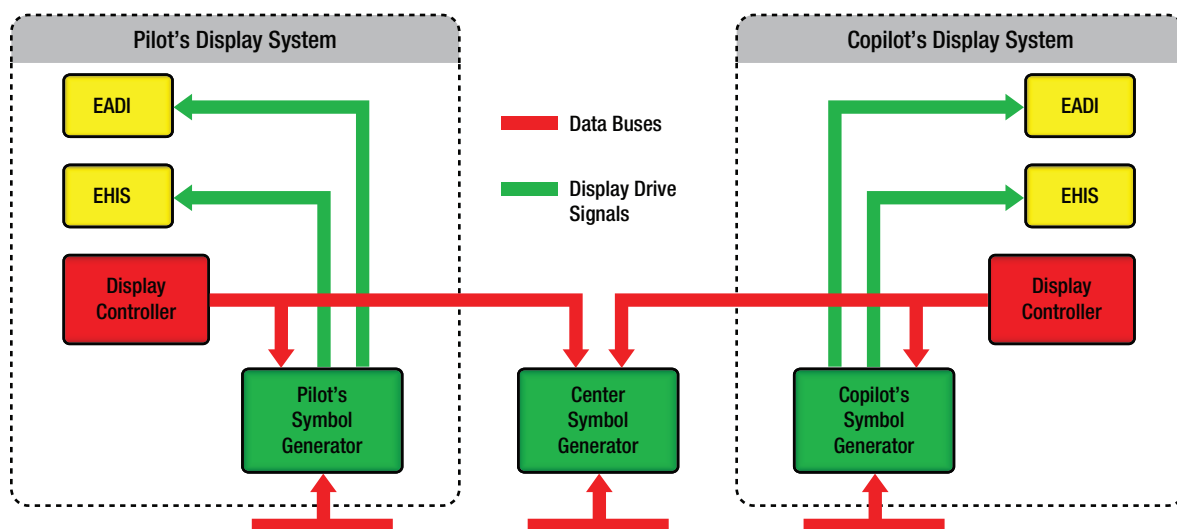


Figure 1-5. Electronic Displays are driven by Symbol Generators.



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

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 displays. Some examples of information that is typically overlaid on the ND include weather information from either the onboard weather radar (WXR) or ground based sensors, and digital maps showing pre-programmed routes and waypoints from the Flight Management System.

ENGINE INDICATION AND CREW ALERTING SYSTEM

The Boeing Engine Indication and Crew Alerting System (EICAS), also called an Electronic Centralized

Aircraft Monitor (ECAM) on Airbus aircraft, performs the monitoring of aircraft systems that was previously performed by the Flight Engineer in three crew member cockpits. As previously shown in **Figure 1-6**, the two EICAS displays on the B777 are located in the center instrument panel. The upper EICAS display shows engine performance data, such as pressure ratio, N1 rotor speed, exhaust gas temperature, total air temperature, thrust mode, etc., in addition to cabin pressure, flap/slat position, landing gear position, and crew status alerts. (**Figure 1-9**)

The EICAS engine display format mimics the round analog instruments, while also providing digital

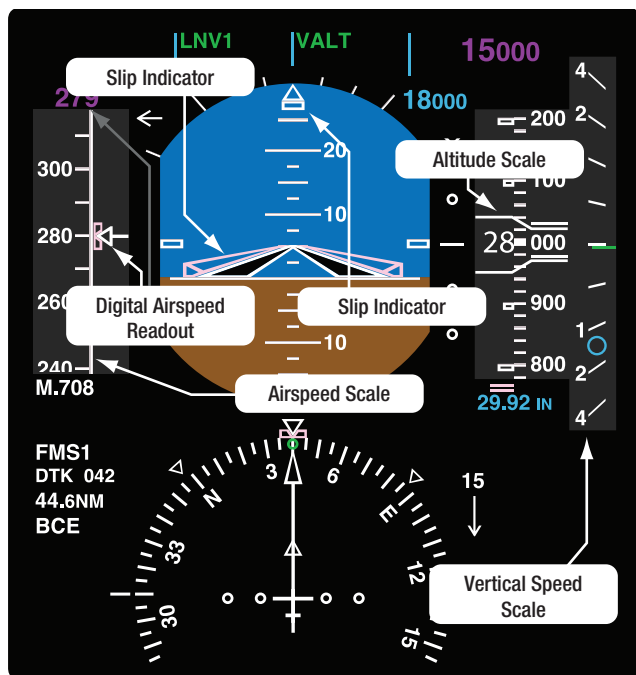


Figure 1-7. Primary flight display format.

readouts of the parameters. EICAS improves situational awareness by allowing the crew to see systems operation in graphical format and alerting them to any failures or impending failures. For example, if low oil pressure is detected, the EICAS will provide an aural alert and show to the oil pressure page on a lower display with a red box outlining which engine has low oil pressure.

The Airbus ECAM system provides the crew with the following levels of warning along with detailed messages as to the nature of the problem and suggested courses of action.

- Level 3: An overspeed, fire, or stall condition will cause a repetitive chime aural warning with a bright red flashing light.
- Level 2: A system failure, but not a safety of flight issue, will result in a single chime aural warning and a steady amber light.
- Level 1: Failure leading to system degradation results only in an amber light.
- Mode or System Status: If everything is normal, a green light will illuminate.

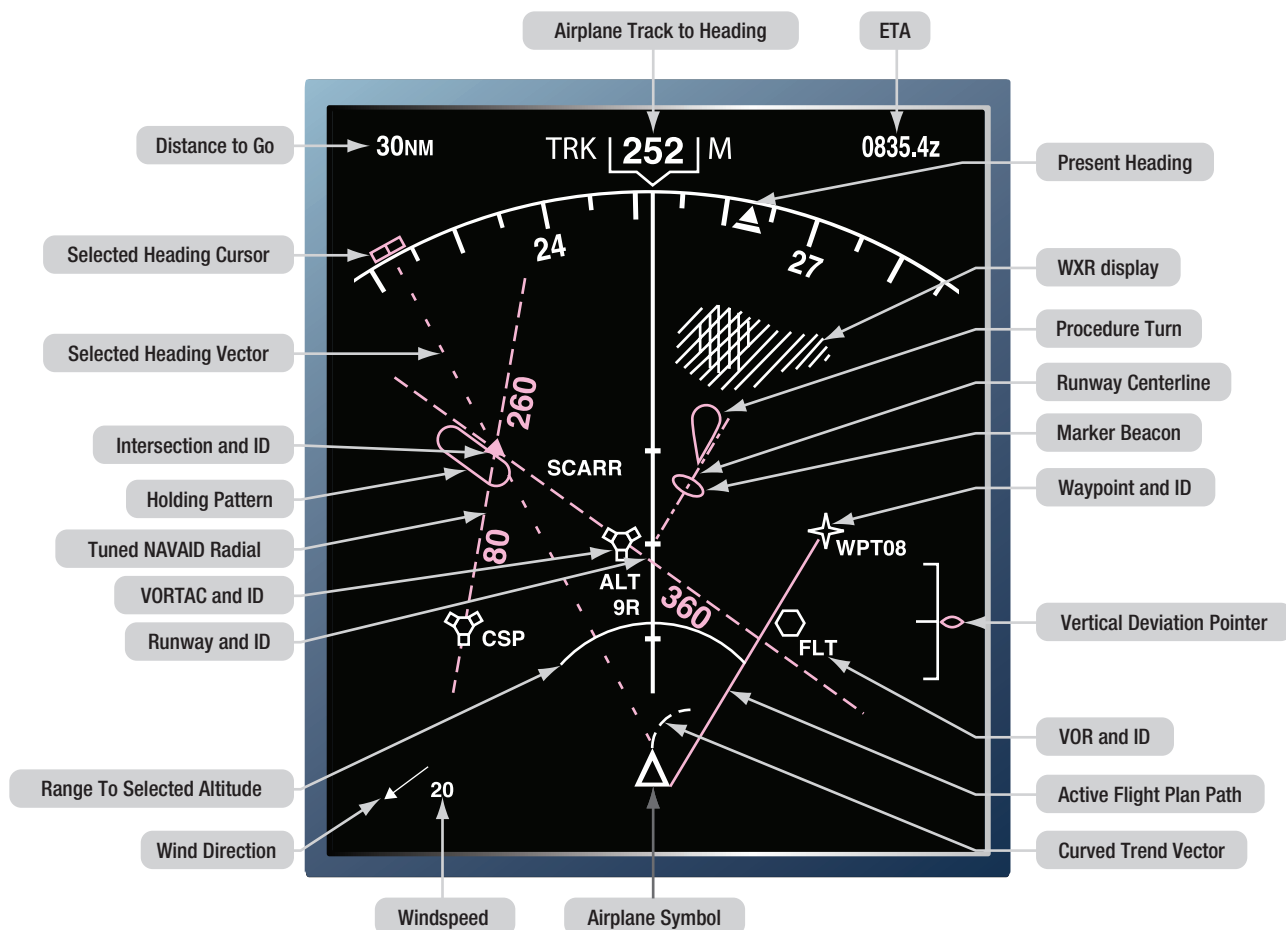


Figure 1-8. Navigation map display format.

The lower EICAS display is called a Multi-Function Display because it provides auxiliary information to the flight crew and maintenance crew. The MFD can be used as a secondary engine display, status display, communications display, maintenance page, or electronic checklist. The MFD formats also include synoptic displays that provide system status diagrams for the fuel, electrical, hydraulic, flight control, and environmental control systems, in addition to showing door and landing gear positions. On some aircraft, the MFD is also used to display images from the ground maneuvering camera system.

Figure 1-10 is a schematic diagram of an Engine Indication and Crew Alerting System with all its associated components. The display select panel allows the crew to choose which computer is actively supplying information. It also controls the display of secondary engine information and system status displays on the lower monitor.



Figure 1-9. EICAS engine display format.

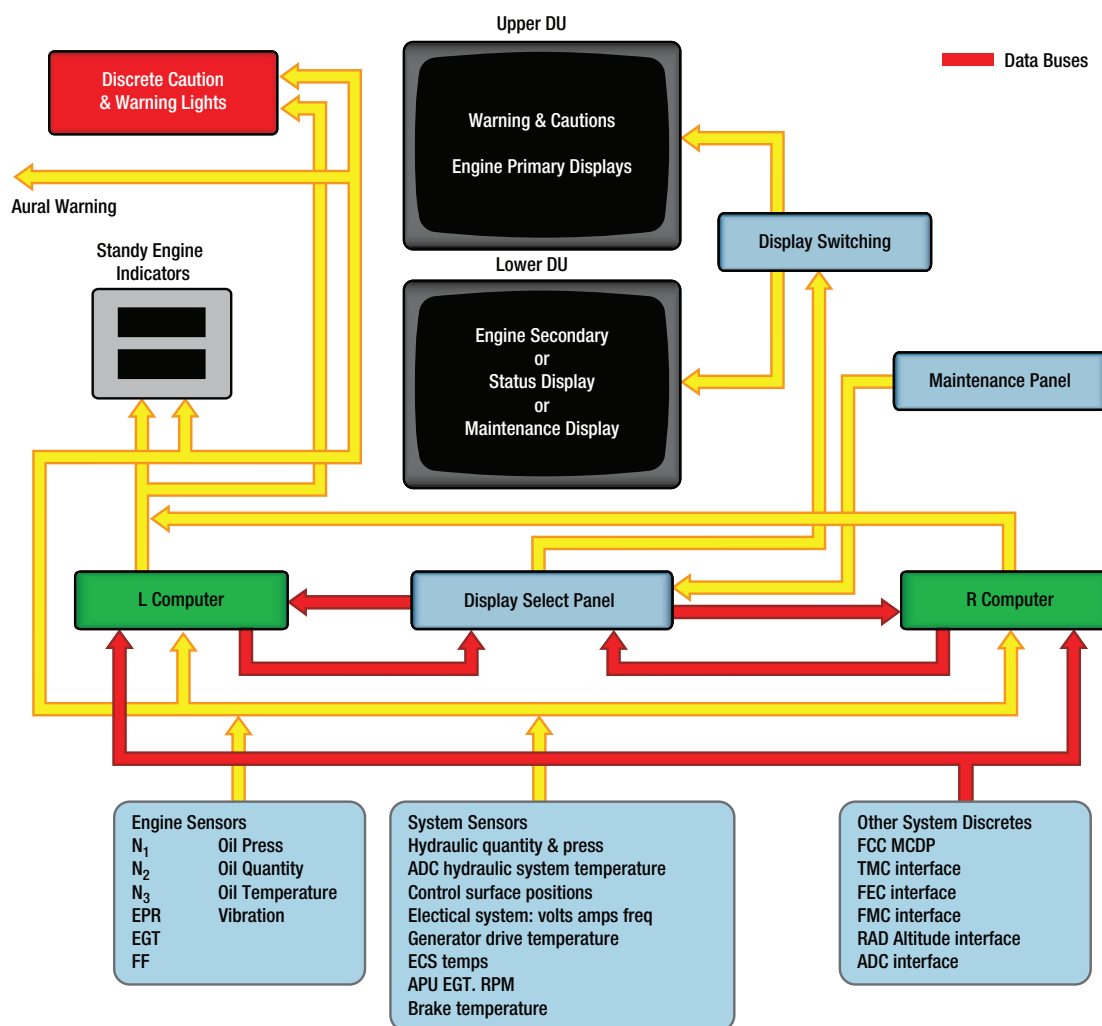


Figure 1-10. EICAS schematic diagram.

EICAS has a unique feature that automatically records the parameters of a failure event to be regarded afterwards by maintenance personnel. Pilots that suspect a problem may be occurring during flight can press the event record button on the display select panel. This also records the parameters for that flight period to be studied later by maintenance. Hydraulic, electrical, environmental, performance, and Auxiliary Power Unit (APU) data are examples of what may be recorded. EICAS uses Built-In-Test Equipment (BITE) for systems and components.

A maintenance control panel is included for technicians. When the aircraft is on the ground, push-button switches display information pertinent to various systems for analysis. (*Figure 1-11*)

This *sub-module* contained an overview of a state-of-the-art aircraft cockpit with its Electronic Instrument System. The following chapters will discuss how digital data streams are formed and processed by aircraft computers and then sent over digital data buses to cockpit displays to provide essential information for the flight crew and maintenance crew.

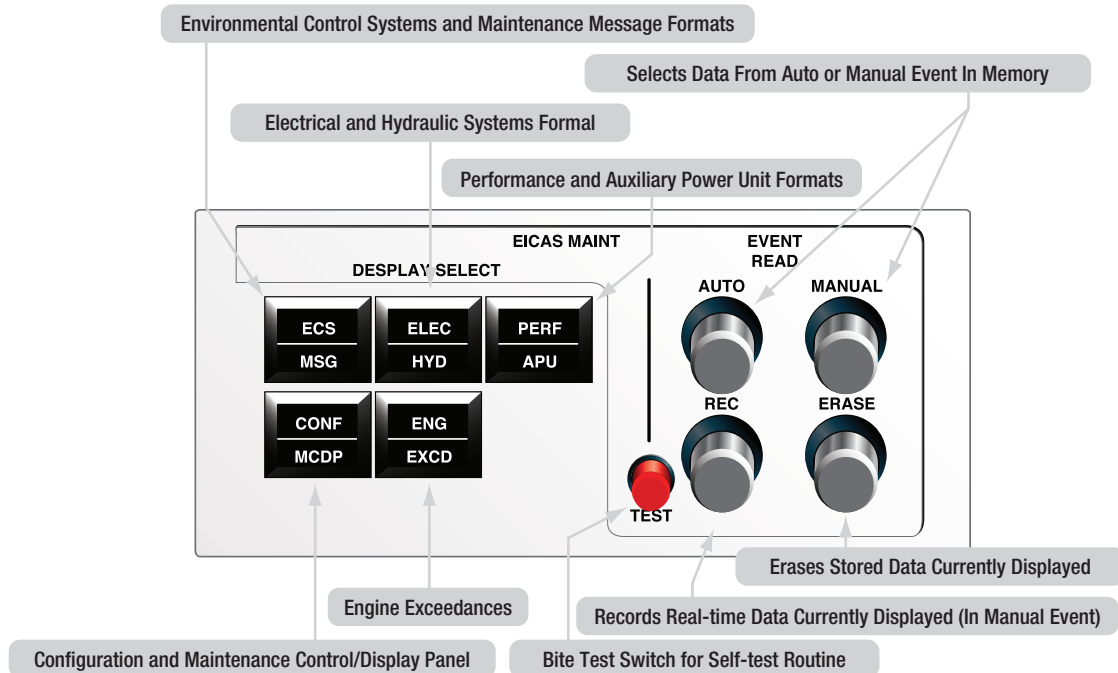


Figure 1-11. EICAS maintenance control panel.