Electronic Flight Instrument System (EFIS)

An **electronic flight instrument system** (**EFIS**) is a flight deck instrument display system in which the display technology used is electronic rather than electromechanical. EFIS normally consists of a primary flight display (PFD), multi-function display (MFD) and engine indicating and crew alerting system (EICAS) display. Although cathode ray tube (CRT) displays were used at first, liquid crystal displays (LCD) are now more common. The complex electromechanical attitude director indicator (ADI) and horizontal situation indicator (HSI) were the first candidates for replacement by EFIS.

EFIS installations vary greatly. A light aircraft might be equipped with one display unit, on which flight and navigation data are displayed. A wide-body aircraft is likely to have six or more display units. An EFIS installation will follow the sequence:

- Displays
- Controls
- Data processors

A basic EFIS might have all these facilities in the one unit.

Display Units

- Primary flight display (PFD)
- Multi-function display (MFD) / Navigation display (ND)
- Engine indications and crew alerting system (EICAS) / electronic centralized aircraft monitoring (ECAM)

Control Panels

The pilots are provided with controls, with which they select display range and mode (for example, map or compass rose) and enter data (such as selected heading).

Where inputs by the pilot are used by other equipment, data buses broadcast the pilot's selections so that the pilot only needs to enter the selection once. For example, the pilot selects the desired level-off altitude on a control unit. The EFIS repeats this selected altitude on the PFD and by comparing it with the actual altitude (from the air data computer) generates an altitude error display. This same altitude selection is used by the automatic flight control system to level off, and by the altitude alerting system to provide appropriate warnings.

Data Processors

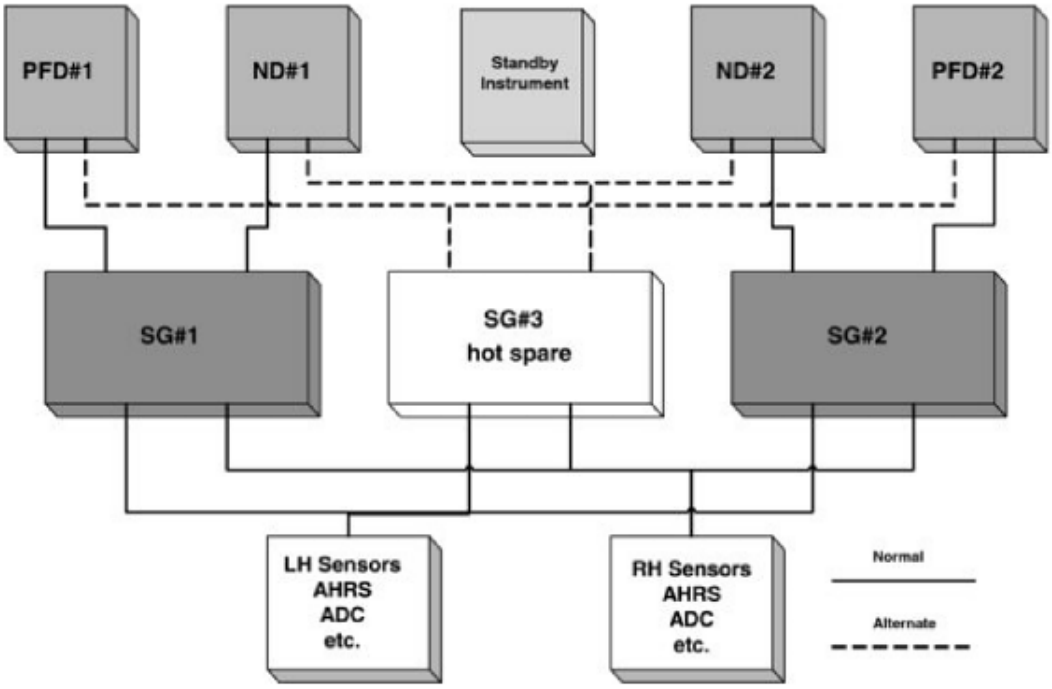
The EFIS visual display is produced by the **symbol generator**. This receives data inputs from the pilot, signals from sensors, and EFIS format selections made by the pilot. The symbol generator can go by other names, such as **display processing computer**, **display electronics unit**, etc.

The symbol generator does more than generate symbols. It has (at the least) monitoring facilities, a graphics generator and a display driver (this is a hardware not a software). Inputs from sensors and controls arrive via data buses, and are checked for validity. The required computations are performed, and the graphics generator and display driver produce the inputs to the display units.

B.1 Electronic Flight Instrument System Architecture

The architecture of an early EFIS system is shown in Figure B.1. Typically, three symbol generators (SGs) source image formats on to four display units (DU). Each SG is able simultaneously to produce both PFD and ND formats. Each DU sources its display format from a normal or an alternate SG source. In normal operation SG#1 sources the images to the captain's displays, PFD#1 and ND#1; SG#2 sources the images to the first officer's displays, PFD#2 and ND#2. SG#3 is a 'hot spare' and can take over the function of either SG#1 or SG#2 in the event of their failure. Each SG sources its inputs from both left-hand and right-hand sensors. An independent integrated standby instrument system (ISIS) is installed on the flight deck to aid the crew in resolving discrepancies and to provide critical flight information (attitude, altimeter and airspeed) in the event of complete failure of the main display system.

FIGURE B.1 Typical EFIS architecture



Monitoring

Like personal computers, flight instrument systems need power-on-self-test facilities and continuous self-monitoring. Flight instrument systems, however, need additional monitoring capabilities:

- Input validation — verify that each sensor is providing valid data
- Data comparison — cross check inputs from duplicated sensors
- Display monitoring — detect failures within the instrument system

Former Practice

Traditional (electromechanical) displays were equipped with synchro mechanisms which would transmit, to an instrument comparator, the pitch, roll and heading that were actually being shown on the Captain's and First Officer's instruments. The comparator warned of excessive differences between the Captain and First Officer displays. Even a fault as far *downstream* (Downstream and upstream refer to the direction of data flow; from sensor, to processor, to display) as a jam in, say, the roll mechanism of an ADI would trigger a comparator warning.

The instrument comparator thus provided both comparator monitoring and display monitoring.

Comparator Monitoring

With EFIS, the comparator function is as simple as ever. Is the roll data (bank angle) from sensor 1 the same as the roll data from sensor 2? If not, put a warning caption (such as **CHECK ROLL**) on both PFDs. Comparison monitors will give warnings for airspeeds, pitch, roll and altitude indications. The more advanced EFIS systems, more comparator monitors will be enabled.

Display Monitoring

An EFIS display allows no easy re-transmission of what is shown on the display. What is required is a new approach to display monitoring that provides safety equivalent to that of the traditional system. One solution is to keep the display unit as simple as possible, so that it is unable to introduce errors. The display unit either works or does not work. A failure is always obvious, never insidious. Now the monitoring function can be shifted *upstream* to the output of the symbol generator.

In this technique, each symbol generator contains two display monitoring channels. One channel, the internal, samples the output from its own symbol generator to the display unit and computes, for example, what roll attitude should produce that indication. This computed roll attitude is then compared with the roll attitude input to the symbol generator from the INS or AHRS (Attitude and Heading Reference System). Any difference has probably been introduced by faulty processing, and triggers a warning on the relevant display.

The external monitoring channel carries out the same check on the symbol generator on the other side of the flight deck: the Captain's symbol generator checks the First Officer's, the First Officer's checks the Captain's. Whichever symbol generator detects a fault, puts up a warning on its own display.

The external monitoring channel also checks sensor inputs (to the symbol generator) for reasonableness. A spurious input, such as a radio height greater than the radio altimeter's maximum, results in a warning.

B737 NG Flight Instruments

The NG's have 6 **Display Units** (DU's), these display the flight instruments; navigation, engine and some system displays. They are controlled by 2 computers – **Display Electronics Units** (DEU's). Normally DEU 1 controls the Captains and theUpper DU's whilst DEU 2 controls the F/O's and the lower DU's. The whole system together is known as the **Common Display System** (CDS).

The DU's normally display the PFD's outboard, ND's inboard, engine primary display centre (upper) and engine secondary display lower. Although they can be switched around into almost any other configuration with the DU selector.

The **CDS FAULT** annunciation will only occur on the ground prior to the second engine start, it is probably a DEU failure but is in any case a no-go item.

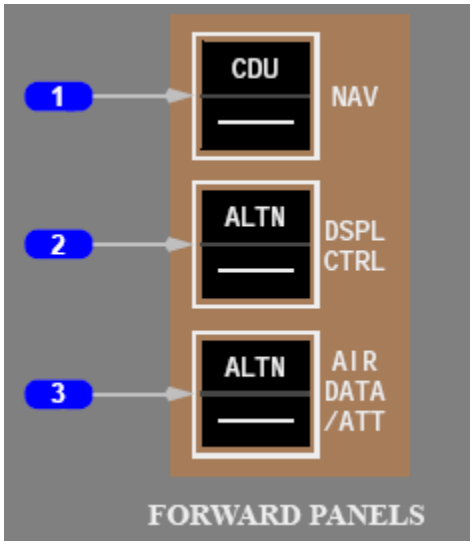
If a DEU fails in-flight, the remaining DEU will automatically power all 6 DU's and a **DSPLY SOURCE** annunciation will appear on both PFD's. The nomenclature requirements for these annunciations were developed by Boeing Flight Deck Crew Operations engineers during the early design phase of the 737NG program. The intent of the design function is as follows:

- The CDS FAULT message is intended to be activated on ground to tell the maintenance crew or air crew that the airplane is in a non-dispatchable condition.

- The DISPLAY SOURCE message is annunciated in air to tell the crew that all the primary display information is from one source and should be compared with all other data sources (standby instruments, raw data, etc.) to validate its accuracy.

Since the DISPLAY SOURCE message is intended to be activated in air and CDS FAULT is intended to be activated on ground, air/ground logic is used by CDS to determine which message is appropriate. The air/ground logic system uses a number of inputs to determine airplane state. One of the inputs used is "engines running". CDS uses the "engines running" logic as the primary trigger for changing the CDS FAULT message to its in-air counterpart. The "engines running" logic is used in case the air/ground data isn't correct as a result of other air/ground sensing faults.

B777 Flight Instruments



2 Display Control (DSPL CTRL) Source Switch

Off – normal position (ALTN not visible, switch out):

- automatically selects display processing channels for the left outboard and inboard, or right outboard and inboard display pairs
- reconfigures display processing channels as required for display unit or processing channel failures.

ALTN – non–normal position (ALTN visible, switch in). An alternate display processing channel is selected to replace the current display processing channel.

Instrument Display Source Selection

The display system automatically reconfigures to compensate for most faults. The instrument display source select panels provide manual switches for the pilots to use if certain faults are not corrected automatically.

Instrument source select switches provide alternate information sources for the PFDs and NDs. These switches provide automatic source selection when in the off position (switch out, with the ALTN and CDU switch annunciations not visible).

If there is an undetected source failure (a display is missing or parts of a display appear faulty), the non–normal (ALTN or CDU) position provides the capability for manual selection of PFD and ND sources.

Undetected display source failures, such as missing/faulty display information or intermittent display blanking, may not result in automatic switching. The CDU position of the NAV switch or the ALTN position of the DSPL CTRL or AIR DATA/ATT switches provide the capability to manually select PFD and ND sources.

The following EICAS messages can be displayed.

Message	Level	Aural	Message Logic
SGL SOURCE DISPLAYS	Caution	Beeper	A single source of display information is being used by some or all display units.

Source:

www.wikipedia.org
B777 Flight Crew Operations Manual
www.aircraftengineering.wordpress.com
Civil Avionics Systems by Ian Moir, Allan Seabridge, Malcolm Jukes