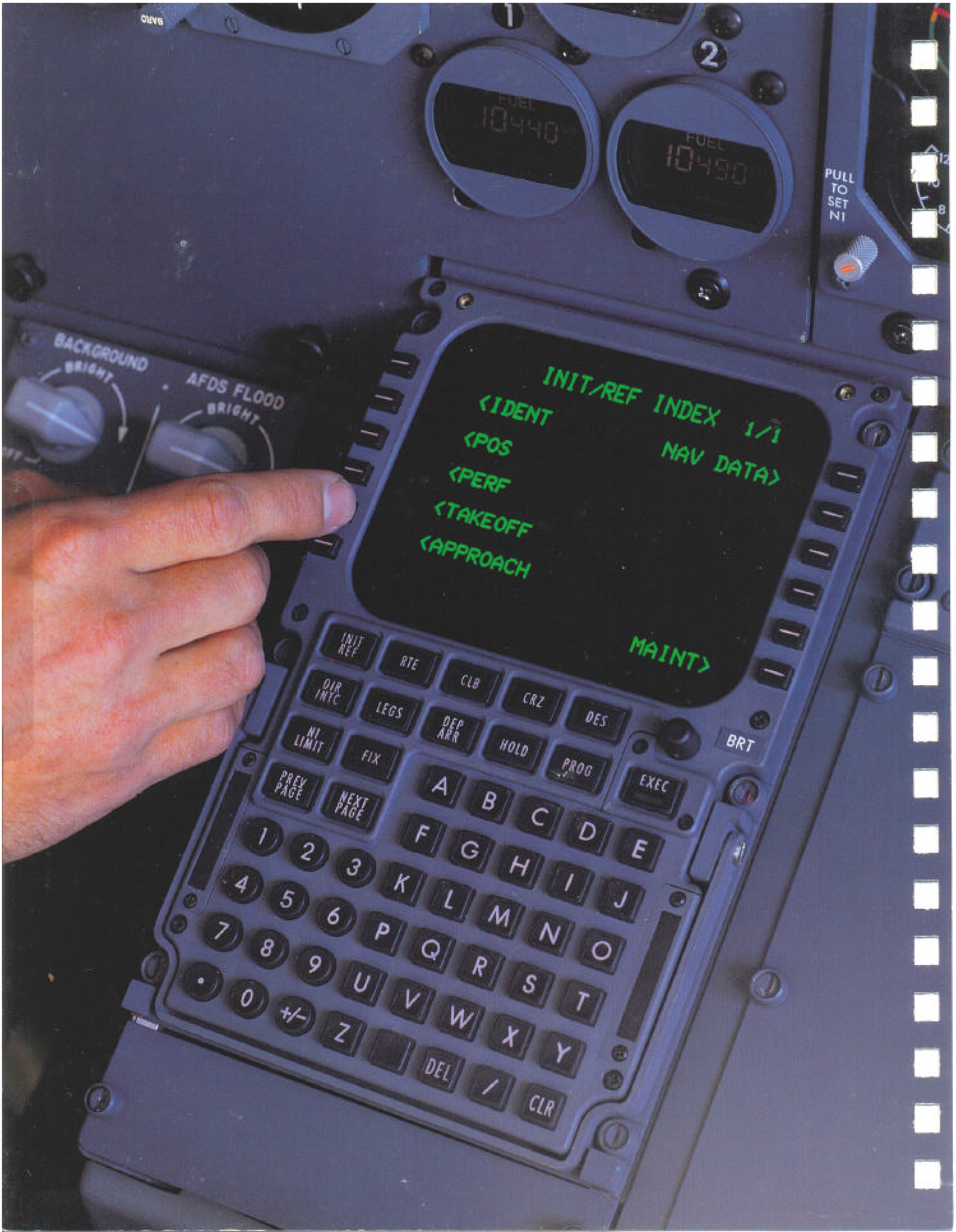
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Flight Management System

Features

FLIGHT MANAGEMENT COMPUTER SYSTEM (FMCS)

- *Preplanned flight profile control*
- *Performance optimized guidance*
- *Performance management*
- *Required time of arrival*

DIGITAL FLIGHT CONTROL SYSTEM (DFCS)

- *All-digital design provides accuracy, reliability, and fast, built-in test capability*

YAW DAMPER

- *Eliminates the yaw rates associated with dutch roll*

AUTOTHROTTLE

- *Engines individually controlled to achieve optimum performance from each engine*

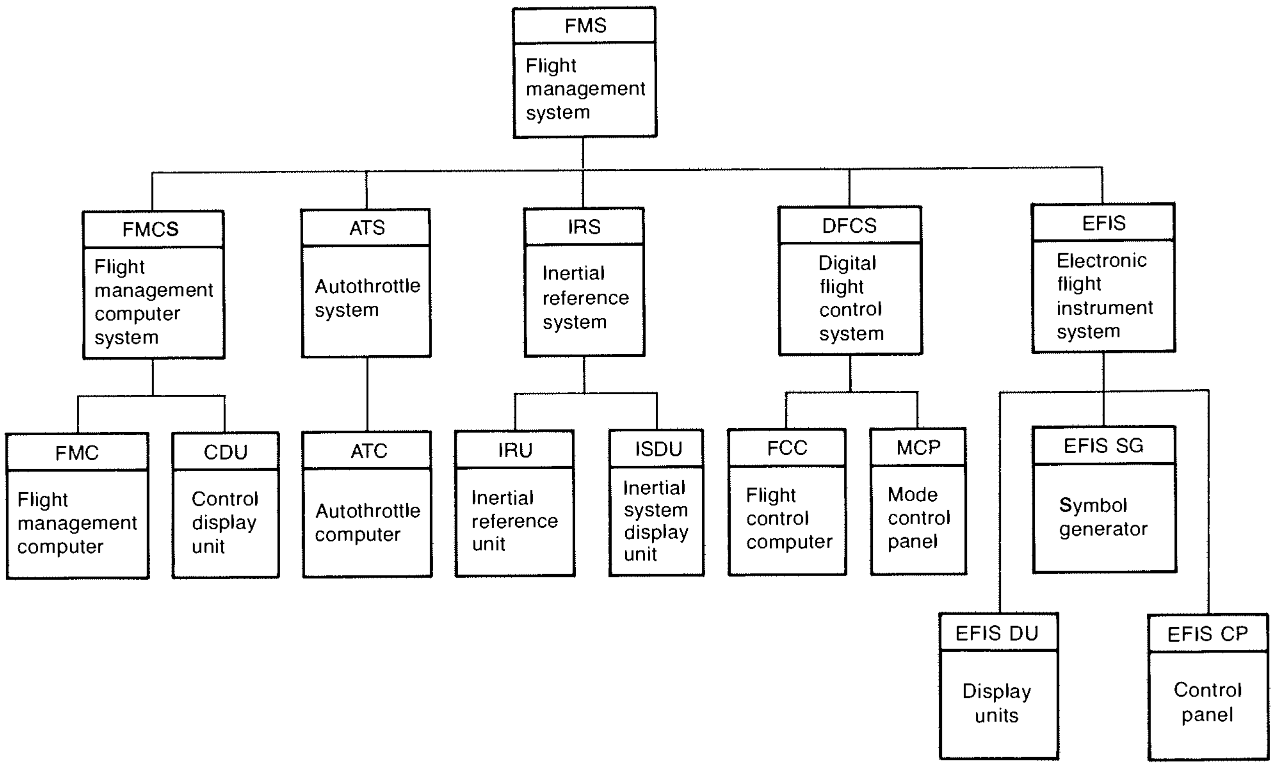
ELECTRONIC FLIGHT INSTRUMENT SYSTEM (EFIS)

Multicolor cathode ray tubes for the primary flight instruments (attitude director indicator and horizontal situation indicator) to replace electromechanical type and provide enhanced displays, such as maps.

BUILT-IN TEST EQUIPMENT (BITE)

- *Provides fast and accurate diagnosis of the main flight management system (FMS) components*

- Flight Management Computer System (FMCS)
- Electronic Flight Instrument System (EFIS)
- Digital Flight Control System (DFCS)
- Autothrottle
- Built-In Test Equipment
- Yaw Damper



Block Diagram of Flight Management System

Flight Management Computer System (FMCS)

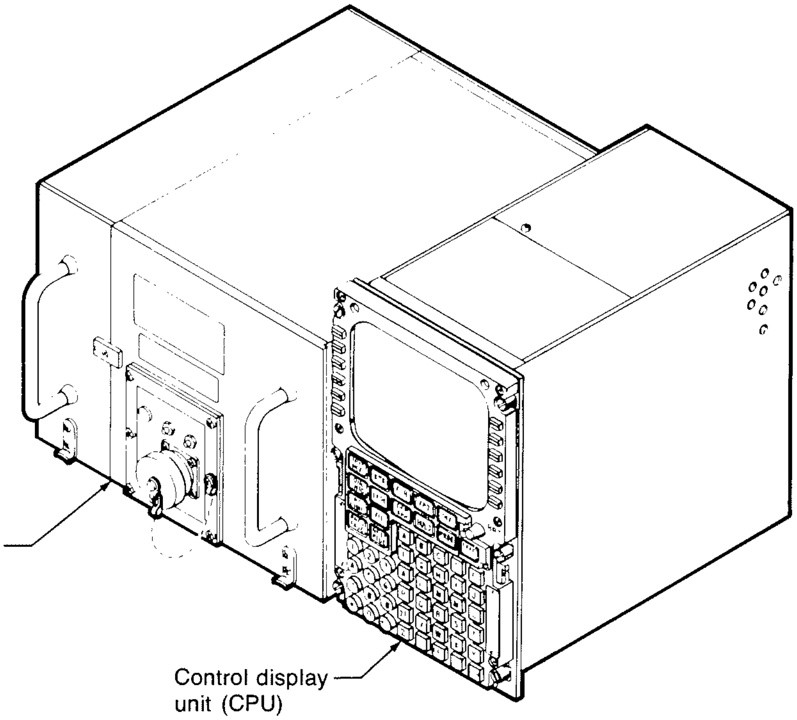
The 737 FMCS is operationally similar to the 757 and 767 FMCS. The central component of the flight management system is the flight management computer (FMC), which communicates with other systems on the airplane via ARINC 429 data buses. Stored in the FMC memory is the NAV DATA base, which includes data on VHF NAVAIDS, waypoints, airways, airports, runways, standard instrument departures (SIDs), standard terminal arrival routes (STARs), and other data required to operate in a specific geographical area. The data base is updated every 28 days. With the use of a portable data base loader, the updated data base can be loaded from the flight deck in approximately 10 minutes when the airplane is on the ground.

The FMC can also accept crew entry of waypoints that are not in the stored (permanent) data base by means of the control display unit (CDU).

The pilot can preselect the entire flight plan from the NAV DATA base using standard air traffic control language. The FMC compares the present position with the planned position, and any deviation is indicated on the flight instruments. Also, by sending signals to the digital flight control system (DFCS), the FMC enables the autopilot to navigate the airplane in the lateral (LNAV) and vertical (VNAV) planes.

As the flight progresses, the FMC searches the NAV DATA base and automatically selects the best pair of distance measuring equipment (DME) stations to update the airplane's present position. If DME/DME positioning cannot be accomplished, the FMC will attempt to compute present position using the nearest VHF omnidirectional range/DME (VOR/DME) station. If an accurate present position cannot be computed using VHF radio NAVAIDS, the FMC will rely on the airplane's dual inertial reference system (IRS) for determining present position. By continuously updating the airplane's position, ground speed and airplane track can be computed. With this information, the FMCS can navigate the airplane to the next waypoint in the flight plan.

Guidance along a lateral or ground-based flight path is only part of the guidance required for economical flight operation.



Flight Management Computer and Control Display Unit

Another important part is to operate the aircraft during climb, cruise, and descent at the most efficient speed and optimum altitude. The FMCS accomplishes these tasks for the pilot.

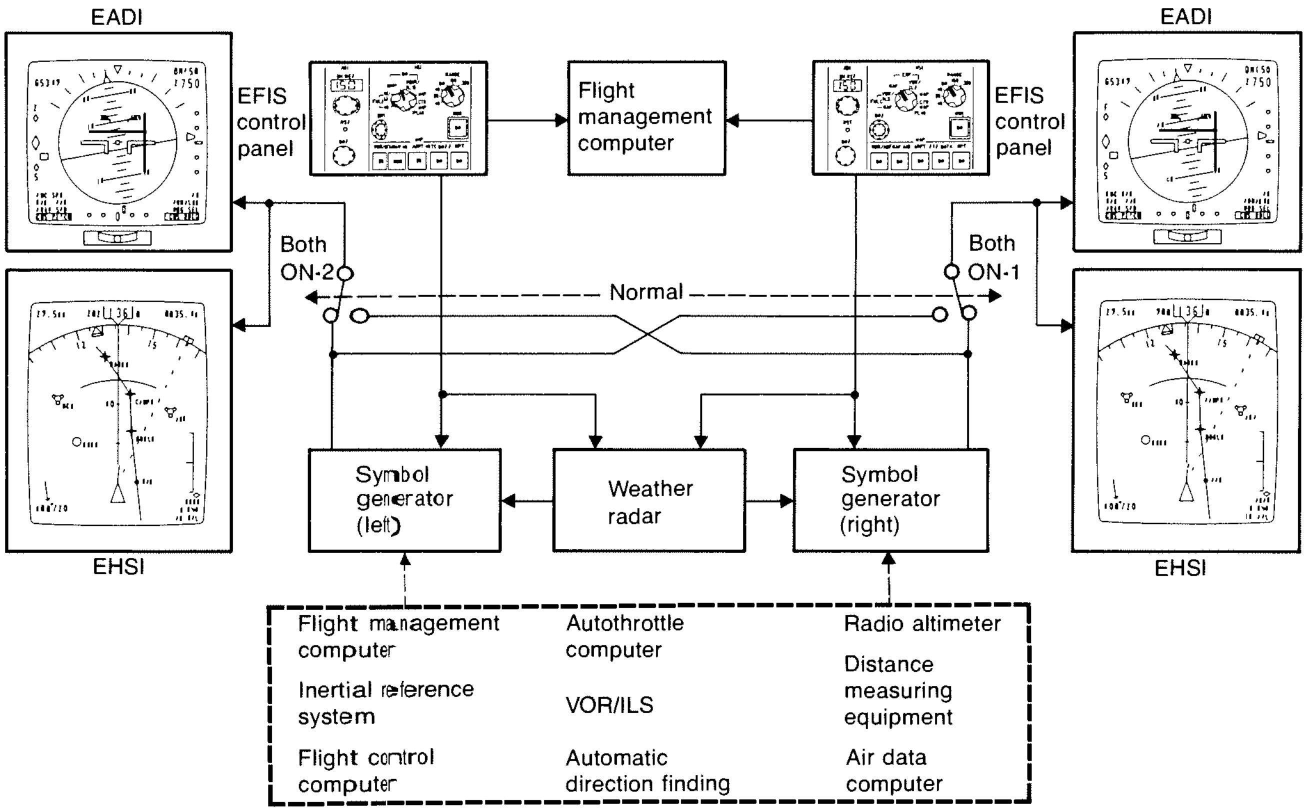
This is made possible by storing in the computer memory the aerodynamics model of the airplane as well as data on fuel flow, engine thrust, and N_1 limits. This is called the performance data base. Fuel quantity information is supplied to the FMC. The gross weight, cruise altitude, and cost index are entered by the crew. The FMC can then accomplish the calculations for economy speeds, optimum altitude, and top of descent point.

With the FMCS coupled to the DFCS and the autothrottle system in VNAV, thrust and speed will be adjusted automatically to the FMC-computed speed targets and vertical path.

A required time of arrival (RTA) feature adds time as a variable in the FMCS algorithms, along with speed, position, and altitude. Prior to departure, the FMCS can provide a takeoff time window which allows the flight to meet its scheduled arrival time based on airplane flight plan routing and speed capability. A recommended takeoff time is also presented, based on the most fuel-efficient flight speed.

During flight, RTA continually updates the earliest and latest arrival time, and recommends speed adjustments based on winds and routing changes. When coupled to the autothrottle, the adjustments will be made automatically. As an alternative, RTA can control arrival times at various waypoints en route, whether part of the flight plan or as requested by Air Traffic Control (ATC).

If delays at the arrival airport are anticipated while en route, the RTA feature can be used to extend the en route time in a fuel efficient manner, avoiding holding patterns. Time control will be a useful tool for pilots and controllers, and when it comes into widespread use, it will have the potential to help increase ATC system capacity.



Electric Flight Instrument System

Electronic Flight Instrument System (EFIS)

The EFIS uses multicolor cathode ray tubes (CRTs) for the primary flight instruments in lieu of the conventional electromechanical type. Each pair of flight instruments, the electronic attitude director indicator (EADI), and the electronic horizontal situation indicator (EHSI) are controlled by a separate symbol generator, and dual control panels are located in the aft aislestand. This allows each pilot to independently select an HSI display mode. Switching is provided to drive all four displays from one symbol generator.

ELECTRONIC ATTITUDE DIRECTOR INDICATOR (EADI)

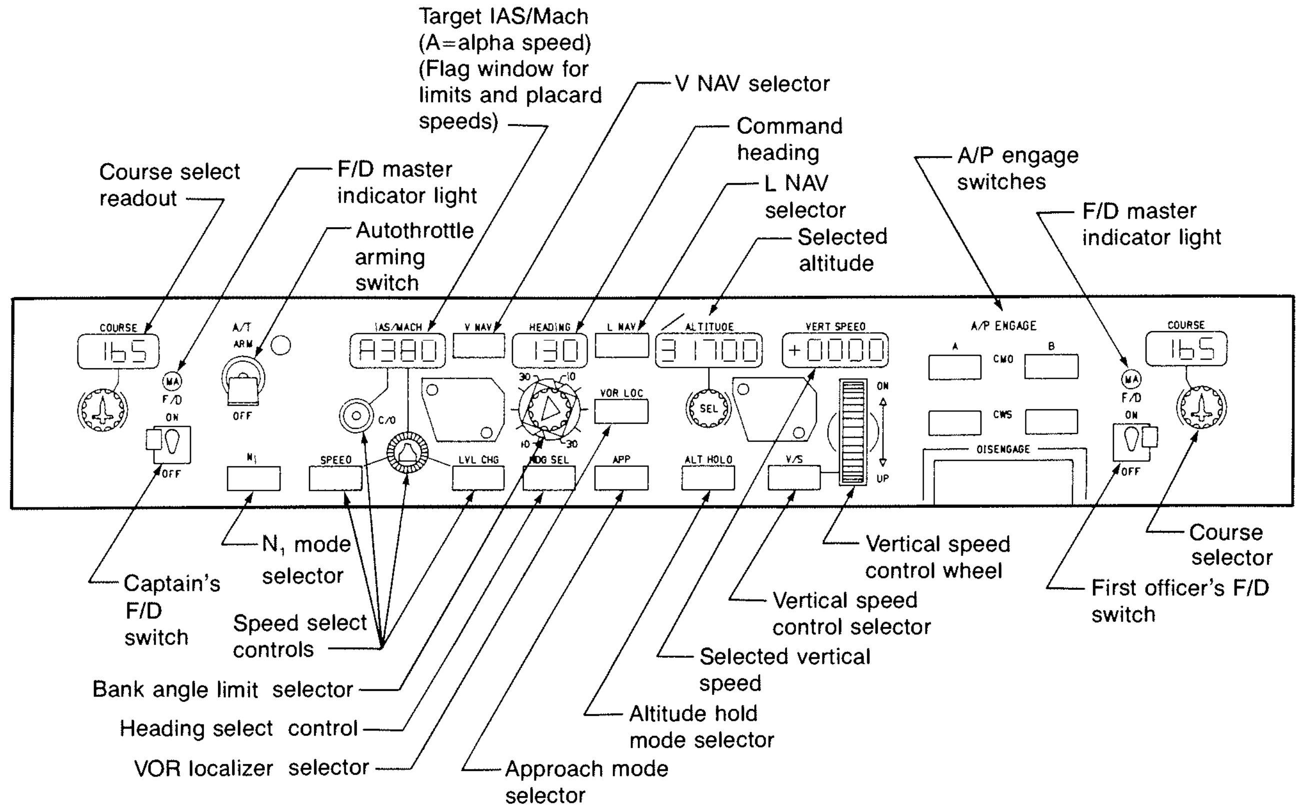
The EADIs consist of large 4.7 by 4.2-in (11.9 by 10.7-cm) CRTs which, in addition to the conventional features—pitch, roll, glideslope and localizer deviations, and flight director command bars—display ground speed, radio altitude, selected decision height, and selected autothrottle and autopilot/flight director pitch and roll armed/engaged mode status. They also provide the crew with a visual indication of the amount of maneuver margin remaining during a windshear condition (pitch limit indicator). A description of the windshear instrumentation operation is in the following section.

A rolling digit cursor airspeed tape is available as an option. The airspeed tape displays calibrated airspeed, flap extension/retraction speeds, V_1, V_R, Max/Min operating speeds and selected target speed.

The true airspeed and ground speed may be displayed adjacently, but not with the airspeed tape.

The Autopilot Mode Annunciator may be either on the bottom (standard) or top of the display. The flight director command may be either split axis or single cue. In addition to the digital readout the radio altitude may be displayed in analog round dial format below 1000 ft and/or as a rising runway below 200 ft.

Roll and pitch display drive values produced by one symbol generator are continuously compared to those produced by the other symbol generator. The roll and pitch drive values are a result of input signals from several sources including the VHF navigation receivers. A disparity between these signals is displayed in amber on both EADIs as "ROLL" or "PITCH" on the top right or left, respectively.



Digital Flight Control System Mode Control Panel

A standby horizon indicator, with integral gyro and power inverter, displays information even if the main electrical power should fail. Standby power is supplied from the airplane battery.

ELECTRONIC HORIZONTAL SITUATION INDICATOR (EHSI)

The EHSIs are 4.7 by 5.7 in. (11.9 by 14.5 cm) and provide the following operational modes:

- Map, center map, plan, and nav, and VOR/ILS (expanded and full compass rose)
- Basic heading and track information is provided in all modes. The map and plan modes display the flight plan and other reference point data programmed into the FMCS.

The operational mode is selected by the pilot through the EFIS control panel. Changes to the flight plan are entered through the flight management computer-control display unit (FMC-CDU).

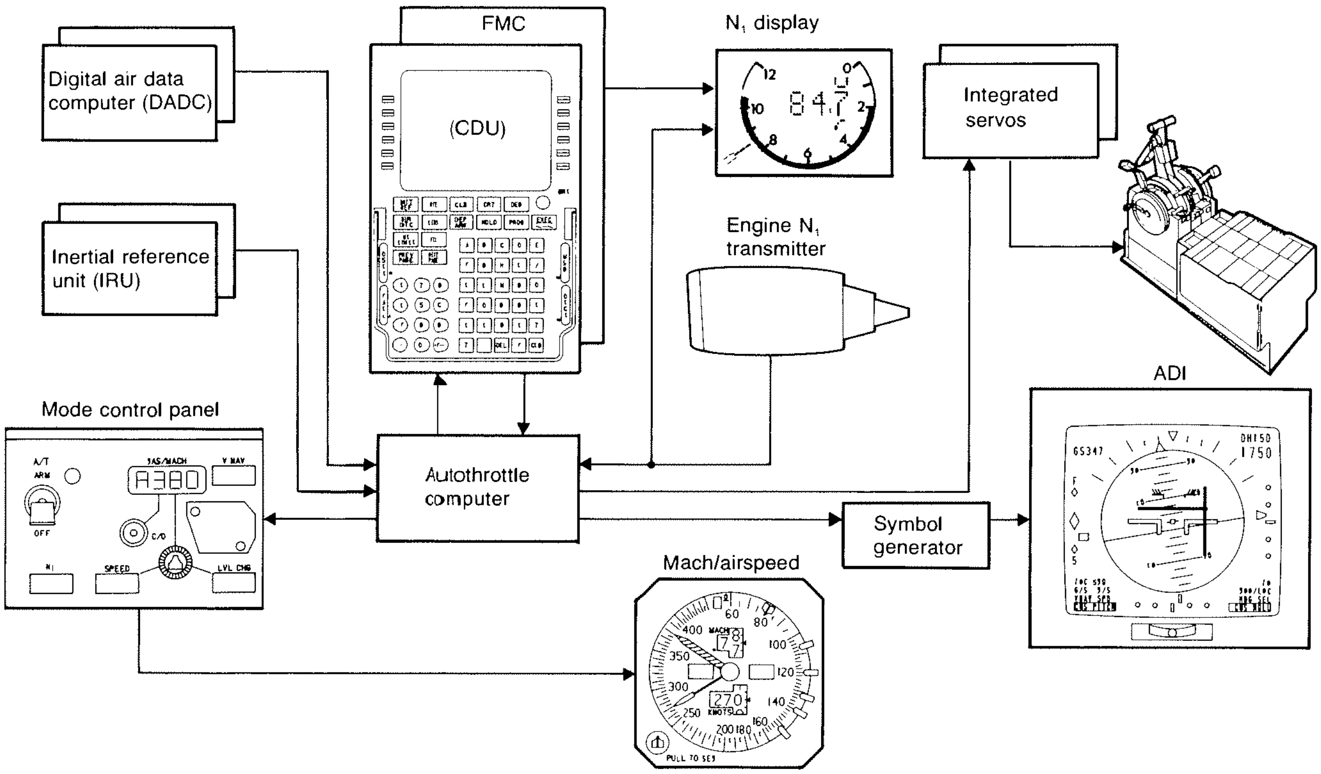
Two optional EFIS control panels are available, one without the NAV mode switch position for aircraft without the alternate navigation-control display unit (AN-CDU) and the other without the full rose VOR/ILS and NAV mode switch positions.

Weather radar images can be displayed in all modes except plan, full rose VOR/ILS, and full rose NAV. The weather radar mode, gain and tilt angle are displayed on the EHSI when the weather radar is selected for display. The mode, gain, and tilt angle display may be optionally deactivated (program pin selected).

Digital Flight Control System (DFCS)

The digital flight control system integrates the functions of autopilot, flight director, altitude alert, Mach/speed trim, and stabilizer trim. It is composed of two independent flight control computers, a mode control panel, and control system actuators.

The mode control panel, located on the pilots' glareshield, provides a centralized location for all autopilot, flight director, and autothrottle control selections. LNAV, VNAV, heading, VOR/LOC altitude, vertical speed, airspeed/Mach, and takeoff modes are available, with roll, pitch, and thrust automatically controlled in a compatible fashion. Automatic



Autothrottle System

approach, with optional dual-channel CAT IIIa autoland, and go-around modes are provided for terminal area operations. Automatic control of the FMCS flight plan guidance commands is initiated on this panel. The pilot may fly the airplane manually using the flight director with LNAV and VNAV modes selected. In these modes, all FMS optimization data are available through the CDU and EHSI, with appropriate bugs on the airspeed and thrust setting indicators, and flight director guidance commands on the EADI.

The all-digital design provides accuracy, reliability, and fast, built-in test capability.

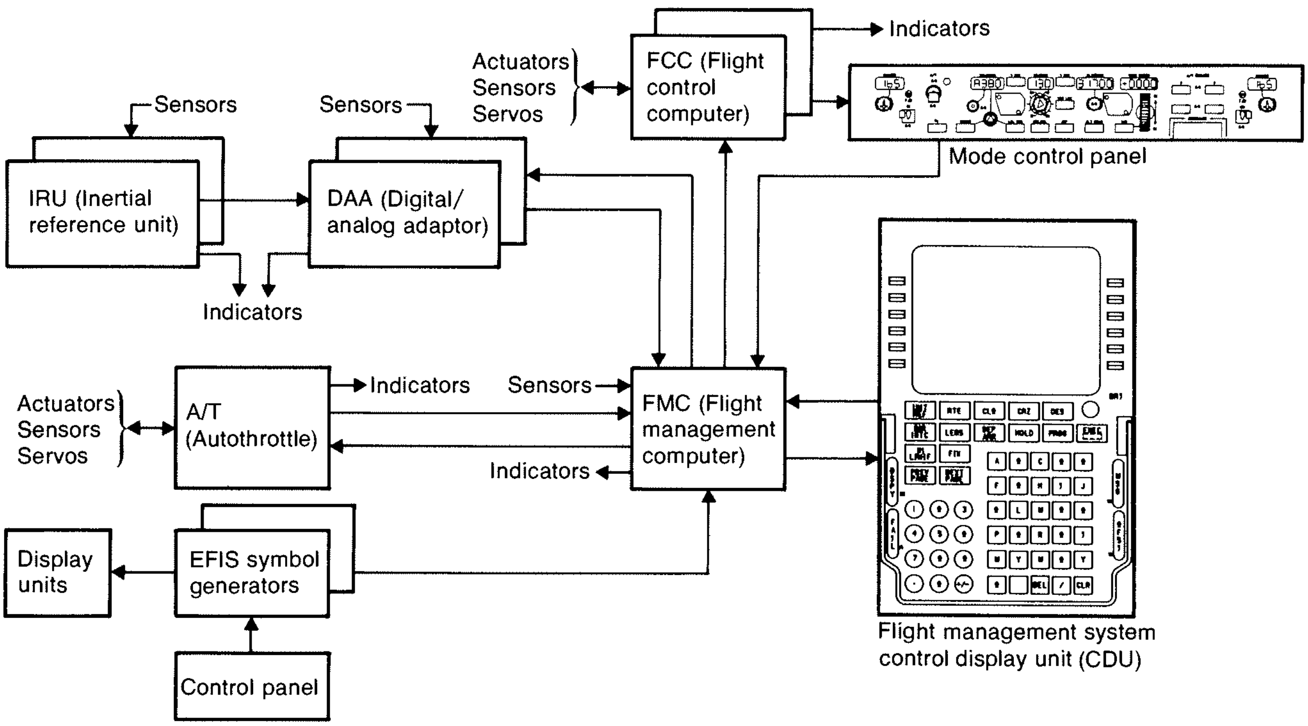
Autothrottle

The full-range autothrottle system provides autothrottle functions from takeoff to touchdown.

Tailored specifically for use with any combination (intermix) of the CFM 56-3B1, -3B-2, and -3C-1 engines, the autothrottle system is designed for maximum fuel conservation through smooth, precise thrust control. The autothrottle can control to N_1 limits as calculated by the FMCS, or can accept Mach and airspeed commands from the pilot or FMC via the DFCS mode control panel.

A key feature of the 737 autothrottle is the dual servo system. Engines are individually controlled to achieve optimum performance from each engine. Like other flight management subsystems, the autothrottle is designed not only for maximum operational and cost benefits, but for ease of maintenance as well.

The autothrottle consists of a computer operating the thrust levers through two independent servomechanisms. The system automatically positions the thrust levers to maintain a computed thrust setting during takeoff, go-around, or climb, and to maintain a selected airspeed or an airspeed computed by the FMC during cruise, descent, holding patterns, and initial approach maneuvers. The autothrottle limits to maintain a minimum safe airspeed; and during automatic landing flare, it retards the thrust levers.



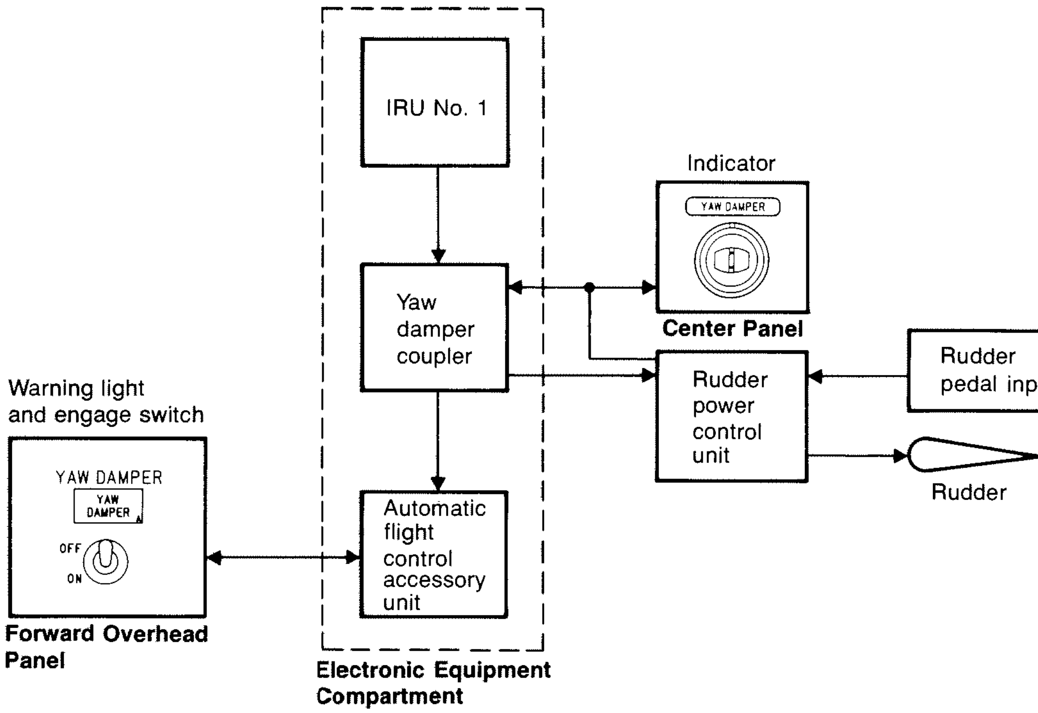
Built-in Test Equipment

Built-In Test Equipment (BITE)

Self-contained inflight monitoring and ground test capabilities are provided for the main FMS components: the FMC, the DFCS, autothrottle, and IRS. Each major FMS component contains comprehensive tests for itself, its sensor inputs, and other interfaces. Inflight fault data are automatically stored for analysis on the ground through the BITE system.

With BITE, line maintenance becomes a one-person operation from the CDU on the flight deck. All system BITE communicates to the technician via the CDU in English. No additional test equipment is required. The technician simply selects from a menu of test options, and supplies interactive operator responses via the CDU. BITE runs the tests and provides corrective action diagnostics. System verification, to check interfaces after corrective maintenance action, is also provided.

The system is designed for line maintenance fault isolation to a single line replaceable unit (LRU) within three minutes. Fast and accurate diagnostics mean fewer delays and smaller spares inventories.



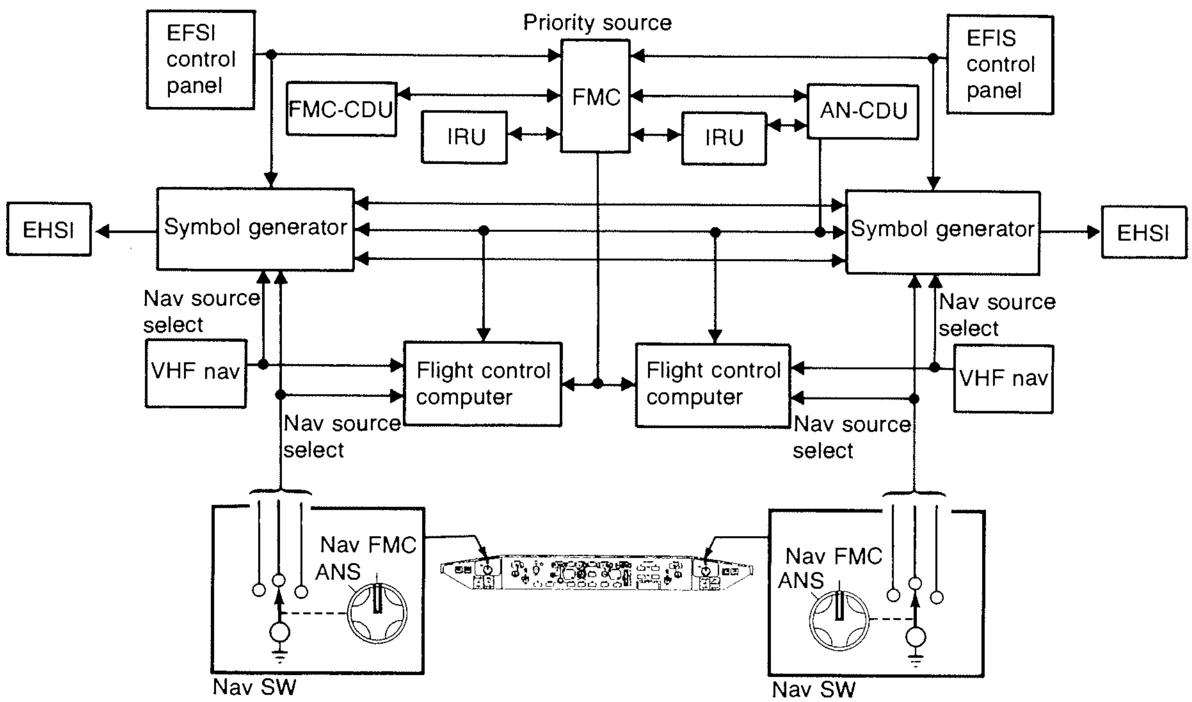
Yaw Damper System

Yaw Damper

The purpose of the yaw damper is to deflect the rudder as required to eliminate yaw rates that are associated with dutch roll.

The yaw damper electronics and rate gyro are combined in a unit called the yaw damper coupler which is located in the electronic equipment compartment. A yaw damper on/off switch, annunciator light, and position indicator are located on the control panels in the flight deck.

Full-time yaw damping is available over the complete flight profile, including takeoff and landing. The yaw rate gyro sends yaw change signals to the circuitry in the coupler. The coupler responds only to those yaw rates that produce dutch roll. Command signals are then sent to the rudder power control unit to deflect the rudder and reduce the oscillation. Turn coordination is provided by reducing the yaw rate gain as a function of roll attitude from an inertial reference unit (IRU). Low gain is also used during localizer capture and track phase. No rudder pedal movement results from yaw damper operation. The automatic flight control accessory unit contains the logic to engage the yaw damper system and illuminate the amber yaw damper disengaged annunciator light. The yaw damper can be tested at the yaw damper coupler.



Single AN-CDU Functional Interfaces

Alternate Navigation System (ANS)

The alternate navigation system is an optional navigation aid consisting of dual alternate navigation-control display units (AN-CDU) which receive inputs from the onside IRU and provide pilots with an independent source of IRS-based navigation, and backup lateral navigation/guidance capability in the event of an FMC failure.

The AN-CDU retains all of the capability of a standard CDU for operating with the FMC, and in addition, can also be used to create flight plans, either by manual entry or "cross load" from the FMC, and can be used for flight plan editing and for sending steering commands to the autopilot.