31
McDonnell Douglas MD-11 Avionics System

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31.1 Introduction

While the MD-11 is a derivative of the DC-10 airplane, the avionics system is an all-new system that represented the state of the art at the time of its introduction into service in December 1990. The MD-11 flight deck, shown in Figure 31.1 is designed to be operated by a two-pilot crew.

The crew is provided with six identical 8-in. color CRT displays, which are used to display flight instrument and aircraft systems information. A navigation system based on triple Inertial Reference Systems (IRS) and dual Flight Management Systems (FMS) is provided to automate lateral and vertical navigation, and reduce pilot workload. An Automatic Flight System (AFS) based on dual Flight Control Computers (FCC) is also installed to provide full flight regime autopilot and autothrottles, including fail-operational Category IIIb autoland capability.

The hydraulic, electrical, environmental, and fuel systems, that on previous aircraft were the responsibility of a flight engineer, were automated, with the system management now performed by Aircraft System Controllers.

The avionics equipment on a commercial airliner can be divided into two general categories, Seller-Furnished Equipment (SFE) and Buyer-Furnished Equipment (BFE). The BFE Avionics comprises the type of equipment that is largely standard from airplane to airplane, such as radios, sensors, and entertainment systems. Airlines generally buy this direct from competing suppliers, and may well use a common supplier for a particular piece of equipment for many different airplane types. Most of this BFE avionics is defined by industry standards, published by ARINC for the Airlines Electronic Engineering Committee (AEEC). The SFE avionics consists of the type of equipment that is specific to the airplane type, and is provided by the airframe manufacturer. It includes such systems as the Auto-Flight System (AFS), the Electronic Instrument System (EIS), Flight Management System (FMS), and the various system controllers. On the MD-11 most

FIGURE 31.1

of this SFE avionics is supplied by Honeywell under a partnership agreement which shared the systems integration function between McDonnell Douglas and Honeywell.

In commercial aviation, the various systems on an airplane are identified under chapter numbers that are defined by the Air Transport Association (ATA). The architectures of each of the systems (communication, navigation, displays, etc.) are discussed below under their respective ATA chapters. Simplified schematic diagrams are provided where appropriate. Note, though, that since the interfaces between the systems are largely ARINC 429 databuses (and in some cases discrete or video), they have been simplified for the purposes of illustration. Some of the data flows, for example, are shown as a single bi-directional arrow. Clearly this is not possible with the point-to-point ARINC 429 databuses, and the single line must therefore represent more than one databus.

31.2 Flight Controls (ATA 22-00 and 27-00)

A dual-dual (four-channel) Auto Flight System (AFS) is installed on the MD-11 to provide autopilot/autothrottle capabilities. The functions of the AFS include:

- Flight Director (FD)
- Automatic Throttle System (ATS)
- Automatic Pilot (AP)
- Autoland (to Cat IIIb minima)
- Yaw damper
- Automatic stabilizer trim control
- Stall warning
- Wind shear protection (detection and guidance)
- Elevator load feel
- Flap limiter
- Automatic ground spoilers
- Altitude alerting
- Longitudinal Stability Augmentation System (LSAS)

The system architecture of the AFS is shown in Figure 31.2. It is built around the dual-dual Flight Control Computers (FCC) and the Glareshield Control Panel (GCP). The GCP is used by the pilots to select AFS modes for pitch, roll, and thrust control and to select targets (e.g., speed or altitude) for those modes. The AFS Control Panel is used by the crew to reconfigure the system in the event of a failure.

The dual-dual FCC architecture is designed around the fail-operational Cat IIIb autoland requirement. Each FCC has two independent computational lanes to provide added integrity and redundancy. Each of these lanes consists of a power supply, two dissimilar microprocessors with dissimilar software (with one of these microprocessor types common to both lanes), and servo-electronics to drive the actuators that move the aircraft's control surfaces. This triple dissimilarity is intended to limit the possibility of software errors in one lane resulting in unsafe operation. This architecture is used for the functions that require high integrity (e.g., autoland and LSAS). Functions having a lower criticality only use a single version and are spread across the different processors. The system is designed to allow the airplane to be dispatched with only one FCC operational, though in this case it would not be able to perform a Cat IIIb autoland.

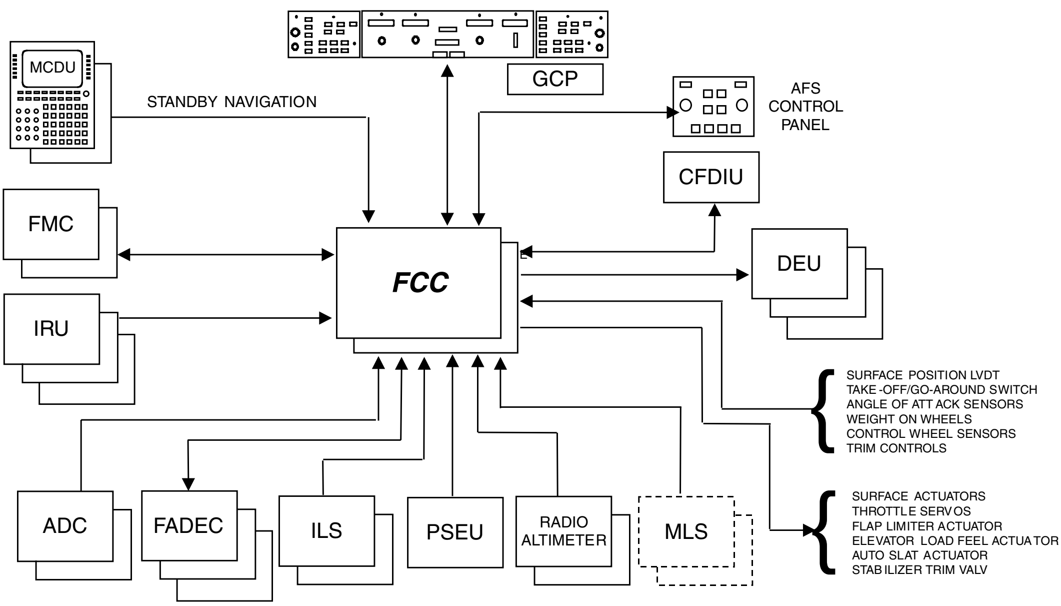

FIGURE 31.2 Auto Flight System (AFS) architecture.

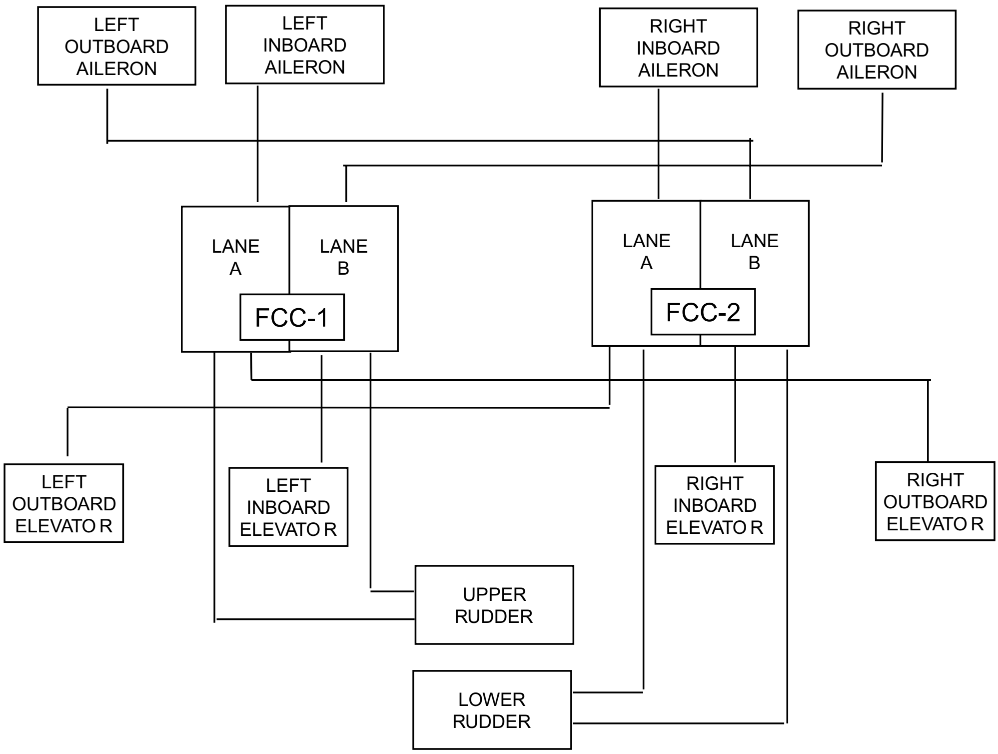

FIGURE 31.3 AFS actuator architecture.

A key element of flight control system design is the need to provide appropriate levels of redundancy in the interfaces to the actuators for the flight control surfaces. A number of related issues have to be considered:

- Dispatch with one Flight Control Computer (FCC) or one lane inoperative.
- Protection against both random and generic hardware and software failures/errors.
- Minimize the probability of a multi-axis hardover.

Figure 31.3 shows how the elevator, aileron and rudder actuators interface to the various channels of the FCC to satisfy these requirements. The control surfaces are also interconnected mechanically, so driving only one elevator, for example, will actually result in all elevator panels moving. Sufficient control authority is retained in the event of loss of a single channel or even of a complete FCC. The diagram does not show the stabilizer control (which is also driven by the FCC) or the spoilers, which are driven by the aileron/spoiler mechanical mixers and are thus driven indirectly by the aileron actuators.

31.3 Communications System (ATA 23-00)

The Communication System installed on the MD-11 is a highly integrated system, designed to reduce the workload of the two-man crew while providing the required levels of redundancy. It includes voice communication with the ground via VHF, HF, and SATCOM, as well as data link communications using an optional Aircraft Communications Addressing and Reporting System (ACARS) over the VHF radio, SATCOM, or HF data link (HFDL). The HF and VHF radios are controlled by the Communication Radio Panels located in the pedestal on the flight deck. Selective calling capability is provided by a SELCAL unit. The architecture is shown in Figure 31.4. The basic features of this architecture, in terms of the communication facilities provided, are dictated by Federal Aviation Regulations (FAR) Part 25, which mandate dual independent communication facilities be provided throughout the flight.

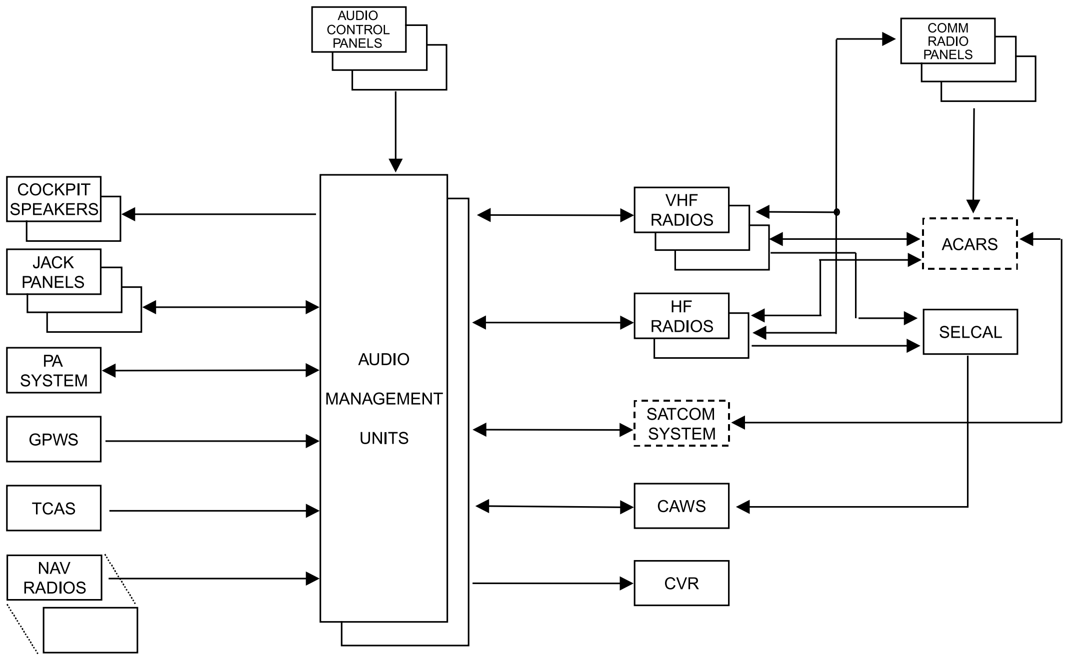

FIGURE 31.4 Communication system architecture.

The Audio Management Units (AMU) are the heart of the voice communication system for the pilots, and provide flight and service interphone capabilities, as well as supporting the aural alerts on the flight deck generated by the Central Aural Warning System (CAWS), Traffic Alert and Collision Avoidance System (TCAS), and Ground Proximity Warning System (GPWS). The Cockpit Voice Recorder (CVR) records all transmissions by the pilots. Audio Control Panels are provided for all crew on the flight deck (including the observer's station) to control volume, etc. Similarly, jack panels are provided for each crew member's headset.

One feature which is becoming more common on transport aircraft today is the SATCOM system, and the MD-11 has provisions to allow this to be installed. Either a single (6-channel) or a dual (12-channel) system may be installed to provide facilities for both passengers and crew transmissions. The data channel provided for crew use comes into its own for the new CNS/ATM environment (discussed below), while the other channels can be used to provide facsimile and telephone services for the passengers and the cabin crew. It is this passenger service use that typically pays for the system's installation on the airplane.

With all these communication systems, and the navigation systems described below, there is a need for a very large number of antennas on the airplane, and the total installation has to be designed to preclude interference between the different systems. The antenna layout on the MD-11 is shown in Figure 31.5.

Much of the communications equipment is defined by standard ARINC characteristics and is procured by the operators as BFE. Thus multiple suppliers are certified, and the operators may choose which they prefer. The same applies to the navigation radios described below.

31.4 Entertainment System (23-00)

On an airplane such as the MD-11, which can have as many as 410 seats, the entertainment system comprises the vast majority of the avionics Line Replaceable Units (LRUs). With one passenger control unit per seat, one seat electronics box per seat group, and one in-seat video monitor per seat (for those operators that provide in-seat video), it can amount to well over 1000 LRUs.

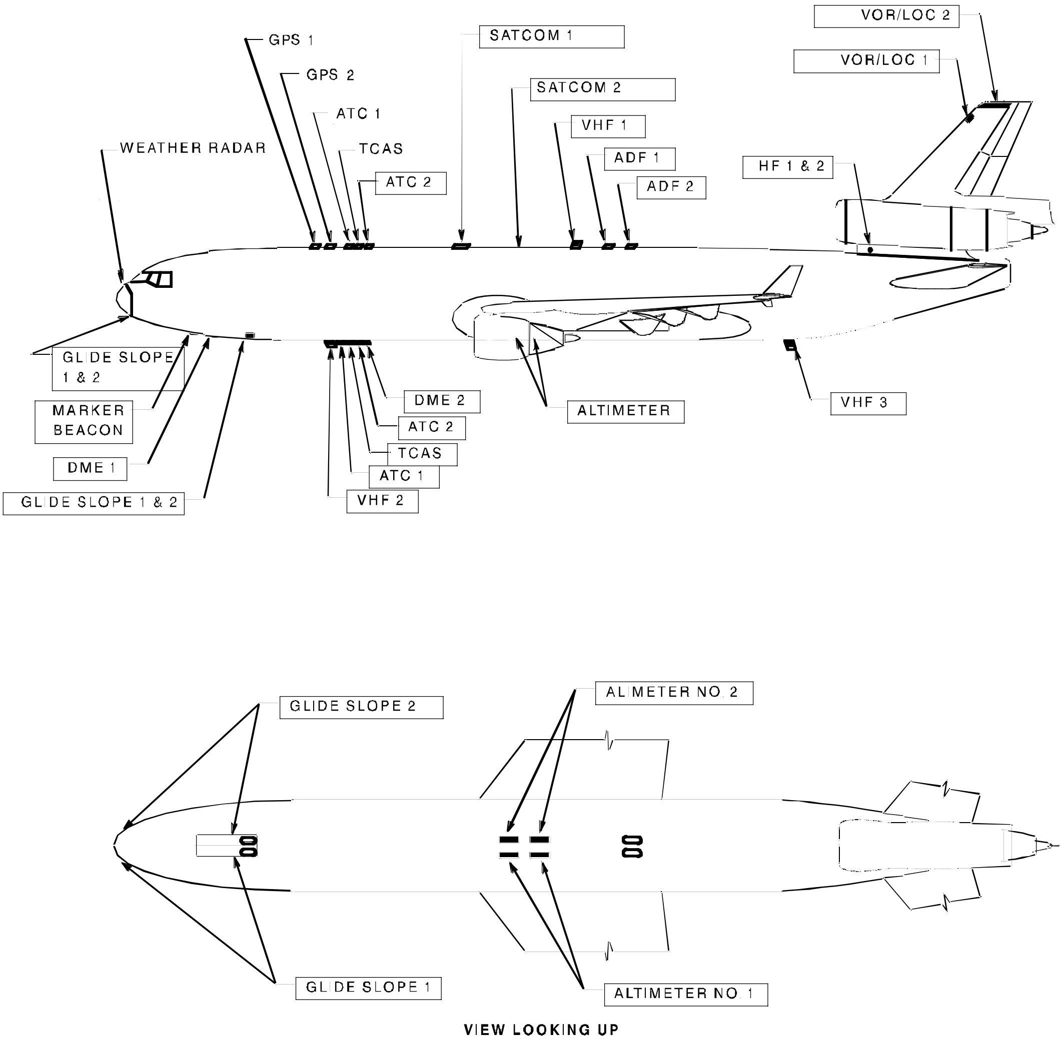

FIGURE 31.5 Antenna layout.

It is, however, typically a system that is almost totally outside the control of the airplane's manufacturer. It is usually BFE, and an airline may well upgrade it significantly (or replace it totally) several times during the life of the airplane. An airline will usually select a supplier for their entire fleet and then have the supplier adapt it to the particular airplane installation. It is therefore not really practicable to talk about a standard MD-11 entertainment system.

The only standard feature is the audio entertainment system/service system, which interfaces with the Passenger Address (PA) system to allow any safety-related announcements to override the entertainment audio.

31.5 Display System (ATA 31-00)

The most prominent feature of the MD-11 flight deck is the Electronic Instrument System (EIS). This consists of six 8-in. by 8-in. Cathode Ray Tube (CRT) Display Units (DU) arranged in two horizontal groups of three. The outer two DUs are Primary Flight Displays (PFD). Inboard of these are two Navigation Displays (ND), which can display any of five different formats. The center two DUs provide the Engine and Alert Display (EAD) and the System Display (SD). The SD has 10 selectable pages to

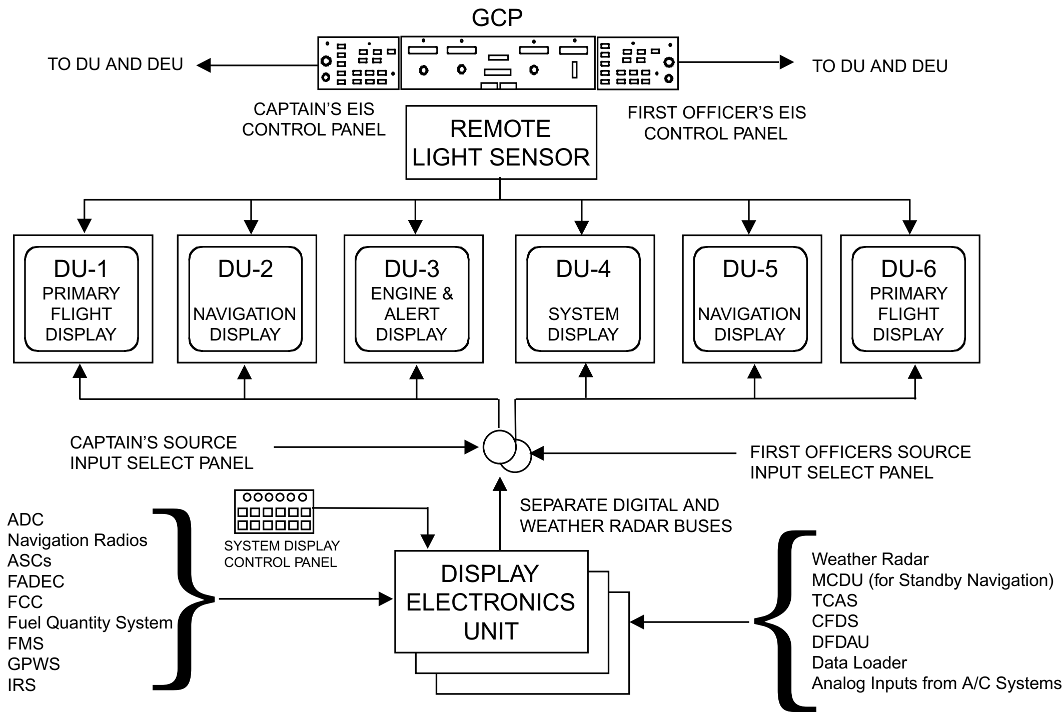

FIGURE 31.6 Display system architecture.

allow synoptic displays for any of the airplane systems to be presented. The SD pages are selected from the System Display Control Panel (SCP).

The architecture of the EIS is shown in Figure 31.6. This is a very simplified presentation. Any Display Electronics Unit (DEU) can support all six DUs, thus allowing the flight to continue in the event of a failure, and dispatch of the airplane with one inoperative. It is also possible to dispatch with one DU inoperative. In the event of loss of one or more DUs, the system will automatically reconfigure to provide the appropriate displays according to a fixed priority scheme. The lowest priority is accorded to the First Officer's Navigation Display (ND), and the highest priority to the Captain's Primary Flight Display (PFD).

In addition to these displays, standby displays of air data (airspeed and altitude) and a standby attitude indicator are provided on the main instrument panel. These are completely independent of the EIS, thus providing an additional level of backup. These standby displays are mandated by Federal Aviation Regulations (FAR).

On the MD-11 the Engine and Alert Display is part of the EIS. The DEUs thus contain all the alerting logic for the airplane and drive the Master Caution and Warning indicators. They also provide outputs to the Central Aural Warning System (CAWS) to generate voice alerts.

31.6 Recording Systems (ATA 31-00)

A number of in-flight recording capabilities are provided on the MD-11, for both voice and data storage. These include:

Cockpit Voice Recorder (CVR)
Flight Data Recorder (FDR)
Auxiliary Data Acquisition System (ADAS)
In-Service Data Acquisition System (ISDAS)

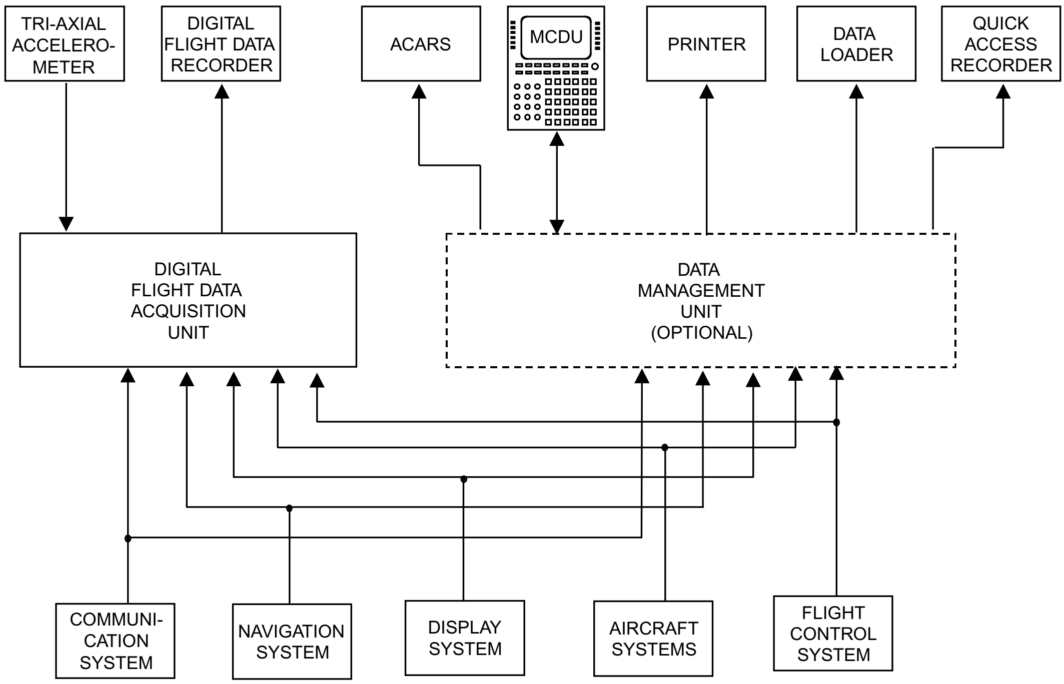

FIGURE 31.7 Recording system architecture.

The CVR was discussed along with the communications systems, to which group it properly belongs. The FDR is the recorder mandated by Federal Aviation Regulations to allow investigations of incidents that have occurred. Figure 31.7 shows how this is driven by a Digital Flight Data Acquisition Unit (DFDAU), which receives data from the other avionics systems in both digital and analog form. There is an FAA Notice of Proposed Rule-Making (NPRM) that mandates expanding the amount of data to be recorded. The MD-11 already records most of these parameters, but will be adapted as necessary to record the remainder.

The Auxiliary Data Acquisition System (ADAS) is also shown in the figure. It uses the Data Management Unit (DMU), and allows both the FAA mandatory data and additional data from the aircraft systems to be recorded for future access via the Quick Access Recorder (QAR). Typically an operator would have the DMU programmed to record specific data for specific events (e.g., recording data for analysis of an aircraft exceedance, or recording aircraft and engine performance parameters to allow trend analysis). The ADAS is an optional feature. The form of the ADAS shown in the figure is one version. There is also a version that uses a combined DFDAU/DMU.

The final recording system is the In-Service Data Acquisition System (ISDAS). Several of the major avionics LRUs have a databus that can be programmed to output an operator-defined set of parameters to allow in-service troubleshooting of the system. The FMS, EIS, and AFS are among those systems having this capability.

31.7 Navigation Systems (ATA 34-00)

The navigation system for the MD-11 is built around a triple Inertial Reference System (IRS) and a dual Flight Management System (FMS). The navigation system is shown schematically in Figure 31.8. The FMS is, of course, much more than just a lateral navigation system. It provides a number of functions that are central to operation of the airplane:

- Ability to create flight plans, including airways, Standard Instrument Departures (SIDs), and Standard Terminal Arrival Routings (STARs) by keyboard entry or data link.

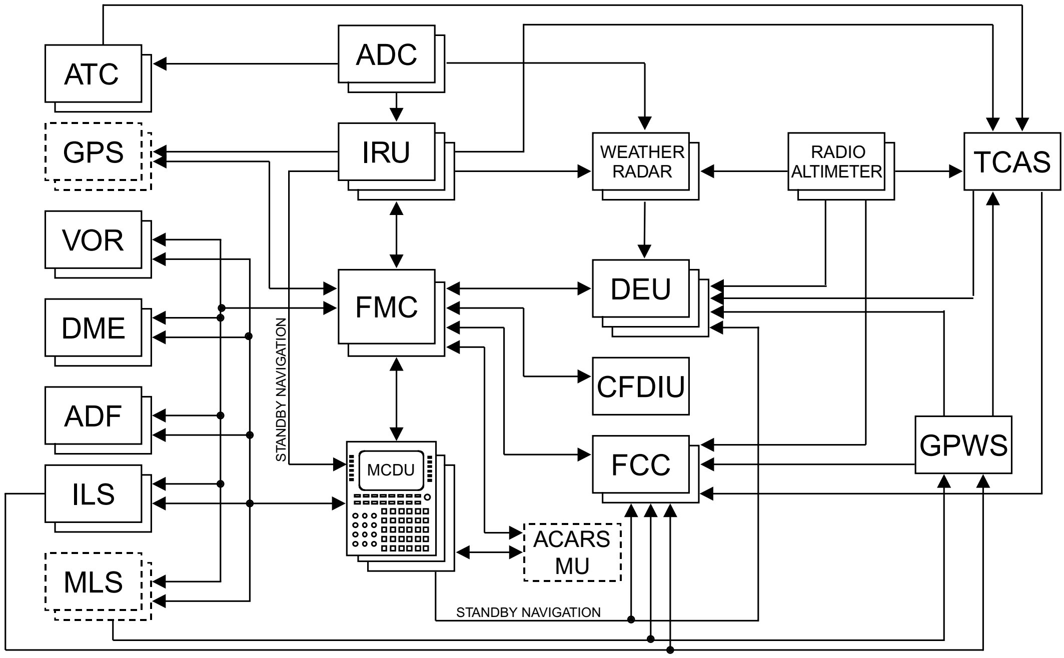

FIGURE 31.8 MD-11 navigation system architecture.

- Multisensor navigation using inertial reference data, together with inputs from GPS, DME, VOR, and ILS.
- Performance predictions for the complete flight plan, including altitude, speed, time of arrival, and fuel state.
- Guidance to the flight plan in three dimensions and controlling arrival time.
- Take-off and approach speed generation.
- Providing the VOR beam guidance mode.

On a long-range airplane, such as the MD-11, being able to dispatch the airplane when it is several thousand miles from the airline's maintenance facility and one navigation system has failed is very important to securing the bottom line for the operator. Such airplanes therefore usually have triple navigation systems. This capability to dispatch with a single failure is provided on the MD-11 by having triple IRS (thus allowing for a failure in this system) and having a standby navigation function provided in the Multipurpose Control/Display Units (MCDU), thus allowing for an FMS failure.

The Inertial Reference System provides a good independent position solution for short-term operation, or even for long-term operation within its capability of a drift of up to 2 nmi/h. However to provide the accuracy necessary for the area navigation required in today's airspace system or for terminal area operations, radio updating is necessary. This is provided on the MD-11 by having dual VHF Omni-Range Receivers (VOR) and dual Distance Measuring Equipment (DME) transceivers. Automatic Direction Finding (ADF) for flying nonprecision approaches and Instrument Landing System (ILS) for precision approach and landing are also provided. At the time that the MD-11 was designed, Microwave Landing System (MLS) was the up and coming system, and provisions are included to install this, although no airline has yet installed MLS. Global Navigation Satellite Systems for en-route operation and even in the future as a precision approach sensor are now the expected future means of navigation, and the option to install this on the MD-11 is now available. All of these navigation sensors are BFE equipment, and thus operators have a choice of suppliers to select from.

The antennas are not shown on the diagram, but one point that calls for a comment is that because of the geometry of the MD-11, the glideslope antennas for the ILS, which are installed in the radome, have to be replicated on the nose landing gear and the ILS must use the gear-mounted antennas on final approach. This is to meet the FAA requirement to have the antenna less than 19 ft above the wheels when crossing the runway threshold. The same rule, obviously, applies to the equivalent MLS antennas.

A dual air data system is also installed to provide airspeed, altitude, etc. for display to the crew and as inputs for the other systems (AFS, FMS, etc.) that need such data. Selection of baro reference is provided on the Glareshield Control Panel (GCP) which is part of the AFS (ATA 22-00) and is described there. Metric altitude displays and barosets are provided in addition to the English units normally used. There is an option to add a third air data system, in which case it is configured as a hot spare with a separate switching unit.

Additionally, dual weather radar systems (with a single flat plate antenna) are provided, together with radio altimeters, ATC transponders, and Traffic Alert and Collision Avoidance System (TCAS). The weather radar is now available with the capability to detect windshear ahead of the airplane. TCAS is a requirement for U.S. operators and foreign operators flying in U.S. airspace. Freighter aircraft (since the FAA regulation applies to aircraft with more than 30 seats) and government-operated aircraft do not require it, although most of these operators do, in fact, install it. These systems, again, are BFE, thus allowing the operators to select from competing suppliers.

All of this equipment is connected to the Centralized Fault Display System (CFDS) to provide fault reporting on each of the units, although for clarity only the FMCU is shown connected to the CFDIU in Figure 31.8. This system is discussed in more detail under ATA 45-00.

31.8 Maintenance Systems (ATA 45-00)

The maintenance system on the MD-11 consists of two main elements, the Centralized Fault Display System (CFDS) that is standard on the airplane, and the On-board Maintenance Terminal (OMT) which is available as a customer option.

The CFDS consists of a Centralized Fault Display Interface Unit (CFDIU) and any of the three MCDUs, with the capability to interface to all the major avionics subsystems on the aircraft, using ARINC 604 protocols, as shown in Figure 31.9. The functions provided by the CFDS are

- A summary of Line Replaceable Units (LRUs) that have reported faults on the last flight
- Capability to select individual "Reporting LRUs" for review of current faults and fault history
- Initiation of Return-to-Service testing of aircraft components (on-ground only)
- Capability to view sensor data
- Erasure of LRU maintenance memory (on-ground only)
- Ability to declare components inoperative for the Aircraft System Controllers (ASC)

The CFDS can also interface to an ACARS Management Unit to transmit fault data to the ground and to a printer on board the airplane.

The optional On-board Maintenance Terminal (OMT), shown in Figure 31.9, expands the capability of the CFDS and automates many of the required maintenance tasks. It contains a fault message database, which allows it to correlate each fault message to a specific flight deck effect. The displays on the OMT are customized by the individual airlines, but a typical display can show which LRU is involved, the fault message, the flight deck effect and alert, the Minimum Equipment List (MEL), documentation reference, and other useful information.

The OMT also incorporates a mass storage device, allowing it to store the aircraft maintenance documents, including the Aircraft Maintenance Manual (AMM), Fault Isolation Manual (FIM), MEL, Wiring Diagrams, etc. The built-in references to this documentation allow these data to be provided automatically as part of the fault-tracing process.

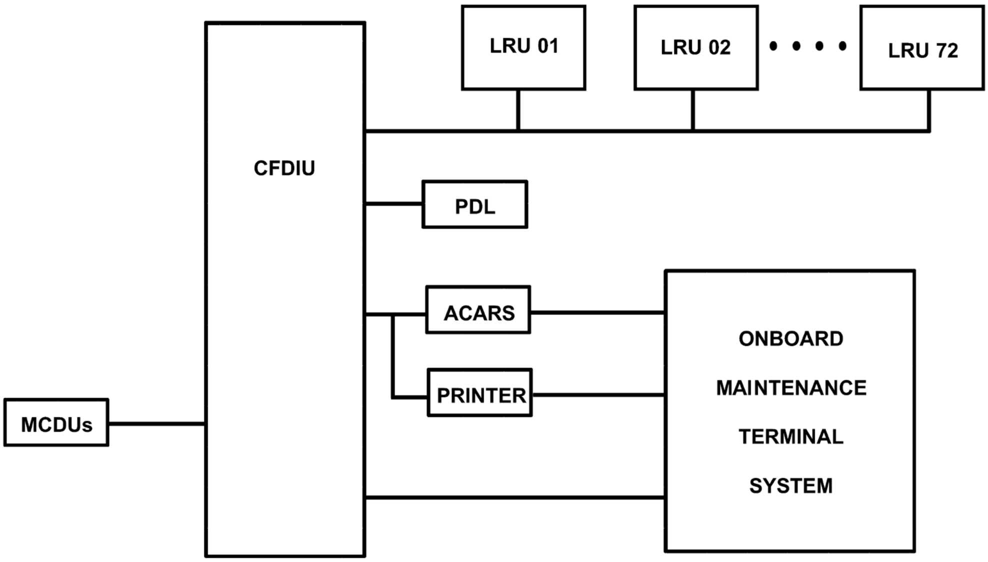

FIGURE 31.9 MD-11 maintenance system architecture.

31.9 Aircraft Systems

One of the major challenges in redesigning the DC-10 to become the MD-11 was to convert the three-crew flight deck of the DC-10 to a two-pilot flight deck, which is the current standard for the industry. To enable the MD-11 to be flown by a two-pilot crew, the normal, abnormal, and emergency system functions performed by the Flight Engineer on the DC-10 have been automated. This was made possible by advances in system control technology that enabled automatic execution of proven DC-10 procedures without extensive redesign or modification of the systems.

The status of the aircraft and its systems are provided to the crew on the main instrument panel Display Units (DUs) without any need to review the overhead panels, which provide backup annunciation and manual interface capability. Alert information is displayed on the Engine and Alert Display (EAD), while system status is displayed in schematic form as System Synoptics on the System Display (SD), allowing a rapid assessment of system failures and their consequences.

The aircraft systems are monitored for proper operation by the Automatic Systems Controllers (ASC). In most cases, system reconfiguration as a result of a malfunction is automatic, with manual input being required for irreversible actions, such as engine shutdown, fuel dumping, fire agent discharge, or generator disconnect. A "Dark Cockpit" philosophy has been adopted. During normal operations, all annunciators on the overhead panel will be extinguished, thus confirming to the crew that all systems are operating normally and are properly configured.

The MD-11 aircraft systems can be controlled manually from the overhead panel area of the cockpit. The center portion of the overhead panel is composed of the primary aircraft system panels, including Air, Fuel, Electric, and Hydraulic Systems, and are easily accessible by either pilot. Each panel is designed so that the left portion controls system #1, the center portion system #2, and the right hand portion system #3.

Each Aircraft System Controller (ASC) has two automatic channels and a manual mode. If the operating automatic channel fails or is shut off by its protection devices, the ASC will automatically select the alternate automatic channel and continue to operate normally. If both automatic channels fail, then the controller reverts to manual operation. The crew would then employ simplified manual procedures for the remainder of the flight. In order to allow operators to maximize the dispatch reliability of the airplane, the MD-11 is certified for dispatch with up to two systems operating in manual mode. The general architecture for Aircraft System Controllers is shown in Figure 31.10.

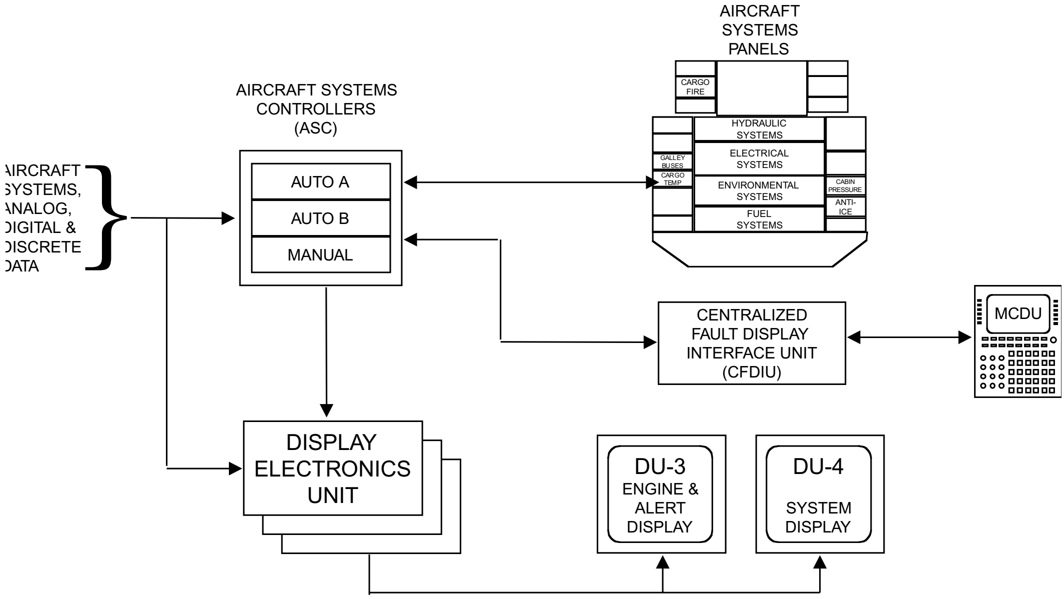

FIGURE 31.10 Generalized architecture for aircraft system controllers (ASC).

Automatic System Controllers (ASC) are provided for the primary systems as follows:

- Environmental System Controller (ESC)
- Hydraulic System Controller (HSC)
- Electrical Power Control Unit (EPCU)
- Fuel System Controller (FSC) and Ancillary Fuel System Controller (AFSC)

Pneumatic System Controller, Air Conditioning Controllers, and Cabin Pressure Controllers are also provided to control their respective subsystems.

31.10 Interchangeability

The MD-11 has been designed to allow interchangeability with the systems installed on other aircraft. The aircraft radios (HF, VHF, SATCOM, GNSSU, VOR, ILS, DME, ADF, ATC transponder, and radio altimeter) and other systems, such as ACARS, recorders, TCAS, and weather radar) are buyer-furnished equipment (BFE). They are all defined by industry standards (ARINC characteristics). Thus an operator is able to select a standard unit that is used on several airplane types and purchase in bulk for his entire fleet. With this standardization, he is also able to obtain spares from the vendor or other airlines at locations where he does not have a spares depot.

Another key element in providing interchangeability is with the MD-11's "single part number" philosophy. Under this philosophy, all the options required by various airlines for a particular system are incorporated in a single standard version of that system, and the individual airline then selects the appropriate options by means of a program pin or software option code. Additionally, as improved versions of the systems are developed, each MD-11 operator receives the latest version of that system (with the new features, if there are any, being selected again by program pin or option code). The advantages of this are considerable. At any time there is only one version of each system in the field to be supported, the airlines stay abreast of system improvements and avoid obsolescence, and there is a single part number available as a spare for airlines, thus improving their availability at remote locations.

Most of the changes to the various avionics systems that have to be kept updated under this single part-number philosophy are software changes. Most of the major avionics systems are software loadable, that is they can have their software loaded via the front or rear connector *in situ*. This simplifies the airlines' task in keeping their aircraft current.

31.11 CNS/ATM Architecture

One of the major changes affecting aircraft manufacturers and operators today is the need to operate in the new Communication, Navigation, Surveillance/Air Traffic Management (CNS/ATM) environment. This began with the ICAO Committee on Future Air Navigation Systems (FANS), and its first in-service application was on the Boeing 747-400 FANS-1 package in the South Pacific. This introduces a number of new CNS features in the airplane avionics systems:

- Controller/Pilot Data Link Communications (CPDLC) to communicate with ATC
- Global Navigation Satellite System (GNSS) navigation
- Required Navigation Performance (RNP) certification
- Required Time of Arrival (RTA) navigation to control arrival times at waypoints
- Automatic Dependent Surveillance (ADS) to provide surveillance data to ATC and the airline

The MD-11's original avionics architecture lends itself well to adaptation for these new functions. In the MD-11 CNS/ATM architecture, the FMC provides the computing resources for the new functions, with the ACARS MU (or CMU) used as a communications link to the ground via the SATCOM, VHF, and HF Data Link (HFDL) to the airline dispatch and ATC centers on the ground. The architecture is shown in Figure 31.11.

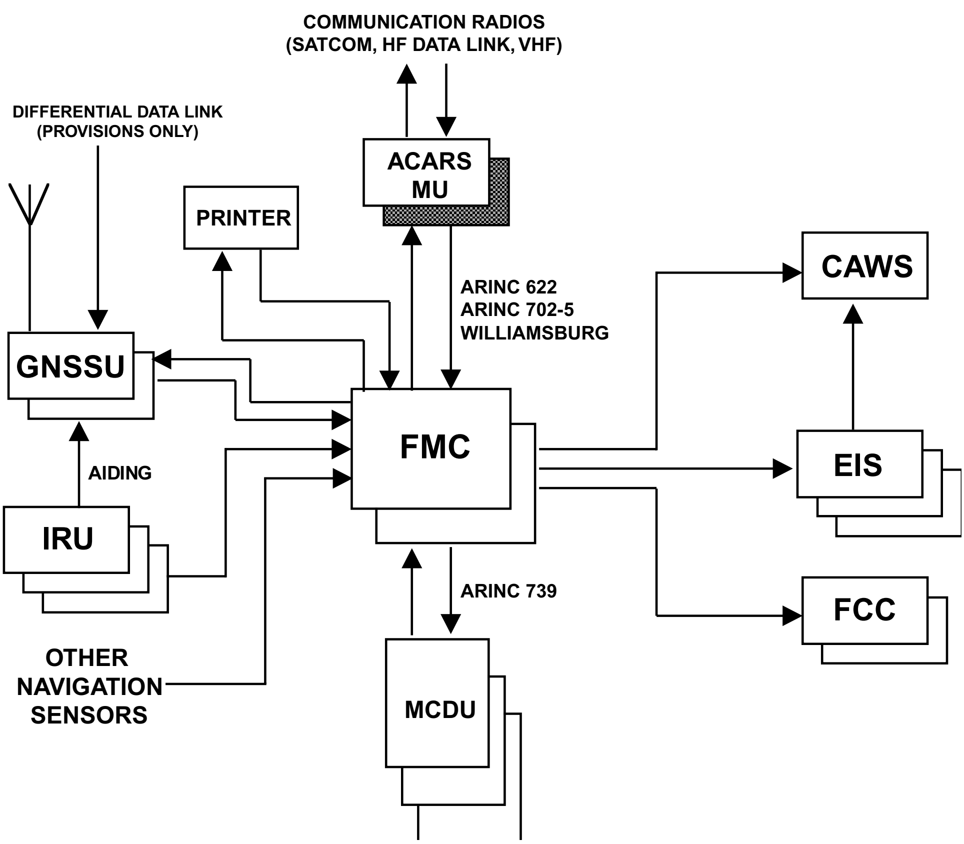

FIGURE 31.11 MD-11 CNS/ATM architecture.

Having the FMC host the applications for the new CNS/ATM functions, and in particular the communication/surveillance functions of CPDLC, AOC, and ADS, allows changes to these functions to be largely limited to the FMC. Similarly changes to the communications protocols can be kept to a single LRU, in this case the ACARS MU. With the migration to the Aeronautical Telecommunications Network (ATN), the ACARS MU will be replaced by an ARINC 758 Communications Management Unit (CMU), which will provide the necessary application gateway between the ATN Open System Interconnect (OSI) protocols and the FMS.

The GNSSU provides position, velocity, and time (PVT) to the Flight Management System (FMS), which determines the multisensor navigation solution based on best available data, i.e., the IRS combined with GNSS data or data from whichever other radio is most suitable. GNSS data are not provided to either the IRU or the MCDU, since standby GNSS navigation is not provided.

The GNSSU is provided today, and will be sufficient for the en route, terminal area, and non-precision approach accuracies required. In the next few years, however, as GNSS comes into use as a precision approach aid, it will be replaced by a unit such as the ARINC 755 Multi-Mode Receiver (MMR) to provide both precision approach capabilities and the outputs for the FMS.

The printer is interfaced directly to the FMC to allow the crew to print the flight plan clearance messages transmitted by ATC.

Obviously the architecture selected for the MD-11 was not the only possibility. AEEC has documented in ARINC 660 a number of possible architectures, some of which adopt a federated approach where the Air Traffic Services (ATS) functions are split between the FMC and the CMU.

McDonnell Douglas has elected to use the integrated approach described here for a number of reasons:

- Keeping the FMS/CMU interfaces simple
- Ability to re-use existing FANS-1 designs in the FMS
- Avoiding having to certify multiple different ATS applications with multiple ACARS/CMU suppliers
- Ability to provide a common ATS capability for all operators and provide commonality with other airplane types

The existing Flight Management Computer was designed to provide sufficient capabilities for the features required at the time of the MD-11's entry into service in 1990. It could probably provide sufficient computational resources (throughput and memory) to allow inclusion of the FANS-1 functionality, albeit with some degradation of the existing response times. However, growth in this configuration would be very limited. It therefore makes sense for such a major change to introduce the new hardware that will provide the necessary growth for the future. This is the Pegasus processor. The Pegasus processor is an Advanced Micro Devices (AMD) 29xxx family processor chip set, as used on the Airplane Information Management System (AIMS) designed by Honeywell for the Boeing 777.

31.12 Derivatives

The MD-11 flight deck was very much the standard to beat at the time of its introduction to service in 1990. In most respects, it still is, although technology developments in some areas, such as flat panel displays, have gone beyond the capabilities introduced by the MD-11. The flight deck layout is, however, still widely regarded as one of the best in the industry.

It was only to be expected, therefore, that the MD-11 flight deck would form the basis for future flight decks on McDonnell Douglas* commercial transport aircraft. For these aircraft, the Advanced Common

*In August 1997, The Boeing Company and McDonnell Douglas Corporation merged. Following that merger, the McDonnell Douglas name disappeared, and products of the former McDonnell Douglas Corporation now appear under the Boeing name. The term *McDonnell Douglas* has been used here where it would be historically inaccurate to use the term Boeing.

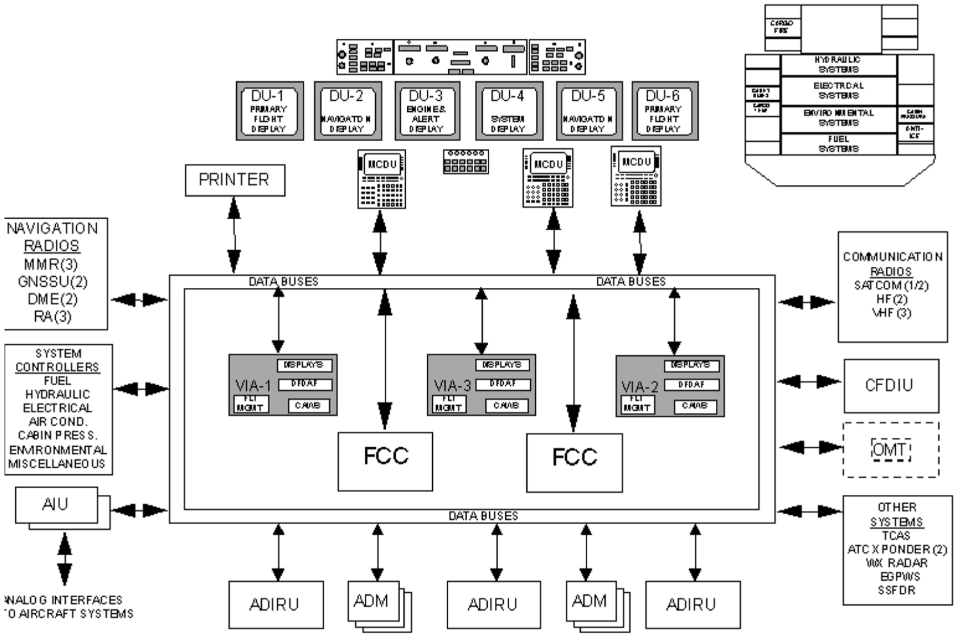

FIGURE 31.12 Advanced common flight deck (ACF) architecture.

Flight Deck (ACF) was developed, with the capability to be adapted to the specific needs of the airplane type. The ACF is based on MD-11 flight deck layout, and in many cases MD-11 components, and takes advantage of a number of technology advances that have occurred in the last few years:

- High-speed Reduced Instruction Set Computer (RISC) processors
- Dual lock-step processing to monitor for hardware errors
- Time and space partitioning to allow software of mixed criticality to exist in the same box
- High levels of functional integration, as on the AIMS cabinet
- Flat panel display technology for the main Display Units and for the standby unit
- Integrated Air Data and Inertial Reference System (ADIRS)
- CNS/ATM capabilities

The ACF uses these technologies not just for the sake of using technology, but because each offers real cost benefits to the operators of the airplane and to the manufacturer. The result is the architecture shown in Figure 31.12.

The heart of the ACF is the Versatile Integrated Avionics (VIA). This unit provides a similar level of integration as is provided by the 48" AIMS cabinets, but contained in an 8MCU Line Replaceable Unit (LRU). On a long-range aircraft, such as derivatives of the MD-11, three of these units will be installed to allow dispatch with one inoperative. On smaller, short-range aircraft, such as the MD-95, only two are installed. The VIAs will have the same hardware, and largely common software on all aircraft types. The key to this is the use of Aircraft Interface Units (AIU). These are data concentrator units that convert most of the analog data to digital form, and allow the VIA to process only digital data received via ARINC 429 databuses. MD-11-type control units (MCDU, Glareshield Control Panel, System Control Panel, etc.) are used to give the flight deck the look and feel of the MD-11.

This advanced flight deck is now in production for the Boeing 717-200 and a two-crew version of the DC-10 known as the MD-10. The diagram in Figure 31.12, in fact, shows the architecture for the MD-10 airplane. For application on a short-range airplane, such as the 717, the architecture is simplified by deleting one of the VIAs. Similarly, if Cat IIIb autoland capability is not required, some of the sensors (ADIRU, ILS, Radio Altimeter) can be reduced from triple to dual installations.