NASA Contractor Report 189561

# Identification of High-Level Functional/System Requirements for Future Civil Transports

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**NASA**

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| AAS | Advanced Automation System |
| ACARS | ARINC Communication, Addressing, and Reporting System |
| ACCC | Aera Control Computer Complex |
| ACF | Aera Control Facility |
| ADC | Air Data Computer |
| ADF | Automatic Direction Finding |
| ADC | Air Driven Generator |
| ADS | Automatic Dependent Surveillence |
| AERA | Automated En Route ATC |
| AFS | Automatic Flight System |
| AGS | Auto Ground Spoiler |
| AP | Autopilot |
| APU | Auxiliary Power Unit |
| ARINC | Aeronautical Radio Inc. |
| ASC | Automatic Systems Controllers |
| ASD | Aircraft Situation Display |
| ASDE | Airport Surface Detection Equipment |
| ASR | Airport Surveillance Radar |
| ASTA | Airport Surface Traffic Automation |
| ATC | Air Traffic Control |
| ATM | Air Traffic Management |
| ATMS | Air Traffic Mangement System |
| ATN | Aeronautical Telecommunication Network |
| ATS | Autothrottle System |
| AVPAC | Aviation VHF Packet Communications |
| AWOS | Automated Weather Observing Station |
| AWPS | Aviation Weather Products Generator |
| BCAS | Beacon Collision Avoidance System |
| CAWS | Central Aural Warning System |
| CFDIU | Centralized Fault Display Interface Unit |
| CFDS | Centralized Fault Display System |
| CG | Center-of-Gravity |

# ACRONYMS AND ABBREVIATIONS

CIP        Capital Investment Plan
CMU        Communications Management Unit
C/N/S      Communication/Navigation/Surveillence
CWP        Central Weather Processor
CWS        Control Wheel Steering
DEU        Display Electronics Unit
DME        Distance Measuring Equipment
DU         Display Unit
EAD        Engine and Alert Display
ECP        EFIS Control Panel
ECU        Engine COntrol Unit
EFIS       Electronic Flight Instrument System
EIS        Electronic Instrument System
ELS        Electronic Library System
EPR        Engine Pressure Ratio
ESC        Environmental System Controller
FAA        Federal Aviation Administration
FADEC      Full Authority Digital Electronic Control
FCC        Flight Control Computer
FCP        Flight Control Panel
FD         Flight Director
F&E        Facilities and Equipment
FMA        Flight Mode Annunciator
FMS        Flight Management System
FSC        Fuel System Controller
GA         Go-Around
GLONASS    Global Orbiting Navigational Satellite System
GNSS       Global Navigation System
GPS        Global Positioning System
GPWS       Ground Proximity Warning System

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| G/S | Glideslope |
| HF | High Frequency |
| HIWAS | Hazardous Inflight Weather Advisory Service |
| HSC | Hydraulic System Controller |
| IAS | Indicated Air Speed |
| IDG | Integrated Drive Generator |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IRS | Inertial Reference System |
| IRU | Inertial Reference Unit |
| ITWS | Integrated Terminal Weather System |
| LLWAS | Low Level Windshear Alert System |
| LORAN | Long Range Navigation |
| LRU | Line Replaceable Unit |
| LSAS | Longitudinal Stability Control System |
| MB | Marker Beacon |
| MCDU | Malfunction Control Display Unit |
| MLS | Microwave Landing System |
| MSC | Miscellaneous System Controller |
| N1 | Engine Low Pressure Rotor RPM |
| NAS | National Airspace System |
| NAV | Navigation |
| MAVAID | Navigation Aid |
| ND | Navigation Display |
| NDB | Nondirectional Beacon |
| NEXRAD | Next Generation Weather Radar |
| NM | Nautical Miles |
| NOTAM | Notice to Airmen |
| NWS | National Weather Service |
| OMS | Onboard Maintenance System |
| OSI | Open System Interconnection |
| PFD | Primary Flight Display |

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| PIREP | Pilot Report |
| PROF | Vertical Profile |
| RA | Radio Altimeter |
| RE&D | Research, Engineering, & Development |
| RNAV | Area Navigation |
| SATCOM | Satellite Communication |
| SCP | System Control Panel |
| SD | System Display |
| SID | Standard Instrument Departure |
| STAR | Standard Terminal Arrival Route |
| TACAN | Tactical Air Navigation |
| TATCA | Terminal ATC Automation |
| TCAS | Traffic Alert and Collision Avoidance System |
| TCM | Thrust Control Monitor |
| TDWR | Terminal Doppler Weather Radar |
| TR | Transformer Rectifier |
| VHF | Very High Frequency |
| VOR | VHF Omnidirectional Range |
| VORTAC | VOR Collocated with TACAN |
| V/S | Vertical Speed |
| VSCS | Voice Switching and Control System |

# Identification of High-Level Functional/System Requirements for Future Civil Transports

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## SUMMARY

In order to accommodate the rapid growth in commercial aviation throughout the remainder of this century, the Federal Aviation Administration (FAA) is faced with a formidable challenge to upgrade and/or modernize the National Airspace System (NAS) without compromising safety or efficiency. A recurring theme in both the Aviation System Capital Investment Plan (CIP), which has replaced the NAS Plan, and the new FAA Plan for Research, Engineering, and Development (R,E,&D) are reliance on the application of new technologies and a greater use of automation.

Identifying the high-level functional and system impacts of such modernization efforts on future civil transport operational requirements, particularly in terms of cockpit functionality and information transfer, was the primary objective of this project.

The FAA planning documents for the National Airspace System of the 2005 era and beyond were surveyed; major aircraft functional capabilities and system components required for such an operating environment were identified, and a hierarchical structured analysis of the information processing and flows emanating from such functional/system components was conducted and the results documented in graphical form depicting the relationships between functions and systems.

# INTRODUCTION

## BACKGROUND

The design and development of future air transport flight decks will be impacted by the advanced technologies and system automation being planned for modernization of the National Airspace System into the next century. Satellites and data links, in particular, will dramatically change communication, navigation, and surveillance capabilities; not only on the ground but in the air as well. Such technologies will not only alter the basic air-ground information transfer and man-machine interfaces but, more fundamentally, automation will change the very nature of the roles allocated to the man and machine; both for air traffic controllers and pilots alike. Although this project has focus primarily on the latter, the ultimate impact of the 21st century National Airspace System should eventually be viewed from a "total system" perspective which would include not only future facilities and equipment but operational concepts and procedures as well. Only then can the true impact on future air transport flight decks be assessed.

The next decade will focus on the evolutionary development of an automated network of NAS facilities and equipment in which the latest levels of available technology will be integrated into a coordinated system of air traffic control and air navigation. The implementation of the Advanced Automation System (AAS) is the foundation for future Air Traffic Control (ATC) systems during the 1990s. Highly automated airspace management and traffic flow control strategies characterize the Automated Enroute ATC (AERA) which will be the backbone of the system. The integration of Advanced Traffic Management System (ATMS) to monitor, analyze, and control the flow of traffic throughout the ATC system and terminal airspace automation to enhance airport capacity and reduce aircraft delay, represent the major NAS modernizations through the end of this century.

Improved communication, navigation, and surveillance (CNS) supported by satellites and digital data links, to replace an ATC system of ground-based radar and voice air-ground communications, will have the greatest impact on future aircraft systems. Mode S data link, the global positioning systems (GPS), and the microwave landing system (MLS) are representative of the type of aircraft systems which will be required in the highly integrated and coordinated operational environment of the modernized NAS for the 2005 era.

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# TECHNICAL APPROACH

The technical approach adopted for this project was an initial effort of a broad-based top-down approach to the design and development of future civil transport cockpits. It consisted primarily of a high-level identification and definition of future operating requirements, in terms of functional capabilities and system components, needed to support commercial flight in a modernized NAS of the 2005 era.*

The objective was to provide a basis for assessing man-machine interface requirements for the effective and efficient transfer of information between the NAS operational environment and the advanced flight deck technologies, including automation. Without a highly integrated and coherent understanding of functional/system requirements; information generation, processing, and flows in terms of cockpit input/outputs; their implications for advanced flight deck/crew interfacing; future design and development efforts for integrating "human centered" automation, minimizing human errors and optimizing crew performance through advanced flight decks, will be negated.

The initial task was to complete a survey of the Federal Aviation Administration's planning documents including the National Airspace System Plan; its 1990 replacement, the Aviation System Capital Investment Plan; and the 1991 FAA Plan for Research, Engineering, and Development (second draft). Based on this planning, through the year 2005 for the modernization of NAS facilities and equipment, a projection of the operating environment for commercial aviation and functional capabilities required to support it was made. These results were documented in the next section entitled, "A Glimpse Into the Future".

The next task, based on the above functional capabilities, was to develop functional descriptions for the major aircraft system and/or subsystem components required to provide these capabilities. These descriptions provided a high-level characterization of the systems/subsystems; their information sources and inputs/outputs; and their relationship to other components; both between and among functions. These results are documented in the section "Functional Descriptions".

The final task was to develop from these data sources a series of ICAM (Integrated Computer-Aided Manufacturing) Definition Method diagrams which graphically depict hierarchical relationships between and among functions and their constituent systems and subsystems. These IDEF$_0$ diagrams also show the flow of information within the hierarchical structure as well as process inputs, outputs, controls, and mechanisms. The results are presented in the "IDEF$_0$ Diagrams" section of this report.

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* The high-level identification of functional capabilities and system components, while generic in nature, were derived from a specific, state-of-the-art commercial transport (viz. MD-11) and limited to nominal modes of operations (i.e., automatic flight system).

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# A GLIMPSE INTO THE FUTURE

### Summary of The National Airspace System Plan
### and
### FAA's Plan for Research, Engineering and Development
### For The Year 2000 and Beyond

## INTRODUCTION

The National Airspace System (NAS) Plan addresses the compelling problems of how best to improve safety and efficiency of the air traffic control system, under increasing demands for greater capacity; through the year 2000 and beyond. The recurring theme is that the solution lies in greater use of automation and the application of new technologies. Increases in system capacity demands have necessitated a reexamination of the operational, technical and personnel requirements in light of these proposed solutions; to ensure that the human components of the system are not being overwhelmed by such technology.

On the horizon are long term evolutionary changes which will dramatic ally improve air traffic control and air navigation systems in terms of *safety* and *capacity*. In fact safety and capacity are also the first two major mission areas of the Federal Aviation Administration's Plan for Research, Engineering and Development (FAA RE&D) of four fundamental mission areas used for top-down planning. Hence, as can be seen there is an inherently synergistic relationship between the FAA's National Airspace System Facilities and Equipment Plan (NAS F&E Plan) and the RE&D Plan in that both are directed to the improved safety and capacity of the air traffic control and air navigation system.

For example, the NAS F&E Plan's goals state that in addition a central objective of providing for the safe and efficient use of the Nation's airspace, its specific objectives include:

o Increasing air traffic (controller and flight specialist) productivity by a factor of at least two by the year 2000.

o Reducing operational errors by 80 percent over the next decade.

Both based on the assumption that, "Aviation demand will grow significantly during the next 20 years".

In the FAA's RE&D Plan's Executive Summary it states that "it is committed to providing a renewed focus and direction... [including]the following objectives:

o Establish a careful balance between support for the National Airspace System (NAS) Facilities Equipment (F&E) Plan....

o Enhance the capability of the FAA and aviation community to meet future challenges."

"Research will focus on how best to introduce and utilize new technologies and capabilities. The new RE&D emphasis, "the maturing of the NAS F&E Plan, and new issues in the air commerce system have influenced resource allocation... most importantly, the allocation of resources will be geared to specific goals for each of the FAA's major missions... capacity, safety and efficiency. These goals will be responsive to both near- and long-term needs and changing operational... requirements. They will also support the attainment of potential visions of aviation for the 21st century".

As previously indicated, "the NAS F&E Plan's emphasis has been on accommodating forecasted air traffic growth, without compromising safety, with far greater efficiency... through the use of ultra-reliable and highly automated C/N/S (communications/navigation/ surveillance) and ATC systems... [which]will enable the FAA to handle twice as much traffic..." Hence, RE&D activities are planned which directly support the NAS F&E Plan. The following table depicts the relationship between RE&D projects and associated NAS F&E Plan components.

## RE&D RELATIONSHIP TO THE NAS F&E PLAN [1]

### Air Traffic Control Systems

#### En Route

Advanced Automated System (Project 3.15)
Voice Switching and Control System (Project 4.3)

#### Flight Service and Weather

Aeronautical Data Link Communications Applications (Project 4.5)
Meteorologist Weather Processor/Real Time Weather Processor (Project 7.5)
Low-Level Windshear Alert System Enhancements (Project 7.3)

### Ground-to-Air Systems

Precision Approach and Landing (Project 5.2)
Aeronautical Data Link Communications Applications (Project 4.5)
Improvements to Navigation Systems (Project 5.1)
Navigation Systems Development (Project 5.3)
Terminal Doppler Weather Radar (Project 7.2)
Next Generation Weather Radar (Project 7.1)
Radar System Improvements (Project 6.1)

### Interfacility Communication Systems

Network Management and Control Equipment (Project 4.2)
Future Communications Requirements and Architecture (Project 4.1)
National Airspace Data Interchange Network II (Project 4.4)

1 from The Federal Aviation Administration Plan for Research, Engineering, and Development, Volume 1, DRAFT, November 28, 1988. (Table 4-29, pp. 4-81)

# BACKGROUND

Over the past decade, commercial aviation has witnessed extraordinary growth. By 1990, the number of domestic passenger enplanements in scheduled service was expected to exceed 500 million. Such growth is projected to continue unabated over the next two decades and reach almost one billion by 2010, which represents an increase in air carrier passenger growth of almost 130 percent. This growth rate also reflects a 55 percent increase in aircraft operations, including takeoffs and landings; a growth of 62 percent in instrument operations in terminal areas; and a 73 percent increase in air carrier hours flown. To accommodate such dramatic growth, the national aviation system is being challenged to respond, through the application of advanced aviation technologies, to these escalating demands by expanding capacity of the air traffic system and airports.

By the year 2005, a great number of such advances are expected to be made particularly in terms of automation; both on the ground and in the air. The flow of information to operators and the Air Traffic Control (ATC) system will have been enhanced by the widespread use of digital data link communications. Cockpit systems that can simplify and optimize the interaction of pilots with automated systems and digital communications devices will also be commonplace. Such technology, however, must not be introduced at the expense of safety. Hence, virtually all aircraft will have access to real time weather data and other flight information via digital data link. Airborne collision avoidance and ground proximity warning systems will be standard equipment. The automated enroute ATC (AERA) and a flow management system will be merged to facilitate the control of high density traffic departures and arrivals at major airports.

With the implementation of the advanced automation system (AAS), which will be the foundation of the 1990s air traffic management system, and various cockpit automation systems, the interface between pilots and controllers with advanced automation devices becomes a major concern. Although recent advances in cockpit design and automation have the potential for minimizing human error and reducing crew workloads, such devices (e.g., autopilots and autothrottles) also increase the potential for operational errors such as misinterpreting displayed information or keying in incorrect information. Hence, a major concern is in the area of the crew interfaces with advanced cockpit systems and the associated information transfer. The history of innovation suggests that such technology will continue to bring surprises even in a field which itself was born of man's dreams; such as aviation.

# AIR TRAFFIC CONTROL (ATC)

The ATC system will remain primarily a ground based radar system with all controlled aircraft, and most uncontrolled aircraft, equipped with altitude-encoding transponders. Most aircraft operating in the instrument flight rule (IFR) system will have random route navigation capability and will be equipped with data link communications. Most will also have very sophisticated flight management systems while others will have only basic two-way radios and VOR navigation equipment.

The ATC system ensures the basic safety functions within the national aviation system, primarily by providing aircraft separation and severe weather advisories. The development of improved means of providing weather data and information to pilots represents the major new developments over the next 10-15 years, combined with continuation of the advanced automation system and digital data link capabilities.

Improvements to ATC surveillance and navigation systems which will provide pilots and air traffic controllers with the aircraft position information for enhanced traffic management are major priorities. For example, integration of LORAN C and the global positioning system (GPS) to establish a sole-means method of navigation, that could eventually reduce the reliance on VOR/DME as well as precision landing approaches based on new microwave landing system (MLS) capabilities, are the main focus.

The Microwave Landing System (MLS) provides precise guidance signals that allow aircraft to make multi-segmented straight and curved approach paths in three dimensions. The basic MLS receiver will allow the pilot to select the approach azimuth and glide angle along that azimuth to the airport. To make a computed centerline, segmented, or curved approach to the runway, Level III Area Navigation (RNAV) capability is needed in addition to the basic MLS receiver. MLS will offer the potential of increasing airport capacity and/or providing precision approaches where none currently exists.

A Global Navigation Satellite System (GNSS), such as GPS or the Soviet GLONASS is expected to become the primary means for enroute, terminal, and transoceanic navigation in the long term. Additionally, GNSS is expected to provide "near Category-1" type instrument approaches with MLS providing Category 2/3 approaches.

Existing ground-based ATC systems, augmented by flight crew vigilance provides a high level of safety. The search for an airborne collision avoidance device was initiated in the 1950s. By the mid 1970s, the FAA had proposed a system, termed Beacon Collision Avoidance System (BCAS), that would recognize the proximity of all aircraft equipped with a transponder. Today's result is TCAS (Traffic Alert and Collision Avoidance System) which requires the threat aircraft to be operating with a Mode C transponder. Presently TCAS III, which combines warnings with recommended evasive maneuvers, is being considered for integration with advanced "glass" cockpits.

To increase the timeliness and accuracy of weather information in order to reduce weather-related incidents, such a windshear, the FAA has focused not only on detection but on dissemination as well. Airborne sensors, processors and cockpit displays offer the most promise but the technology development and integration is still at least a decade away. The real time transmission of other weather data to pilots, however, is being addressed through automated data link utilizing Mode S which bypasses the controller. A ground-based weather communication processor is being developed which will receive requests for weather data from pilots, decode the request, format the reply and return it to the pilot in the cockpit as either a computer printout or a display.

The FAA's RE&D program contains numerous efforts to more effectively manage the nations airspace and facilitate traffic flow. Many can be broadly categorized as ATC automation such as AERA whose primary objective is to facilitate the accommodation of user-preferred IFR routes, altitudes and speeds. Automation will reduce many constraints due to weather, airport layouts, and ground-based equipment failure thorugh more efficient flow and metering capabilities, both nationally and locally. This three phase AERA program consists of automatic checking for potential conflicts involving separation standards and traffic flow restrictions as well as automatic identification and conflict resolution in the first two phases; by 1999. Phase three (AERA III) will not only fully automate aircraft separation functions but will also integrate all traffic management activities with terminal ATC, departure flow management and runway configuration management systems. It will also take advantage of an aircraft's airborne flight management system capabilities and advanced navigation avionics in order to accommodate preferred flight profiles and, hence, the cockpit interfaces become crucial enabling technologies for Advanced Automation Systems (AAS).

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The evolution in electronic design technology underway for the past few decades will continue unabated in the foreseeable future. Digital techniques for data link communications and onboard displays as well as airborne computers will facilitate and enhance weather and traffic information transfer between the ground and the air. New man-machine interfaces will be needed to ensure that this technology can be fully integrated and is compatible with human performance capabilities and limitations. New and emerging cockpit technologies such as touch panels and voice recognition systems may be integrated with existing multifunction controls and displays which currently populate todays so called "glass" cockpits. More advanced concepts such a synthetic vision and "smart" interfaces will mature by the turn of the century providing the opportunity to augment human abilities rather than supplant them. The ability of the flight crew to cope with and effectively manage increasing levels of flight and ATC information, as well as automation, is a major focus of cockpit design effort for the next generation civil transport.

## ATC AUTOMATION

The Advanced Automation System (AAS) provides the computing capacity and expandable software for the development and implementation of highly automated airspace management and traffic flow control strategies. Key elements of the program include Automated En Route ATC (AERA), terminal airspace automation and the Advanced Traffic Management System (ATMS).

The primary object of AERA is to facilitate the accommodation of user-preferred IFR routes altitudes and speeds. It consists of three phases of software that provide progressively advanced functions in conjunction with the AAS.

> o  AERA 1 - will provide the capability for more frequent use of the
>    user-preferred trajectories. Controllers will have an automated means
>    of checking for potential conflicts involving separation standards,
>    special-use airspace, and traffic flow restrictions.
>
> o  AERA 2 - will enable the automated identification and resolution of air
>    traffic conflicts.
>
> o  AERA 3 - will not only fully automate aircraft separation functions but
>    will, like phase 2, integrate all traffic management activities.

AERA 2 and 3 are to operate in a totally integrated partnership with the ATMS, supported by terminal ATC, departure flow management and runway configuration managements systems. AERA 3 will also be able to take advantage of an aircraft's airborne flight management system capabilities and advanced navigation avionics in order to accommodate preferred flight profiles. The net result of AERA 2 and 3 will be that users will realize more frequent approval of requested trajectories, even in the face of heavy traffic loads.

The terminal airspace automation objective is to provide automation aids to controllers that will support improvements in airport capacity by increasing IFR throughputs, reducing controller workload through regularized traffic demand, reducing operational errors, and reducing aircraft delays. It will provide traffic advisories to accomplish this as well as a traffic planner and coordinator to automatically monitor flight progress and compute landing orders based on predicted arrival sequences. Other automated tools will allow properly equipped aircraft to fly uninterrupted, fuel-efficient, conflict-free and accurately timed descents from cruise altitude to final approach.

The Aircraft Situation Display (ASD) is a portion of ATMS which provides the ability to monitor, analyze, and control - via a single display - the flow of air traffic in real time on a national basis or within any chosen geographic area. The system can predict that traffic congestion will occur, hours in advance, allowing controllers to restrict planes from these areas until there is reasonable assurance that it can be accommodated. ATMS generally is intended to be used to identify and resolve imbalances between traffic demand and system capacity. It will suggest reroutings, traffic-flow rate adjustments, or ground delays as strategies for traffic management. The ATMS will also be able to analyze how well air traffic is being handled on a day to day basis. Direct user access to certain ATMS information is planned, allowing pilots to consider potential traffic congestion, ATC traffic flow restrictions, and special-use airspace restrictions when formulating flight plans.

The AAS will continue to modernize ATC facilities and provide forms of automation previously beyond today's capabilities. For example, AERA will provide for realization of automated decision making, with the controller's role advanced from tactician to manager. The range of advanced concepts and future operating scenarios that will exploit advanced technologies and scientific breakthroughs are boundless. As previously indicated, the evolution in electronic design is likely to continue into the future future. Digital techniques will continue to replace analogue, resulting in much greater capabilities and increased capacities. Data link communications and onboard displays of weather and traffic information will become realities.

## DATA LINK

Data link is a digital communication system medium between ground based systems and individual aircraft. Its use will reduce frequency congestion and misinterpretation of instruction through discrete addressibility. It will become the primary communication medium for ATC services such as routine information requests from pilots for weather, Notices to Airmen (NOTAMS), and terminal arrival and departure information; all weather and ATC advisories broadcasts from controllers to pilots; as well as wind/temperature and Pilot Reports (PIREPS) from the aircraft to the ground based ATC system.

The present air-ground, very high frequency (VHF) voice communications facilities will be augmented with a Mode S data link. The data link will provide a discrete addressability capability through the utilization of a surveillance radar system and onboard beacons which will complement the VHF network. Satellite-based digital data links will also supplement line-of-sight digital communications networks. Air-ground exchanges used by pilots to report flight progress and obtain air traffic advisory information will be facilitated by digitized data links. Information will be transmitted through both synthesized voice and advanced cockpit displays.

In the near term, navigation improvements will include the integration of LORAN C and the global positioning system (GPS) to establish a sole-means method of navigation as well as specifications for weather processors and data link capable of providing real time weather information to aircraft enroute. This could eventually permit reduced reliance on the VOR/DME system; precision landing approach standards, procedures and guidelines; and take advantage of new microwave landing system (MLS) capabilities.

With the development of automated digital air-ground data link, such as Mode S, pilots will be given direct access to weather data providing more timely information regarding hazardous conditions (e.g., windshear alerts). To receive information via data link in the future aircraft will be equipped with a Mode S transponder, an onboard computer, and a computer printer or display. A ground-based weather communications processor will act as the interface

between aircraft equipped with Mode S data link and pilot-desired weather information. The processor receives requests for weather data, decode the requests, format the reply and return them to the pilot. Such aviation weather systems will be operational in the early 1990s.

## ONBOARD DISPLAYS

New cockpit systems designed to improve the aircraft's ability to avoid airborne hazards or to operate safely under hazardous conditions, such as airspace congestion in terminal areas, are also being developed. One such system component is the traffic alert and collision avoidance system (TCAS), designed to provide a safety backup to the ATC system. The search for an airborne collision avoidance device was based on a need to provide independent backup for the ground-based ATC system and to ensure safe aircraft separation in airspace outside the system's coverage. The proposed system is based on a concept which recognizes the proximity of all similarly equipped aircraft as well as those having only an operating air traffic control radar beacon transponder onboard, termed beacon collision avoidance system (BCAS). Today's result, TCAS, requires the "threat aircraft" to be operating with a Mode C transponder which operates at maximum advantage because the threat aircraft is equipped with an altitude encoder. TCAS offers a choice of three levels of complexity, ranging from a simple visual and auditory warning (TCAS I), to a combination of warnings and recommended evasive maneuvers is altitude and heading (TCAS III). The TCAS approach offers the best solution to the need for a collision avoidance system, having true independence of the present ground-based system of air traffic control. Additionally, Airport Surface Traffic Automation (ASTA), designed to detect and alert cockpit crews to ground collision threats are also under development.

The effects of hazardous atmospheric conditions, especially windshear, are also a significant concern. Despite improved detection and dissemination of low-altitude windshear and microbursts, the use of Doppler weather radar networks are not the optimal solution. The sensors are located at the airport and cannot detect windshear that occurs above ground or beyond the network periphery. The optimal solution would be airborne sensors because they do not have the coverage limitations of ground sensors, do not depend on ground-to-air communications, and provide early warning directly in the cockpit. An airborne windshear sensor which would enable the flight crew to reliably detect hazardous conditions along an intended flight path with sufficient time to avoid it is currently being considered for development; as is the potential for integrating windshear information from both ground and airborne sensors at some future date. The priority of this information will be identified so that it can be channeled to the aircraft to aid flight crews in decision making and/or to assist air traffic controllers with metering and spacing to avoid known windshear hazards.

## SUMMARY

The highlights of the NAS Plan, for which the RE&D support is focused , can be summarized as follows:

### En Route and Terminal ATC

     o  Higher levels of automation will improve safety and efficiency.

Enroute and terminal radar approach control facilities will be consolidated into area control facilities (ACF). Within each AFC, the advanced automation system (AAS) will have capabilities distributed between individual sectors. The advanced functions of automated en route air traffic control (AERA) for flow planning and traffic management will be added incre-

mentally. Computer-generated clearance message, weather and flight information will be transmitted directly to aircraft via data link.

**Flight Service and Weather**

      o Automation and consolidation will allow better and more complete services.

      o Direct automated pilot access will provide weather, flight plan filing and information about system status (i.e., delays).

      o Greatly improved aviation weather services will increase safety.

The intent is to provide current aviation weather information through out the National Airspace System by pilots, center and tower controllers and traffic management personnel. Automatically composed, routine enroute and terminal weather will be broadcast to pilots over a national VOR network. Automated weather information will be available via data link to pilots. Request/reply will be provided as well as the transmittal of significant meteorological reports.

**Ground-to-Air**

      o Consolidation and modernization of navigation, radar and communications facilities.

      o Microwave landing systems (MLS) will replace instrument landing systems (ILS) and provide multiple, curved and segmented approaches and selectable glide angles.

      o A discretely addressable surveillance capability (Mode S) with an integral data link will replace the present ATC radar beacon interrogator systems a most terminal and enroute surveillance sites.

The ground-to-air system, based on a networking concept, will provide nationwide service and coverage for surveillance, navigation, and voice/data link communications. Enroute surveillance coverage via an integrated national network of solid-state enroute and terminal search and beacon systems. Search radar for FAA weather and air traffic control will be replaced and Mode S and data link coverage will be expanded. En route navigation consisting of very high frequency omnidirectional ranges (VOR), VORs colocated with tactical air navigation (VORTAC) and VOR/distance measuring equipment (DME) will also be solid-state, as will be ILS components until MLS replaces it. The direction finder sensor network will be expanded to provide additional emergency assistance to pilots as well as nondirectional beacons (NDB) in limited numbers.

The NAS Plan presents a realistic approach to meeting the ever increasing demand for aviation services. The FAA Plan for Research, Engineering and Development (RE&D) describes the research, engineering and development to support the NAS Plan for F&E programs including aviation safety and advanced technological development; which will constitute the essence of the high-level functional/system requirements of future civil transports identified in this report.

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# ADDENDUM A

## INTRODUCTION

The Federal Aviation Administration's (FAA) first annual (1990) Aviation System Capital Investment Plan (CIP) describes the policies and strategies that the FAA will pursue in addressing key concerns of the National Airspace Systems (NAS). It creates a foundation for evolution of the existing NAS through use of new technologies and development of new products obtained from continuing research.

The CIP has several major changes from its predecessor, the original NAS Plan, since it represents a change in focus. This Plan addresses safety, efficiency, traffic demands, aging equipment and facilities, and airspace use as before but recognizes that support and upgrade of the NAS is a continuing process, not a singular effort ending in a final end-state system.

> "It became obvious that a new plan was needed to implement NAS improvements which met stated goals and objectives. The National Airspace System Plan for Facilities, Equipment and Associated Development, first issued in 1981 and revised through 1989, satisfied the need to define the orderly and rational evolution of the system. But, with deregulation of the airline industry and the widespread use of hubbing, aviation grew tremendously in terms of flights receiving air traffic control services and passengers enplaned. This growth, changes in airspace regulation and new technologies have caused a need to revise current planning for NAS improvements." [1]

This new plan makes the approach to air traffic modernization more precise, flexible, understandable and dynamic. It distinguishes among near-term (1991-1995), mid-term (1996-2000) and far-term (2001-2005) planning.

## TO THE YEAR 2000

The CIP provides near-term improvements to solve immediate problems. These improvements are taking place as part of an orderly, planned evolution. On the horizon is a modern, automated network of facilities and equipment in which the latest levels of available technology are integrated into a coordinated system of air traffic control and air navigation. Long range advances in automation, communication, and satellite services that are being researched and developed will facilitate more automated control concepts, remove fixed-routing constraints, provide high levels of civil aviation safety and facilitate operations of future generations of aircraft.

A sound planning process will provide the flexibility to capture the opportunities that new technologies provide and use these new technologies to achieve the FAA mission; which comes from the Federal Aviation Act of 1958 as a statutory mandate:

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1 Aviation System Capital investment Plan (CIP), Federal Aviation Administration, December, 1990

"To serve the nation by providing a safe, secure and efficient aviation system which contributes to national security and promotion of U.S. aviation."

The FAA's capital investment planning is linked to other FAA plans. Research and development, for example, leads to decisions to invest capital in certain new technologies. Hence, the relationship between the FAA's Plan for Research, Engineering and Development (RE&D) and the CIP is important. Successful research projects will lead to CIP projects, and the direction taken by the CIP will influence RE&D planned research requirements.

In the introduction to the Aviation System Capital Investment Plan the FAA summarizes the user benefits of its strategic planning, as represented by the CIP as follows:

"As a result of the planned actions, users will benefit from the following improvements:

o  Increased safety through collision avoidance systems and improved weather information
o  Reduced delays
o  Reduced fuel use
o  Increased flexibility in routing

Although no additional equipment will be required for most new services, users will need to purchase certain avionics related to Traffic Alert and Collision Avoidance System (TCAS), Mode S Data Link, Microwave Landing System (MLS), Global Positioning System (GPS), and 25 kHz communications in order to take full advantage of these investments. The cost of these avionics will be borne by the user.

The following new requirements are anticipated to permit full participation in the system.

o  Increased safety through collision avoidance systems and improved weather

o  The Instrument Landing System (ILS) will be supplemented with, and subsequently replaced by MLS. Supplemental airborne equipment will be needed to use this new service, and in some cases, a number of aircraft may need to carry both ILS/MLS avionics during transition.

o  It is expected that pilots who wish to receive full Air Traffic Control (ATC) services in all controlled airspace will need 720 channel 25 kHz VHF communications capability in their aircraft."

In the NAS of the future, safety will be improved by reducing system errors. Flight paths desired by airspace users will be accepted on a regular basis and the growing demand of flight operations will be accommodated with a minimum of constraint. The highest practical fuel efficiency as well as dynamic flow management, to reduce airborne delays, will further enhance user efficiency. The following is a summary of that future:

"The Advanced Automation System (AAS), Automated En Route Air Traffic Control (AERA), and related projects such as the Voice Switching and Control System (VSCS), Mode S, Central Weather Processor (CWP),

and improvements in Traffic Management collectively account for the majority of airspace system user efficiency benefits."

# 2000 AND BEYOND

The following briefly outlines the far-term (2001-2005 and beyond) improvements in five of the functional areas outlined in the CIP:

## Automation

The next generation Traffic Management system will be an integrated system for the national, enroute, and terminal levels of traffic management. It will integrate data from mid-term improvements such as Area Control Computer Complex (ACCC), Automated En Route ATC (AERA2) and Terminal ATC Automation (TATCA). This system, in conjunction with enroute and terminal automation, will accommodate user-preferred routing and altitude assignments as well as reduction in oceanic separation standards. The system will be predicated on safety, maximum throughout, and accommodation of user-preference wherever possible.

## Telecommunications

At the highest level, the telecommunications architecture for the years 2001 to 2005 will be characterized as an improved air/ground voice communications with new data link services to support the aircraft from gate to gate including airport surface, terminal, enroute and oceanic airspace. A communication data link will be available in all areas but transmission medium may vary. Mode S will be the enroute and terminal choice while satellite will serve the oceanic airspace. Commercial aircraft will have Mode S, satellite and VHF data links to carry ATC, weather and airline business data, all displayed to the crew in the cockpit on the basis of priority ordering of message to allow time-critical ATC message to interrupt all others.

## Surveillance

Enroute surveillance will be provided primarily by the beacon system. However, primary radar will continue to be employed as an adjunct to the beacon in certain airspace. The functions of the radar, in order of priority, will be: intruder detection, weather detection in terminal airspace, and ATC backup. The weather detection, however, will be taken over near-term by the Next Generation Weather Radar (NEXRAD) network. Oceanic surveillance will be enhanced by higher aircraft positional accuracy combined with more frequent reporting by satellite-based navigation systems, backed up with onboard collision avoidance systems which will enable a substantial decrease in separation standards. Airport surface surveillance during low visibility conditions, relying on radar, for runway incursion detection will depend on Airport Surface Detection Equipment (ASDE3) utilizing Mode S transponders and data link.

## Navigation and Landing

By the year 2005 the NAS may have available two sole-means navigation systems: a satellite system based on Global Positioning System (GPS) in combination with Global Orbiting Navigational Satellite System (GLONASS) and Long Range Navigation (LORAN-C), as well as VOR/DME/TACAN system currently available. Additionally, the potential use of a combination GPS/LORAN-C as a sole-means navigation system is a possibility. Microwave Landing System (MLS) should achieve parity with Instrument Landing System (ILS) in 2001 and is expected to totally replace it for precision approaches capability by 2005. MLS will

provide Category I, II, and III precision approaches as well as area navigation capabilities in the terminal airspaces.

**Weather**

The FAA and the National Weather Service (NWS) are embarked on a major aviation weather program consisting of weather systems and weather sensor upgrades. Increased safety will be realized through expanded hazard detection and integration of terminal area weather. The near-term Low-Level Wind Shear Alert System (LLWAS) and the Automated Weather Observing System (AWOS) will allow real-time weather information to be digitally displayed in the cockpit. AWOS, utilizing automated sensors, broadcasts aviation-critical weather data (e.g. wind velocity, temperature, dew point, altimeter setting, cloud height, visibility, precipitation type, occurrence and accumulation) which will compliment other existing services such as the Hazardous In Flight Weather Advisory Service (HIWAS). The Central Weather Processor (CWP) will be applied to flow management. Several existing radar systems including Airport Surveillance Radar (ASR-5) include a separate Doppler weather channel capable of generating weather map contours for six levels of precipitation intensity. The Terminal Doppler Weather Radar (TDWR) system detects microbursts, gust fronts, wind shifts and precipitation used for hazardous weather alerts in the terminal area. The Next Generation Weather Radar (NEXRAD) with is extensive network of deployed sensors and long range Doppler Weather Radar provides en route applications such as precipitation reflectivity, wind velocity, and turbulence indicators. Additional integration (e.g. Integrated Terminal Weather System (ITWS)) and generation (e.g. Aviation Weather Products Generator (AWPG)) projects, initiated mid-term, will further enhance forecasting at airports, and with wake vortex detection/tracking, allow precise acceptance/departure rate prediction and increased capacity.

## SUMMARY

The FAA summarizes their CIP as follows:

> "The FAA continually seeks ways to increase production, reduce workload, improve safety, and enhance fuel efficiency. Implementation of the CIP will offset the FAA costs required to meet increasing demands for air traffic growth in a system which would be otherwise inadequate to handle them. These offsetting effects will have a significant return on investment to the FAA. Users of the system will benefit from improvements in flight services, more efficient routing, reduced delays, and greater safety."

# ADDENDUM B

The Federal Aviation Administration Plan for Research, Engineering, and Development (Second Draft), dated March 19, 1991, is focused on "the pursuit of a vigorous Research and Development (R&D) program" and determination "to seize the opportunities presented by modern technology". The FAA has published a vision of the future aviation system and recognizes that additional research will be necessary to further develop technologies to support such a system. They indicate that;

> "The outline of the future system leading to the early 21st century is fairly clear. It will evolve from the system modernization effort currently underway in the Aviation System Capital Investment Plan (CIP)... In moving from the current to the future system, a number of major issues and tasks relating to air traffic management and other challenges facing the FAA are already clear...they include:
>
> > o The scope and direction of ATC automation services and integration efforts (e.g. airport surface, terminal, en route, and oceanic ATC automation); and establishment of standard interfaces among them;
> >
> > o Decisions on the optimum balance of responsibilities of aircraft (pilot) and ground (controller) air traffic management system;
> >
> > o Achievement of an airport surface traffic management system, integrating appropriate functions of several system elements such as surveillance, visual aids, signage, automated surface traffic management, etc;
> >
> > o Achievement of an integrated national aviation weather system that establishes the interrelationships with the automation components of the air traffic management system and cockpit;
> >
> > o Establishment of the most efficient information flow and communications interfaces for the aviation system; and
> >
> > o Establishment of a rational, threat-driven, flexible aviation security system.
>
> Continuing FAA emphasis on system engineering, in tandem with an aggressive R,E&D program, will be necessary to successfully address these issues and demands the future system brings."

# FUNCTIONAL DESCRIPTIONS

## INTRODUCTION

After the survey of the FAA's planning documents, a projection of the operating environment for commercial aviation and the functional capabilities required to support it was made. The next task was to develop the functional descriptions for the major aircraft system and/or subsystem components required to provide the capabilities. These descriptions are contained in this section and they provide a high-level characterization of the systems/subsystems in a narrative form.

The functional descriptions are divided into four major categories, each dealing with one of the four major functions:

        o Manage Flight Systems
        o Manage Navigation Systems
        o Manage Communications Systems, and
        o Manage Aircraft Systems

Generic systems to support each of these functions have been identified and are included in the appropriate subsections that provide the functional descriptions. The functional descriptions have been arranged in a hierarchy that relates to the diagrams that are presented in the last section of this report. The numbering system as well as the subsection divisions of each functional category, relate to the hierarchical structure and Node number of the appropriate diagram. Diagrams have been prepared for each **bold** print entry in the functional descriptions.

The reader may use the narrative descriptions of each function/system to supplement the Glossary that accompanies each IDEF diagram.

# A1 - FLIGHT MANAGEMENT

## A11 - AUTOMATIC FLIGHT SYSTEM (AFS)

The automatic flight system (AFS) provides guidance from takeoff to landing. The AFS processes signals from airframe sensors, navigational sensors, air data computers, flight management system (FMS) computers and engine controls. These signals are then sent to the electronic instrument system (EIS) displays as well as to aircraft controls for pitch, roll, yaw and engine thrust.

The AFS provides the following functions:

- o  Automatic landing
- o  Speed envelope limiting
- o  Autopilot/flight director
- o  Autothrottle/engine trim
- o  Automatic pitch trim
- o  Roll control wheel steering
- o  Yaw damping
- o  Elevator load feel
- o  Flap limiting
- o  Automatic ground spoiler
- o  Stall warning
- o  Windshear warning
- o  Altitude alerting

The AFS provides for the selection of the correct thrust level for the flight regime automatically to conform to standard practice without any crew action being required. The proper pitch and thrust control combinations are programmed into the AFS while the Flight Control Computer (FCC) directs the correct combinations of thrust, pitch and roll to accomplish the commands while the Flight Mode Annunciator (FMA) advises the crew of the results. The FMA displays speed, roll and altitude control windows which indicates how parameters are controlled (e.g., Autopilot, Autothrottle) and targeted values.

The Flight Control Panel (FCP) is used to control speed, heading and altitude by selecting values manually or by enabling the FMS. An AUTO FLIGHT selection on the FCP engages the Autothrottle System (ATS) and Autopilot (AP).

### A111 - Autopilot/Flight Director (AP/FD)

The AP/FD has pitch modes, roll modes and combined pitch and roll modes. Engaging the AP/FD vertical speed (V/S) mode sets the ATS to control speed with V/S annunciated in the vertical control window and THRUST in the speed control window. Altitude control consists of a capture mode and a hold mode. The AFS controls altitude set in the altitude display window automatically or by the FMS targets climb or FMS steering commands in descent. The AP/FD can capture and hold either the commanded airspeed or Mach number in the speed control window.

A heading or track angle select can be engaged from the FCP and a HDG/TRK display window show selected heading for AP/FD capture. Heading and tracking angle hold can also

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be selected with held reference value in display window. Bank angle limits are also available through commanded selection or AUTO schedule as a function of Mach with VStall and VMin protection.

AP/FD also provides automatic flying of precision ILS/MLS approaches with automatic landing capability. When AP is in lateral or vertical control modes APPR/LAND can be engaged with altitude control window displaying glideslope (G/S) once it is intercepted and controlled. During approaches, the autothrottle speed is referenced to IAS/MACH display window value with aircraft tracking lateral/vertical beams in the FD approach mode. A flare mode is initiated automatically at about fifty (50) feet radio altitude with autothrottle retarded at the same time. Engaging a Go-Around (GA) switch enables the AP/FD to hold the magnetic heading existing when GA was initiated. During GA the reference speed and PITCH are displayed in speed control window, GO-AROUND in the altitude control window and HEADING in the roll control window. Bank angle is limited to ten degrees in the GA mode.

FMS lateral navigation (NAV), vertical profile control (PROF), optimum speed control (FMS SPEED) and nonprecision approach (NAV and PROF) are coupled to the AP/FD through targets and steering commands.

## A112 - Autothrottle System (ATS)

The ATS automatically positions the throttles to maintain engine thrust required for the modes selected (e.g., IAS select/hold, MACH select/hold, Thrust Limit/Target, RETARD, etc.).

The engine thrust trim system maintains the engines at a common thrust setting to eliminate the need to adjust throttles. The trim system can operate during either manual or automatic throttle operations. Each FCC contains an autothrottle control channel to drive a separate section of a dual actuator. The ATS is designed for full flight envelope operation from ground engagement through automatic disengagement when thrust reverse is applied upon landing rollout. The ATS can be engaged by the AUTO FLIGHT or PROF switch on the FCP.

ATS thrust control provides automatic thrust limiting for all thrust and speed control modes. The EPR/N1 of each engine is constrained between the maximum limit defined the FMS and a flight idle limit as well as by the engine full authority digital electronic control (FADEC). The RETARD mode is also a form of thrust control in which the throttles are driven to the idle stop in response to radio altitude and arming logic.

ATS speed control is automatically constrained by the following limiting speed conditions:

- o Vmin + 5 knots as per FMS and either normal or abnormal flap/slat configuration
- o Vmo/Mmo (maximum operating speed/mach)
- o Flap, slat and landing gear placard speeds
- o 1.3 buffet speed

The ATS controls speed targets during approach, altitude hold, vertical speed, flight path angle and profile modes of the AFS/FMS system.

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## A113 - Stability Augmentation

The Longitudinal Stability Augmentation System (LSAS) provides longitudinal stability and command augmentation through series control of the elevators when the AP is not engaged. With it engaged, the AFS elevator control returns to parallel control. With no force on the control column, the LSAS holds the current pitch attitude.

The LSAS uses + 5 degrees of series elevator deflection to provide pitch-rate command/attitude hold system for longitudinal control. The LSAS also includes envelope protection; this introduces elevator inputs to prevent flying below Vmin or above Vmax.

Each FCC contains redundant LSAS control channels enabling self-monitoring. The LSAS compensates reference pitch attitude as a function of bank angle and prevent envelope (i.e., pitch attitude, speed) exceedance.

The AFS roll Control Wheel Steering (CWS) provides lateral stability and command augmentation through parallel control of a single aileron when the AP is not engaged. With no force on the control wheel, the aircraft holds the current roll attitude. Forces on the control wheel command an aircraft roll rate proportional to the applied force, so that when the force is removed, the aircraft holds the new roll attitude.

At bank angles above thirty degrees (30°), a bank angle error is commanded by the AFS to roll the aircraft back to thirty degrees (30°) when the control wheel is released. Pushing an AFS OVRD OFF switch disengages the CWS as well as the AP and ATS systems.

## A114 - Flight Controls

Primary flight controls consist of ailerons, elevators and rudders. Secondary controls are trailing edge flaps, leading edge slats and combination speed-brake/spoilers.

The lateral control system consists of inboard and outboard ailerons augmented on the down-going wing by spoilers operating in proportion to control wheel displacement and/or spoiler input. The motion of the control wheel through + 90 degrees of rotation is transmitted by a cable system. The lateral control system is a full power system. There is no aerodynamic feedback to provide load feel.

The longitudinal control system consists of inboard and outboard elevators with each surface powered by the hydraulic system. The elevators segments respond to commands from the flight crew, the LSAS and the AP. An elevator load feel system is self-monitoring and in the AUTO position it regulates the control column force per degree of column rotation as a function of airspeed.

The yaw control system consists of an upper and lower rudder in which the upper rudder is hydraulically controlled by one system and the lower rudder by another. The full power rudder control system requires an artificial load feel since no aerodynamic surface loading is fed back to the pedals. A dual yaw damper system provide directional stability augmentation. Normally, there is no feedback here either, except during autoland operations. The yaw damper provides turn coordination and damping of dutch roll characteristics. It is always on, except during AP localizer tracking.

The spoilers on the upper surfaces of each wing serves to; (1) assist aileron lateral control; (2) reduce speed during flight; and (3) spoil lift to increase brake efficiency. When used to aid lateral control, all panels on one wing are fully deflected while those on the opposite wing are

fully retracted. When used as a speedbrake, the system extends all panels on both wings simultaneously. During flight, the spoilers function symmetrically as speedbrakes for slow-down and/or emergency descent while retaining controlled differential motion for lateral control. Spoiler extension can be accomplished automatically by the Auto Ground Spoiler (AGS) actuator. This provides an increase in drag and a rapid transfer of weight to wheels during landing or rejected takeoffs.

The flap system is mechanically controlled by a FLAT/SLAT handle which independently busses both inboard and outboard flaps. An infinitely positionable detent is provided for takeoff which allows setting the flaps at exact position for best performance for a given set of field conditions.

The slats system has leading edge segments on each wing for lift augmentation and are extended for takeoff and landing to provide maximum lift. The slats are programmed by the FLAP/SLAT handle which operate both flaps and slats together.

The trim systems consist of a lateral, directional and longitudinal for ailerons/spoilers, rudders and stabilizers. The latter operates automatically as a function of airspeed and/or altitude for optimum performance. When LSAS is engaged, it also provides automatic pitch trim as does the AP.

## A115 - Warning Systems

The Takeoff Warning is a aural signal and voice warning of unsafe takeoff configuration for flaps, slats, spoilers or stabilizer. Slats Extended Warning is a clacker sound and voice warning of SLATS OVERSPEED when slats are extended and airspeed exceeds placarded limit. Stall Warning activates a stick shaker on the control column when approaching stall and extended outboard slats or at a specified angle of attack scheduled to ensure an acceptable margin above stall speed. The Altitude Alert system automatically activates when the aircraft is approaching a preselected altitude or the aircraft is deviating from a preselected and acquired altitude. It is always on except when the FD or AP is engaged in the glideslope mode, in which case, it is inhibited.

## A12 - FLIGHT MANAGEMENT SYSTEM (FMS)

The Flight Management System (FMS) provides for flight planning, navigation, performance management, aircraft guidance and flight progress monitoring. The FMS processes the flight plan data and provides for selection of various flight control mode as well as monitoring flight progress through the electronic instrument system (EIS) and the multifunction control display units (MCDUs). The FMS consists of flight management computers (FMCs) interfaced through MCDU.

## A121 - Flight Management Computers (FMCs)

The FMCs generate flight profiles from origin to destination as well as guiding the aircraft along the profile by providing pitch, roll, speed and thrust commands to the autopilot and autothrottle systems.

The following functions are provided by the FMC:

- o Determine position and wind velocity from radio/inertial data.
- o Compute flight path for best time/fuel.
- o Compute flight plan and speed deviations as well as thrust,

pitch and roll commands for corrections.
o   Generate EIS map and situation data and process MCDU inputs.


The following systems receive information from the FMC and send information back for processing:

o   MCDU.
o   Centralized fault display system (CFDS).
o   ARINC communication addressing and reporting system (ACARS).
o   Display electronic units (DEUs).


The following systems provide inputs to the FMC for processing:

o   Flight control computer (FCC).
o   Inertial reference system (IRS).
o   Global positioning system (GPS)
o   Instrument landing system (ILS).
o   Microwave landing system (MLS).
o   VHF omni-range system (VOR).
o   Distance measuring equipment (DME).
o   Radio altimeter.
o   Air data computer (ADC).
o   Advanced fuel quantity gaging system.
o   Environmental system controller.
o   Weight and balance computer.


The FMC, after processing the inputs, outputs data to the following:

o   Fuel system controller.
o   Digital flight data acquisition unit.
o   Cabin pressure control system.
o   Automatic direction finding system.


The FMS also provides automatic tuning of VOR/DME, ADF, GPS, ILS and MLS in accordance with selected Standard Instrument Departures (SIDs), Standard Terminal Arrival Route (STAR) and en-route navigational-aid requirements.

### A122 - Display Electronic Units (DEUs)

The DEUs transmit flight instrument data, engine and alert data and aircraft systems data to all six (6) Display Units (DUs) which constitute the Electronic Instrument System (EIS); consist of two (2) each Primary Flight Displays (PFD) and Navigation Displays (ND) as well as an Engine and Alert Display (EAD), and a System Display.

A EFIS Control Panel (ECP) controls the upper portion of the DUs which displays config-urations, and the lower portion which is used to select Systems Display (SD) pages. The SD presents information about aircraft systems, alerts and their consequences.

**A123 - Centralized Fault Display System (CFDS)**

The CFDS consists of a Centralized Fault Display Interface Unit and a dedicated Multifunction Control and Display Unit (MCDU) which has the capability to interface with numerous sub-systems.  The CFDS provides the following:

- o A summary of Line Replaceable Units (LRUs) which report faults during a flight.
- o Ability to select individual LRU reports for later review of fault histories.
- o Initiation of return-to-service testing on the ground for selected aircraft components.
- o Capability to review sensor data in the applicable units.
- o Erasure of LRU maintenance memory once on the ground.
- o Ability to declare components inoperative to the Aircraft System Controllers (ASCs) assuring that failed components will not be used without ground testing.


The CFDS also interface with ACARS and an onboard printer.

**A124 - ARINC Communication Addressing and Reporting System (ACARS)**

The ACARS can be used to download CFDS data to ground stations or to preview and then transmit the most recent flight's Fault Lists or selected LRU reports via the CFDS menu selection on its dedicated MCDU.

# A2 - NAVIGATION

### A21 - GROUND-BASE NAVIGATION

### A211 - VHF Omnidirectional Range (VOR)

A Very High Frequency (VHF) radio navigation system which operates in the 108.00 - 117.95 MHz frequency band. It is subject to line-of-sight restrictions and its range varies as a function of altitude with a course alignment accuracy of + 2.5∗. The ground station transmits an RF signal with two (2) 30 Hz signals whose relative phase defines radial lines in space with respect to the ground station. The VOR airborne equipment receives, detects and present this information in such a way that relative bearing with respect to the ground station can be presented. Most VORs are equipped with voice transmission, however, Morse code is the primary identifier.

### A212 - Distance Measuring Equipment (DME)

A VHF navigation aid in the 962 - 1213 MHz frequency band. It transmits a coded interrogation signal to ground stations (co-located with VOR and ILS stations) which measures slant range distance from the aircraft to the ground station. Paired spaced pulses are sent to the ground and the time required for the round trip back to the aircraft is used to measure distance in nautical miles to within an accuracy of + 1/2 mile or 3% of the distance up to 200 miles.

### A213 - Instrument Landing System (ILS)/Microwave Landing System (MLS)

An instrument landing system which provides an approach path for precise alignment and descent on final. The data is extracted from AM modulated RF signals in a localizer band from 108.10 - 111.95 MHz and the glideslope band from 329.15 - 335.00 MHz. The ILS receiver provides both localizer and glideslope deviation outputs. Each receiver receives guidance signals from two (2) separate ground station transmitters. The glideslope path is the angle-of descent for landing while localizer course is the centerline of the runway on an instrument approach. The receiver detect differences in the 90 Hz and 150 Hz modulated signals for resultant glideslope deviation while differences in two (2) localizer modulated signals provide course deviation. The localizer signal is accurate to a range of 18 NM from the antenna while this glideslope signal is usable up to a distance of 10 NM.

The MLS provides precise guidance for aircraft approach paths in three (3) dimensions that allow multisegmented straight and curved approaches as well as multiple glide path angles. MLS transmits in the 5000 - 5250 MHz frequency band with the azimuth transmitter located 1,000 feet beyond the departure end of the runway, and the elevation transmitter located to the side of the runway near the approach threshold. The precision distance measuring equipment (DME/P), which provides range information, is collocated with the azimuth transmitter.

MLS integrates azimuth, elevation angle guidance and range information for precision aircraft positioning and guidance required for curved approaches. Both lateral and vertical guidance is displayed as conventional course deviation indicators with range displayed as conventional DME. Guidance information for curved approaches are frequently integrated within multi-

functional displays and requires Area Navigation (RNAV) capabilities as well as a fight director for manual approach steering commands and path guidance.

## A214 - Marker Beacon (MB)

A 75 MHz transmitter which serves to identify a location in space on an instrument approach to a runway. It transmits a directional signal which is received as aircraft overflys the beacon that is located in conjunction with an ILS or enroute NAVAIDS. The signals are both aural and visual indicating three (3) geographically located positions along an approach path. They are coded as follows:

    o  OUTER MARKER - A sequence of dashes or flashing blue lights.
    o  MIDDLE MARKER - A sequence of dots and dashes or flashing amber lights.
    o  INNER MARKER - A sequence of dots or flashing white lights.

## A215 - Automatic Direction Finding (ADF)

The ADF radio is an aircraft navigation aid in the frequency range of 190 - 1750 KHz. The receiver provides relative bearing information from omnidirectional signals as well as an audio signal.

## A216 - LOng RAnge Navigation (LORAN-C)

LORAN is a hyperbolic system of electronic navigation which provides lines of position over the Earth's surface. The long range (up to 2,800 miles) is made possible by employing low frequency radio waves which can follow the curvature of the Earth. LORAN consists of a series of synchronized radio transmitting stations which broadcast in eight (8) pulse groups with a constant time interval between them. The measurement of the time needed for a radio signal to travel between two (2) points is converted to distance. The point on two (2) different hyperbolic curves or lines of position, having the same time difference, provide position fixes.

LORAN-C operates in the low frequency band between 90 - 110 KHz and provides precision navigation fixes (within + 600 feet error) out to 250 NM with usable fixes out to 500 NM. LORAN-C random navigation (i.e., Area Navigation) provides an alternative to VOR/DME particularly in low-altitude, remote or offshore areas of the world. It is a supplemental radio navigation system providing at least single-level coverage for enroute and terminal IFR navigation as well as supporting nonprecision approaches.

## A22 - AIRBORNE NAVIGATION

## A221 - Inertial Reference System (IRS)

The IRS consists of three (3) Inertial Reference Units (IRUs) which provide triple redundant navigation sensors for basic navigation and attitude to the aircraft systems.

The IRS is the primary source of aircraft attitude, heading (magnetic and true), vertical speed, ground speed, body angular rates and linear acceleration. It also provides navigational data such as latitude/longitude, track vector, and track oriented acceleration.

The basic system consists of acceleration sensors mounted on a gryo stabilized, gimbaled platform, a computer to process raw data and maintain present position. It operates by sensing movement of the aircraft and its accuracy is theoretically unlimited since it neither

transmits nor receives any signal. Before it can be used, however, it must be aligned. During alignment, present position coordinates are inserted while local level and true north are derived by the system.

## A222 - Global Positioning System (GPS)

The GPS is a space based navigation system which has the capability to provide highly accurate three (3) dimensional position, velocity and time anywhere on Earth. In addition, it is capable of providing altitude, steering information, ground speed and ground track error, heading and variations much like inertial systems. It also provides constant self monitoring of system status and accuracy.

GPS measures distance, which is used to fix position, by timing a radio signal that starts at a satellite and ends at the receiver. The signal carries data on satellite position, time of transmission and synchronization with the satellite clock. There are two (2) levels of accuracy: Coarse acquisition within 100 meters and precision within 15 meters for authorized users with proper code. GPS will require four (4) satellites, of the 18 available in six orbital planes plus three (3) space, for worldwide coverage. Integration with IRS greatly enhances its capabilities.

## A223 - Radio Altimeter (RA) System

The radio altimeter provides accurate terrain clearance data during approach, landing or climb out. The altitude range of the system is from 2,500 feet to touchdown.

The radio altimeter uses a wide band, frequency modulated (FM) radio wave to measure the distance between the aircraft and the terrain beneath it. The decision height minimum for an approach can be set for automatic alerting.

## A224 - Weather Radar

The weather radar is a lightweight, color system operating in the X-band frequency range. It detects and displays severe weather areas in terms of their range and bearing relative to the aircraft. Different levels of precipitation are displayed in the following color codes:

    Green   - 0.03 to 0.15 inch/hour rainfall
    Yellow  - 0.15 to 0.50 inch/hour rainfall
    Red     - 0.50 to 2.00 inch/hour or greater rainfall
    Magenta - indicating turbulence


The radar system can also be used for ground mapping by producing a terrain map of the area ahead of the aircraft.

# A3 - COMMUNICATIONS

## A31 - VOICE COMMUNICATIONS SYSTEMS

### A311 - High Frequency (HF) Communication Systems

The HF communication systems provided long range radio (voice) communications between the aircraft and ground as well as between other aircraft. It utilizes the 2.000 to 29.9999 MHz in the wide range and 2.8000 to 23.9990 MHz in the narrow range, on channels spaced at 1.0 KHz to 100 Hz.

### A312 - Very High Frequency (VHF) Communication Systems

The VHF communication systems provide short range radio two-way communications between the aircraft and ground or between other aircraft. It uses line-of-sight communications in the 118.000 to 136.975 MHz frequency range.

### A313 - Interphone Systems

### A3131 - Flight Interphone System

The Flight Interphone System provides two-way communication among the flight crew members. It consists of a headset and a microphone as well as speakers. Transmissions are controlled through a push-to-talk switch on either control wheel.

### A3132 - Service Interphone System

The Service Interphone System is a call system which allows communication between the cockpit and cabin attendant stations or the maintenance service areas. Handsets are installed in the cockpit and at each cabin attendant station. The cockpit can call either a selected station, all stations or the maintenance service area. Each station can call the other stations or the cockpit. The maintenance interphone jacks are located at various locations on the aircraft. The call system consist of call lights, aural signals and call switches which provide both visual and aural signals to alert flight and/or ground crews to call from one another.

## A32 - DIGITAL DATA LINK COMMUNICATIONS SYSTEMS

### A321 - VHF Data Link Systems

VHF data link, because of its wide-spread use and availability, provides a number of services in support of longer, less-time sensitive message such as ACARS and AVPAC.

### A3211 - ARINC Communication Addressing and Reporting System (ACARS)

ACARS is a character-oriented air/ground data link system whose initial services included automatic reporting of out of gate, off the ground, on the ground and into the gate (OOOI) information in reporting flight progress to company dispatches. It is currently used to transact a variety of company business from reporting flight delays to obtaining weather

information from destination airports. ACARC uses a character-based link and message protocol to transfer such information.

A3212 - Aviation VHF Packet Communication (AVPAC)

AVPAC is the upgrading of ACARS to a bit-oriented protocol which will be fully compatible with ACARC and interconnected through support of the Aeronautical Telecommunication Network (ATN) architecture. ATN's objective is to allow applications to pass data without concern for the sub-networks required to connect applications. It is based on an Open System Interconnection (OSI) architecture to provide a common communication layering system for prioritizing messages.

A322 - Mode S Data Link System

The Mode S discrete digital data link system is ideally suited to Air Traffic Control (ATC) services (e.g., clearances, traffic advisories, etc.) because it can support short, time sensitive messages ideally suited to the terminal area for tactical control. Mode S is a beacon system which can serve both; (1) ATC surveillance and tracking of transponder-equipped aircraft, and (2) as a modem for two-way digitally encoded data exchange between the ground and the aircraft, making use of the same scanning equipment employed for the ATC surveillance. The surveillance capabilities incorporates a discrete addressing and lockout feature whereas the modem provides a means to exchange data once a discrete link is established.

A323 - Gatelink Communications

Gatelink involves bringing a terrestrial communications link directly to the aircraft and connecting the aircraft as part of the ground data network system. Gatelink communications capabilities support large file transfers and batch processing between the aircraft at the gate and the Operations and Maintenance computer.

A324 - Satellite Communications (SATCOM)

The satellite based data link is envisioned to be utilized initially for oceanic coverage as part of the Automatic Dependent Surveillance (ADS) communications. ADS provides position information to the ground when the aircraft location is over the ocean or regions of the world not covered by VHF or Mode S.

A3241 - Communications Management Unit (CMU)

A key element of avionics on future aircraft which are capable of operating with and managing the airborne portion of the OSI ATN architecture will be a CMU. It will process incoming communications and direct data to the appropriate equipment. The equipment could be an electronic library system (ELS), onboard maintenance system (OMS), and/or associated printers, displays and data bases. It will provide the routing of outgoing data to the appropriate communications link from the aircraft. The CMU will interface with all onboard data communication systems regardless of the frequency used or the intended function. A critical function of the CMU will also be the routing of Automatic Dependent Surveillance (ADS) communications as an integral part of the future Air Traffic Management (ATM) system. (See "A Glimpse in the Future")

## A33 - MISCELLANEOUS COMMUNICATIONS SYSTEMS

### A331 - Central Aural Warning System (CAWS)

The CAWS receives and processes signals from selected sources for activation of an appropriate aural warning. These aural warnings are provided over both the cockpit speakers and the cockpit headsets.

These warning cover such areas as engine fires, autopilot disconnects, altitude advisories, and windshear warning as well as takeoff/landing configuration omissions. They are available as both auditory tones, bells, clackers or chimes with voice warnings as a pin-selectable option.

### A332 - Ground Proximity Warning System (GPWS)

The GPWS is designed to provide visual and aural warning/alerts associated with the following flight conditions:

```
Mode 1 - Excessive descent rates during cruise/approach
Mode 2 - Excessive closure rates to terrain (AGL)
Mode 3 - Significant altitude loss after takeoff
Mode 4 - Insufficient terrain clearance
Mode 5 - Inadvertent descent below Glideslope on ILS
```

The aural warnings associated with GPWS are provided over both the cockpit speakers and headsets.

### A333 - Traffic Alert and Collision Avoidance System (TCAS)

The TCAS is designed to alert the flight crew of the potential of a conflict with another aircraft in the area. The system uses the existing Mode S data link transponders to interrogate similarly equipped aircraft in the immediate vicinity. It provides two (2) types of advisories to the crew; a traffic advisory, and a resolution advisory which provides recommended corrective action to avoid the intruder.

# A4 - SYSTEMS MANAGEMENT

## A41 - AUTOMATIC SYSTEMS CONTROLLERS (ASC)

Automatic Systems Controllers (ASC) automates many of the conventional control and monitoring functions associated with the major aircraft systems such as, fuel, hydraulics, electrical and environmental (pneumatics and air conditioning). Systems controllers provide system interface, annunciation and automatic control logic for hands-off operation. The system controllers also perform automatic corrective actions for malfunctions and subsequent reconfiguration.

The primary aircraft systems (e.g., FUEL, HYD, ELEC, AIR) are monitored for proper operation by the ASCs. In most cases, system reconfiguration as a result of a malfunction is automated while manual inputs are required for irreversible actions such as engine shutdown, fuel dump or Integrated Drive Generator (IDG) disconnect. During normal operations, when the cockpit is configured for flight, all annunciators on the overhead panel are extinguished which is referred to as the "Dark Cockpit" which enables the crew to immediately confirm proper configuration and that no abnormalities exist. Primary system annunciation are shown in text on the alert area of the Engine and Alert Display (EAD).

The aircraft systems can also be manually controlled from the overhead area of the cockpit. The center portion of the overhead panel is composed of the primary aircraft system panels which are easily accessible from both crew positions. These system panels are laid out in a pictorial schematic of the system which symbolically connects the systems and controls on the panel. This schematic resembles the system synoptics shown on the System Display (SD).

A System Display (SD) of synoptic pages, as schematic representation of each system, are usually included as part of the Engine and Alert Display (EAD) system on one of the secondary display units (e.g., multifunction displays/units). These pages show the effects of any malfunction, such as reduced capability or loss of specific components as well as consequences, if any.

An Alerting System is designed to alert the crew and indicate the underlying fault or failure in the event of abnormal or emergency operations. Information about faults and their consequences are normally displayed on the main instrument panel display units. Alert prioritization is not necessary because of automatic fault correction, however, various fault types are indicated such as:

Level 3 - emergency type required immediate crew action.
Level 2 - abnormal type requiring crew interaction.
Level 1 - advisory type requiring crew awareness.
Level 0 - information type providing only system information with
automatic corrective action occurring simultaneously.

The entire alerting process includes Master Caution and Warning lights on the glare shield, an alert message on an Engine and Alert Display (EAD) unit, a cue light on the systems control panel and annunciations on the primary aircraft system panels. The crew's response is to depress the cue light which extinguishes the system control panel and Master Caution and Warning lights and automatically activates the system synoptic page of the system display unit and simultaneously removes the alert message as a consequence message is displayed.

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## A411 - Fuel System

The fuel system is managed automatically throughout all phases of flight by the Fuel System Controller (FSC). A self-monitoring capability is provided to operate fuel system pumps and valves to provide fuel to the engine from appropriate fuel tanks, located in the wings, according to a preprogrammed fuel schedule. Backup procedures are automatically implemented to compensate for component failures. In the event of a FSC failure, control will be transferred to an ancillary FSC. Should this secondary fail, the system automatically reverts to a manual mode requiring backup crew procedures to operate the fuel system.

During engine start, boost pumps are activated and the FSC initiates fuel scheduling. Fuel feed and transfer are automatically controlled throughout the flight. Fuel is automatically transferred between tanks in flight for center-of-gravity (CG) management. Total fuel quantity, gross weight, and CG are displayed on the Secondary Engine (ENG) page of the System Display (SD), as well as individual fuel quantities displayed on the FUEL page.

After refueling, the FSC automatically performs a preflight check of the fuel system components. If a failed component is found, an alert is generated on the Engine and Alert Display (EAD). Maintenance can review all faults using the Centralized Fault Display System (CFDS).

Faults and failures of fuel system elements are detected and accommodated automatically. The FSC is programmed to implement alternate fuel system configurations when it determines that certain components cannot be controlled. Displays of faults and failures are shown on the EAD as well as on the SD.

## A412 - Hydraulic System

The hydraulic system provides power to operate the flight control surfaces, nose wheel steering, wheel brakes and landing gear. The Hydraulic System Controller (HSC) has two (2) operating modes, AUTO and MANUAL, with automatic reversion to manual backup.

Hydraulic pressure is provided by redundant pumps driven by each engine. Two (2) electrically driven auxiliary pumps provide an additional source of pressure as well as that available should the Air Driven Generator (ADG) be deployed to drive the auxiliary pumps. Reversible hydraulic motor pumps provide an alternate source of hydraulic pressure, and nonreversible pumps provide alternates to the rudders and stabilizer trim.

Accumulator on each brake system provides a backup source of hydraulic pressure and full antiskid capability in the event of a system malfunction. Direct-reading gages for pressure are located near each accumulator as well as a dedicated hydraulic gage on the Electronic Instrument System (EIS).

Backup procedures are automatically implemented to compensate for component failures. In the event of a failure of the Hydraulic System Controller (HSC), control will be transferred to an alternate HSC channel. Should a second HSC channel fail, the system automatically reverts to the MANUAL mode for crew employment of backup procedures.

## A413 - Electrical System

The electrical power system control is highly automated to safely configure it during both normal and abnormal operations. In a normal operating mode the Integrated Drive Generators (IDGs) and the Transformer Rectifiers (TRs) as well as all buses are powered. The

emergency electrical power system automatically transfers aircraft battery power to the emergency buses when either this AC or DC buses lose electrical power.

Primary power is provided by IDGs installed on each engine and are normally operated in parallel. If an IDG is tripped off-line a single reset will automatically occur to restore it to operation. A no-break in power transfer control logic is incorporated in the electrical power system to provide interrupt-free electrical power to all equipment when transferring power between the IDGs and the Auxiliary Power Unit (APU).

The APU generator can be used on the ground or in flight to provide auxiliary source of power for the AC Generator Buses which are normally powered by the IDGs which provide 120 kVA, 3-phase 115/200 volt, 400 Hz electrical power. The 75-ampere TRs provide 28 volt DC power to the aircraft buses. Remote control circuit breakers protection of the DC distribution isolates only that portion of the system with a fault, keeping much of the remaining system in the active status. Battery power is supplied to the Battery Direct Bus which is powered by the TRs. When the Air Driven Generator (ADG) is deployed, the emergency AF bus is powered by the ADG which has both a hydraulic and electric mode. In the electric mode, the ADC will power the Emergency buses and charge the battery.

Electrical System Control switches and annunciators are arranged to provide schematic representations on the Electrical Synoptic (ELEC) page of the Systems Display.

## A414 - Air System

The engines supply bleed air to air conditioning packs which provide ventilation, pressurization and temperature control for the cabin and cargo compartment of the aircraft. Isolation valves permit cross-connections of these pneumatic systems.

The Environmental System Controller (ESC) automatically configures the pneumatic systems and monitors itself and other components of the air system for proper operation. It also detects and reports faults to the Centralized Fault Display System (CFDS). The ESC reverts to a manual mode for system and internal failures. Alerts on the EAD and SD notify the crew of such failure in the air system.

Cabin pressure is maintained within preselected limits automatically by a programmed schedule; as a function of altitude of flight. An interface with the Flight Management System (FMS) assures nominal cabin climb and descent rates and automatically select the appropriate cabin altitude pressure for the landing field elevation.

Backup procedures are automatically implemented to compensate for component failures. In the event of failure of an active air conditioning or pressurization ESC channel, control is transferred to an alternate channel. If a second channel should fail, the system automatically reverts to a MANUAL mode and the crew employs backup procedures to operate the air system.

Air system synoptics can be called up on the SD. System failures and associated consequences are also shown. Cabin altitude, differential pressure and rate, and landing field elevation are also shown.

Avionics cooling is accomplished with forced air moving through the Line Replaceable Units (LRUs) with an exhaust system to remove the heated air from the LRUs.

Engine-bleed air is used for anti-icing of wings, engine cowls, and horizontal tail. Anti-icing and defogging of the windshields is accomplished electrically as is the heating of the air data sensors.

## A415 - Miscellaneous Systems

The Miscellaneous Systems Controller (MSC) manages and reconfigures such desperate components as the Auxiliary Power Unit (APU) and the Engine Ignition (ENG ING).

The APU provides pneumatic and electrical power for ground operations of the air conditioning, electrical systems and for starting the main engines. The MSC relays start/stop command to the ECU which controls the start sequencing, on-speed operation and aircraft interfacing.

The MSC also provides automatic control of the ignition and starting systems, emergency lights, air data sensor heaters, and cargo door/fire detection systems as well as the Central Fault Display System (CFDS).

## A42 - ENGINE/THRUST CONTROLS

### A421 - Full Authority Digital Electronic Control (FADEC)

The FADEC provides enhanced basic engine control functions and engine limit protection. Each engine has an FADEC in which changes in throttle position, either manual or automatic, results in changes in the position of separate resolvers for each engine, which have two (2) separate channels for redundancy, for setting the thrust as commanded.

Thrust limits are derived from the Flight Management System (FMS) and are automatically sequenced to correspond with the phase of flight. The FADEC also limits full throttle to maximum rated thrust at the forward stop, and $N_1$/EPR equalization between engines is automatic. Throttle movement during autothrottle (ATS) operation is provided to prevent underspeed/overspeed, but may be overriden by the crew to increase or decrease thrust at anytime. The FADEC ensures that maximum rated thrust is developed when the throttles are at the forward stop. It also provides for optimized engine efficiency and transient performance. Automatic fault detection and onboard diagnostics are also available with FADEC.

The FADEC is controlled by an Engine Control Unit (ECU) which is a dual channel control which allow for normal engine control and operation with the failure of one (1) channel. The ECU is the primary interface between the aircraft and the engine which responds in responses to crew commanded thrust settings transmitted to dual electrical resolvers mechanically linked to each throttle. The ECU also interfaces with the Air Data Computers (ADCs) through data buses for the parameters of; (1) pressure altitude, (2) total pressure, and (3) total air temperature. The ECU also interface with the Flight Control Computers (FCCs) for the following parameters: $N_1$ trim, GMT, flap/slat position, minimum idle selection and approach idle selection. The ECU also transmits data to the Centralized Fault Data Integration Unit (CFDIU).

### A422 - Thrust Control Module (TCM)

A self-contained, fly-by-wire TCM is installed in the forward pedestal. The TCM contains the dual resolvers which transmits throttle position to one (1) of the two (2) channels of the ECU. The TCM also contains an autothrottle servo and a reverse idle blocker solenoid. All of these components are LRUs as is the go-around (GA) switch, Autothrottle disconnect switches, ENG START switches and engine FUEL switches.

Forward travel of the throttles is limited by an overboost stop. The throttles are allowed to continue forward only when excessive force is applied. This extra forward travel signals the

ECU to go to the overboost mode which provide maximum thrust for emergency situations. The reverse idle blocker mechanisms which prevents reverser levers from being advanced until the reversers have been deployed. These mechanisms provide a soft detent as the reverser levers are retarded towards reverse idle.

Motion from the autothrottle servo is transferred to the throttle linkage and levers through a clutch. The clutch also provides load feel when the levers are operated manually. The flight crew can manually operate the throttles to override automatic flight authority, even though the throttles are driven automatically during nominal automatic flight.

A423 - Ignition/Starting Systems

The engine ignition system consists of two (2) completely independent systems. The function of the system is to ignite the fuel/air mixture during starting or condition requiring continuous ignition. During ground start, either system may be energized by selecting the ENG IGN switch on a forward overhead panel. During air starts, the ENG IGN OVRD switch is used which energizes both systems.

With either system selected, continuous ignition is provided automatically during takeoff, landing and icing conditions. The ignition override can be used for emergency conditions (engine flameout) or when flying in heavy turbulence or precipitation.

The ignition system indicating lights are integral with the ENG IGN switches and the ENG START switches. The Miscellaneous System Controller (MSC) provides automatic control of the ignition system.

The starting system of an air turbine starter whose function is to provide enough torque to accelerate the engine to a speed at which it can sustain itself. A starter air valve (pneumatic butterfly shutoff valve) controls the flow of air (supplied by APU or ground power unit) to the engine air turbine starter. The air start valve is powered from the battery bus.

The starting system is energized by pulling the ENG START switch on the forward pedestal which energized a coil and the engine starter valve and supplies power to the Engine Control Unit (ECU).

When $N_2$ rotation is between 8 and 15 percent, electrical power is provided to the ECU to complete the engine start sequence.

When the engine attains a predetermined speed, an electrical signal to the starter air valve is discontinued shutting off the air supply to the turbine. As the engine continues to accelerate, a starter clutch automatically disengages the starter.

A424 - Fuel/Oil Control

The engine FUEL switch supplies electrical power that operates a high pressure fuel shutoff valve. When moved to ON, it starts ignition and fuel provided ENG START and ENG IGN switches are selected.

The Fuel System Controller (FSC) automatically turns on the fuel pumps when the engine FUEL switch is ON. Fuel flowing through the fuel/oil heat exchanger cools the engine oil and heats the fuel. The fuel flow is controlled by the ECU.

Each engine has a self-contained oil system which provides engine lubrication from an oil tank. Oil is pumped under pressure to the engine and returns to the tank.

An oil pressure indicating system is on each engine and an oil quantity sensor is installed in the oil tank. A low oil pressure switch senses pressure drops for OIL alerts. All oil indications are shown on the secondary ENG page of the System Display (SD) and appropriate alerts appear on the Engine and Alert Display (EAD) and the SD.

A425 - Engine Failure Detection

An $N_1$ (engine low pressure rotor RPM) difference detector senses a loss (an 11% RPM drop on any engine differing from the others) during takeoff ground roll and illuminates the ENGINE FAIL light on the glareshield. Engine failure detection logic will prevent the light from illuminating at other than takeoff when airspeed is between 80 knots and $V_1$ (critical engine failure speed or decision speed).

A426 - Thrust Reversing System

The engine thrust reversers are powered by regulated pneumatic pressure from the engines. The thrust reversers are armed when the Flight Control Computer (FCC) receivers input from either the Radio Altimeter (RA) at seven feet or wheel spinup in greater than 80 knots.

Each system is operated by movement of the associated reverse thrust lever. The reverser lever cannot be operated unless the applicable throttle is at the idle stop. To deploy the reverser, the reverse thrust levers must be moved to the throttle interlock position which is a physical stop that prohibits further lever movement until the reverser is safely deployed. When the reverser is 60 percent deployed, the ECU removes the throttle interlock, allowing uninhibited movement of the thrust levers.

If the reverser position data and the throttle resolver angle data provided to the ECU disagree, the ECU will reduce engine power to idle on the affected system. The alert REVER DISA-GREE will be displayed on the EAD if this occurs. Reverser position indications are also shown on the EAD.

## A43 - AIR DATA SYSTEM

A431 - Pitot/Static Air

Pitot tubes sense aircraft pitot (static Pressure and route it to the two CADCs and the standby altimeter and airspeed indicators.Two of the pitot tubes send data to the CADCs and the auxiliary pitot tube send data to the standby altimeter/airspeed indicators. Static source (position) errors are corrected in each CADC.

A432 - Air Temperature

The total air temperature (TAT) sensor (one for both CADCs) provides electrical resistance proportional to the outside air temperature to the CADCs. The CADCs then calculate the temperature. Total air temperature is corrected for anti-ice heater effects.

A433 - Central Air Data

The Central Air Data Computers (CADC) compute and output airspeed, Mach number, altitude, maximum airspeed, vertical velocity, total air temperature, static air temperature, angle of attack (AOA), true airspeed TAS), and pressures (pitot, impact, and static).

# IDEF DIAGRAMS

## ANALYSIS APPROACH

The Structured Analysis and Design Technique (SADT) was selected by the U.S. Air Force to describe the functional architecture of manufacturing. The name was changed to IDEF₀ to accommodate copyright restrictions. The technique provides a structured, disciplined approach to the decomposition of a top objective into the hierarchy of functions which are necessary to the accomplishment of the top objective. It is particularly well suited to creating a functional description of the objective "Manage Commercial Transport Functions/Systems". The IDEF₀ method provides the assurance that every significant lower level function that is logically necessary to the accomplishment of a higher level function is shown. The approach is also useful in identifying the data associated with each function. IDEF₀ does not address time or sequence, which may have been essential had this project had a requirement for these.

## IDEF₀ SYNTAX

The syntax used in this method is simple. It consists of boxes and arrows. Boxes represent functions, objectives, or activities. Functions are always active verbs or verb phrases. Arrows are data. They represent "things". They are always labeled as a noun or noun phrase, and can be any "thing", including people. There are four kinds of arrows: *Input, Output, Control,* and *Mechanism.* As shown in Figure 1, Input arrows enter the function box from the left; Output arrows leave the box from the right side; Control arrows enter the box from the top; Mechanism arrows enter the box from the bottom. The concept is that Inputs are converted to Outputs by Mechanisms, subject to the constraints imposed by the Controls. The existence of a Mechanism arrow implies that a function allocation has been made. In this exhibit, Mechanisms are provided only as probable candidates and no assumptions are being made concerning allocation.
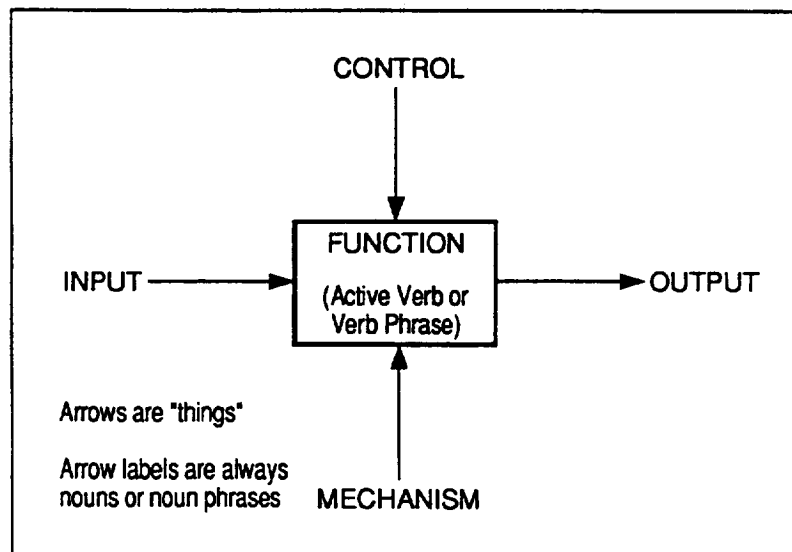


**FIGURE 1. IDEF SYNTAX**

## CONCEPTUAL MODEL

The IDEF0 diagrams depict the top-down analysis of the various aircraft functions and their related systems. The analysis starts with a representation of the four major functional areas collapsed into a single unit top-level structure--a box with arrow interfaces to activities outside of the unit. Since the single box represents the commercial transport's functions/systems as a whole, the descriptive name written in the box is general. The same is true of the interface arrows since they represent the complete set of external interfaces to the whole activity.

The top-level box (Node A-0) that represents the management of functions/systems as a single module is then decomposed (broken down into subfunctions/subactivities) on the following diagram (Node A0).

The decomposed diagram contains the boxes that represent the four major functional areas of the single parent module. Each of the four functions have been similarly decomposed to expose the essential detail at the selected lower levels. The decomposition eventually reveals the complete set of subfunctions/subactvities, each represented as a box showing boundaries as defined by the interface arrows.

Each diagram im the IDEF0 model is shown in precise relationship to the other diagrams by means of interconnecting arrows. When a module has been decomposed into its subfunctions/subactivities, the interface between the subfunctions are shown as arrows. The name of each subfunction box, plus its labeled interfaces, define a bounded context for that module.

In all cases, every subfunction/subactivity is restricted to containing only those elements that lie within the scope of the parent module. Furthermore, the module cannot omit any elements. Thus, as already indicated, the parent module, or activity box, and its interfaces provide a context--nothing can be added or removed from that boundary. due to the unique requirements of this project, and the nature of the functions/systems that were involved, not every subfunction/subactivity was decomposed. Decomposition included the subfunctions and continued to the level necessary to reveal the detail that was believed to be essential to this project's needs.

## MODEL CHARACTERISTICS

Inputs to the development of the IDEF0 model included the data derived from the functional description narrative and the hierarchy implied in the structure of the narrative. The model was created by an analyst experienced in the use of the method and with extensive experience as a flight deck crew member in high-performance jet aircraft. Elements of the model were created manually, then entered into Meta Software *design/IDEF*, running on a Macintosh II workstation.

The IDEF0 model exhibits that are contained in this document are composed of text, diagram, and glossary pages, in that sequence. The first text page provides an overall description of the model's structure, followed by pages that give an overview of the model in the form of a Node Index. The reader of the IDEF0 model will find a series of diagrams and glossary pages that are arranged in sequence to develop the analysis process to the "Manage Aircraft Systems" function.

IDEF0 has its greatest strength in its effectiveness as a tool for dealing with complexity, because it starts with a very general level of detail and gradually introduces more detail as the analysis proceeds to the lower levels.

There is no attempt to show time or sequence in the diagrams in this report. However, in some instances, sequences of events are implied through the arrangement of activities within each diagram structure. Feedback of data or information transfer between activities indicate the critical interfaces between and among functions. The IDEF0 reader is encouraged to take particular notice of these feedback loops to gain an essential perspective of the interrelationships and complexity of interfaces between the functions and systems. Glossaries are provided for each applicable diagram so that the reader of the IDEF0 model has sufficient understanding of the interfaces between activities or the "things" produced by the activities.

| USED AT: | AUTHOR: R. T. Goins | DATE: 5/30/91 | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | WORKING | | |
| | | | X DRAFT | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | |
| | | | PUBLICATION | | |

The decomposition of A-0 into its major constituent activities yields the top diagram, A0.

The selected activities (functions) have been partitioned into four groups as shown in Boxes 1,2,3, and 4 on Node A0. These four boxes represent the major functions associated with the activities related to aircraft flight.

An extensive decomposition of each function shown on Node A0 has been accomplished to the level necessary to identify the essential information requirements and interfaces between functions.

The systems and functions that are depicted in the IDEFø diagrams are generic—there is no intent by the analyst to represent a specific air vehicle, but merely a class of air transport vehicle that will be in operation by the year 2005.

The reader of the IDEFø diagrams is reminded that the process does not address timing and sequencing of a activity. The structure of each diagram, on many occasions, may show evidence of activity sequence, based upon the ability of the individual analyst. The diagrams do, on all occasions, show how one activity may constrain others.

Glossary entries are required for all new terms. No entry is required for terms used throughout the various levels of decomposition. The reader is encouraged to refer to the parent diagram if definition of a terminology is required.

No specific values have been identified for Glossary entries such as attitude, airspeed, altitude, or lift device boundaries that may be applicable to a selected series of aircraft or aircraft model.

| NODE: F/SD Text | TITLE: MANAGE COMMERCIAL TRANSPORT FUNCTIONS / SYSTEMS | NUMBER: DGT-01 |
|---|---|---|

USED AT: | AUTHOR: R. T. Goins    DATE: 7/16/91 | WORKING | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION   REV: | X DRAFT
RECOMMENDED
PUBLICATION

NOTES: 1 2 3 4 5 6 7 8 9 10

NODE INDEX:

A-0 MANAGE COMMERCIAL TRANSPORT FUNCTIONS/SYSTEMS
A0 MANAGE COMMERCIAL TRANSPORT FUNCTIONS/SYSTEMS
A1 MANAGE FLIGHT SYSTEMS
A11 MANAGE AUTOMATIC FLIGHT SYSTEM
A111 CONDUCT AUTOPILOT/FLIGHT DIRECTOR ACTIVITIES
A112 CONDUCT AUTOMATIC THROTTLE SYSTEM/ENGINE TRIM ACTIVITIES
A113 CONDUCT STABILITY AUGMENTATION SYSTEM ACTIVITIES
A114 CONDUCT FLIGHT CONTROL SYSTEM ACTIVITIES
A115 CONDUCT WARNING/ALERTING SYSTEM ACTIVITIES
A12 MANAGE FLIGHT MANAGEMENT SYSTEM
A121 CONDUCT FLIGHT MANAGEMENT COMPUTER ACTIVITIES
A122 CONDUCT DISPLAY ELECTRONICS UNIT ACTIVITIES
A123 CONDUCT CENTRAL FAULT DISPLAY SYSTEM ACTIVITIES
A124 CONDUCT ACARS ACTIVITIES
A2 MANAGE NAVIGATION SYSTEMS
A21 MANAGE GROUND-BASE NAVIGATION SYSTEMS
A211 CONDUCT VHF OMNI-RANGE ACTIVITIES
A213 CONDUCT ILS/MLS ACTIVITIES
A22 MANAGE AIRBORNE NAVIGATION SYSTEMS
A221 UTILIZE INERTIAL REFERENCE SYSTEM
A222 UTILIZE GLOBAL POSITIONING SYSTEM

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| USED AT: | AUTHOR: R. T. Goins | DATE: 7/16/91 | WORKING | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

NODE INDEX:

A3 MANAGE COMMUNICATIONS SYSTEMS
  A31 COMMUNICATE VIA VOICE SYSTEMS
  A32 COMMUNICATE VIA DATA LINK SYSTEMS
  A33 COMMUNICATE VIA MISCELLANEOUS SYSTEMS
A4 MANAGE AIRCRAFT SYSTEMS
  A41 ACCOMPLISH AUTOMATED SYSTEMS CONTROLLER FUNCTIONS
    A411 CONTROL FUEL SYSTEM
    A412 CONTROL HYDRAULIC SYSTEM
    A413 CONTROL ELECTRICAL SYSTEM
    A414 CONTROL AIR SYSTEM
    A415 CONTROL MISCELLANEOUS
  A42 ACCOMPLISH ENGINE/THRUST CONTROL
    A421 ACCOMPLISH FULL AUTHORITY DIGITAL ENGINE CONTROL ACTIVITY
  A43 CONTROL AIR DATA SYSTEM

| NODE: F/SD Text | TITLE: TEXT: NODE INDEX | NUMBER: DGT-03 |

USED AT: | AUTHOR: R. T. Goins | DATE: 5/9/91 | READER | DATE | CONTEXT:

PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV:

| WORKING | X DRAFT |
| RECOMMENDED |
| PUBLICATION |

NOTES: 1 2 3 4 5 6 7 8 9 10

Received ATC Communications

Navaid Signal Transmissions

Aircraft Mission Configuration

Guidance and Direction

Routing and Clearances

Aircraft Operational State

Environmental Factors

NAS Operational Environment

**MANAGE COMMERCIAL TRANSPORT FUNCTIONS / SYSTEMS**

0

Transmitted ATC Communications

Aircraft Post-Mission Position, Configuration, and Status

Systems, Controls and Indicators

Ground Crew

ATC Controller

Flight Crew

NODE: F/SD A-0 | TITLE: MANAGE COMMERCIAL TRANSPORT FUNCTIONS / SYSTEMS | NUMBER: DG-01

| USED AT: | AUTHOR: R. T. Goins | DATE: 5/30/91 | WORKING | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: 7/16/91 | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A-0:

AIRCRAFT OPERATIONAL STATE - The aircraft's operational status. Includes the configuration, operational capabilities, and technologies that are available in the baseline aircraft.

AIRCRAFT MISSION CONFIGURATION - The mission condition of the baseline aircraft. Includes the fuel state, physical location, system capabilities, and general functional status of the aircraft prior to the execution of the mission.

ATC COMMUNICATIONS (RECEIVED) - Communications received via the ARTCC network. Includes voice and data link communications. Reception may be either via VHF or HF.

ATC COMMUNICATIONS (TRANSMITTED) - Communications transmitted from aircrew/aircraft via the ARTCC network to include SATCOM. Reception may be either via VHF or HF.

ATC CONTROLLER - communications via the ARTCC network is handled primarily by the Controller that functions as an advisor/director of air traffic, route clearance, and enroute navigation support to the flight crew. ATC Controllers interface with the flight crew through the on-board communications systems by voice and/or data link facilities as applicable to the information being transmitted.

AIRCRAFT POST-MISSION STATUS - The post-mission condition of the aircraft. Includes the fuel state, physical location, systems capabilities, and general status of the aircraft after the mission is complete.

ENVIRONMENTAL FACTORS - Temperature, humidity, barometric pressure, wind velocity and direction, cloud obscuration, turbulence, precipitation, visibility, runway surface conditions, and abnormal meteorological conditions.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE COMMERCIAL TRANSPORT FUNCTIONS / SYSTEMS | NUMBER: DG- 01 A |

USED AT:

AUTHOR: R. T. Goins    DATE: 5/31/91

PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV: 7/16/91

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | READER | DATE | CONTEXT: |
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| X DRAFT | | | |
| RECOMMENDED | | | |
| PUBLICATION | | | |

GLOSSARY - F/SD A-0 (CONT'D):

FLIGHT CREW - The cockpit crew that is responsible for the operation of the aircraft during airborne and ground operations. Includes the Captain, First Officer, and Second Officer (if applicable).

GROUND CREW - The ground servicing and maintenance personnel that are responsible for the ground operations that prepare the aircraft for flight and the recovery of the aircraft after the mission is complete.

GUIDANCE AND DIRECTION - Guidance and direction provided though the use of FARs, Advisory Circulars, NOTAMS, various airline company regulations and requirements, and information provided by the ATC Controller. Includes Air Route Traffic Control Centers (ARTCCo, available Navaids, operational sequences, the mission flight plan, and local operating procedures.

NAS OPERATING ENVIRONMENT - The total operating environment of the National Airspace System (NAS). Includes the air transportation route structure, the ARTCC physical and functional configurations, operational capabilities and technologies that support both ground and airborne operations, in addition to the communications, navigation, and surveillance facilities.

NAVAID SIGNAL TRANSMISSIONS - Navigation aids (Navaids) signals that are transmitted to the various systems on board the aircraft. Includes VHF Omnidirectional Range (VOR), Distance Measuring Equipment (DME), Instrument Landing System (ILS), Marker Beacon (MB), Automatic Direction Finding (ADF), Long Range Navigation (LORAN), and both Microwave Landing System (MLS) and the Global Positioning System (GPS).

SYSTEMS, CONTROLS, AND INDICATORS - The aircraft systems, controls, and indicators that are the mechanisms that provide the physical and functional interfaces that support the various functions via the interaction of the flight or ground crew.

USED AT:

AUTHOR: R. T. Goins  DATE: 5/9/91  READER  DATE  CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION  REV: 7/1/91

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING  | X DRAFT
RECOMMENDED
PUBLICATION

TOP

Guidance and Direction

Aircraft Operational State

Aircraft Mission Configuration  I3

Navaid Signal Trans  I2

I1

Received ATC Communications

Flight Crew  M2

C1 C3 C4 Environmental Factors  C2 Routing and Clearances  C5 NAS Operational Environment

MANAGE FLIGHT SYSTEMS  1

Aircraft Control Signals

MANAGE NAVIGATION SYSTEMS  2

Initial Position and Flight Plan Data

Airborne and Ground-Based Navigation Data

Alert/ Warning Displays

MANAGE COMM SYSTEMS  3

Processed ATC Communications

Cockpit Communications

Pitch and Roll From INS

ATC Controller

Ground Crew  M1 M3

MANAGE AIRCRAFT SYSTEMS  4

Aircraft Post-Mission Position, Configuration, and Status  O2

Transmitted ATC Communications  O1

Systems Sensor Data

Systems, Controls, and Indicators  M4

NODE: F/SD  A0  TITLE: MANAGE COMMERCIAL TRANSPORT FUNCTIONS / SYSTEMS  NUMBER: DG-02

AUTHOR: R. T. Goins   DATE: 6/10/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION   REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| | READER | DATE | CONTEXT: |
|---|---|---|---|
| WORKING | | | |
| X DRAFT | | | |
| RECOMMENDED | | | |
| PUBLICATION | | | |

GLOSSARY - F/SD A0:

AIRCRAFT CONTROL FUNCTIONS - These are the functionally-oriented signals that are utilized by the associated aircraft system. Control signals emanate from the various flight management systems that process airframe, engine, air, and navigation sensor data. Control signals may be in the form of analog, digital, or discrete data transmissions.

AIRBORNE AND GROUND-BASED NAVIGATION DATA - This is the navigation data that is generated by the on-board navigation systems. The navigation data varies dpendent upon the specific system that produces it. Typical navigation data may be presented as relative bearing, distance, course deviation/course steering, heading, velocity, and/or geographic position.

COCKPIT COMMUNICATIONS - Communications that occur within the aircraft cockpit, either between the crewmemebers or between crew members and cockpit systems.

INITIAL POSITION AND FLIGHT PLAN DATA - The initial geographic position of the aircraft and the flight plan data that is used to generate flight profiles from departure through arrival.

PROCESSED ATC COMMUNICATIONS - Any communications with Air Traffic Control agencies that are received and processed through on-board communications systems. Processed ATC communications are primarily those associated with datalink systems communications, to include SATCOM/GPS processed data.

SYSTEMS SENSOR DATA - Data that originates within each of the aircraft systems. Sensor data is primarily an electrical/electronic reperesentation of aircraft altitude, airspeed, attitude, etc. Sensor data may be provided in the form of analog, digital, or discrete signals.

| NODE: F/SD   Text | TITLE: GLOSSARY: MANAGE COMMERCIAL TRANSPORT FUNCTIONS / SYSTEMS | NUMBER: DG- 02A |
|---|---|---|

USED AT:

AUTHOR: R. T. Goins   DATE: 6/10/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION   REV: 6/12/91

NOTES: 1 2 3 4 5 6 7 8 9 10

READER   DATE   CONTEXT:

| WORKING | X DRAFT |
| RECOMMENDED | |
| PUBLICATION | |

A0

C1 Guidance and Direction

AP/FD Functional Data
ATS/Engine Trim Functions
Stability Augmentation Functions
Flight Controls Functions
Warning Systems Functions
Flight Management Computer Functions
Display Electronic Unit Functions
ACARS Functions
Central Fault Display System Functions
FMS Climb/Steer Commands

O3 O2 O2 O2 O2 O2 O1 O1

C3 Environmental Factors
C2 Aircraft Operational State

Systems Sensor Data I4

Aircraft Mission Configuration

Airborne and Ground-Based Navigation Data I1 I3 I2 I5

Cockpit Communications

Processed ATC Communications

Flight Crew M1

Systems, Controls, and Indicators M2

MANAGE AUTOMATIC FLIGHT SYSTEM 1

MANAGE FLIGHT MANAGEMENT SYSTEM 2

NODE: F/SD   A1   TITLE: MANAGE FLIGHT SYSTEMS   NUMBER: DG- 03

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| USED AT: | AUTHOR: R. T. Goins | DATE: 6/10/91 | | READER | DATE | CONTEXT: |
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| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | | |
| | | | WORKING | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | | | PUBLICATION | | | |

GLOSSARY - F/SD A1:

AP/FD FUNCTIONAL DATA - This is the data that originates within the Autopilot / Flight Director system. The Autopilot / Flight Director functions as the controller for automatic flight. It provides control signals to the various aircraft systems to control speed, heading, attitude, and attitude.

ACARS FUNCTIONS - The ARINC Communications Addressing and Reporting System (ACARS) provides the capability to download fault display data to selected ground receiving stations or to review and transmit recent fault lists or LRU reports.

ATS / ENGINE TRIM FUNCTIONS - these are functions that automatically position the throttles to maintain the engine thrust required for selected modes. In addition, the engine thrust / trim functions maintains a common thrust setting for all engines, thereby eliminating the need for periodic throttle adjustments. Includes functions that provide automatic thrust limiting and speed control during specific mode selections.

CENTRAL FAULT DISPLAY FUNCTIONS - The Centralized Fault Display System (CFDS) provides functions for 1) fault reporting, 2) fault histories, 3) component checks, and 4) initiating return-to-service (RTS) checks for selected aircraft components.

DISPLAY ELECTRONIC UNIT FUNCTIONS - Flight instruments data, engine and alert data, in addition to navigation data are displayed on the Display Units of the Electronic Instrumentation system (EIS).

FLIGHT CONTROLS FUNCTIONS - The functions for controlling the pitch, roll, and yaw of the aircraft are related to the longitudinal, lateral, and cdirectional control systems, respectively. Movement of the major control surfaces (ailerons, elevators, and rudder) is initiated and controlled by the functions that cause deflection of these surfaces.

USED AT: | AUTHOR: R. T. Goins | DATE: 6/10/91 | | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: 7/17/91 | | WORKING | |
| | | X DRAFT | |
NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | |
| | PUBLICATION | |

## GLOSSARY - F/SD A1 (CON'T):

FLIGHT MANAGEMENT COMPUTER FUNCTIONS - Flight Management Computer (FMC) functions generate flight profiles from departure to arrival and provide commands to guide the aircraft along the flight plan through climb and steering inputs to the autopilot and autothrottle systems. The FMC provides for functions that allow for the interface between and the processing of information from the ACARS, CFDS, and DEUs.

FMS CLIMB AND STEER COMMANDS - These are the commands that control the vertical flight profile and lateral steering of the aircraft when operating outside of the inhibit regions. The vertical and lateral control commands are coupled to supporting functions resident in the autopilot / flight director (AP/FD).

STABILITY AUGMENTATION FUNCTIONS - These are the functions that control the flight stability of the aircraft through the longitudinal, lateral, and directional control systems. Stability augmentation is provided through the use of limited control surface deflection by command / attitude hold. Stability control is applied to pitch, roll, and yaw axes.

NODE: F/SD    Text | TITLE: GLOSSARY: MANAGE FLIGHT SYSTEMS | NUMBER: DG- 03B

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/10/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: 6/12/91 | | | |
| | | WORKING | X DRAFT | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | A1 |
| | | | PUBLICATION | | |

Aircraft Operational State

C1  C2 Environmental Factors

FMS Climb/Steer Commands
I2

System Sensor Data
I1

IAS/Mach/Select/-Hold

**CONDUCT AP / FD ACTIVITIES** 1

"ATS Engaged" Signal

Throttle Position

Aircraft Roll Angle

Aircraft Airspeed

Aircraft Altitude

Flight Crew
M1

Systems, Controls, and Indicators
M2

**CONDUCT ATS / ENGINE TRIM ACTIVITIES** 2

Auto Pitch Trim

ATS Speed/Retard Reference

Pitch, Roll, and Yaw Control

"Autopilot Engaged" Signal

**CONDUCT STAB-AUG SYSTEM ACTIVITIES** 3

Lateral/Longitudinal/ Directional Stability Commands

Spoiler Control

**CONDUCT FLT. CONT. SYSTEM ACTIVITIES** 4

Windshear Component

**CONDUCT WARN/ALERT SYSTEM ACTIVITIES** 5

Automatic Slat Extension Command

Windshear Detection

Autopilot/ Flight Director Functions O1

"AP/FD Engaged" Signal

ATS Engine Trim Functions O2

Stability Augmentation Functions O3

Flight Control System Functions O4

Alerting/Warning Indications O5

NODE: F/SD  A11 | TITLE: **MANAGE AUTOMATIC FLIGHT SYSTEM** | NUMBER: DG- 04

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/11/91 | WORKING | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

## GLOSSARY - F/SD A11:

AIRCRAFT ALTITUDE - The altitude of the aircraft as it is measured above the Standard Datum Plane (pressure altitude with 29.92 Hg set in the Kolsman indicator), or as it is measured above sea level (true altitude with the local area altimeter setting in the Kolsman indicator), or altitude above the terrain or above ground level (AGL) (absolute altitude as determined by either a radar or radio wave emitting altimeter). Specific altitudes are utilized as appropriate.

AIRCRAFT AIRSPEED -
The velocity of the aircraft relative to the air mass that it is operating in. The following airspeeds are available and are used as required throughout the system:

- IAS -- Indicated Airspeed. The uncorrected reading of aircraft airspeed as it is shown on the indicator.

- TAS-- True Airspeed. The true airspeed of the aircraft. It is computed by applying true air temperature and pressure altitude to the equivalent airspeed value.

The basic differences in IAS and TAS include the errors that are inherent in the mechanical properties of an aircraft instrument installation error, and the air density and temperature changes from standard conditions.

AIRCRAFT ROLL ANGLE - This is a measurement of the aircraft's attitude around the longitudinal axis of the aircraft as described relative to the vertical. Aircraft roll angle is measured in degrees right or left from the vertical position–zero degrees.

"ATS ENGAGED" SIGNAL - The annunciation that an automatic throttle control system (autothrottle) is engaged and is capable of providing throttle control inputs.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE AUTOMATIC FLIGHT SYSTEM | NUMBER: DG- 04A |

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/11/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | | WORKING | | | |
| | | X DRAFT | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | RECOMMENDED | | | |
| | | PUBLICATION | | | |

GLOSSARY - F/SD A11 (CONT'D):

AUTOMATIC PITCH TRIM - The automated control of the pitch trim schedule and rate of change of the horizontal stabilizer position so as to provide the best performance for all flight conditions.

AUTOTHROTTLE SPEED/RETARD REFERENCE - The reference used to control the automatic positioning of the engine throttles during thrust changes and throttle retard during automated landing modes.

"AUTOPILOT ENGAGED" SIGNAL - The annunciation that the automated piloting system is engaged and is active in the control of the aircraft attitude, altitude, heading, and speed.

AUTOPILOT/FLIGHT DIRECTOR FUNCTIONS - Systems functions that are associated with autopilot and flight director system. These are the functions that:

   - Operate pitch, roll, and combined pitch and roll modes of the autopilot / flight director systems.

   - Provide autopilot coupled operation through a flight management system.

AUTOMATIC SLAT EXTENSION COMMAND - This is a command that is used to initiate the automatic extension of the wing slats whenever a prestall or approach to stall condition is detected through logic in the automated flight system.

"AP/FD ENGAGED" SIGNAL - The annunciation that either the automatic pilot or the flight director is engaged.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE AUTOMATIC FLIGHT SYSTEM | NUMBER: DG- 04B |

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/11/91 | READER | DATE | CONTEXT: |
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| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | WORKING | | | |
| | | X DRAFT | | | |
| | | RECOMMENDED | | | |
| | | PUBLICATION | | | |

GLOSSARY - F/SD A11 (CONT'D):

PITCH, ROLL, AND YAW CONTROL - These are the signals that provide the control of both primary and secondary flight control components.

WARNING INDICATIONS - These are indications to the flight crew that require awareness, actions , and/or impose specific limitations on the aircraft.

WINDSHEAR COMPONENT - The calculated direction and velocity of the windshear affecting the aircraft's flight path.

WINDSHEAR DETECTION - The signal that indicates the presence of a windshear effect upon the aircraft. Initiates the use of windshear command guidance to the autopilot and flight director.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE AUTOMATIC FLIGHT SYSTEM | NUMBER: DG- 04C |
|---|---|---|

Aircraft Operational State

O1

O2

O2

Autoland Control

"Engaged" Signals

O1
O3

Autothrottle Speed Reference

Aircraft Operational State

C1

CONDUCT AUTOMATIC LANDING
5

Environmental Factors

C2

Vertical Control

CALCULATE WINDSHEAR CORRECTION
4

Systems, Controls, and Indicators

M2

M1

Yaw Control

MAINTAIN YAW CONTROL
3

Bank Angle Limit Control

Roll Control

MAINTAIN ROLL CONTROL
2

Flight Crew

Auto Pitch Trim

Pitch Control

Auto Flare Control

MAINTAIN PITCH CONTROL
1

FMS Climb/Steer Commands

I1

Windshear Detection

I3

I2

Aircraft Altitude

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/12/91 | WORKING | READER | DATE | CONTEXT: |
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| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A111:

AUTOFLARE CONTROL - An automatically initiated signal that controls the pitch attitude of the aircraft just prior to touchdown (approximately 50 feet above ground level [50 FT AGL]). Autothrottle control simultaneously provides throttle retard at the time the flare attitude is commanded.

AUTOLAND CONTROL - The automated landing of the aircraft through modes that control speed, descent, and attitude. Includes both flare and bank angle limit control.

BANK ANGLE LIMIT CONTROL - This controls the limit of the bank angle during the autoland configuration. The bank angle limit control minimizes the opportunity for large-scale corrections at near touchdown altitudes.

VERTICAL CONTROL - Vertical control from the windshear correction function provides windshear pitch guidance to the autoland function.

YAW CONTROL - This is the control of the aircraft crab angle while the automated landing mode is being used. Coordinated control of the aircraft is applied to the rudder and up-wind wing of the aircraft in order to maintain runway centerline tracking.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT AUTOPILOT / FLIGHT DIRECTOR ACTIVITIES | NUMBER: DG - 05A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/12/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | | | WORKING | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | X DRAFT | | |
| | | | RECOMMENDED | | |
| | | | PUBLICATION | | |

GLOSSARY - F/SD A112:

ATS THROTTLE CONTROL - The control of the engine throttles that is provided by the autothrottle system.

AUTOMATIC THROTTLE POSITIONING - The command that results from the throttle control function. The command initiates throttle position changes as required to adjust engine thrust during takeoff, cruise, and landing phases.

ENGINE COMMON THRUST SETTINGS - This is an output of the engine trim function that automatically positions the throttles to maintain the engine thrust required for the mode selected. Maintaining the engines at a common thrust setting eliminates the need for periodic throttle adjustments.

FLAP / SLAT CONFIGURATION - The configuration (extended, retracted, or in transit) of the flaps or slats as determined by sensors or position indicating devices that are attached to the flaps/slats.

IAS/MACH/SELECT/HOLD - This is the part of the aircraft's operational state that provides the capability to select a common speed and to automatically capture and hold the commanded speed.

Δ SPEED - Commanded change to the airspeed of the aircraft.

Δ SPEED RATE - The commanded rate of change in the airspeed of the aircraft.

THRUST / SPEED TARGETS - This is a "target" or desired airspeed as determined by the flight crew or the flight management system during specific or critical phases of flight, e.g., takeoff, flap/slat extension/retraction and during landing.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT ATS / ENGINE TRIM ACTIVITIES | NUMBER: DG - 06A |

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/12/91 | WORKING | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A112 (CONT'D):

THRUST LIMIT / TARGET - This is an automatic thrust limiting control that originates within the automatic throttle (autothrottle) system. The thrust limit/target ensures that each engine is constrained between the maximum limits as defined by the flight management system and the flight idle limit.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT ATS / ENGINE TRIM ACTIVITIES | NUMBER: DG- 06B |

GLOSSARY - F/SD All3:

LATERAL STABILITY COMMANDS - These are the commands that provide signals to roll control mechanisms to improve the handling characteristics of the aircraft in the roll axis. They are used external to the stability augmentation system.

LONGITUDINAL STABILITY COMMANDS - These are the commands that provide signals to pitch control mechanisms to improve the handling characteristics of the aircraft in the pitch axis. They are used external to the stability augmentation system.

DIRECTIONAL STABILITY COMMANDS - These are the commands that provide signals to yaw control mechanisms to improve the handling characteristics of the aircraft in the yaw axis. They are used external to the stability augmentation system.

ADVERSE YAW COMPENSATION (AYC) - AYC is provided to improve turn coordination whenever the aircraft is in a takeoff or landing configuration. AYC augments directional stability with a sideslip to rudder feedback that produces rudder deflection in the direction of roll proportional to the roll rate.

PITCH CONTROL - This is the signal that provides the control to the pitch attitude channel that controls the pitch angle and rate.

ROLL CONTROL - This is the signal that provides the control to the roll attitude channel that controls the roll angle and rate.

YAW CONTROL - This is the signal that provides control of the aircraft's yaw angle and rate.

PITCH STABILITY COMMANDS - These are the commands that provide signals to effect the pitch stability of the aircraft during turns.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT STABILITY AUGMENTATION SYSTEM ACTIVITIES | NUMBER: DG-07A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/17/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A113 (CONT'D):

ROLL STABILIZATION COMMANDS - These are the commands that are used internally to provide signals to effect the roll stability of the aircraft during turns and extension/retraction of aircraft spoilers.

YAW DAMPING COMMANDS - The yaw damping commands povide turn coordination and damping of the "dutch roll" characteristics through rudder control.

SPOILER CONTROL - This is a control signal that is used to decrease or increase lift by extending or retracting wing-attached spoilers, respectively.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT STABILITY AUGMENTATION SYSTEM ACTIVITIES | NUMBER: DG-07B |
|---|---|---|

USED AT:

AUTHOR: R. T. Goins    DATE: 6/17/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | READER | DATE | CONTEXT: |
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| RECOMMENDED | | | |
| PUBLICATION | | | A11 |

Pitch, Roll, and Yaw Control
I3
I2
Stability Commands

Longitudinal Stability Commands

C1   High-Lift Devices Position

CONTROL LONGITUDINAL AXIS   1

Elevator Deflection Commands

Longitudinal Trim

Lateral Stability Commands

Lateral Trim

CONTROL LATERAL AXIS   2

Aileron Deflection Commands

Directional Stability Commands

Directional Trim

Spoiler Control
I1

CONTROL YAW AXIS   3

Rudder Deflection Commands

I5
Automatic Slat Extension Command

CONTROL LIFT   4

High-Lift Device Positioning Commands

I4
Auto Pitch Trim

Longitudinal Control Devices

Lateral Control Devices

Directional Control Devices

Lift Control Devices

M1

CONTROL TRIM   5

Trim Indicator Control

Lateral, Directional, Logitudinal Trim

O1
O1
O1
O1
O1

NODE: F/SD   A114    TITLE: CONDUCT FLT. CONT. SYSTEM ACTIVITIES    NUMBER: DG-08

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| USED AT: | AUTHOR: R. T. Goins | DATE: 6/17/91 | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | |
|---|---|
| X DRAFT | |
| RECOMMENDED | |
| PUBLICATION | |

## GLOSSARY - F/SD A114:

**AILERON DEFLECTION COMMANDS** - Commands that signal the deflection of the aileron in order to effect roll controll of the aircraft.

**ELEVATOR DEFLECTION COMMANDS** - Commands that signal the deflection of the elevators in order to effect pitch control of the aircraft

**RUDDER DEFLECTION COMMANDS** - Commands that signal the deflection of the rudder in order to control aircraft yaw.

**LATERAL, DIRECTIONAL, AND LONGITUDINAL TRIM** - These are the control outputs that are used to effect the displacement of the ailerons, rudder, and elevator for selected trim settings.

**LATERAL TRIM** - Control inputs to effect the trimming displacement of the lateral control devices (ailerons).

**LONGITUDINAL TRIM** - Control inputs to effect the trimming displacement of the longitudinal control devices (elevators).

**DIRECTIONAL TRIM** - Control inputs to effect the trimming displacement of the directionall control device (rudder).

**TRIM INDICATOR CONTROL** - Control output that is used to position flight control surface trim indicators.

**LONGITUDINAL CONTROL DEVICES** - These are the devices that effect the longitudinal control of the aircraft. The devices are controlled by commands from the autopilot, the stability augmentation system, or the flight crew.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT FLIGHT CONTROL SYSTEM ACTIVITIES | NUMBER: DG-08A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/17/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | | | WORKING | | |
| | | | X DRAFT | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | |
| | | | PUBLICATION | | |

GLOSSARY - F/SD A114 (CONT'D):

LATERAL CONTROL DEVICES - These are the devices that effect the lateral control of the aircraft. The devices are controlled by commands from the autopilot, the stability augmentation system, or the flight crew.

DIRECTIONAL CONTROL DEVICES - These are the devices that effect the directional control of the aircraft. The devices are controlled by commands from the autopilot, the stability augmentation system, or the flight crew.

LIFT CONTROL DEVICES - These are the devices that provide lift augmentation during critical phases of flight. The devices may be controlled automatically or manually.

TRIM CONTROL DEVICES - These are the devices that are used to provide trimming displacement of longitudinal, directional, and lateral control devices.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT FLIGHT CONTROL SYSTEM ACTIVITIES | NUMBER: DG-08B |

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USED AT: | AUTHOR: R. T. Goins | DATE: 6/18/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING | X DRAFT
RECOMMENDED
PUBLICATION

A11

NODE: F/SD A115 | TITLE: CONDUCT WARN/ALERT SYSTEM ACTIVITIES | NUMBER: DG-09

Aircraft Airspeed
I1

High-Lift Device Positions
C3

Non-Speech Alert/Warn Command

Speech Alert/Warn Command

CONTROL TAKEOFF WARNING SYSTEM 1

Aircraft Operational State
C2

Windshear Component
C1

Stick Shaker Command

Automatic Slat Extension Command

CONTROL STALL/SLAT WARNING SYSTEM 2

Windshear Detection

MANAGE WINDSHEAR DETECTION SYSTEM 3

"AP/FD Engaged" Signal
C4

Preset Altitude

Altitude Alert Commands

MANAGE ALTITUDE ALERTING SYSTEM 4

Aircraft Altitude
I2

Warning Systems, Controls, and Indicators
M1

GENERATE ALERTING/ WARNING DISPLAYS 5

Alert/Warning Signals
O1

O2

O3

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/8/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A115:

NON-SPEECH ALERT/WARNING COMMAND - This is the command that initiates the non-speech auditory displays that are used to provide an alert or warning signal quickly, irreespective of head position or eye fixation. Non-speech systems rely on a symbolic (buzzer, tone, etc.) form that requires attention to a particular aircraft function.

SPEECH ALERT/WARNING COMMAND - This is the command that initiates the speech auditory displays that are used to provide an alert or warning signal quickly irrespective of eye fixation or workload. Speech type systems rely upon a verbal form that requires attention to particular aircraft function.

STICK SHAKER COMMAND - The stick shaker command provides artificial control stick (column) displacement as a means of directing attention to stall warning conditions.

PRESET ALTITUDE - Operator-designated or predetermined altitude setting.

ALTITUDE ALERT COMMANDS - These are the commands that initiate either the auditory or visual altitude alerting opr warning displays.

WARNING SYSTEMS CONTROLS AND INDICATORS - The aircraft systems, controls, and indicators that are used specifically to support warning systems functions.

ALERT/WARNING SIGNALS - The various alert and warning signals that are used to genertae displays via the various communications systems.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT WARN/ALERT SYSTEM ACTVITIES | NUMBER: DG-09A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/18/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | | | WORKING | | ☐ |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | X DRAFT | | ❋ |
| | | | RECOMMENDED | | |
| | | | PUBLICATION | | A1 |

C1   C2   Environmental Factors

C3   Guidance and Direction

Aircraft Operational State

FMS Lateral Navigation and Speed Control
I1
I2
I3
Airborne and Ground-Based Navigation Data

Aircraft Mission Configuration

**CONDUCT FMC ACTIVITIES**   1

Position and Wind Data

Flight Profiles

EIS Map Data

EIS Situation Data

Navigation Display Data   Aircraft Systems Data

Flight Instruments Data

Aircraft Event Times

**CONDUCT DEU ACTIVITIES**   2

**CONDUCT CFDS ACTIVITIES**   3

CFDS Data

Aircraft Flight Fault Lists

**CONDUCT ACARS ACTIVITIES**   4

FMS Climb / Steer Commands   O3

Flight Management Computer Functions   O1

Engine Alert Data   O2   O2   O2   O2

Sensor Data Readouts   O4

ACARS Data   O5

Cockpit Communications
I5
I4
ACARS Uplinked Data

Flight Crew   M1

Controls and Indicators   M2

| NODE:  F/SD   A12 | TITLE:  MANAGE FLIGHT MANAGEMENT SYSTEM | NUMBER:  DG-10 |

| AUTHOR: R. T. Goins | DATE: 7/8/91 | | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | WORKING | | | |
| | | X DRAFT | | | |
| NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | | |
| | | PUBLICATION | | | |

GLOSSARY - F/SD A12:

AIRCRAFT EVENT TIMES - Times extracted from the aircraft chronometer such as the time systems are activated, message receipt/transmission, etc.

AIRCRAFT SYSTEMS DATA - Data that is displayed on each display electronics unit that relates to the status and current operation of the various aircraft sysytems.

ACARS DATA - ARINC Communications and Addressing and Reporting System (ACARS) data that is downlinked via a VHF (aircraft-to-ground transmission) to ground reception stations.

ACARS UPLINKED DATA - ACARS data that is received via a VHF ground-to-aircraft transmission link.

AIRCRAFT FLIGHT FAULT LISTS - These are the listings of recent aircraft systems' faults, malfunctions, and abnormal conditions that are compiled for maintenance purposes.

CFDS DATA - This is the Central Fault Display System data that is used to report aircraft system faults, initiate ground return-to-service testing, and declare components inoperative via the Aircraft Systems Controllers (ASC). CFDS data is also utilized by the ACARS when downlinking to ground stations.

EIS MAP DATA - Data that is provided by the flight management computer (FMC) to the DEUs for navigation map presentation. Map data creates the majority of the information that is available on navigation charts.

EIS SITUATION DATA - dta that is provided by the flight manangement computer to the DEUs for display of the aircraft's situation on the primary flight display (PFD). The PFD will display airspeed, attitude, altitude, vertical velocity, and aircraft heading. Includes engine and alerting data in addition to systems synoptics.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE FLIGHT MANAGEMENT SYSTEM | NUMBER: DG-10A |
|---|---|---|

USED AT: | AUTHOR: R. T. Goins | DATE: 6/18/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING
X DRAFT
RECOMMENDED
PUBLICATION

A12

FMS Lateral Navigation and Speed Control

C1 Aircraft Operational State

C2 Environmental Factors

I1

Airborne and Ground-Based Navigation Data

I2

I3 Aircraft Mission Configuration

COMPUTE PERFORMANCE PARAMETERS 1

Guidance and Control Targets

Trajectory Determination

Flight Path Predictions

COMPUTE NAVIGATION PARAMETERS 2

Position and Wind Data

COMPUTE GUIDANCE PARAMETERS 3

Vertical Guidance ( Δ Altitude )

COMPUTE THRUST PARAMETERS 4

Target Thrust

CALCULATE LIMITS 5

Climb Limit Thrust

Lateral Guidance

Climb/Thrust Adjustments

EIS Situation Data

O2
O2

O1

UPDATE FLIGHT PLAN DATA 6

EIS Map Data

O2

Flight Profile

O2

Controls and Indicators

M1 M2

Flight Crew

NODE: F/SD  A121 | TITLE: CONDUCT FMC ACTIVITIES | NUMBER: DG-11

GLOSSARY- F/SD A121:

FLIGHT PATH PREDICTIONS - This is a performance function that produces a destination trajectory based on aircraft gross weight, predicted cruise winds, speed/altitude/time constraints at specific waypoints, and specified modes for climb, cruise, descent, and approach. Cost indices may be used in this prediction also.

CLIMB/THRUST ADJUSTMENTS - These are climb thrust adjustments that are based on the target (computed) thrust and thrust limit (climb limit thrust). Climb thrust adjustments are combined with lateral guidance commmands to produce FMS climb/steer comands for automatic, performance-optomized flight path guidance.

CLIMB LIMIT THRUST - This is computed performance constraint that is determined by speed and altitude constraints at lateral waypoints. Climb limit thrust produces climb thrus adjustments through modification of target thrust values.

GUIDANCE AND CONTROL TARGETS - These are performance functions that reflect the computation of optimal speeds, estimates of fuel consumption/gross weight, and computations of refrence parameters such as optimum/maximum altitude, and approach speed.

FLIGHT PROFILE - This is the computed fligt path of the aircraft from origin to destination. The flight profile is produced to include course, distance, and altitude or the lateral, linear, and vertical flight path dimesions, respectively.

LATERAL GUIDANCE - This is a navigation function that compares the actual aircraft flight path with the desired flight path and generates steering commands to the autopilot and flight director.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT FMC ACTIVITIES | NUMBER: DG-11A |
|---|---|---|

USED AT: | AUTHOR: R. T. Goins | DATE: 6/18/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING | X DRAFT
RECOMMENDED
PUBLICATION

C1

Aircraft Operational State

GENERATE AIRCRAFT STATE DATA 1

Aircraft Systems Data

EIS Situation Data

I4

GENERATE MAP DATA 2

EIS map Data

I3

Position and Wind Data

I1

I2

Flight Profiles

GENERATE NAVIGATION DATA 3

Waypoint and Chart data

MCDU

Flight Crew

M1

Controls and Indicators

M2

GENERATE ADVISORY/ ALERTS 4

O4

Navigation Display Data

O1

Engine Alert Data

O2

Flight Instruments Data

O3

NODE: F/SD A122 | TITLE: CONDUCT DEU ACTIVITIES | NUMBER: DG-12

| AUTHOR: R. T. Goins | DATE: 7/9/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | RECOMMENDED | | | |
| NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A122:

AIRCRAFT SYSTEMS DATA - Information that is associated with the primary and secondary engine displays and synoptics related to other aircraft systems. Information is displayed on the engine and alert display and the system display, respectively.

ENGINE ALERT DATA - This is the data that initiates engine alerting displays on the appropriate display electronic unit.

FLIGHT INSTRUMENTS DATA - This is the primary flight display data that is presented on the primary flight instruments. Flight instrument data includes attitude, airspeed, barometric altitude, radio/radr altitude (absolute), vertical velocity, heading, vertical and lateral deviation, in addition to flight modes.

AIRCRAFT PRESENT POSITION - The current geogpahics positions (latitude and longitude) and altitude of the aircraft.

NAVAIDS AND CHARTED DATA - This is the data generated from the map display function. Data includes relevant waypoints, navigational aids, and other charted data such as airports, alternate landing facilities, restricted areas, etc.

NAVIGATION DISPLAY DATA - This is the combined presentation of both aircraft present position and the navaids and charted data. Data is displayed as information on the navigation display.

MCDU - The Multifunction Control and Display Unit is the interface unit between the crew and the flight management system. The MCDU provides themeans to manually insert system control parameters and selectt various modes of operation.

WAYPOINT AND CHART DATA - This is the manually-inserted waypoint and chart data that is accomplished through the MCDU.

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT DEU ACTIVITIES | NUMBER: DG-12A |
|---|---|---|

USED AT:

AUTHOR: R. T. Goins  DATE: 6/18/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION  REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING
X DRAFT
RECOMMENDED
PUBLICATION

READER  DATE  CONTEXT:

A12

**Aircraft Systems Data**

I2

**Aircraft Operational State**

C1

GENERATE
LRU
FAULT
SUMMARY  1

Fault Summaries

CONDUCT
LRU
FAULT
REPORTING  2

Fault Reports

CONDUCT
RTS
TESTING  3

Test Results

REVIEW
SENSOR
DATA
READ-OUTS  4

Sensor Data Readouts

PROVIDE
ASC/ACARS
INTERFACE  5

O1

O1

Aircraft Flight Fault Lists

ACARS Printer

Controls and Indicators

M1  M2

Flight Crew

Engine Alert Data

I1

NODE: F/SD  A123  TITLE: CONDUCT CFDS ACTIVITIES  NUMBER: DG-13

GLOSSARY - F/SD A123:

FAULT REPORTS - This is the transmission of fault data as it has been detected through the built-in-test (BIT) monitor. BIT has the capcity to identify failed LRUs, store faults and perform system tests.

ACARS PRINTER - this is an optional item that provides the flightcrew with a permanenet record of past messages.

FAULT SUMMARIES - These are the consolidated fault reports that are summarized into complete listings of all reported faults. fault summaries are used to generate fault lists for air-to-ground transmissions via ACARS and ground return-to-service (RTS) testing.

TEST RESULTS - The results of completing the return-to-service test activity. test results are reviewed as sensor data and routed as applicable to generate revised fault summaries.

USED AT:

AUTHOR: R. T. Goins          DATE: 6/18/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|
| X DRAFT | | | |
| RECOMMENDED | | | |
| PUBLICATION | | | A12 |

NODE: F/SD    A124

TITLE: CONDUCT ACARS ACTIVITIES

NUMBER: DG-14

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| AUTHOR: R. T. Goins | DATE: 7/12/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | RECOMMENDED | | | |
| NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSRAY F/SD A124:

ACARS DOWNLINKED DATA - This is the data that is downlinked to the selected ground stations.

ACARS CONTROLS AND DISPLAYS - The ACARS controls and displays include a control unit and a management unit. in addition, a clock is available for chronology recording.

CODED CFDS PAGES - These are pages of fault listings that have been generated as result of a prior activity. During the downloading activity, the pages are coded and formatted in order to produce the fault lists that are provide to ACARS.

CFDS - The Centralized Fault Display System (CFDS) that normally operates in an automatic fault reporting mode. The CFDS monitors all systems that are designed to continuously transmit fault data.

FAULT LISTS - The aircraft fault lists that are formatted for ACARS use.

HARDCOPY PRINTOUT -Hardcopy print of either the transmitted or received ACARS messages. Hardcopy provides the flight crew with a permanent record of past messages.

OPERATIVE CFDS - CFDS must be in operation to be able to accomplish the associated functions.

| NODE: F/SD    Text | TITLE: GLOSSARY: CONDUCT ACARS ACTIVITIES | NUMBER: DG-14A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/19/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | X DRAFT |
| RECOMMENDED |
| PUBLICATION |

A0

**Inputs / Controls:**

C2 C4 — Routing and Clearances
C1 C3 — Guidance and Direction
C5 — Environmental Factors
NAS Operational Environment
Aircraft Operational State

I2 — Aircraft Mission Configuration
I1 — Initial Position and Flight Plan Data
I3 — 
I4 — Navaid Signal Transmissions
Processed ATC Communications

**Boxes:**

MANAGE GROUND-BASE NAVIGATION SYSTEMS 1

MANAGE AIRBORNE NAVIGATION SYSTEMS 2

**Outputs:**

O1 — Ground-Base Navigation Data

O1 — Airborne Navigation Data

**Mechanisms:**

M1 M2 — Flight Crew
Systems, Controls, and Indicators

| NODE: F/SD A2 | TITLE: MANAGE NAVIGATION SYSTEMS | NUMBER: DG-15 |

AUTHOR: R. T. Goins    DATE: 7/12/91

PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|
| X DRAFT | | | |
| RECOMMENDED | | | |
| PUBLICATION | | | |

GLOSSARY - F/SD A2:

See GLOSSARY A-0 and A0.

NODE: F/SD   Text    TITLE: GLOSSARY: MANAGE NAVIGATION SYSTEMS    NUMBER: DG-15A

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/19/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |

| | WORKING | |
| X | DRAFT | |
| | RECOMMENDED | |
| | PUBLICATION | A0 |

NOTES: 1 2 3 4 5 6 7 8 9 10

**Boxes / Activities:**

- CONDUCT VHF OMNI-RANGE ACTIVITIES  1
- CONDUCT DME ACTIVITIES  2
- CONDUCT ILS/MLS ACTIVITIES  3
- CONDUCT MARKER BEACON ACTIVITIES  4
- CONDUCT ADF ACTIVITIES  5
- CONDUCT LORAN-C ACTIVITIES  6

**Inputs / Controls / Labels:**

Init Pos & Guid &
Flt Pln Direct
Data Routing &
Actt Miss Clear
Config
I1
I2
I3
I4
Navaid Signal Trans
Proc ATC Comm
Preset Channel Freq
RF Modulated Signals
Directional Signal
Omni-Directional Signal
Audio Signal
Time Interval Pulses
Flight Crew

C1 C2 C3 C4 C5
NAS Oper Environ
Oper State
Environ Factors
Slant Range to Station
Paired Spaced Pulses
Approach Clearance
Middle Marker Indication
Sytems, Controls, and Indicators
M1 M2

**Outputs:**

Relative Bearing to Station  O1
Course Deviation Indication  O1
Approach Path Guidance  O1
Outer Marker Indication  O1  O1  O1
Inner Marker Indication  O1
Relative Bearing to Station
LOP Fixes

| NODE: F/SD A21 | TITLE: MANAGE GROUND-BASE NAVIGATION SYSTEMS | NUMBER: DG-16 |

GLOSSARY - F/SD A21:

APPROACH CLEARANCE - This is a communication received from ATC. The approach clearance may either be a voice transmission or data link to the aircraft.

APPROACH PATH GUIDANCE - Guidance provided by either the aircraft's Instrument Landing System (ILS) or Microwave Landing System (MLS) that provides precise alignment and descent to final approach.

AUDIO SIGNAL - The audio signal that originates in the radio that is used in the automatic direction finding (ADF) mode.

DIRECTIONAL SIGNAL - The transmitted signal from a fixed beacon that serves to identify a specific location in space that is received by the aircraft's marker beacon (MB).

LOP FIXES - These are the lines of position (LOP) fixes that are computed from the point of intersection of two different hyperbolic curves formed by constant time interval pulses from master and slave LORAN stations.

OUTER MARKER INDICATION - A sequence of dashes and flashing blue lights that identify the farthest extension of the runway centerline at the time the aircraft overflies the Outer Marker beacon.

MIDDLE MARKER INDICATION - A sequence of dashes and flashing blue lights that identify the midway extension of the runway centerline at the time the aircraft overflies the Middle Marker beacon.

INNER MARKER INDICATION - A sequence of dashes and flashing blue lights that identify the close-in extension of the runway centerline at the time the aircraft overflies the Inner Marker beacon.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE GROUND-BASE NAVIGATION SYSTEMS | NUMBER: DG-16A |

AUTHOR: R. T. Goins     DATE: 7/12/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|
| X | DRAFT | | | |
| | RECOMMENDED | | | |
| | PUBLICATION | | | |

GLOSSARY - F/SD A21 (CONT'D):

COURSE DEVIATION - The difference between the actual course of the aircraft and the desired course.

OMNI-DIRECTIONAL SIGNAL - A multi-directional radio signal (190-1750 Khz) that is used to rpovide relative bearing information for conducting automatic direction finding (ADF).

PAIRED SPACED PULSES - A transmission configuration that is used to measure distance from the aircraft to aground transmitting station by time-delayed pulses.

PRESET CHANNEL/FREQUENCY - The preset (or designated) radio frequency or channel determined during pre-mission activities.

RF MODULATED SIGNALS - The amplitude modulated radio frequency signals that produce both localizer and glideslope position to the aircraft's Instrument Landing System.

RELATIVE BEARING TO STATION - Angular measurement from aircraft to ground transmission station.

SLAT RANGE DISTANCE (TO GROUND STATION) - The distance measured line-of-sight from aircraft to ground transmitting station.

TIME INTERVAL PULSE GROUPS - The methodology used to transmitt low-frequency, constant time interval radio signals.

NODE: F/SD   Text     TITLE: GLOSSARY: MANAGE GROUND-BASE NAVIGATION SYSTEMS     NUMBER: DG-16B

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/12/91 | | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | X DRAFT | | | |
| | | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | | PUBLICATION | | | |

GLOSSARY - F/SD A211:

See GLOSSARY A2

| NODE: F/SD Text | TITLE: GLOSSARY: CONDUCT VHF OMNI-RANGE ACTIVITIES | NUMBER: DG-17A |
|---|---|---|

C-2

USED AT:

AUTHOR: R. T. Goins
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION

DATE: 7/13/91
REV:

| WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|
| X DRAFT | | | |
| RECOMMENDED | | | |
| PUBLICATION | | | |

NOTES: 1 2 3 4 5 6 7 8 9 10

GLOSSARY - F/SD A123:

AVAILABLE AIRCRAFT EQUIPMENT - The on-board aircraft equipment that is required to accomplish the function. Includes ILS/MLS receiver/processor, controls and display units, etc.

OPERATING MLS LOCALIZER - The MLS localizer that is in operation. The localizer generates the MLS curved path.

CURVED APPROACH GUIDANCE - Guidance indications or steering commands that direct the path of the aircraft on the MLS approach.

GLIDESLOPE DEVIATION INDICATIONS - These are the deviations from the computed or generated glideslope. Glideslope deviation may be displayed to the crew or coupled to the auromated landing system for vertical steering and throttle control.

OPERATING GLIDESLOPE - The glideslope that is available for use from the operating navigational aid — ILS transmitter.

GLIDESLOPE POSITIONING DATA - Data that is used by the MLS to generate the glideslope that follows the curved approach path.

LATERAL DEVIATION INDICATIONS - Indications that represent deviations from the computed approach course. Lateral or course deviations may be displayed to the crew or coupled to the automated landing system for lateral steering control.

OPERATIONAL GROUND NAVAIDS - These are part of the NAS operating environment and they are the ILS/MLS navigational aids that transmit the localizer and glideslope data.

NODE: F/SD Text

TITLE: GLOSSARY: CONDUCT ILS/MLS ACTIVITIES

NUMBER: DG-18A

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | **X** DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A123 (CONT'D):

OPERATING LOCALIZER - The localizer that is in use from the operating navigational aid—ILS transmitter.

VISIBILITY AND ALTITUDE RESTRICTIONS - These are the weather and terrain restrictions that apply to the ILS/MLS approaches. Visibility and altitude restrictions may be included as preset data and applied to approach clearance data provided by ATC.

| NODE: F/SD    Text | TITLE: GLOSSARY: CONDUCT ILS/MLS ACTIVITIES | NUMBER: DG-18B |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 6/20/91 | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |

| WORKING | X DRAFT |
|---|---|
| | RECOMMENDED |
| | PUBLICATION |

□

A2

NOTES: 1 2 3 4 5 6 7 8 9 10

Guidance and Direction

Initial Position and Flight Plan Data

I1

Processed ATC Communications

I2

C1 C2 Aircraft Operational State

C4 NAS Operational Environment

C3 Environmental Factors

UTILIZE INERTIAL REFERENCE SYSTEM 1

Aircraft Altitude

UTILIZE GLOBAL POSITIONING SYSTEM 2

Aircraft Altitude

Position, Altitude, and Velocity

UTILIZE RADIO ALTIMETER 3

Vertical Axis Trim

UTILIZE WEATHER RADAR 4

Aircraft Ground Track

Aircraft Present Position O1

Ground Velocity

Aircraft Altitude/ Aircraft Heading

Aircraft Altitude/ Vertical Velocity O1

Position, Altitude, Velocity, and Time O1

Absolute Altitude O1

Weather Bearing and Distance O1

Flight Crew M1 M2 Systems, Controls, and Indicators

NODE: F/SD A22 | TITLE: MANAGE AIRBORNE NAVIGATION SYSTEMS | NUMBER: DG-19

GLOSSARY - F/SD A22:

AIRCRAFT ATTITUDE - The pitch and roll angles of the aircraft as determined by the Inertial Reference Unit (IRU).

AIRCRAFT ALTITUDE/VERTICAL VELOCITY - The altitude of the aircraft as it is computed by the inertial rference unit or the rate of change in the altitude —vertical velocity. Vertical velocity is computed in feet per minute (FPM).

ABSOLUTE ALTITUDE - Aircraft altitude above the terrain or above ground level (AGL).

AIRCRAFT GROUND TRACK ANGLE - The true course of the aircraft or the actual track of the aircraft over the ground. Measured in degrees relative to True North.

AIRCRAFT HEADING - The measurement of the longitudinal axis of the aircraft relative to True North.

GROUND VELOCITY - The speed of the aircraft relative to the ground—groundspeed. Measured in nautical miles per hour (knots).

POSITION, ALTITUDE, AND VELOCITY - The present position, altitude, and velocity of the aircraft as determined by data received from the Global Positioning System (GPS).

VERTICAL AXIS TRIM - This is the refinement vertical axis (z-axis) altitude reference in the Inertial Reference Unit. This is accomplished using the altitude from the radar altimeter.

WEATHER: BEARING AND DISTANCE - The relative bearing and nautical mile distance of weather phenomena that is "seen" by the weather radar.

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| USED AT: | AUTHOR: R. T. Goins | DATE: 6/20/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: 7/18/91 | | | |

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING — X DRAFT — RECOMMENDED — PUBLICATION

A22

C2

Aircraft Operational State

Initial Position and Flight Plan Data

I1

C1 · Guidance and Direction

Vertical Axis Trim

I2

I3

Position, Altitude, and, Velocity

**DETERMINE AIRCRAFT ATTITUDE** 1

**COMPUTE AIRCRAFT HEADING** 2

Aircraft Heading

**DETERMINE VERTICAL VELOCITY ALTITUDE** 3

**COMPUTE AIRCRAFT GROUND VELOCITY** 4

Ground Velocity

**DETERMINE PRESENT POSITION** 5

Aircraft Present Position

**COMPUTE GROUND TRACK** 6

Aircraft Ground Track

Aircraft Attitude — O6

Aircraft Altitude/ Vertical Velocity — O5

O4

O3

O2

O1

Flight Crew — M1 M2 — Systems, Controls, and Indicators

NODE: F/SD A221

TITLE: UTILIZE INERTIAL REFERENCE SYSTEM

NUMBER: DG-20

| AUTHOR: R. T. Goins | DATE: 7/13/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | RECOMMENDED | | | |
| NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY -F/SD A221:

See GLOSSARY A22

| NODE: F/SD Text | TITLE: GLOSSARY: UTILIZE INERTIAL REFERENCE SYSTEM | NUMBER: DG-20A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins    DATE: 6/21/91 | READER | DATE | CONTEXT: |
|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION   REV: | WORKING | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | X DRAFT | | |
| | | RECOMMENDED | | |
| | | PUBLICATION | | |

Aircraft Operational State

C1   C2   NAS Operational Environment

SATCOM/GPS Data

I1

Position Data

Present Position

PROVIDE POSITION   1

Altitude Data

PROVIDE ALTITUDE   2

Aircraft Altitude   O1

PROVIDE VELOCITY   3

Aircraft Velocity   O1

Time Reference Data

PROVIDE TIME REFERENCE   4

Time (GMT)   O1

Systems, Controls, and Indicators

M1

| NODE: F/SD   A222 | TITLE: UTILIZE GLOBAL POSITIONING SYSTEM | NUMBER: DG-21 |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | | | WORKING | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | X DRAFT | | |
| | | | RECOMMENDED | | |
| | | | PUBLICATION | | |

GLOSSARY - F/SD A222:

ALTITUDE DATA - The altitude dimension of the GPS-generated navigational data. Used in the on-board GPS user segment to provide a computed aircraft altitude.

POSITION DATA - The position dimension of the GPS-generated navigational data. Position data is used in the on-board GPS user segment to generate a geographic position of the aircraft.

TIME REFERENCE DATA - The time dimension of the GPS-generated navigation data. Time data is used to synchronize the user segment clock and to establish the basis for time delay measurement in order to calculate range for position and altitude determination.

TIME (GMT) - The 24-hour time measurement that is referenced to the Greenwich meridian (zero degrees longitude).

SATCOM/GPS DATA - Data that is part of the processed ATC communications. The data is carried via the Satellite Communications (SATCOM) data link network. SATCOM is used primarily for communications that do not involve the transmission of navigation data. Aircraft navigation data is transmitted via a specific satellite-based communications network called the Global Positioning System (GPS).

| NODE: F/SD Text | TITLE: GLOSSARY: UTILIZE GLOBAL POSITIONING SYSTEM | NUMBER: DG-21A |

101

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | WORKING | | |
| | | | X DRAFT | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | |
| | | | PUBLICATION | | |

GLOSSARY - F/SD A3:

AURAL ALERT/WARNING DISPLAYS - These are the speech or non-speech auditory displays that are presented aurally.

GATELINK DATA - The data related to Gatelink communications.

MODE S DATA - Data that is part of the VHF data link systems that contain short, time-sensitive mesages used in an encoded data exchnage between the ground and the aircraft.

VISUAL ALERT/WARNING DISPLAYS - These are the alert or warning displays that are presented visually.

VHF DATA - Data that is carried via the VHF data link systems. Includes both ACARS and Aviation VHF Packet Communications (AVPAC), a bit-oriented protocol of the ACARS. AVPAC has provisions to pass data without concern for sub-networks to connect ACARS applications.

VOICE COMMUNICATIONS - Communications through the use of the human voice.

| NODE: F/SD Text | TITLE: GLOSSARY: MANAGE COMMUNICATIONS SYSTEMS | NUMBER: DG-22A |

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| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | WORKING | | | |
| | | | X DRAFT | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | | |
| | | | PUBLICATION | | | |

GLOSSARY - F/SD A31:

See GLOSSARY A3

| NODE: F/SD Text | TITLE: GLOSSARY: COMMUNICATE VIA VOICE SYSTEMS | NUMBER: DG-23A |
|---|---|---|

USED AT: | AUTHOR: R. T. Goins | DATE: 6/24/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV:

WORKING | X DRAFT
RECOMMENDED
PUBLICATION

NOTES: 1 2 3 4 5 6 7 8 9 10

A3

C1 C2 C3 Environmental Factors

Guidance and Direction

Routing and Clearances

Voice Communications

I1

I2

I4

Navaid Signal

Received ATC Communications

Aircarft Mission Configuration

I3

UTILIZE VHF DATA LINK SYSTEMS 1

UTILIZE MODE S DATA LINK SYSTEMS 2

UTILIZE GATELINK SYSTEMS 3

UTILIZE SATCOM/GPS SYSTEMS 4

C4 NAS Operational Environment

VHF Data O1

Mode S Data O2

Gatelink Data O4

SATCOM/GPS Data O3

Flight Crew

ATC Controller M1 M2 M3

Systems, Controls, and Indicators

NODE: F/SD  A32 | TITLE: COMMUNICATE VIA DATALINK SYSTEMS | NUMBER: DG-24

| AUTHOR: R. T. Goins | DATE: 7/13/91 | | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| NOTES: 1 2 3 4 5 6 7 8 9 10 | | | PUBLICATION | | | |

GLOSSARY F/SD A32:

GATELINK DATA - The data (or information) that is passed through the Gatelink communications activity. Gatelink provides the means to bring a terrestrial communications link directly to the aircraft by connecting the aircraft to the ground communications network.

MODE S DATA - The data (or information) that is passed via the Mode S digital data link system. Mode S is a beacon system that incorporates a discrete addressing and lookout feature capable of providing two-way digitally encoded data exchange.

SATCOM/GPS DATA - The data that is passed via the satellite-based communications system. SATCOM provides voice and similar data transmissions, where GPS provides only navigational data.

VHF DATA - The data that is passed via the VHF data link. The VHF data link includes ACARS that is currently used to transact airline company business, and AVPAC, which is an upgraded version of ACARS.

| NODE: F/SD Text | TITLE: GLOSSARY: COMMUNICATE VIA DATA LINK SYSTEMS | NUMBER: DG-24A |
|---|---|---|

USED AT:

| AUTHOR: R. T. Goins | DATE: 7/1/91 | READER | DATE | CONTEXT: |
|---|---|---|---|---|
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | |
|---|---|
| X DRAFT | |
| RECOMMENDED | |
| PUBLICATION | |

A3

Alert/Warning Displays
I1

Aircraft Operational State
C2

Environmental Factors
C1

NAS Operational Environment
C3

UTILIZE CAWS
1

UTILIZE GPWS
2

UTILIZE TCAS
3

Aural Alert/ Warning Displays
O2

Visual Alert/ Warning Displays
O1

Traffic Advisory

Resolution Advisory

Systems, Controls, and Indicators
M2

Flight Crew
M1

NODE: F/SD  A33

TITLE: COMMUNICATE VIA MISC SYSTEMS

NUMBER: DG-25

GLOSSARY - F/SD A33:

RESOLUTION ADVISORY - An alerting advisory to the flight crew that recommends a corrective action to be taken to avoid a collision with another aircraft in the area of conflict.

TRAFFIC ADVISORY - An advisory to the flight crew of the potential of conflict with another aircraft in the area.

NODE: F/SD    Text | TITLE: GLOSSARY: COMMUNICATE VIA MISCELLANEOUS SYSTEMS | NUMBER: DG-25A

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USED AT: | AUTHOR: R. T. Goins | DATE: 7/2/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: 7/8/91

NOTES: 1 2 3 4 5 6 7 8 9 10

WORKING | X DRAFT
RECOMMENDED
PUBLICATION

A0

Guidance and Direction
Aircraft Operational State

C1 C2 C3 C4

Environmental Factors
Aircraft Operational State

Aircraft Mission Configuration

I1

I2

Aircraft Control Signals

ACCOMPLISH ASC FUNCTIONS
1

Fuel System Sensor Data

ACCOMPLISH ENGINE/ THRUST CONTROL
2

FADEC Sensor Data

Thrust Control Sensor Data

Ignition/ Starting Sensor Data

Fuel/Oil Sensor Data

Thrust Reverse Sensor Data

Engine Failure Sensor Data

Air System Sensor Data

Miscellaneous Systems Sensor Data

Electrical System Sensor Data

Hydraulic System Sensor Data

O1

O1

CONTROL AIR DATA SYSTEM
3

Central Air Data

O1

Flight Crew

M1 M2 M3

Ground Crew

Systems, Controls, and Indicators

NODE: F/SD   A4 | TITLE: MANAGE AIRCRAFT SYSTEMS | NUMBER: DG-26

USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | |

| WORKING | |
| RECOMMENDED | |
| PUBLICATION | |

NOTES: 1 2 3 4 5 6 7 8 9 10

X DRAFT

GLOSSARY - F/SD A4:

AIR SYSTEM SENSOR DATA - The electrical/electronic representation of cabin air conditioning and/or cabin pressurization, to include avionics cooling and anti-ice control.

ELECTRICAL SYSTEM SENSOR DATA - The sensor data that is related to the AC/DC power distribution, and the auxiliary, battery, and emergency power status and configuration.

FADEC SENSOR DATA - The sensor data that is related to the Full Authority Digital Electronic Control (FADEC) unit that provides engine control functions and engine limit protection.

FUEL SYSTEM SENSOR DATA - The sensor data that is related to the aircraft fuel system. Sensors include data related to fuel transfer, fuel delivery, refueling, and fuel dumping.

HYDRAULIC SYSTEM SENSOR DATA - The sensor data that is related to the aircraft hydraulic system. Hydraulic system sensor data includes that related to flight control operation, nose wheel steering, wheel braking, and landing gear operation.

MISCELLANEOUS SYSTEMS SENSOR DATA - The sensor data that relates to the auxiliary power unit, engine ignition and starting, and the cargo facilities.

THRUST CONTROL SENSOR DATA - This is the sensor data from the thrust control module (TCM) that automatically controls the engine throttle position. Sensor data includes both forward and retard throttle movement and position, and the ignition/start signal from the thrust control module.

NODE: F/SD    Text | TITLE: GLOSSARY: MANAGE AIRCRAFT SYSTEMS | NUMBER: DG-26A

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GLOSSARY - F/SD A4 (CONTD):

CENTRAL AIR DATA - The output from the air data computer. Includes airspeed, Mach number, altitude, maximum airspeed, vertical velocity, true air temperature (TAT), static air temperature, angle of attack (AOA), true airspeed (TAS), and pitot, impact, and static pressures. Central air data is used in the engine control unit (ECU) for thrust control.

ENGINE FAILURE SENSOR DATA - The sensor data that provides the alert to the flight crew of the loss of N1. Sensor data summarizes the engine failure detection logic.

FUEL/OIL SENSOR DATA - The sensor data related to the position of the fuel flow control switch (es) and the oil level/filtering systems for each engine.

IGNITION/STARTING SENSOR DATA - The sensor data that is related to the position of the engine ignition select switches and engine starting switches. Sensor data includes signals that permit the use of the thrust reversing system. Sensor data provides control over the throttle interlock until the thrust reversers achieve a preset deployment configuration.

THRUST CONTROL SENSOR DATA - The sensor data that transmits the throttle position to the engine control unit.

NODE: F/SD    Text | TITLE: GLOSSARY: MANAGE AIRCRAFT SYSTEMS | NUMBER: DG-26B

Environmental
Factors

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/3/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | A4 |

NODE: F/SD    A41    TITLE: ACCOMPLISH ASC FUNCTIONS    NUMBER: DG-27

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| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | | WORKING | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | X DRAFT | | | |
| | | RECOMMENDED | | | |
| | | PUBLICATION | | | |

GLOSSARY - F/SD A41:

AC/DC POWER - The 3-phase, 115/200 volt, 400 Hz alternating current, and the 28 volt direct current that is provided to the aircraft buses.

AUXILIARY POWER SENSOR DATA - Sensor data that provides the configuration and status of the auxiliary electrical power system.

BATTERY POWER SENSOR DATA - Sensor data that provides the configuration and status of the aircraft battery power system.

AUXILIARY POWER CONTROL - The control signal to the auxiliary power unit.

CABIN PRESUURIZATION SENSOR DATA - Sensor data from the cabin pressurization system. Sensor data includes cabin altitude, differential pressure and rate, and landing field elevation.

CARGO FACILITIES CONTROL - Sensor data that provides the configuration and status of the cargo door and cargo area fire detection.

COOLING AIR SENSOR DATA - Sensor data that provides the status of the cooling air moving through the line replaceable units (LRUs), and/or cockpit and cabin compartments.

WHEEL BRAKE SENSOR DATA - Sensor data that provides the configuration and status of the wheel braking system to include hydraulic pressure, brake temperature, tire pressure, and parking brake position.

| NODE: F/SD Text | TITLE: GLOSSARY: ACCOMPLISH ASC ACTIVITIES | NUMBER: DG-27A |

GLOSSARY - F/SD A41 (CONTD):

AIRCONDITIONING SENSOR DATA - Sensor data that provides the configuration and status of the cockpit and cabin conditioned air distribution system. Sensor data includes temperature and airflow status.

AC POWER SENSOR DATA - Sensor data that provides the configuration and status of the AC power systems. Sensor data includes AC electrical power availability and distribution status.

DC POWER SENSOR DATA - Sensor data that provides the configuration and status of the DC power systems. Sensor data includes DC electrical power availability and distribution status.

FLIGHT CONTROLS SENSOR DATA - Sensor data that provides the configuration and status of the primary and secondary flight controls. Sensor data includes control surface position signals for the lateral, longitudinal, and directional control devices.

EMERGENCY POWER SENSOR DATA - Sensor data that provides the configuration and status of the emergency electrical power system. Includes data related to the main battery, battery charging unit, emergency generator, and the power inverter system.
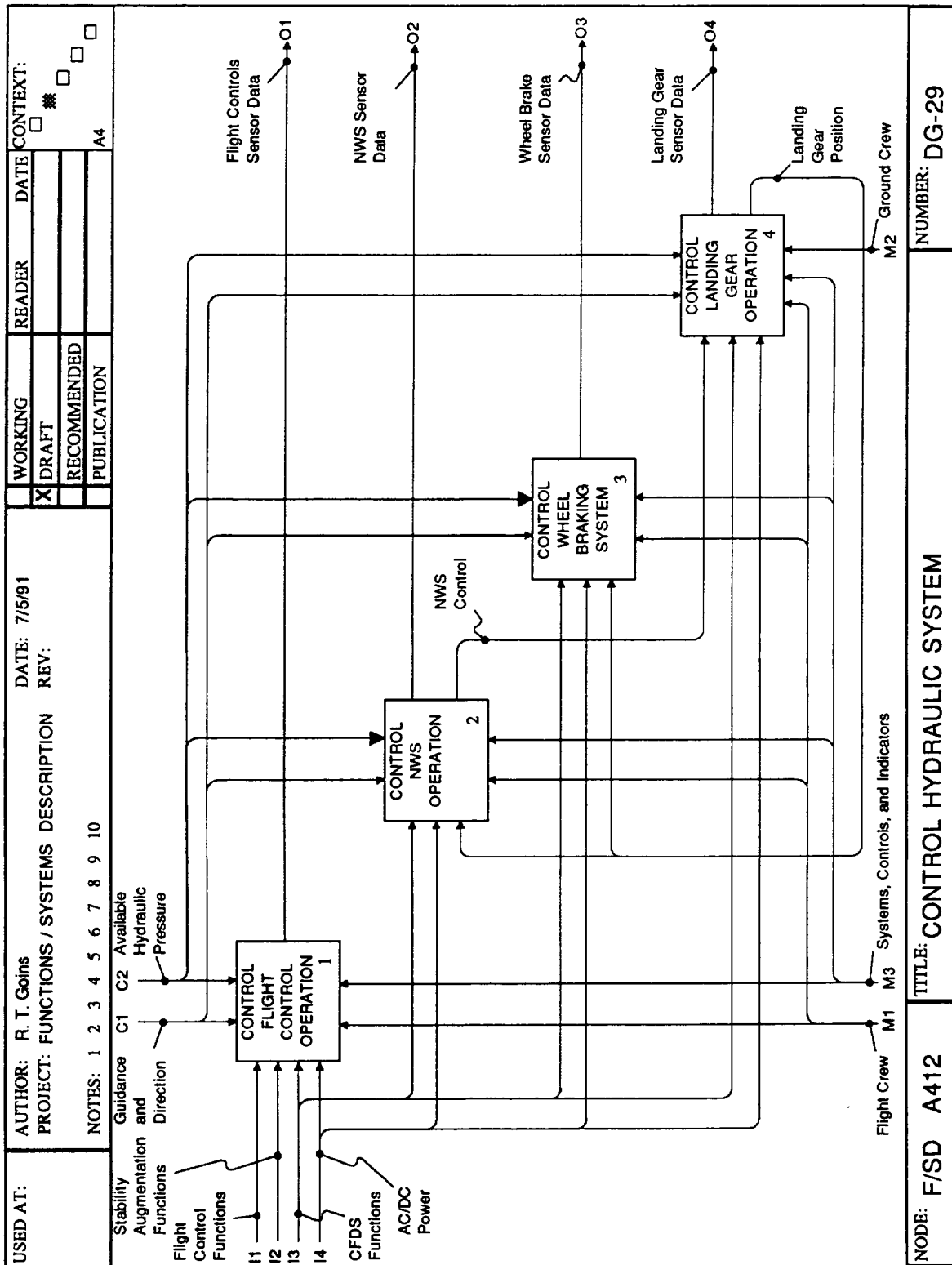
FUEL DELIVERY SENSOR DATA - Sensor data that provides the configuration and status of the fuel boost pumping system. Data includes boost pump pressure and operating condition.

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USED AT:

AUTHOR: R. T. Goins  DATE: 7/13/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION  REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|
| X DRAFT | | | |
| RECOMMENDED | | | |
| PUBLICATION | | | |

GLOSSARY - F/SD A41 (CONTD):

FUEL DUMP SENSOR DATA - Sensor data that provides the configuration and status of the fuel dumping system. Sensor data includes that related to the fuel dump activation alerting signal, dump valve position, and dumping operation.

IGNITION STARTING CONTROL - Sensor data that provides the configuration and status of the engine ignition system. Includes data related to any ignition systems indicating systems, igniter status, starting mechanisms (turbine starter and air control valves), and fuel feed control during engine start.

LANDING GEAR SENSOR DATA - Sensor data that provides the configuration and status of the main and nose landing gear to include retracted, extension, ground contact sensing of the gear position.

NOSE WHEEL STEERING (NWS) SENSOR DATA - Sensor data that provides the configuration and status of the nose wheel steering system. Data includes steering engagement status, and wheel position.

FUEL TRANSFER SENSOR DATA - Sensor data that provides the configuration and status of the fuel transfer pumping system. Includes data related to fuel transfer scheduling and balance requirements.

REFUELING SENSOR DATA - Sensor data that provides the configuration and status of the refueling (and defueling) system. Includes data on the fuel crossfeed valves, the fuel float switches and fill valves, and any appropriate refueling alerts that may be essential to the refueling operator during the refueling operation.

NODE: F/SD  Text    TITLE: GLOSSARY: ACCOMPLISH ASC ACTIVITIES    NUMBER: DG-27C

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/3/91 | | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | WORKING | | | |
| | | | X DRAFT | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | RECOMMENDED | | | A41 |
| | | | PUBLICATION | | | |

Planned Fuel Load

AC/DC Power

I1

I2

I3

CFDS Functions

C3 Aircraft Operational State

**CONTROL REFUELING** 1

**CONTROL FUEL DELIVERY** 2

Boost Pump Status

**CONTROL FUEL TRANSFER** 3

Transfer Pump Status

Guidance and Direction

C1 C2 Routing and Clearances

**CONTROL FUEL DUMPING** 4

Refueling Sensor Data — O3

Fuel Delivery Sensor Data — O1

Fuel Transfer Sensor Data — O2

Fuel Dump Sensor Data — O4

Boost/Transfer Pumps "ON" Command

Systems, Controls and Indicators

Ground Crew

M2

M3

Flight Crew

M1

| NODE: F/SD A411 | TITLE: CONTROL FUEL SYSTEM | NUMBER: DG-28 |

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| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A411:

BOOST PUMP STATUS - Status (either operative or inoperative) of the fuel boost pumps. Boost pump status determines the use of the transfer pumps for fuel boost in case of boost pump failure.

BOOST/TRANSFER PUMPS "ON" COMMAND - This is the command that activates the fuel boost and transfer pumps during the fuel dumping operation.

TRANSFER PUMP STATUS - Status (either operative or inoperative) of the fuel transfer pumps. Transfer pump status determines the use of the boost pumps for fuel transfer in case of transfer pump failure.

| NODE: F/SD Text | TITLE: GLOSSARY: CONTROL FUEL SYSTEM | NUMBER: DG-28A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/13/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | X DRAFT | | | |
| | | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | PUBLICATION | | | |

GLOSSARY - F/SD A412:

LANDING GEAR POSITION - The landing gear position signal is used to either permit or prohibit the use of nose wheel steering and/or wheel braking.

NOSE WHEEL STEERING (NWS) CONTROL - Steering control to the nose landing gear.

| NODE: F/SD Text | TITLE: GLOSSARY: CONTROL HYDRAULIC SYSTEM | NUMBER: DG-29A |
|---|---|---|

| USED AT: | AUTHOR: R. T. Goins | DATE: 7/5/91 | READER | DATE | CONTEXT: |
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | | WORKING | | A41 |
| | | | X DRAFT | | |
| | | | RECOMMENDED | | |
| | | | PUBLICATION | | |

Aircraft Operational State — C2

Guidance and Direction — C1

CFDS Functions

I1

Auxiliary Power Control — I2

IDG Power

**CONTROL AC POWER DISTRIBUTION** 1

**CONTROL DC POWER DISTRIBUTION** 2

APU Power

**CONTROL AUXILIARY POWER** 3

Battery Power

**CONTROL BATTERY POWER** 4

**CONTROL EMERGENCY POWER** 5

AC Power Sensor Data — O1

DC Power Sensor Data — O2

Aux Power Sensor Data — O3

Battery Power Sensor Data — O4

Emergency Power Sensor Data — O5

AC/DC Power — O6

ADG Power

Flight Crew — M1

Systems, Controls, and Indicators — M3

Ground Crew — M2

| NODE: F/SD A413 | TITLE: CONTROL ELECTRICAL SYSTEM | NUMBER: DG-30 |

GLOSSARY - F/SD A413:

AUXILIARY POWER UNIT (APU) POWER - This is the electrical power output from the auxiliary power unit (APU). The APU provides power for ground operations. It also serves as a supplemental power source when required during specific flight phases. The APU generator should provide 120/208 volt, 3-phase, 400 Hz electrical power

AIR DRIVEN GENERATOR (ADG) POWER - This is the electrical power output from the emergency power source, the air driven generator (ADG). The ADG provides 115/200 volt, 400 Hz single phase emergency power to a single AC bus.

INTEGRATED DRIVE GENERATOR (IDG) POWER - The IDG is an engine driven generator power source that provides 3-phase, 115/200 volt AC, 400 Hz electrical power. Each IDG should be capable of supplying sufficient power to operate all essential electrical systems.

BATTERY POWER - This is the electrical power from the aircraft's main battery. The main battery provides 50 AMP, 28 volt DC power.

NODE: F/SD   Text     TITLE: GLOSSARY: CONTROL ELECTRICAL SYSTEM     NUMBER: DG-30A

USED AT:

AUTHOR: R. T. Goins    DATE: 7/5/91

PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV:

| WORKING | DATE | READER | DATE | CONTEXT: |
|---|---|---|---|---|
| X DRAFT | | | | |
| RECOMMENDED | | | | |
| PUBLICATION | | | | A41 |

NOTES: 1 2 3 4 5 6 7 8 9 10

AC/DC Power

Guidance and Direction

I1

I2

I3

CFDS Functions

Aircraft Mission Configuration

C1  C3  Aircraft Operational State

Cooling Air

CONTROL AIR CONDITIONING — 1

CONTROL COCKPIT/ CABIN PRESSURE — 2

CONTROL AVIONICS COOLING — 3

CONTROL ANTI-ICING — 4

C2  Routing and Clearances

Air Conditioning Sensor Data  O1

Cabin Pressure Sensor Data  O2

Cooling Air Sensor Data  O3

Anti-Ice Sensor Data  O4

M1  Flight Crew

M2  Systems, Controls, and Indicators

NODE: F/SD  A414    TITLE: CONTROL AIR SYSTEM    NUMBER: DG-31

| USED AT: | AUTHOR: R. T. Goins          DATE: 7/13/91 | WORKING | READER | DATE | CONTEXT: |
|---|---|---|---|---|---|
| | PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION     REV: | X DRAFT | | | |
| | | RECOMMENDED | | | |
| | NOTES: 1 2 3 4 5 6 7 8 9 10 | PUBLICATION | | | |

GLOSSARY: F/SD A414:

COLLING AIR - The cooling air from the air conditioning and ventilation system. Cooling air flows to the avionics equipment racks and the display electronics units (DEUs) in the cockpit compartment. Alerts are displayed to the aircrew when cooling airflow is low and the ventilation fans are not operating.

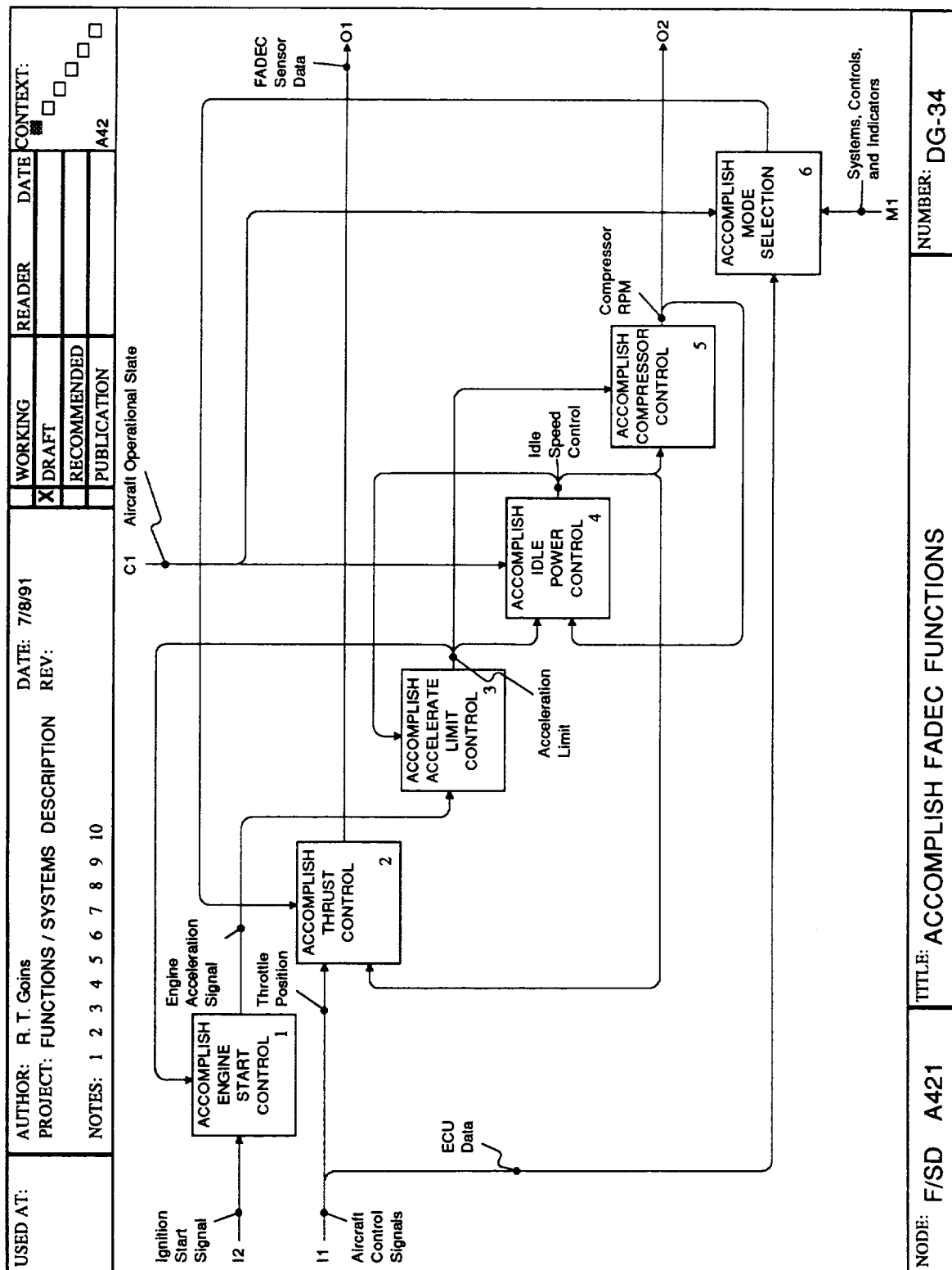| NODE: F/SD     Text | TITLE: GLOSSARY: CONTROL AIR SYSTEM | NUMBER: DG-31A |
|---|---|---|

USED AT:

| AUTHOR: R. T. Goins | DATE: 7/5/91 | READER | DATE | CONTEXT: |
| PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION | REV: | | | |

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | | |
| X DRAFT | | |
| RECOMMENDED | | |
| PUBLICATION | | A41 |

NODE: F/SD A415    TITLE: CONTROL MISC SYSTEMS    NUMBER: DG-32

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USED AT: | AUTHOR: R. T. Goins          DATE: 7/8/91 | READER | DATE | CONTEXT:
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION     REV:

WORKING | □
DRAFT | X
RECOMMENDED | ▨
PUBLICATION | □

NOTES: 1 2 3 4 5 6 7 8 9 10

A4

C1   Aircraft Operational State

ACCOMPLISH FADEC FUNCTIONS    1

Compressor RPM

CONTROL THRUST CONTROL MODULE    2

Engine Ignition Select

CONTROL IGNITION/ STARTING    3

Ignition Start Signal

ACCOMPLISH FUEL/ OIL CONTROL    4

Reverse Idle Prohibit

ACCOMPLISH ENGINE FAILURE DETECTION    5

CONTROL THRUST REVERSING    6

FADEC Sensor Data    O1

Thrust Control Sensor Data    O2

Ignition/ Starting Sensor Data    O3

Fuel/Oil Sensor Data    O4

Engine Failure Sensor Data    O5

Thrust Reverse Sensor Data    O6

Aircraft Control Signals   I2

Fuel System Sensor Data   I1

Systems, Controls, and Indicators

M2          M1   Flight Crew

NODE: F/SD  A42 | TITLE: ACCOMPLISH ENGINE/ THRUST CONTROL | NUMBER: DG-33

GLOSSARY - F/SD A42:

ENGINE IGNITION SELECT - The signal that permits the activation of the ignition exciters and the igniter plugs in each engine.

REVERSE IDEL PROHIBIT - The signal that prohibits the positioning of thrust reversing mechanisms until the thrust reversers are sufficiently deployed.

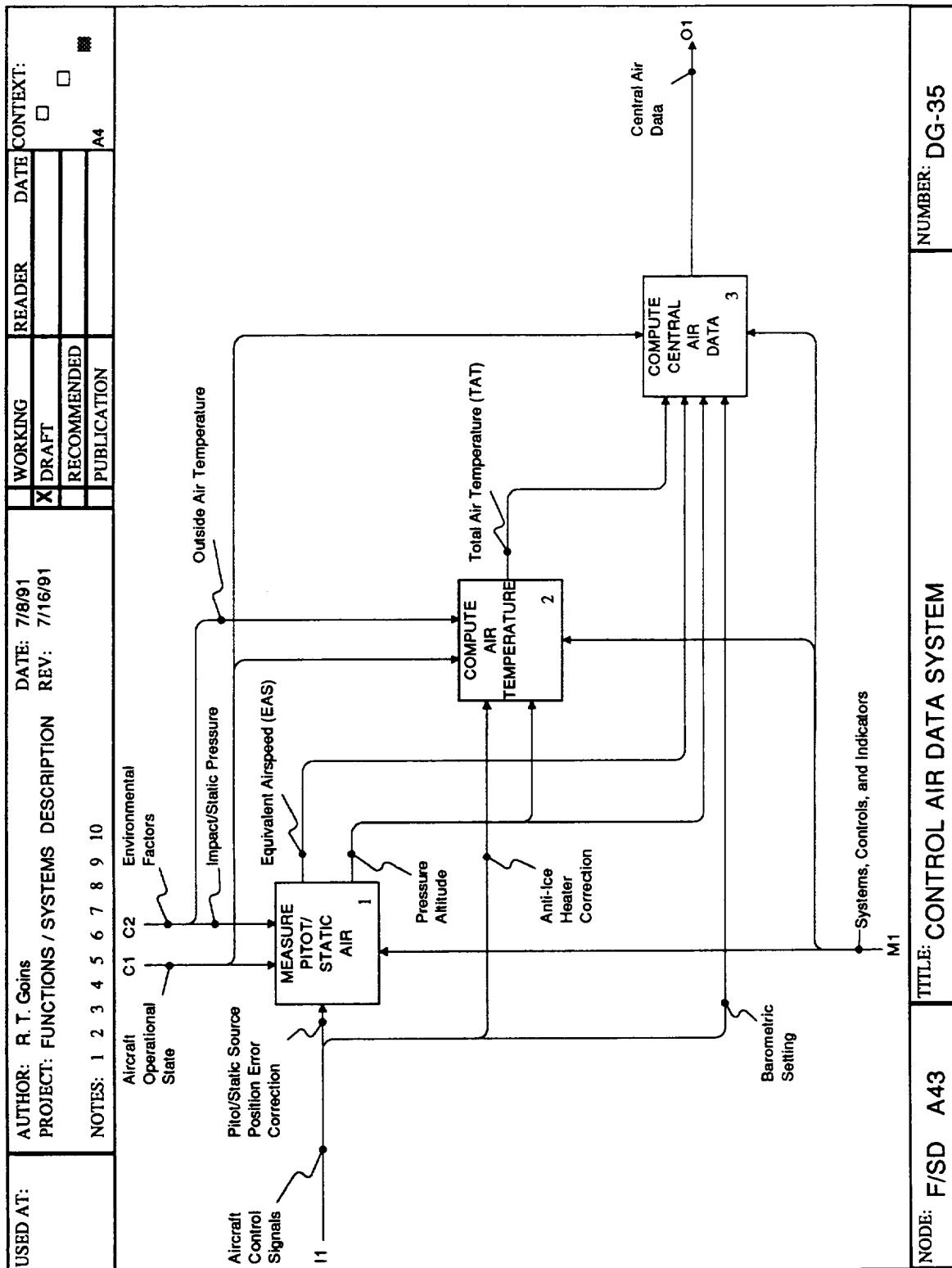| NODE: F/SD Text | TITLE: GLOSSARY: ACCOMPLISH ENGINE/THRUST CONTROL | NUMBER: DG-33A |
|---|---|---|

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GLOSSARY - F/SD A421:

AUTOMATIC CONTROL OF AVAILABLE THRUST - This is the output that, as a result of changes in throttle position, either automatic or manually, ensures that engine EPR is equalized between engines. Full throttle selection limits each engine to maximum rated thrust (MRT), and engine underspeed/overspeed is prevented during ATS operation.

COMPRESSOR RPM - The revolutions per minute (RPM) of the low pressure compressor (N1). Thrust is controlled ultimately by the N1 speed.

ENGINE ACCLERATION SIGNAL - This is the signal that commands the acceleration of each engine to ground idle RPM.

ACCELERATION LIMIT - The limit on engine RPM changes that prevents engine overspeed during throttle advances and/or engine underspeed during throttle retard.

FADEC MODE SELECT - This is the signal that permits operation of the FADEC in an alternate mode whenever the central air data is not available to the FADEC-controlling engine control unit (ECU).

ECU DATA - This is the data sent from each engine control unit (ECU) to the FADEC.

IDLE SPEED CONTROL - The control of the RPM of the low pressure compressor during ground operations and minimum/approach idle speeds during descent.

| NODE: F/SD Text | TITLE: GLOSSARY: ACCOMPLISH FADEC FUNCTIONS | NUMBER: DG-34A |

AUTHOR: R. T. Goins  DATE: 7/13/91  READER  DATE CONTEXT:

PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION  REV:

NOTES: 1 2 3 4 5 6 7 8 9 10

| WORKING | |
|---|---|
| X DRAFT | |
| RECOMMENDED | |
| PUBLICATION | |

GLOSSARY - F/SD A421 (CONTD):

IGNITION/START SIGNAL - This is the signal that initiates the engine start sequence. It is part of the sensor data that comes from the ignition/starting function.

THROTTLE POSITION - The measured angle of each throttle lever. Used to determine desired thrust settings. Controlled manually by the flight crew or automatically by the ATS.

NODE: F/SD  Text  TITLE: GLOSSARY: ACCOMPLISH FADEC FUNCTIONS  NUMBER: DG-34B

USED AT:

AUTHOR: R. T. Goins      DATE: 7/8/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV: 7/16/91

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Aircraft Operational State

Environmental Factors

Impact/Static Pressure

Outside Air Temperature

Pitot/Static Source Position Error Correction

Equivalent Airspeed (EAS)

C1   C2

I1

Aircraft Control Signals

MEASURE PITOT/ STATIC AIR   1

Pressure Altitude

Total Air Temperature (TAT)

COMPUTE AIR TEMPERATURE   2

Anti-Ice Heater Correction

Barometric Setting

Systems, Controls, and Indicators

M1

COMPUTE CENTRAL AIR DATA   3

Central Air Data

O1

131

USED AT:

AUTHOR: R. T. Goins    DATE: 7/13/91
PROJECT: FUNCTIONS / SYSTEMS DESCRIPTION    REV: 7/16/91

NOTES: 1 2 3 4 5 6 7 8 9 10

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GLOSSARY - F/SD A43:

ANTI-ICE HEATER CORRECTION - The correction to the indicated outside air temperature probe output to compensate for static port anti-ice heating.

CENTRAL AIR DATA - The data that is provided by the air data computer. Central air data includes airspeed, Mach number, altitude, maximum airspeed, vertical velocity, total air temperature (TAT), angle of attack )AOA), and true airspeed (TAS).

EQUIVALENT AIRSPEED (EAS) - Indicated airspeed (IAS) corrected for pitot system installation and error.

PRESSURE ALTITUDE - The barometric altitude of the aircraft as determined by the static port sensing devices.

TOTAL AIR TEMPERATURE (TAT) - This is the outside air temperature corrected for compressibility and temperature probe installation error.

BAROMETRIC SETTING - The setting in inches of mercury (Hg) that adjusts the standard datum plane to agree with local atmospheric pressures. Barometric settings, other than 29.92 Hg, provides true altitude (altitude above Mean Sea Level) rather than pressure altitude to systems.

IMPACT/STATIC PRESSURE -Air pressures that are sensed at the pitot and static port locations.

OUTSIDE AIR TEMPERATURE (OAT) - The air temperature as it is sensed at the static air temperature probe.

NODE: F/SD   Text | TITLE: GLOSSARY: CONTROL AIR DATA SYSTEM | NUMBER: DG-35A

# REFERENCES

1. Federal Aviation Administration, *National Airspace System Plan: Facilities, Equipment, Associated Development and Other Capital Needs*, June 1988.

2. Federal Aviation Administration, *The Federal Aviation Administration Plan for Research, Engineering, and Development*, November 1988.

3. Federal Aviation Administration, *Aviation System Capital Investment Plan (CIP)* December 1990

4. Federal Aviation Administration, *The Federal Aviation Administration Plan for Research, Engineering, and Development*, (Second Draft), November 1988.

# EPILOG

In the process of surveying and preparing a summary of the National Airspace system for the next century, it became quite clear that the major impact on future transport aircraft is not in terms of facilities and equipment but rather in operational philosophy and concepts. Nowhere is this more evident than in the area of air traffic control which will rely extensively on automation and digital data link communications for system-wide traffic flow management. The effect of these changes on future transport aircraft will be most apparent in the extensive amount of integration of flightdeck and ATC functions. This integration, and the changing nature of the operational philosophy and concepts, presents a major challenge in terms of reassessing the the function allocations throughout the entire system; reexamining the roles assigned to the human components, both controllers and pilots; and generally ensuring that the ATC automation environment, on the ground and in the air, is "human centered". This indeed may be a greater challenge for the 21st century than adapting to new functions/systems.

# THE NAS OF THE 21ST CENTURY

"Greater use of automation will modernize nearly every component of the National Airspace System (NAS). Advanced computer aiding such as AERA will facilitate controller handling of increased traffic, Mode S, Data Link and satellites will enhance communications capabilities on the ground, in the air, and between the air and ground; and 4D and satellite navigation capabilities will increase the flexibility of aircraft routing. In addition, intelligent automation in the flightdeck such as TCAS, will enhance pilot performance. The success of the future NAS depends upon the careful integration of all of these automated components with the human that will operate them".

> from *The National Plan for Aviation Human Factors* Vol II, Introduction to "Flightdeck/ATC Integration" Nov. 1990, (draft)

## FUTURE NATIONAL AIRSPACE SYSTEM (NAS) PLANS[1]

### NEAR-TERM

Area Control Facilities (ACF) will consolidate Terminal Radar Approach Control (TRACON) by mid-1990s with en route and terminal functions being merged through the Air Traffic Control (ATC) system.

Automated En Route Air Traffic Control (AERA) functions will incorporate Advanced Automation System (AAS) in old Air Route Traffic Control Center facilities with new computers and sector suites. The consolidation of en route and terminal functions in ACF's provides for standardization, flexibility and expandability of systems capacity and enhance flow control. These upgrades will set the stage for operational usage of AERA utilizing Mode S ATC Data Link.

The terminal systems including Terminal Radar Approach Control (TRACON) and Airport Traffic Control Tower (ATCT) will also be upgraded to facilitate the separation and sequencing of aircraft into the traffic pattern; expedite arrivals and departures; and provide clearances and weather information. Automated Radar Terminal System (ARTSII) is a data processing system which can interface with Air Routs Traffic Control Center (ARTCC) computers. ARTSIII is a beacon tracking system which displays aircraft identification, altitude, ground speed and flight plan data.

The radar approach control facilities will be consolidated into area control facilities. Terminal facilities including new tower suites and software enhancements for flight conflict alerting are also being developed.

Ground-to-air systems which provide electronic interfaces to aircraft and support air traffic control surveillance including communication, navigation, approach and landing aids. Communication is presently by voice radio being upgraded to Mode S Data Link. Navigation is primarily VOR, DME and VOR/TACAN upgraded to include satellite GPS. Approach/landing systems are currently ILS being upgraded to MLS. Surveillance is pres-

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1 Proceeding of Aeronautical Telecommunications Symposium on Data Link Integration, Annapolis, Maryland, May 15-17, 1990.

ently being provided by both search and beacon radar, but Mode S will soon augment aircraft positioning information and discrete identification.

Mode S digital data link will have a profound effect on ATC. It provides discrete interrogation and processing aircraft replies. Traffic Alert and Collision Avoidance System (TCAS) will also utilize Mode S formats and frequencies. Terminal and en route surveillance radars will also be collocated with Mode S. Additionally Mode S can be used to transmit weather data to aircraft.

The Microwave Landing System (MLS) will also provide dramatic enhancements in precision guidance during landing including multiple-curved and segmented approaches and selectable glide slope angles as well as precision distance measuring with 100' accuracy. The radiated signals are minimally affected by terrain, structure and/or weather.

The NAS Plan calls for an evolutionary upgrade and expansion of the ATC system and supporting activities for new and improved automation capabilities and facility consolidation. The overriding objective behind the evolution strategy is to preserve the safety and integrity of ATC operations while introducing new functions and higher levels of automation to the operational environment for enhanced system capability and efficiency.

## UPGRADES

The FAA is currently planning major upgrades to the National Airspace System (NAS) which will replace many ATC and associate flight service resulting in the automation of many functions as well as adding new capabilities. One important capability to be added is digital data communication between FAA ground facilities and the aircraft. The new capability, referred to as Data Link (DL), will enable the introduction of a new group of diverse services (air-ground information exchange to enhance safety, increase capacity/productivity) as well as support more efficient usage of airspace resources.

The air-ground system the FAA has chosen to use initially is the Mode Select (Mode S) Data Link. The Mode S system provides a secondary surveillance radar capability to all transponder equipped aircraft as well as the data link capability to discretely address Mode S equipped aircraft.

The aircraft communication systems will be engineered by airframe/avionics manufacturers. It will connect various processors and I/O devices on board the aircraft to available air-ground networks. The communications system architecture will allow processors and I/O devices to be used for communications conducted over any available air-ground network.

Data Link services in the ATC category will utilize the Host Computer Replacement currently in service at the ARTCC and the Advanced Automation System (AAS) with its Area Control Computer Complex (ACCC) and its Automated En Route Air Traffic Control (AERA) software.

The ATC services initially implemented will provide major improvements in controller/pilot communications including:

       o  Assignment/Confirmation of Assigned Altitude
       o  Automated Airspace Alert
       o  Clearance Delivery
       o  Designated Traffic Report
       o  En Route Metering Advisory

o In Flight Plan Filing and Amendment
o Minimum Safe Altitude Warning
o Predeparture IFR Clearance
o Transfer of Communications

An additional set of advanced automation ATC capabilities, scheduled for later implementation, will further require direct communication between the ATC ground facilities and the aircraft's avionic suite, primarily the Flight Management System (FMS), as well as controller/pilot interfaces. These services include:

o Aircraft Estimated Trajectory*
o Aircraft Identification and State
o Automated Flight Services
o Arrival Time Control*
o Tactical Maneuver*
o TCAS/AERA Interface Message
o Trial Plan Probe
o VFR Flight Plan Activation/Following

* FMS/AERA Exchange

## FMS INTEGRATION[2]

The FMS integrates information from crew entered data, air data, inertial reference, internal navigate data and engine/fuel flow data to provide automatic navigation, guidance, map displays and performance optimization.

The basic FMS consists of Flight Management Computers (FMCs) and Control Display Units (CDUs) from which the crew enters flight plans, takeoff data, wind data and performance data. The potential for data entry errors is substantial, especially for latitude/longitude way-points. Because of this error entry potential the sending of information directly to the FMS from ground station, utilizing data link, is increasingly being considered as a viable option. ATC is considering the use of data link both for strategic planning (flight plan clearances) and tactical, time critical messages (en route amendments to clearances), directly to the aircraft's FMS.

Progress in the development of schemes for FMS and data link integration are predicated on an architecture based on Open System Interconnect (OSI) which refers to a communication system that is "open" to any end system as long as the system communicates using a standard set of protocols. This is crucial since there are currently three diverse digital communication subnetworks (VHF, Mode S, SATCOM). The transition from the character-oriented protocol to a bit-oriented protocol is a major step towards compatibility with the future Aeronautical Telecommunication Network (ATN) for OSI expansion.

The OSI architecture also enables other specific end system functions beside FMC to be accommodated such as Onboard Maintenance Systems (OMS) and Electronic Library Sys-

2 Ray, Ingeborg L., *Flight Management System Application of Data Link*, Ibid., pp. 111-114.

tems (ELS). These functions will be integrated with the communication management function, serving as an ATN router, to eliminate potential bottlenecks in the expanded airborne system. Although these are termed "systems" what is really of interest are functions performed by the communication element and how they are finally assembled into a system is still evolving.

Data Link (DL) holds a unique position among technologies which form the FAA's plan to enhance ATC systems. In the long term, DL will act as the essential pathway for advanced automation by providing a direct, real-time connection between ground-based ATC computer systems and airborne avionics computers. Even before this, it will provide a new communication channel between air traffic controllers and aircrews which has the potential to revolutionize information transfer between those focal elements of the National Airspace System (NAS).

Data Link offers a communications medium which transmits coded, digital data to individual addressees, unlike the analogue, broadcast nature of the voice radio communication system. The acknowledgment and verification of the communications process, which is required in a voice system will become an integral part of the DL transmission. Message transmission will also be improved through reduced noise interference, discrete addressability and improved interpretability due to enhanced visual vs auditory performance. In fact estimates are that the implementation of data link technology in the ATC communication process may well enhance performance by some 50% due primarily to error reductions and clear ungarbled transmissions.

## AERA[3]

One of the key elements of the National Airspace System (NAS) Plan is the Advanced Automation System (AAS). In addition to incorporating functions of, and enhancements to, the current ATC system, the AAS incorporates a collection of automation capabilities known as Automated En Route ATC (AERA). AERA is being designed with several goals in mind: primarily to enhance safety and increase system capacity as well as increase controller productivity and user benefits.

To meet these goals many of AERA capabilities will rely on increased utilization of Data Link (DL) to reduce ATC's verbal communications with aircrews as well as reduce communication errors. To understand the context in which DL capabilities will be implemented, a brief overview of AERA automation is provided.

Host AERA capabilities depend on the AERA Control Computer Complex (ACCC) to provide trajectory estimation. Trajectory estimation provides a path in four (4) dimensions that an aircraft is expected to take all the way to its destination based on flight intent information. The ACCC also includes functions called Automated Problem Detection (APD), which detects potential problems such as conflicts between aircraft, violations of airspace and non-adherence to ATC traffic flow instructions. Several capabilities, such as controller reminders and reconformance, are also provided to assist controllers.

The automatic detection of problems will consist of various look-ahead times, (depending on the type of problem), For example, problems with airspace and flow instructions will be

3 Lawson, Nora, *Data Link in the Automated En Route ATC (AERA) Environment* Ibid., pp. 91-98.

detected to the end of the flight while problems among aircraft are detected out to about 20 minutes in the future, allowing controllers sufficient time to analyze the problem and determine an appropriate resolution.

AERA will automatically generate several resolutions for detected problems, rank those resolutions according to minimal deviation from User Preferences (UPs) (e.g. preferences for route, altitude profile and speed schedule as filed by pilot's initial Flight Plan) and display the Highest Ranked Resolution (HRR) to the controller. The function of providing the automatic generation of resolutions is the Automated Problem Resolution (APR) which generates a set of resolution maneuvers based on aircraft intent; conflict geometry; airspace characteristics and constraints (e.g. restricted airspace); and flow instructions.

The AERA environment will consist of aircraft equipped to verifying degrees of sophistication. Many will be equipped with a random route navigation capability and data link communications. Some will have very highly sophisticated flight management systems, while others will have basic two-way radio and VOR navigation equipment.

Data Link (DL) will be the primary medium for controller/pilot communications for DL equipped aircraft. Clearances will be sent to aircraft via data link, reducing the amount of verbal communication required and eliminating communication error. Pilot clearance change request can be data linked to controllers for approval and routine information can be data linked without any controller action.

These capabilities will aid the ATC system in realizing improved safety, expeditious and efficient operation of all aircraft, and increase controller productivity.

## AERA AND DATA LINK

The current data link programs are designed to provide communication capabilities to link ground systems with the aircraft. To communicate with DL equipped aircraft AERA will interface with ATN which has the capability to communicate through all air-ground subnetworks (e.g. VHF, Mode S, SATCOM).

It is assumed that basic data link will be available for both ATC and non-ATC services as well as for controllers and pilots alike. For example, pilot requests for weather and aeronautical information such as NOTAMS (Notices to Airmen) and terminal arrivals and departures will be automated services.

Initial en route ATC data link services will consist of transfer of communications and altitude assignment but will be augmented by an On Frequency response and the Clearance Delivery function. Additionally, trajectory information from onboard computers can be down-linked to the ground system. Since these computers control the aircraft's flight they can contain more accurate information such as expected arrival time at a fix which would enable AERA to more accurately predict conflicts and generate conflict-free resolutions.

One of AERA's capabilities, IFR Clearance Actuation Request, requires a flight plan to be filed prior to activation which characterize the evolution from today's tactical control to a strategic one. The Clearance Delivery is the only message that always operates manually in order for the controller to maintain a mental picture of and control of aircraft intent. Flight Plan Amendment Request are down-linked to request modifications to flight plans which are checked against all flow instructions; current plans of other aircraft; and against all active airspace; prior to data linking clearance to requesting aircraft via Clearance Delivery. The Time-Of-Arrival Metering Goal provides a specific time for an aircraft to arrive at a fix and

the aircraft's current trajectory to assist controller in selecting maneuvers to comply with metering requirements. These metering goals are also automatically submitted to Automated Problem Resolution and Schedule Adherence Maneuvers.

Start Maneuver Reminders, Monitor Maneuver Reminder and Altitude Out-of-Conformance are all automatically up-linked to the aircraft. Start Maneuver Reminders are sent for both altitude and speed maneuvers included in the flight plan as cleared on departure or en route. Once delivered and acknowledged by the pilot the maneuver is expected to begin within a parameter time and continue as programmed just as when the aircraft drifts out of altitude conformance. All such message must be acknowledge by pilots and if not responded to the controller must alert by voice communications.

The Top Of Descent (TOD) point is calculated for each flight plan which is the point at which the aircraft should begin its descent to the destination. At a parameter time prior to the calculated point a TOD Preference Request is automatically sent to the aircraft. The aircraft responds with a position and time or a "no preference" message. Upon response the aircraft's preference is checked by a trial plan calculation and by Automated Problem Detection (APD) until parameter time when a TOD reminder is initiated automatically, some 15 to 20 minutes prior to reaching the TOD point.

One of the goals of AERA is to accommodate pilot preferences when flying in ATC controlled airspace. Parts of the Flight Data Base for each controlled aircraft will be a set of User Preferences (UPs) for route altitude profile and speed schedule as initially filed in the Flight Plan. These UPs are used by Automatic Problem Resolution prior to issuing any automatically data linked clearance, resolution maneuver or flow instruction.

## AERA2 OPERATIONS

All Traffic Management instructions will be entered into the AREA2 automation. Routine operations will be accomplished automatically with controller action only required for exception.

When a clearance message is initiated for an aircraft via data link a Pending Plan will be activated in which continual problem detection is established. When no problems are detected with the controller initiated plan, automation will immediately send the plan via data links. When the pilot acknowledges the clearance the Pending Plan automatically becomes the Current Plan.

A response from the aircraft is required for confirmation of a clearance or clearance change. When no response is received, receipt of the clearance cannot be assured, however, the Pending Plan can be used to protect unacknowledged clearances by continuously performing problem detection.

AERA2 will provide controllers with a message or alert on aircraft that require clearance changes to meet Traffic Management instructions. Automation, however, will autonomously issue frequency changes, beacon code assignments and altimeter setting as well as reminders for beginning altitude or speed transitions cleared prior to departure or previously cleared en route.

The Transfer of Communications, will also be accomplished without controller intervention, with data link used to inform the aircraft to change frequencies and radio communication treated only as a backup. The aircraft will data link the new frequency and the system (ATC) checks their accuracy. Other routine operations such as handoffs and pointouts will also be

accomplished automatically due to the continuous checks for problems and automatic problem resolutions which provide problem-free alternatives for efficient routing.

Detection and resolution of problems will not only be highly automated but will be done earlier and more rapidly than in today's system. Automated Problem Detection and Resolution will resolve aircraft to aircraft conflicts as soon as they are detected, up to 20 minutes prior to a violation, which will eliminate surprise incursions and time-critical situations. Controllers will be altered and advised of Highest Ranked Resolution (HRR) automatically.

Controllers will take action to ensure separation for aircraft referenced in all alerts. This action, in most cases, will be implementation of the resolution generated by the Automated Problem Resolution (APR) function. These machine-generated resolution are problem-free as presented to the controller for evaluation along with their machine-generated HRR. A graphic depiction of the conflict may be displayed to the controller if requested. If for some exceptional circumstance the HRR is not accepted by the controller he may reinvoke APR or invoke a Controller Assisted Resolution (CAR) which reactivates APR with constraints imposed on maneuvers by the controller based on special information not available to the automatic system such as bad weather. The results are then returned to the controller with a new HRR.

Controllers will respond to all aircraft requests by submitting them to APR for generation of a solution free of any aircraft, airspace or flow instruction problems. Any request with problems will automatically be checked periodically until a problem-free resolution is issued. When this happens the controller is notified that a User Preference (UP) can be issued since previously restrictions have been lifted. UP is a generic term referring to "how the pilot wants to fly to the destination." That is the trajectory the pilot wants to fly in terms of x, y, z and t. There are UP components such as UP-Altitude or "vertical" profile, UP-Route which is "lateral" or plan-view, UP-speed as the "longitudinal" or speed schedule and the UP-TOA or Time Of Arrival. UPs used by the automation will be updated to reflect current aircraft preferences.

The AERA activities are prioritized in almost the same order as todays system. The highest priority are safety related activities such as issuing clearance changes for traffic, airspace and flow problems, as well as analyzing conflicts and resolutions presented by automation. Additional activities include reviewing, evaluating and approving requests for clearance changes issuing clearance and monitoring/integrate operational information. AERA2 Traffic Management uses both ground delays and metering of airborne flights to manage arrival traffic at the destination airport. Ground delays and metering are used to sequence and schedule aircraft en route to the airports. AERA2 will determine maneuvers necessary to comply with the metering schedule, while maintaining safe separation. AERA2 will accommodate an aircraft's UP while incorporating Traffic Management constraints and necessary conflict resolution maneuvers for separation purposes as well as automatic problem detection and resolution functions.

## FAR TERM[4]

An integrated approach to the implementation of air-ground interchange will be an essential role in the future. New Communications, Navigation, Surveillance (CNS) and Air Traffic

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4 O'Keeffe, H.B., *The Need for Digital air-Ground Data Interchange in the Global Future Air Navigation System* Ibid., pp. 3-6.

Management (ATM) systems are a vital part of this integrated approach as is digital data links with global coverage and exploration of satellite technology.

The Future Air Navigation Systems (FANS) Committee of the International Civil Aviation Organization (ICAO) has developed a system concept for CNS together with the evolution of ATM to meet the needs of global aviation into the 21st century. The essential elements of the CNS systems are:

> o Voice and data communication would be by direct satellite-aircraft links to achieve global coverage. In the terminal area and some other airspaces, VHF and Mode S would continue to be appropriate.

> o The Global Navigation Satellite Systems (GPS and GLONASS) now being deployed would be developed to become the sole means of navigation for en route, terminal, and nonprecision approach and landing. MLS would be used for precision approach and landing.

> o Surveillance on a global scale would be by Automatic Dependent Surveillance (ADS) where the aircraft automatically transmit its enroute position and other data to the air traffic center. In terminal areas, Mode S would continue to be used.

All of these CNS systems use data links for the interchange of specific data to implement the communication, navigation and surveillance functions. Hence, ephemeral data from the navigation satellite is data linked to the aircraft to enable the position of the aircraft to be determined. Similarly, the aircraft position is data linked to the air traffic center to implement the ADS function by displaying it to ATC. The state and intentions of the aircraft are other specifically defined data that are transmitted from aircraft to ground as part of ADS.

It is, however, the communication element which provide the data link capability for messages, particular air traffic control messages which will be the basis for the developments in ATM. While the satellite and Mode S data links are designed for digital modulation, the present VHF communication systems will need further development to use digital modulation techniques to optimize performance and spectrum utilization.

The primary objective of ATM is to expedite and maintain a safe and orderly flow of traffic. The efficiency of the system, both in airspace and airport capacity, will have to be greatly increased in order to meet future demands for growth without a dramatic increase in congestion.

The air-ground data link is essential to such efficiency as are the previously mentioned new CNS systems. Systems are needed to allow data communications between the aircraft and air traffic centers to take place at high speed and in a computer compatible format. This enables information processing and decision making to occur in the aircraft and/or the air traffic center using all the available data in the total system. This means not only that the current range of calculations would be vastly improved by access to more complete and timely data, and that calculations not currently possible could now be attempted, leading to better decision making for Air Traffic Management; both on the ground and in the air.

The FANS committee conceptualized CNS improvements, as previously indicated, as well as the following data link provisions which would; a) improve data handling and transfer of information between ATC and aircraft operators, b) extend surveillance through automation

(e.g. ADS), and c) provide advanced ground-based data processing. These provisions allow the following increases in capability and/or efficiency:

o Enable advantage to be taken of the improved navigation accuracy in four (4) dimensions for modern aircraft.

o Improve accommodations of a flight's preferred profile in all phases of flight.

o Improved conflict detection and resolution, automated generation and transmission of conflict-free clearances and rapid adaptation to changing traffic conditions.

The development will lead to improvements in dynamic airspace and air traffic flow management essential for coping with increased growth and reductions in congestion without compromising safety.

## SUMMARY

The foregoing discussion of future Communications, Navigation, Surveillance (CNS) and Air Traffic Management (ATM) systems was taken from an article by Mr. H. B. O'Keeffe, Chairman of the ICAO FANS Interim Committee, which presented a dramatic illustration of the potential impact of such systems on future air operations is provided by the following:

"As an example, a scenario for flight planning of the future might be along the following lines. All the prerequisite data from air traffic services would be data linked to the aircraft flight management system and, together with operator and aircraft specific data, an "optimum" flight plan would be computed. This would then be data linked to ATC where the automated systems would compare this flight plan with all other known flights. Areas of conflict would be noted and some advisory solutions would be suggested and data linked back to the aircraft. The aircraft would then recalculate the flight plan with these constraints and suggestions and data link the revised flight plan back to ATC. After some iterations, a flight plan acceptable both to the aircraft and ATC would be produced. This would be displayed to the aircraft captain and, if acceptable, formally submitted to ATC for acceptance. If the aircraft is delayed on takeoff enough to invalidate the optimized flight plan, the iterative data linking process would begin again. A similar recalculation would occur during the flight if there were any significant changes to the aircraft or the ATC environment."

From this operational scenario of the future it should be obvious that the NAS for the 21st century consists of more then new system components; be they flightdeck or ATC. It also deals with the fundamental operational philosophy and concepts for the entire global air transportation system. Ultimately the major issues consist primarily of the transfer and management of information between the airborne flightdeck and the ground-based traffic management system, both of which are dramatically altered through advanced automation and the reassessment of the human role in the system. The area of information transfer such as ATC clearance, traffic, weather, etc., for both ground-to-air and air-to-ground data exchanges, as well as facilities and equipment such as TCAS, Datalink, AERA 2, FMS, OMS/ELS. Each play a critical and increasingly synergistic role in the future.

The National Plan for Aviation Human Factors correctly assessed the situation in their Volume I introduction to the area of Flightdeck/ATC Integration by stating;

> "In particular, advanced computer aiding such as AERA 2 will facilitate controller handling of increased traffic, but will also affect pilots who receive instructions from AERA-equipped sectors. Mode S, Data Link, and satellites should improve two-way communication capabilities, but may influence the way pilots and controllers process information. Intelligent automation on the flightdecks, such as TCAS, promises to enhance aircraft safety, but may influence controller's airspace management plans. The operational impacts on human performance of such new subsystems must be carefully understood in the context of the entire system."

Be the task of designing and developing new advanced transport flightdecks or air traffic controllers' workstations such admonishments should be heeded, for the 21st century and beyond!

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**13. ABSTRACT (Maximum 200 words)**

In order to accommodate the rapid growth in commercial aviation throughout the remainder of this century, the Federal Aviation Administration (FAA) is faced with a formidable challenge to upgrade and/or modernize the National Airspace System (NAS) without compromising safety or efficiency. A recurring theme in both the Aviation System Capital Investment Plan (CIP), which has replaced the NAS Plan, and the new FAA Plan for Research, Engineering, and Development (R,E,&D) are reliance on the application of new technologies and a greater use of automation.

Identifying the high-level functional and system impacts of such modernization efforts on future civil transport operational requirements, particularly in terms of cockpit functionality and information transfer, was the primary objective of this project.

The FAA planning documents for the National Airspace System of the 2005 era and beyond were surveyed; major aircraft functional capabilities and system components required for such an operating environment were identified, and a hierarchical structured analysis of the information processing and flows emanating from such functional/system components was conducted and the results documented in graphical form depicting the relationships between functions and systems.

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