ARINC CHARACTERISTIC 702A
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APPENDICES

1.0 INTRODUCTION AND DESCRIPTION

1.1 Purpose and Scope

This document sets forth the characteristics of an advanced Flight Management Computer System (FMS) specifically designed for installation in new generation aircraft. The system is also intended for retrofit in aircraft that presently use ARINC 700 series equipment. The advanced FMS is expected to provide expanded functional capability beyond that defined in ARINC Characteristic 702, and support the necessary requirements for operation in the future Communication, Navigation, and Surveillance/Air Traffic Management (CNS/ATM) operational environment. As described in ARINC Report 660B, ~~T~~this includes extensive use of Global Navigation Satellite System (GNSS), Required Navigation Performance (RNP) based navigation, air to ground data link for communications and surveillance, and the associated crew interface control/display capabilities. The functional requirements defined herein also apply to a Flight Management Function (FMF) in an integrated modular avionics (IMA) architecture with software partitions.

The ICAO Future Air Navigation System (FANS) Standards and Recommended Practices (SARPs) for CNS/ATM are currently evolving and are expected to continue to evolve. The requirements included in this document are intended to support performance based navigation (PBN) and trajectory-based operations (TBO) and be consistent with:

ICAO Doc 9613: Performance-Based Navigation Manual (PBN Manual)~~,~~

RTCA DO-236()~~,~~: Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation (RNP MASP), and

~~-~~RTCA DO-283()~~,~~: Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation (RNP MOPS).

~~and support performance based navigation (PBN) and trajectory-based operations (TBO).represent a best guess at the CNS/ATM related functions to be supported by the advanced FMS.~~

This document does not characterize the requirements for a Control Display Unit (CDU). While the CDU is included in the original version of ARINC Characteristic 702, the capabilities of the Multi-Purpose Control Display Unit (MCDU) are separately defined in ARINC Characteristic 739.

This document defines the functional and interface characteristics of the FMS and assumes that the appropriate MCDU characteristics are defined separately in ARINC Characteristic 739A or elsewhere.

ARINC originated with the airlines and the ARINC documents were created as airline requirements for system implementers. Therefore, the use of the word “should” in this document carries with it the expectation of incorporation. This is especially true in the context of fit, form, interface requirements, and crew indication requirements. In allowing for the various architectures described in this document it is still expected that the functions will operate, at a system level, as described in this document.

COMMENTARY

End users should be aware that there can be possible differences in hardware and/or tailored implementation of certain functions from ARINC 702A standard so that the FMC may meet fit, form, and intended functional requirements for the particular airframe. Differences may be due to the various airplane architectures, system limitations, and/or specific end user needs which take precedence over complete compliance with ARINC 702A.

1.2 Relationship to Other Documents

This document is one of a family of ARINC Characteristics for advanced navigation equipment that includes:

- ARINC Characteristic 756: GNSS Navigation and Landing Unit
- ARINC Characteristic 760: GNSS Navigation Unit

The functional characteristics of these three systems are very similar, and consequently, significant portions of these three equipment characteristics are highly common. Users of these documents should consider this commonality issue when planning future revisions.

The vast majority of military and government specifications for equipment design and construction usually employ specification language; that is, terms such as thou shalt and thou shalt not. However, that type of language makes it difficult to describe preferences which have grown out of airline experience which designers might weigh differently. For this reason, this characteristic, like other AEEC documents, represents guidance material which attempts to acquaint the manufacturer with the need for specific design practices rather than to tell them that they must meet certain requirements under all circumstances.

A complete list of documents referenced herein can be found in Appendix A.

1.3 Functional Overview

The FMS provides the following functions: navigation, flight planning, lateral and vertical guidance, performance optimization and prediction, air ground data link, and pilot interfaces via the Electronic Flight Information System (EFIS) and MCDU displays or, in newer architectures, a graphical Cockpit Display System (CDS). The following paragraphs provide a summary description of these characteristics, with references to their functional descriptions in later sections of this characteristic.

Navigation (Section 4.3.1) - The navigation function determines the position and velocity of the aircraft using input data from all appropriate sources. The outputs include position in terms of altitude, latitude and longitude, and velocity in terms of ground speed and track angle, wind, true and magnetic headings, drift angle, magnetic variation, and inertial flight path angle.

Flight Planning (Section 4.3.2) - This function provides the sequence of waypoints, airways, flight levels, departure procedures, and arrival procedures to fly from the origin to the destination and/or alternates. The flight plan may be entered manually on the MCDU or automatically by uplink via the air-ground data link. A navigation data base in the Flight Management Computer (FMC) contains the necessary data associated with every flight plan element identifier for the entire aircraft flight domain.

Lateral and Vertical Guidance (Section 4.3.3) - Lateral guidance is computed with respect to ~~great circle~~geodesic paths defined by the flight plan, and to transitional paths between the ~~great circle~~geodesic paths, or to preset headings or courses. Vertical guidance is computed with respect to altitudes assigned to waypoints, or to paths defined by stored or computed profiles. Speed control along the desired path is provided during all phases of flight.

Trajectory Predictions (Section 4.3.3.2.1) - This function predicts distance, time, speed, altitude, and gross weight at each future waypoint in the flight plan, including computed waypoints such as top-of-climb and top-of-descent.

Performance Calculations (Section 4.3.4) - The objective of this function is to optimize the vertical and speed profiles to minimize the cost of the flight or meet some other criterion, subject to a variety of constraints.

Air-Ground Data Link - Two-way data communication can be provided to the Airline Operations Facility and to Air Traffic Services (ATS). Airline Operational Communication (AOC) data link (Section 4.3.6) is used for flight plans, weather data, takeoff speeds, preflight initializations, etc., from the airline operations facility directly into the FMC. Air Traffic Control (ATC) data link (Section 4.3.7) is used to communicate predefined ATS controller-to-pilot uplink and pilot-to-controller downlink messages via the MCDU.

Pilot Interface via the MCDU (Section 6.0) ~~-~~ – In legacy architectures, ~~T~~the MCDU is the pilot interface to the FMS. It transmits button pushes to the FMC and displays data on the MCDU screen in response to transmissions from the FMC. The MCDU may also provide backup functions should both FMCs fail. In newer architectures, the MCDU is replaced by a graphical user interface provided by the Cockpit Display System (CDS). The FMS is a User Application (UA) which requests graphical widgets to be displayed on the display and the CDS provides the FMS with actions performed on those widgets. The CDS interface is documented in ARINC 661.

COMMENTARY

> Within this document, references to crew input from the MCDU and display of FMS information on the MCDU should be treated as generic references which also apply to a CDS architecture. It is hoped that future supplement will perform a more comprehensive update to this document relative to a CDS architecture.

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Electronic Flight Instrument System ~~Display~~ (Section 7.0) - The FMC generates a variety of outputs ~~data~~ in support of a Primary Flight Display (PFD), Navigation Display (ND), and optionally a Vertical Situation Display (VSD). Within this document, the terms Electronic Flight Instrument System (EFIS) and Cockpit Display System (CDS) are used in reference to the display system hardware and associated interfaces; the terms PFD, ND, and VSD are used generically to refer to the various graphical display areas or windows. Based on the interface, the FMC may provide data for use by an external symbol generator or may provide a series of drawing commands. The EFIS ND interface is detailed in Section 7.0; the CDS interface is in ARINC 661. ~~for display on the EFIS for display of command and reference data on the Primary Flight Display (PFD) and for graphic map display of the flight plan on the Navigational Display (ND) as well as display of dynamic data such as ground speed, wind, etc.~~

~~Future provisions for Airport Surface Guidance (Section 4.3.8) are included.~~

COMMENTARY

The airlines wish to avoid the installation of equipment that becomes throw-away when additional related functionality is added. Provisions for growth need to be inherent to the initial configuration of the equipment. The equipment also needs to be designed to support the flexibility that allows the airline to configure the system for the specific capabilities required for different aircraft types and operational needs without incurring unnecessary penalties for unused functionality. The growth and flexibility provisions must allow the system to be easily upgraded after initial installation and certification to accommodate the changes in airline and airspace operational requirements.

1.4 Flight Management Computer Description

The FMC should contain all of the components, electronic circuitry, memory, etc., incident to the functioning of the system. The unit should also contain, as a minimum, sufficient data storage for all required active engine and airplane performance data, all navigation data required to support the active flight plan~~,~~ and any ~~alternate~~ secondary flight plan which may have been entered into the system. The FMC should be capable of storing all data required by the system. The computer should be designed such that normal and abnormal power switching transients and other primary power interruptions as defined in RTCA DO-160() do not cause essential memory contents to be lost. Provisions should be made in the design of the computer to allow for future growth of the system. Expanding the capabilities of the computer should be possible with a minimum of rework and at a minimum cost to the airline customer.

1.5 Interchangeability

1.5.1 General

One of the primary functions of an ARINC Characteristic is to designate, in addition to certain performance parameters, the interchangeability desired for aircraft equipment produced by various manufacturers.

1.5.2 Interchangeability ~~Desired~~ for the ARINC 702A Flight Management Computer System

System interchangeability of the FMC with respect to the standard aircraft installation is desired regardless of the manufacturing source. The standards necessary to ensure this level of interchangeability are set forth in Section 2.0 of this Characteristic.

1.5.3 Generation Interchangeability Considerations

The advanced FMS defined by ARINC 702A represents an evolutionary development beyond the FMS defined by ARINC 702. Consequently, general form factors and interwiring are similar, but strict interchangeability is not the intended goal.

The air transport industry desires that future evolutionary equipment improvements and the inclusion of additional functions in new equipment during the next few years do not violate the interwiring and form factor standards set forth in this document. Provisions to ensure forward-looking generation interchangeability (as best can be predicted) are included in this document to guide manufacturers in future developments.

1.6 Regulatory Approval

The equipment should meet all applicable regulatory requirements. This Characteristic does not and cannot set forth the specific requirements that an equipment must meet to be assured of approval. Such information must be obtained from the appropriate regulatory authority.

1.7 Integrity and Availability

Since this equipment is the primary means of navigation on most aircraft, the utmost attention should be paid to the need for integrity and availability in all phases of system design, production, and installation. This equipment should provide the system performance, design and operational integrity, and availability necessary for CNS/ATM and Required Navigation Performance (RNP) operations. Integrity should consider design assurance for reduced risk of operational excursions beyond RNP containment limits, and functional assurance via system capabilities and features consistent with CNS/ATM and RNP operations. The system production and installation processes and methods should be consistent with the required integrity and availability of the system.

1.8 Reliability

The anticipated operational use of the system demands the utmost attention to the need for reliability in all phases of system design, production, installation, and operation of the FMC. It is of paramount importance to the airlines to operate a trouble-free unit with minimum impact on scheduling and maintenance. A special emphasis should be given to total system quality, including built in testing, ramp testing, and shop testing to increase the Mean Time Between Unscheduled Removals (MTBUR). MTBUR has a profound effect on airline operations despite a high MTBF.

COMMENTARY

Airlines have a heightened interest in identifying and correcting the root cause(s) of unnecessary LRU removals, many of which result in a No Fault Found (NFF) disposition. Each NFF occurrence represents an unacceptable additional and excessive cost of ownership to the airline. All efforts in the developmental process to eliminate NFF occurrences will help improve the MTBUR.

1.9 Testability and Maintainability

The total system quality should include adequate ability for the operator to test and maintain the FMS effectively. The FMS designer should confer with the user to establish goals and guidelines for testability to minimize unnecessary removals. The use of advanced Built-In Test Equipment (BITE), ramp testing equipment, and adequate documentation will help the operators improve MTBUR. For airline operations, MTBUR is at least as important, perhaps more so, than MTBF. Testability should provide for the rapid identification of the root cause(s) of repeat removals and ultimate elimination of unconfirmed faults.

For shop maintainability, the design of physical access and functional partitioning of the FMS should be such to minimize repair time. Where possible, excessive unit disassembly should not be required for internal component replacement. Full and complete documentation included in a Component Maintenance Manual will also facilitate effective maintainability.

1.10 Flight Simulators

Flight simulators are recognized as an important part of the aviation industry. Airlines depend upon simulators for flight crew and maintenance training. FMS equipment should be designed for use in flight simulators. Airlines typically desire simulators to be available as early as possible to allow for crew training prior to introduction into revenue service. The guidelines of ARINC Report 610~~B~~(): Guidance for Use of Avionics Equipment and Software in Simulators apply.

2.0 INTERCHANGEABILITY STANDARDS

2.1 Introduction

This section sets forth the specific form factor, mounting provisions, interwiring, input and output interfaces, and power supply characteristics desired for the Flight Management Computer (FMC). These standards are necessary to ensure the continued independent design and development of both the equipment and the airframe installations. Manufacturers should recognize the practical advantages of developing equipment in accordance with the form factor, interwiring, and signal standards of this document.

2.2 Form Factor, Connectors, and Index Pin Coding

The FMC should comply with the dimensional standards in ARINC Specification 600: Air Transport Avionics Interfaces, for the 8 Modular Concept Unit (MCU) or 4 MCU form factor. The FMC should also comply with ARINC Specification 600 with respect to weight, racking attachments, front and rear projections, and cooling.

The FMC should be provided with a low insertion force, ARINC 600 Size 2 service connector. This connector should be located on the center grid of the FMC rear panel, and index code 04 should be used. The top and center inserts of the connector Top Plug (TP) and Middle Plug (MP) should each provide 150 socket-type contacts. The lower insert Bottom Plug (BP) should provide 11 pin-type contacts and spaces for two small diameter coaxial contacts. Attachment 2 to this document shows the connector arrangement. Attachment 3 shows the pin assignments.

If functions (not assigned pins on the service connector in Attachment 2-2 to this document) are needed to be brought to the outside world to facilitate testing, they should be assigned pins on an auxiliary connector whose type and location is selected by the equipment manufacturer. The manufacturer should refer to ARINC Specification 600 when choosing the location for this connector and note that, other than to accommodate the needs for equipment identification by the ATE described in this document, he is free to make whatever pin assignments he wishes. The airlines do not want the unassigned (future spare) pins of the service connector used for functions associated solely with ATE use.

2.3 Standard Interwiring

The standard interwiring for the FMC is set forth in Attachment 2-2. The interwiring for a given installation needs only to ensure interconnection with those sub-systems actually installed and supported on a particular aircraft type. Wiring associated with alternate sub-systems shown in Attachment 2-2 need not be installed. Equipment manufacturers are cautioned not to rely on special wires, cabling, or shielding for their particular units because they will not exist in an ARINC 702A installation.

2.4 Power Circuitry

2.4.1 Primary Power Input

The FMC should be designed to use 115 volt 400Hz single phase power from a system designed for Category (A) utilization equipment per ARINC Specification 413A.

The primary power inputs to the FMC will be protected by a circuit breaker. Installation designers should note that the FMC circuit breaker may need to be capable of handling the current drain of an ARINC 615 or 615A data loader. When such a device is used with the FMC, it may derive its power from the FMC power source.

The equipment designer should be aware that severe switching and other transient interruptions to primary power occur during normal aircraft operations. He should ensure that such interruptions do not cause the computer to lose the contents of its memory or impose the need to provide an external battery to maintain operations. No pilot action should be needed to cause the system to return to normal operation following such normal power interruptions.

Equipment designers should take precautions to prevent anomalous operation of equipment during and after interruptions or transients in the aircraft power system. The equipment should, as a design goal, continue normal operation while sourcing current to all active guidance and flag outputs during power interruptions of up to 200 milliseconds. If the equipment shuts down during a power interruption, normal operation should resume without the need to recycle circuit breakers or clear memories when power is restored.

System response and data retention requirements for primary power interruptions longer than 200 milliseconds are discussed in Section 3.3.

Note: Airframe installation designers should verify that the aircraft power systems satisfy the primary power interruption criteria of ARINC Specification 413A.

2.4.2 Power Control Circuitry

There should be no master on/off power switching within the FMC system.

2.4.3 The AC Common Cold

The wire connected to the FMC connector pin labeled 115 VAC Cold will be grounded to the same structure that provides the dc chassis ground but at a separate ground stud. Airframe manufacturers are advised to keep AC ground wires as short as practicable in order to minimize noise pick-up and radiation.

2.4.4 The Common Ground

The wire connected to the FMC connector pin labeled Chassis Ground should be employed as the DC ground return to aircraft structure. It is not intended as a common return for circuits carrying heavy ac currents, and equipment manufacturers should design their equipment accordingly.

2.4.5 Batteries

If battery devices are used in equipment designs, they should not degrade the MTBF and MTBUR targets for the equipment and should also have a life expectancy greater than the MTBF target.

COMMENTARY

Airline experience has shown that batteries have proven to be maintenance problems in avionic equipment. Manufacturers may consider the use of batteries to hold-up memory devices through power transients or long term power outages. Batteries might also be utilized to maintain real time clock circuits or for other purposes. However, the airlines encourage the manufacturers to consider other design solutions instead of using batteries for these functions.

2.5 Standardized Signaling

The desire for interchangeability necessitates standardization of the FMC input and output interface parameters.

The FMC should be capable of exchanging data in digital form and as discrete inputs and outputs. The characteristics of digital signals and discrete signals are defined herein. These standards should be used as design guidelines to assure the desired interchangeability of equipment.

Certain basic standards established herein are applicable to all signals. Unless otherwise specified, the signals should conform with the standards set forth in the subparagraphs below.

2.5.1 General Accuracy and Operating Ranges

The accuracies specified herein should apply under all combinations of the environmental conditions referenced in Section 2.5 of this document. Accuracy measurements should be made on the assumption that the inputs to the FMC are perfect. Accuracies are specified on the basis of 95% of observations and do not include typical reading inaccuracies of the pilot's instruments.

2.5.2 Resolution

For the purposes of this Characteristic, the resolution or the function threshold sensitivity is considered to be the maximum cyclic input change (double amplitude) that can occur without detectable change in the output. The specific figures set forth for threshold sensitivity of each function should be made without vibration of any kind being applied and it should be checked approaching the reading with signals from either direction.

2.5.3 ARINC 429 Data Bus

The FMS equipment utilizes digital signal interfaces defined by ARINC Specification 429: Digital Information Transfer System (DITS).

ARINC 429 data bus input labels are defined in Attachment 4 of the document. Material in this document is included for reference purpose only.

COMMENTARY

In the event of conflict between this document and ARINC Specification 429, the equipment designer is encouraged to contact the supplier of equipment sourcing the ARINC 429 data words.

ARINC 429 data bus output labels sent by the FMS are defined in Attachment 4 of this document. Material in this document is intended to be used by the FMS equipment designer.

2.5.4 Standard "Open"

The standard "open" signal is characterized by a resistance of 100,000 ohms or more with respect to signal common.

COMMENTARY

In many installations, a single switch is used to supply a logic input to several Line Replaceable Units (LRUs). One or more of these LRUs may utilize a pull up resistor in its input circuitry. The result is that an open may be accompanied by the presence of +27.5 VDC nominal. The signal could range from 18.5 to 36 VDC.

2.5.5 Standard "Ground"

The standard "ground" signal may be generated by either a solid state or mechanical type switch. For mechanical switch type circuitry, a resistance of 10 ohms or less to signal common would represent the ground condition. Semiconductor circuitry would exhibit a voltage of 3.5 VDC or less with respect to signal common in the ground condition.

2.5.6 Standard "Applied Voltage" Output

The standard "applied voltage" is defined as having a nominal value of +27.5 VDC. This voltage should be considered to be applied when the actual voltage under the specified load conditions exceeds 18.5 VDC (+36 VDC maximum) and should be considered to be not applied when the voltage at the output is 3.5 VDC or less when loaded with no less than 50,000 ohms.

2.5.7 Standard Discrete Input

A standard Discrete Input should recognize incoming signals having two possible states, open and ground. The characteristics of these two states are defined in Sections 2.5.4 and 2.5.5. The maximum current flow in the ground state should not exceed 20 milliamperes.

COMMENTARY

Some older installations use a number of voltage levels and resistances for discrete states. In addition, the assignments of valid and invalid states for the various voltage levels and resistances were sometimes interchanged, which caused additional complications. A single definition of discrete levels is being used in an attempt to standardize conditions for discrete signals. The voltage levels and resistances used are, in general, acceptable to hardware manufacturers and airlines. This definition of discrete is also being used in the other ARINC 700-series characteristics. However, there are few exceptions for special conditions.

The logic sources for the Discrete Inputs to the unit are expected to take the form of switches mounted on the airframe component (flap, landing gear, etc.) from which the input is desired. These switches will either connect the Discrete Input pins on the connector to airframe dc ground or leave an open circuit as necessary to reflect the physical condition of the related components. The unit will, in each case, be expected to provide the DC signal to be switched. Typically, this is done through a pull-up resistor. The equipment input should sense the voltage on each pin to determine the state (open or closed) of each switch.

The selection of the values of voltages and resistances is based on the assumption that the Discrete Input will utilize a ground-seeking circuit. When the circuit senses a low resistance or a voltage of less than +3.5 VDC, current flow from the input will signify a ground state. When a voltage level between +18.5 and +36 VDC is present or a resistance of 100,000 ohms or greater is connected to the input, little or no current should flow. The input should be in a quiescent state. The input should also utilize an internal pull-up to provide for better noise immunity when a true open is present at the input.

The probability is quite high that the sensors (switches) will be providing similar information to a number of users. The probability is also high that unwanted signals may be impressed on the inputs to the unit from other equipment, especially when the switches are in the open condition. For this reason, equipment manufacturers are advised to base their logic sensing on the ground (less than +3.5 VDC) state of each input. Also, both equipment and airframe suppliers are cautioned concerning the need for isolation to prevent sneak circuits from contaminating the logic. Typically, diode isolation is used in the avionics equipment to prevent this from happening.

2.5.8 Standard Discrete Output

A standard Discrete Output should exhibit two states, open and ground, as defined in Sections 2.5.4 and 2.5.5. The open state of each discrete is defined as a voltage greater than +18.5 VDC (+36 VDC max.), or a resistance of 100,000 ohms or more, from the assigned equipment connector pin to airframe dc ground. The ground state is defined as a voltage less than +3.5 VDC (0 VDC min.) to airframe dc ground at the assigned pin. The maximum current flow through the discrete wire in the ground state should not exceed 20 mA.

COMMENTARY

The probability is quite high that the switches will be providing similar information to a number of users. The probability is also high that unwanted signals may be impressed on the inputs to the unit especially when the switches are in the open condition. For this reason, equipment manufacturers are advised to base their logic sensing on the standard ground (less than +3.5 VDC) state of each input. Avionics suppliers are alerted to the need for isolating diodes in the equipment to prevent sneak circuits from contaminating the logic.

2.5.9 Ethernet Interface

ARINC Specification 646: Ethernet Local Area Network (ELAN) defines the characteristics of this interface. In the event of conflict between this document and ARINC Specification 646, the latter should be assumed to be correct. <<Change to A664>>

2.5.10 Standard Annunciators

A standard annunciator output should exhibit the same characteristics as the standard discrete output described in Section 2.5.8, except the annunciator output should be capable of sinking up to 200 mA when in the ground state.

2.6 Environmental Conditions

The FMC should meet the requirements of the latest versions of RTCA ~~Document~~ DO-160() and EUROCAE ED-14(). Attachment 5 to this document tabulates the relevant environmental categories.

2.7 Cooling

The FMC may be designed to utilize, and the airframe installation should provide, cooling air in the manner described in Section 3.5 of ARINC Specification 600. The airflow rate provided to the FMC in the aircraft installation should be 44 kg per hour and the pressure drop of the coolant airflow through the equipment should be 25 ± 5 mm of water at this rate. The unit should be designed to expend the pressure drop in a manner to maximize the cooling effect within the equipment. Adherence to the pressure drop standard is needed to allow interchangeability of equipment.

In addition to the above, individual aircraft installations may require operation with loss of cooling air to meet Extended-Range Twin-Engine Operations (ETOPS) operating requirements.

COMMENTARY

Current ETOPS rules can require operation up to 180 minutes without cooling air.

Equipment failures in aircraft due to inadequate thermal management have plagued the airlines for many years. Section 3.5 of ARINC Specification 600 provides design guidance for airframe equipment suppliers to prevent such problems in the future. Airlines regard this material as required reading for all potential suppliers of unit and aircraft installations.

2.8 Weights

System manufacturers should take note of the guidance information on weights contained in ARINC Specification 600.

2.9 Grounding and Bonding

The attention of equipment and airframe manufacturers is drawn to the guidance material in Section 3.2.4 of ARINC Specification 600 and Appendix 2 of ARINC Specification 404A on the subject of equipment and radio rack grounding and bonding.

COMMENTARY

A perennial problem for the airlines is the location and repair of airframe ground connections whose resistance has risen as the airframe aged. A high resistance ground usually manifests itself as a system problem that resists all usual approaches to rectification, and invariably consumes a wholly unreasonable amount of time and effort on the part of maintenance personnel to fix. Airframe manufacturers are urged, therefore, to pay close attention to assuring the longevity of ground connections.

3.0 SYSTEM DESIGN CONSIDERATIONS

3.1 System Configurations

Different configurations of the ARINC 702A Flight Management Computer System, illustrated in ATTACHMENT 1 to this document, are described in this section. The FMC is expected to be capable of operating interchangeably in all configurations. In an IMA architecture, the FMF is analogous to the FMC for the purpose of these system configurations.~~Single or multiple FMF partitions may be provided in an integrated modular avionics architecture.~~

3.1.1 Single System Configuration

In this configuration, the system accepts inputs from one, two, or three Inertial Reference System (IRS), Air Data/Inertial Reference System (ADIRS), or Altitude Heading Reference System (AHRS); one or two GNSS Sensors; two each Air Data System, VHF Omni-Range Navigation (VOR), and Distance Measuring Equipment (DME); and one Instrument Landing System (ILS)/Microwave Landing System (MLS) to provide the various navigation and guidance functions. An ARINC 615 and ARINC 615A (growth) data loader input is provided for both software and navigation data base loading. Also, an interface is provided for an ACARS Management Unit (MU) or an ARINC 758 Communications Management Unit (CMU) Mark 2.

Inputs of fuel quantity, fuel flow, and engine/airplane configuration parameters and inputs from the flight control computer (and for some installations, the thrust control computer) combined with the air data inputs are used to provide the performance and prediction functions. Initial condition inputs may be inserted manually using the MCDU, automatically from airplane sensor systems or loaded using the data link function.

The system should be capable of ~~independently~~ driving two flight control computers, two navigation displays, and two communication management units.

3.1.2 Single System/Dual MCDU Configuration

In this configuration, the interface is the same as for the single system, with the addition of a second MCDU. Both MCDUs have the capability of data entry and display independently.

3.1.3 Dual System Configuration

A typical Flight Management System installation is dual, consisting of two MCDUs and two FMCs. The FMCs are linked together via the intersystem bus and both the MCDUs are connected to both FMCs. MCDU button pushes are processed for mode control and display changes. The left and right MCDUs may be operated independently; they can display different data pages and the crew can insert data using either of them to affect the FM operation. The FMCs transmit certain data to each other for comparison and validation. For example, if the computed position between the FMCs differs by more than a set threshold, a message is issued to warn the crew.

Please refer to Section 3.5 for Dual System Design Considerations.

3.1.4 Other Configurations

Some installations have provided for a third MCDU since one of the MCDUs is primarily used to manage the data link activity. For this configuration, the third MCDU may be used as a repeater that can be switched in or out as necessary.

Additionally, some installations have provided for a third FMC. This unit is usually not synchronized with the other two FMCs unless it is switched in as a replacement because of a unit failure. At this point the unit is fully synchronized by the remaining FMC and used in the dual configuration.

3.2 Certification Design Considerations

3.2.1 Partitioning Considerations

Manufacturers should carefully consider the internal structure of software in partitioning sub-functions within an overall function. In an integrated architecture, the FMF may be a partition within a system which provides all CNS/ATM airborne functions. The flight management function itself may consist of several sub-functions such as Navigation, Flight Planning, Crew Interface, I/O, etc., which may be separate partitions. As the objectives of software partitioning are efficient design and effective functional allocation, as well as reduced software change costs and lead times, manufacturers must ensure that the software structure eliminates the need to revalidate software partitions and modules that have not been affected by a particular change.

In some configurations, the system may be a mixed criticality unit. In other words, this unit may house software of more than one DO-178B/C level. In these configurations, manufacturers must ensure that partitioning is robust enough to accommodate changes in any lower level software (i.e., less critical software) without mandating the rigors of the more critical software validation, certification, and maintenance.

3.2.2 Operational Functional Independence

While the system makes extensive use of shared resources as a multi-function system (e.g., power supplies, processors), manufacturers may provide for some system functions to be retained during failure conditions.

COMMENTARY

Airlines strongly desire to continue to operate the system even if one or more functions or external interfaces have failed, as long as the aircraft operation is not predicated on the use of the failed sensor or function(s). Therefore, a failure condition unique to one function or sensor should not adversely impact normal operation of any other system functions.

3.2.3 Unit Identification Considerations

COMMENTARY

Avionics and airframe manufacturers are strongly encouraged to implement an FMS unit identification methodology that does not correlate the software version with the basic face plate part number of the unit. The objective is that a software revision should not result in the re-identification – part number roll – of the unit. A further objective is that a common FMS platform (i.e., a single face plate part number) could be used across multiple fleets and airframe manufacturers without re-identification of the unit, even if fleet specific software is required for each fleet type.

With this approach an individual manufacturer's part numbers are assigned and maintained for (1) the FMC hardware, (2) the FMC software, and (3) the overall unit (i.e., face plate part number). In this case, the face plate part number is referred to as the generic or system part number and is not affected by normal revisions to the FMS software (e.g., all software or data that can be loaded into the unit via a data loader will not require a re-identification of the unit).

For this scenario, the operator may stock a given FMC under its system part number. This unit could be effective across multiple fleet types, each with fleet specific software requirements. When an FMC is replaced on an aircraft, the software configuration can be verified from the MCDU. If necessary, the FMC may be loaded with the applicable certified software for that fleet via data loader or system crossload.

This scheme allows the operator to minimize sparing when a given FMC is used on multiple fleet types, even when unique software is required for each fleet. It will also enable new FMC software loads on the aircraft without requiring a revision to the FMC ID plates or the aircraft Illustrated Parts Catalog (IPC).

3.3 System Response to Power Interrupts

An appropriate period of time, usually between 5 and 10 seconds, should be selected to differentiate between inadvertent power loss and normal equipment turn on. The reason for this distinction is to provide a basis for when the system should be reinitialized.

For power outages greater than this time period, the system should automatically perform a power-up test cycle. Failure to complete this test cycle successfully should cause appropriate flight deck annunciation. The system should also reset any flight dependent data such as initial position, flight plan, performance initialization, etc., and prompt the crew for entry of this data. Configuration related data from program strapping, configuration files, or Airplane Personality Module (APM) should be read.

For power outages less than this time period the system should resume normal functions as quickly as possible. The power up test cycle should not be performed and initialization, configuration, and flight plan data should not be reset and the crew should not be prompted for data entry. The crew may be prompted to select the appropriate fly-to waypoint since flight plan points may have been passed during the power outage.

COMMENTARY

Some systems may also make a distinction of being on the ground or in the air. Typically, in-air power ups will be treated as inadvertent power outages regardless of the power outage time period. The system should be designed to protect data from a power interrupt for a period of time consistent with its intended use. Since some methods of protecting data do not ensure data validity indefinitely, data integrity should be checked before it is used after a power outage, especially if the system uses in-air status for determining normal power turn on.

3.4 FMC ~~Accuracy and~~ Performance

3.4.1 Accuracy, Integrity, and Continuity

Accuracy, integrity, and continuity requirements for the ~~lateral navigation~~Lateral Guidance function are defined by the ~~RTCA~~ DO-236(). ~~: Minimum Aviation System Performance Standards (MASPS) Required Navigation Performance for Area Navigation. RTCA D~~DO-236() also addresses accuracy requirements for the ~~vertical navigation~~Vertical Guidance and ~~trajectory prediction~~Trajectory Predictions functions.

The system design should comply with the aeronautical data quality and integrity requirements set forth in RTCA DO-200A() and RTCA DO-201A().

The system should ensure data integrity in all operations such as:

- Dataload of program and databases into system memory
- Reading of program and databases from memory
- Input of sensor information into the system
- Entry and edit of information in the flight plan
- Navigation, performance, and guidance computations
- Output of information to the various external systems and displays

3.4.2 Response Time ~~Standards~~

Specification of precise response time standards is dependent on the detailed system operational design. This section provides general guidelines that should be considered by system designers in determining computer processing requirements and software architecture.

Unless explicitly stated otherwise, flight plan response times throughout this document are for modifications to the active flight plan. The response times listed below are from the completion of crew action until the output of data on the display.

~~**Requirements and Measurements**~~

Task Description	Max. Response Time
Direct to a Waypoint ~~in the Flight Plan - Lateral Data Display-~~ Display of direct-to lateral path on ND	2 seconds
~~Direct to a Waypoint in the Flight Plan - Vertical Data Display~~	~~3 seconds~~
~~Direct to a Waypoint Not in the Flight Plan - Lateral Data Display~~	~~3 seconds~~
~~Direct to a Waypoint Not in the Flight Plan - Vertical Data Display~~	~~3 seconds~~
~~Steering~~ Lateral Guidance ~~Command~~ Output following flight plan change	3 seconds

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Revise Speed or Altitude Constraint in climb or cruise – Time to display target altitude and target speed	3 seconds
Revise Speed or Altitude Constraint ~~Restriction at Descent Waypoint~~in descent (no RTA) ~~(~~ Time to display target altitude, target speed, and ~~of the predicted altitude at the next waypoint~~vertical deviation~~)~~	5 seconds
Revise RTA target speed	~~5~~30 seconds (15 seconds typical)
Full Flight Plan Prediction ~~-~~ 4D Trajectory (Note 1) ~~Vertical Data (performance depends on factors such as flight plan length and number of waypoints)~~	30 seconds (15 seconds typical)
Background data update in response to a Mode, ~~s~~Scale, or ~~o~~Option change on the ~~EFIS~~Navigation Display	1 second
Software and Data ~~base~~ Base ~~l~~Loading (Note 2)~~ref. Section 10.3.3)~~ ~~Note: may be limited by file size, media, or loader interface~~	~~g~~Goal: ~~less~~ Less than 15 minutes
ATS Uplink Messages	Note ~~1~~3
ATS Downlink Messages	Note ~~1~~3

Figure 3.4.2-~~13.4.2-13.4.2-~~1 Response Time Requirements

~~Note:~~NOTES

1. 4D Trajectory includes predictions of distance, altitude, airspeed, time, and fuel. The response time depends on many factors such as the number of flight plan waypoints.
2. The response time depends on file size, media, and/or loader interface. Refer to Section 10.3.3 for additional data loader requirements.
3. The International Civil Aviation Organization (ICAO) CNS/ATM-1 SARPS allocate part of the total system end to end response time to the avionics. Further allocation to individual avionics subsystems (e.g., FMS, CMU, EFIS) is system architecture dependent and beyond the scope of this document.

3.5 Dual System Design Considerations

Different approaches may be followed in defining the functional architecture of the dual system installation. Design considerations should include operational independence of the two MCDUs, redundancy management, system integrity, functional availability, and failure response mechanisms. The dual FMCs should exchange information so that in the event of a failure or loss of power in one FMC, the second FMC is available for engagement without additional crew input and without significant discontinuity in the outputs.

In a dual synchronous configuration, one of the FMCs is designated as master and the other as slave. The master designation may be based on the FMC operational status, autopilot or flight director engagement logic, and for some installations, a source select switch. The master FMC performs tasks such as directing the slave to tune radios, determining the order of MCDU button push processing, initiating flight plan leg sequencing, and other system events. Otherwise, the FMCs operate independently.

In another possible dual configuration, a master FMC may be designated that directs all FM operations and synchronizes its data with the spare FMC such that the spare FMC can resume FM operations should the master fail or the spare be selected as the master. Other dual system configurations may exist as well.

4.0 FLIGHT MANAGEMENT FUNCTIONS

4.1 Introduction

This section describes the characteristics of the flight management functions.

4.2 Functional Initialization and Activation

4.2.1 Navigation Sensor Initialization

The system should provide for the initialization of various navigation sensors.

4.2.1.1 IRS Initialization

The system should be capable of initializing up to three ARINC 704 Inertial Reference Systems or ARINC 738 ADIRS when called upon to do so by flight crew action at the MCDU. In response to this initialize command, the system should output on its general data buses a burst of not more than four or less than two initial position latitude/longitude pairs. This data should consist of BCD-encoded set latitude and set longitude words having the labels and data standards defined for these quantities in ARINC Specification 429. Position data can be entered as a latitude/longitude or selected from the navigation data base as an airport and optionally gate, or input from the Global Navigation Satellite System Unit (GNSSU).

4.2.1.2 IRS Heading Set

The system should also be optionally capable of setting the IRS magnetic heading output to the value entered by the crew at the MCDU. The system should respond to the set heading command by transmitting a burst of not more than four or less than two BCD-encoded set heading words. ARINC Specification 429 defines the applicable label and data standards. Consult ARINC Specification 704: Inertial Reference System, for further information on initialization and heading set.

4.2.1.3 GNSS Initialization

The system should be optionally capable of initializing up to two ARINC 743A GNSS Sensors when called upon to do so by flight crew action at the MCDU. In response to this initialize command, the navigation system should output on its general data buses, current time and date and a burst of not more than four or less than two initial position of a latitude/longitude pair. This data should consist of BNR encoded current time in Universal Time Coordinated (UTC), and BCD encoded current date, set latitude, and set longitude words.

COMMENTARY

GNSS sensors may be indirectly connected to the navigation system through the IRS or ADIRS.

4.2.2 Flight Plan Initialization and Activation

~~Once the present position is initialized, a flight plan must be constructed.~~ There are various methods for constructing a flight plan such as:

- Pre-defined company routes

- Entry using FROM/TO format
- Menu selection of procedures and/or airways
- Individual waypoint entry
- Flight Plan Copy
- AOC/ATC Uplink

Refer to ~~Individual waypoint entry~~ Section 4.3.2.4 for additional details regarding ~~4.3.2.4, Lateral Flight Planning, details~~ these methods.

This initialization should be performed for every desired flight plan type. Once a flight plan has been constructed facilities should be provided to allow the crew to select a flight plan as the active flight plan or route.

4.2.3 Performance and Predictions Initialization

To initialize performance and trajectory prediction computations, gross weight (or ~~or~~ zero fuel weight ~~or~~ and block fuel), cost index, and cruise altitude ~~must be entered~~are required as a minimum. ~~Block fuel and zero fuel weight would be used instead of gross weight prior to aircraft fueling.~~ Other vertical flight planning parameters may also be initialized as desired. These are discussed in Section 4.3.2.5~~4.3.2.5, Vertical Flight Planning~~.

The trajectory prediction function also requires a specified flight plan or routing; most of the performance functions do not.

4.2.4 Lateral and Vertical ~~Navigation~~ Guidance Activation

Lateral ~~navigation~~ Guidance computations are activated by position initialization and the presence of an active route. Vertical ~~navigation~~ Guidance computations are activated by crew entry of gross weight, cost index, and cruise altitude. Coupled guidance can be selected using the ~~autoflight system~~AFCS ~~control~~ Control ~~p~~Panel. In most systems, lateral and vertical guidance are independent selections on the AFCS Control Panel ~~though in some,~~. Of those systems with independent selections, lateral guidance ~~is~~may or may not be a prerequisite for vertical guidance. Both methods are acceptable. In some systems, vertical guidance managed speed control ~~-~~(i.e. control to the FMF vertical guidance speed target)~~speed targets selected by the Flight Management function)~~ can be selected independent of vertical guidance level change control. On other systems, vertical guidance managed speed control requires managed level change control. ~~can be activated independent of vertical guidance. In other systems, managed speed control is a part of vertical guidance.~~ Both methods are acceptable.

4.2.5 Use of Data Link for System Initialization

The data link function can also be used to provide initialization data as described in Sections 4.2.2 and 4.2.3.

4.3 Functional Description

4.3.1 Navigation

The navigation function furnishes continuous, real-time, three dimensional solutions to the crew and provides the following navigational outputs:

- Estimated Aircraft Position (latitude, longitude, altitude)

- Aircraft Velocity
- Drift Angle (optional)
- Track Angle
- Magnetic Variation (optional)
- Wind Velocity and Direction
- Time
- Required Navigation Performance (RNP)
- ~~and an estimate of~~ Actual Navigation P~~actual p~~erformance (ANP) or Estimate of Position Uncertainty (EPU)

COMMENTARY

For the purpose of this document, ANP and EPU are intended to mean the same thing. In system architectures utilizing IRS sensors, drift angle and magnetic variation may be provided directly by the IRS and are not required to be computed by the FMS.

~~Further guidance on GNSS requirements for primary means navigation in oceanic and remote operations is defined in FAA Notice 8110.60.~~

For vertical ~~navigation~~aspects, the navigation function provides altitude, vertical speed and flight path angle. Unless explicitly stated otherwise, ~~A~~altitude computations operate upon inputs of smoothed inertial altitude from the Inertial Reference Units (IRUs), Air Data/Inertial Reference Units (ADIRUs), or Attitude and Heading Reference System AHRS, corrected by barometric (corrected or uncorrected) pressure altitude from the air data system. Flight path angle is derived from vertical speed and computed ground speed. ~~If augmented GNSS altitude is available it may be combined with the air data altitudes to produce a more accurate and stable altitude reference.~~

4.3.1.1 Multi-Sensor Navigation

The navigational output data is computed using the following:

~~Inertial Reference Unit (IRU or ADIRU) or Air Data Inertial Reference Unit (IRU or ADIRU) or alternatively, on some aircraft, Attitude and Heading Reference System (AHRS) or Vertical Gyro/Directional Gyro (VG/DG)~~

- Attitude and Heading
    - IRU or
    - ADIRU or
    - AHRS
- GNSS Receiver
- DME Transponder
- VOR/LOC Receiver
- ILS/MLS Receiver(s)
- Air Data Computer

The navigation function automatically selects the combination of available sensors that provides the best solution for estimating the aircraft position and velocity. Using the sensor accuracy characteristics, sensor raw data, and information about the current conditions, the best combination of position sensors (GNSS, IRU, DME, VOR, etc.) is selected to minimize the position determination error.

~~COMMENTARY~~

As a minimum, the navigation function must provide for GNSS data integrated with a heading/attitude sensor and air data system~~. S~~as some aircraft installations may not include other navigation radios. Adequate navigation availability must be a consideration in any implementation.

Commented [GE1]: Question was raised in Toulouse whether this should be a requirement and moved out of commentary?

~~While some installations utilize VG/DG sensor inputs, no specific interface provisions are defined in Section 5. VG/DG inputs in these installations are typically provided in ARINC 429 format by an intermediate system such as the autoflight system providing the appropriate data conversion.~~

4.3.1.2 Navigation Modes

Available navigation sensor data is validated before it is used for updates to the aircraft position. On aircraft with IRUs installed, the primary mode of operation utilizes IRS heading, attitude, position, and velocity, with IRS position and velocity combined with GNSS or VHF radio data (e.g.~~from~~ DME, Tactical Air Navigation System (TACAN), VOR, and LOC~~/MLS~~). On aircraft without IRUs the primary mode of operation is position and velocity from available sensors with heading and attitude being provided from an AHRS~~ or VG/DG source~~. The filtering algorithm should give appropriate weighting based on the sensor accuracy and should provide for sensor error modeling such that the navigation solution accuracy can be maintained through short term unavailability of various sensors. The navigation function should behave smoothly regardless of sensor availability or sensor transitions.

COMMENTARY

With the transition to RNP-based navigation, standardized navigation sensor selection logic is not required; however, in some implementations, a navigation mode sensor hierarchy such as the following may be utilized:

- LOC~~/MLS~~ (approach only)
- GNSS
- DME/DME
- DME/VOR

It may be desirable for non-IRU aircraft to correct heading/attitude sensor data based on the other available sensors to provide for a more accurate coasting mode of operation.

4.3.1.3 RNP-Based Navigation

The navigation function should satisfy the accuracy, integrity, and availability criteria set forth for aircraft systems intended to operate in RNP airspace. The systems criteria are specified in ~~RTCA~~ DO-236()~~: Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation~~.

The capabilities of the system should encompass position estimation, path definition, and path control and tracking, as well as computing position uncertainty. These capabilities, in addition to a means to evaluate and mitigate flight technical error, should form the basis for evaluating and determining total aircraft systems performance for RNP operations. The system should provide design, function, and operational integrity to ensure acceptable, repeatable, and error-free performance. The system should provide for clear and unambiguous indications of the navigation situation, including alerting to the flight crew when the navigation system does not comply with the requirements of the RNP airspace.

COMMENTARY

RNP is the required navigation performance necessary for operation within a defined airspace. RNP is specified in terms of accuracy, containment integrity, containment continuity, and availability of navigation signals and equipment for a particular airspace, route or operation.

The intent of the material in this section is to provide additional insight into ~~the emerging~~ RNP criteria, especially ~~the~~ system and integration considerations.

4.3.1.3.1 RNP Determination

The system should provide the appropriate RNP selection and entry capabilities to support determination of the applicable RNP for a flight plan path terminator (leg), procedure, or environment based upon the following, in order of priority:

- Manual RNP entry by the crew
- Leg-Based RNP value from ~~As established in~~ the navigation data base ~~for each leg in the flight plan~~or ATS datalink
- The default RNP value

COMMENTARY

RNP flight plans will consist of a limited subset of the path terminators defined in Section 4.3.2.2~~4.3.2.2, Navigation Data Base~~. These RNP routes and procedures will contain embedded information which establishes the RNP values which apply to the active or next path terminator; in the absence of the embedded RNP information, RNP may be determined or designated by default according to the airspace or environment. ~~In the event,~~When the system is operated using the default RNP values, the system will require ~~flight phase or~~ navigation environment (e.g. oceanic, enroute, terminal, approach) logic to ensure the proper transition from one RNP default value to another.

~~For some proposed architectures, the RNP versus actual performance comparisons or the determination of the applicable RNP may be allocated to a different unit. To support these architectures, the FMC should be designed to broadcast the current applicable RNP value on the general purpose output busses every 2 seconds.~~

The system should output the current RNP and ANP values on the ~~general purpose~~general-purpose output busses.

4.3.1.3.1.1 Manually ~~Selected~~ Entered RNP Values

The system should support manual entry within a range of possible RNP values appropriate for the PBN operation to be flown.

A manually entered RNP value should supersede any pre-programmed RNP value associated with a route, procedure or leg, or any default value. The manually entered RNP value should be clearly distinguishable as a manually entered value. In the event of a manually entered value larger than the value being overridden, an advisory alert or annunciation, as appropriate, should be provided to the crew. When a manual entry is deleted, the system should return to the appropriate RNP value based upon its priority. Unless deleted by the crew, the manual entry should remain the active RNP value.

COMMENTARY

The annunciation and alerting requirement for manually entered RNP values which exceed the active RNP value may be applied in various ways. One instance is upon entry of the value; this assures pilot awareness of his action relative to overriding limits applicable to the route, procedure, leg, or airspace, and which form the basis for separation. However, conditions such as NOTAMs or diversions due to weather may be among the reasons why a manual entry is made. Once accepted, the system should also actively monitor the manual entry relative to the RNP for the procedure, route, leg or default, in the event they change to a smaller value. Advance annunciation or alerting would also be advisable in this case.

4.3.1.3.1.2 Preplanned RNP Values

When an RNP approach procedure offers multiple lines of minima, the system should allow the flight crew to specify or pre-select the desired RNP value for the final approach segment.

COMMENTARY

Some RNP Authorization Required (AR) approaches are designed with multiple lines of minima corresponding to the respective RNP requirement. For these approaches, ARINC 424 specifies that the least restrictive “level of service” be coded in the primary record of the approach procedure~~NDB~~. Additional lines of minima are contained in the approach continuation records. For RNP approaches designed with multiple RNP values associated with lines of minima, the flight crew may desire a more restrictive RNP value than the one coded in the NDB. The system should provide a means for the flight crew to specify or pre-select the RNP value to use on the final approach segment prior to commencing the procedure.

~~4.3.1.3.1.2~~4.3.1.3.1.3 ~~Navigation Data Base~~Leg-Based RNP Values

~~The system should provide the capability to retrieve RNP values from the NDB. The format of the NDB records should be as specified in ARINC Specification 424.~~

The system should support the definition of an RNP on a leg-by-leg basis. The Leg-Based RNP value should be initialized to the navigation database value associated with the leg upon insertion of the navigation procedure into the flight plan. Uplink of a Leg-Based RNP Value via ATS datalink should be supported as part of dynamic RNP operations.

COMMENTARY

The system designer may need to consider that although an RNP value may be specified for individual leg(s) of a procedure (SID, STAR, Airway, Approach, Transition, etc.), one is not required. The procedure ~~planner~~ designer may develop procedures where the RNP value is designated leg by leg, or possibly for only selected flight legs. In this case, where nothing is specified, the system default value would apply.

On some routes and terminal procedures, restrictions along the route (e.g., terrain, airspace, environmental) may require that RNP values be placed on individual legs. These values may be other than the default values (for the respective ~~phase of flight~~navigation environment), and the values may decrease as the aircraft proceeds along the route. This RNP structure is referred to as the “Scalable RNP” element of Advanced RNP. It is assumed that published procedures which employ the Scalable RNP element will retrieve the respective RNP value for each leg from the NDB. In addition to the values coded in the NDB, RNP values may be transmitted via ATS datalink for dynamic operations.

When the RNP value is provided on downpath legs, the system should provide an indication to the flight crew when the RNP performance cannot be met at the next waypoint. The indication should be provided sufficiently early such that the flight crew can take action to resolve the situation.

~~4.3.1.3.1.3~~4.3.1.3.1.4 Stored Default Values

The system should provide the capability for stored default RNP values for the various navigation environments (e.g., oceanic, enroute, terminal, approach). These values may be established as pre-programmed values and/or loadable into the system.

Please refer to ICAO Doc 9613: *Performance-Based Navigation Manual* for the appropriate default values for the various navigation environments.

~~Point to ICAO PBN. The default values should be one of the PBN values.~~

COMMENTARY

The system design may establish the stored defaults with pre-programmed default values which can be overridden by loadable values via a separately loadable data file. As an alternative, the default values may be established by the loadable data file only. The approach taken will be influenced by the system built-in test design for faults and response, as well as the system design integrity.

~~**4.3.1.3.2 The two-step approach of hard coded values which can be overridden by loadable values offers the potential to compensate for a corrupted file or non-valid RNP values; supposedly the system could be used with the hard**~~

~~coded defaults and avoid any delays in service or operation due to the corrupted file or non-valid RNP value. The loadable file only approach avoids the potential for erroneous selection of default values. The RNP file could be adequately protected with an error detection and correction code to ensure fault detection and correction of the data. In addition, the procedures for establishing the defaults should provide assurance of the correctness and validity of the RNP defaults, along with verification prior to and during development of the file.~~

~~4.3.1.3.3~~4.3.1.3.2 Determination of Navigation System Performance

Navigation system performance should be evaluated considering position estimation error, path definition error, and flight technical error, which are the key elements of total system error. The total system error components in the cross-track and along track directions should be less than the RNP value 95% of the flying time.

COMMENTARY

The complete set of criteria for evaluating navigation system performance should be as set forth in the ~~RNP MASPS~~DO-236(). It should be noted that while all system integrators will need to evaluate their systems using the same standards and criteria, the systems implementations will vary and will dictate the acceptable operating modes and systems configurations. In one method, the system operation will be predicated on a design which relies upon comparisons of the systems' estimate of position uncertainty versus RNP, while at the same time evaluating integrity. However, this may carry with it restrictions on the mode of system operation (e.g. flight director mode or coupled with autopilot for RNP 1) necessary to achieve and assure consistent performance. In another method, the system operation will be predicated upon a real-time evaluation of all factors in total system error such that mode limitations or restrictions may not apply.

~~4.3.1.3.4~~4.3.1.3.3 Navigation Alerting and Display

The system should provide for clear and unambiguous indications of the state of the aircraft navigation system, including situational awareness information and alerts.

COMMENTARY

The system should provide information which allows the determination that the equipment is functioning properly. In addition, indications should be provided which allow the operator to determine the navigation sensors in use and the actual level of navigation performance. The system should also provide annunciations and alerting of unacceptable degradation in navigation performance, including alerting to the flight crew when the navigation system does not comply with the requirements of the RNP airspace, routes, and procedures. Some solutions for this could include indications and alerts when the system estimate of position uncertainty exceeds the RNP value. In others, the estimate of position uncertainty and flight technical error may have correlated indications and alerts.

Additional display and alerting requirements relative to manually entered RNPs and determination of navigation system performance are described in Sections 4.3.1.3.1.1 and 4.3.1.3.2.

4.3.1.4 Navaid Data

In support of the navigation function, the system must contain an extensive navigation data base. This database typically includes the enroute, terminal, and approach procedures (including RNP criteria) ~~along with applicable RNP requirements~~, the navigation aid ground station information, and the procedure recommended navaid information required for flight in the area in which the aircraft operates. See Section 9.2 for additional details regarding the navigation database~~9.0 Reference the Data Base Storage Considerations section for further detail~~.

4.3.1.5 Crew Controlled Navigation Options

Some sensor inputs to the navigation function should be capable of being blocked by pilot action. Localizer updates should always occur when in approach with an ILS approach selected as part of the flight plan. DME, VOR, and GNSS updating may be stopped by manual selection on the MCDU. Additionally, DME and VOR navaids may be individually blocked from the navigation solution by entering their identifiers on the MCDU or by data link. This manual blockage of individual navaids should be cleared at flight completion.

Capability may also be provided for navigation override where the operator can force the navigation position to coincide with a selected navigation sensor or reference position~~,~~ (e.g.~~,~~ takeoff runway threshold or intersection point). This position shift action aligns the system position to the selected sensor. Override of the navigation position to a manual reference point (i.e.~~,~~ overfly fix) is inconsistent with RNP operation.

These options are intended as backup options for use in the event that a system generated message, such as verify position, alerts the crew to a problem in the navigation that the system cannot correct itself.

Facilities should be provided to accommodate manual tuning by the crew of the DME/VOR radios. If a receiver is being manually tuned, the navigation function should continue to auto tune any available channels with station selection as specified for auto tuning. If insufficient channels remain for satisfactory auto-tuning, then the navigation function may utilize the manually tuned stations if appropriate.

4.3.1.6 VHF Radio Tuning

4.3.1.6.1 Automatic Station Selection

When the navigation VHF radio receivers are available for automatic tuning, the navigation function should select and tune appropriate ground radio navigation facilities and use their position fixing data to refine the current navigation position. The navaids considered to be available for selection should be those contained within a usable distance from the estimated current aircraft position. This group of navaids, combined with any additional navaids defined by crew entry, should make up the set of navaids from which the best navigation aids can be drawn.

With scanning DME installations, up to five frequencies can be allocated to tune each interrogator and, depending upon the aircraft, may be designated for multiple DME range measurements, VOR/DME position fixing, ILS/DME or procedure-specified or pilot-selected navaids. If a procedure being flown has a specified navaid associated with it, then that navaid must be tuned and used for navigation purposes.

Station selection criteria should be designed to limit station switching activity to a minimum.

4.3.1.6.2 Navaid Reasonableness Determination

DME range measurements received by the navigation function should be compared with that of the expected radio range measurement as a reasonableness test. When the comparison is outside of a reasonable tolerance, the data should be rejected and should not be used in the position computations.

4.3.1.7 Real Time Clock

The system should receive real time (UTC) clock data from the GNSS. For back up purposes, the system should utilize a GNSS-updated (or manually synchronized) on-board clock (See Section 5.1.15), or provide an internal UTC time clock capability which is synchronized with the external input or may be manually initialized. In the event of loss of the external input, the internal time clock should maintain UTC within a ±1 second accuracy over the duration of the flight.

4.3.2 Flight Planning

The flight planning facilities provide for the assembly, modification, and selection of active and secondary flight plans. Data can be extracted from the navigation data base that contains airline-unique company flight plans, navigational aids, airways, waypoints, published departure and arrival procedures, approaches along with associated missed approach procedures, etc. The selection of flight planning data is done through the MCDU, through the data link function or optionally ~~with the pointing device~~via a graphical user interface. Flight plan capacity should be a minimum of 1~~0~~50 waypoints in each flight plan. For longer range aircraft, a minimum of 200 waypoints in each flight plan is highly encouraged.

Commented [BM(AU2]: Change to graphical

COMMENTARY

Various system implementations use different flight plan designations such as active, modified, temporary, primary, and secondary. Within this document, the following designations are used: Active, Modified, and Secondary. With respect to a flight plan, the terms Primary and Alternate are also used and refer to the series of waypoints in an active, modified, or secondary flight plan associated with the route to the primary and alternate destination respectively.

~~provide for differing flight planning designations, such as active, modified, temporary, primary, secondary, inactive, Route 1, or Route 2. These are all acceptable, and are referred to generically herein as active, modified, and secondary flight plans.~~

4.3.2.1 Flight Plan States

Once a route is entered or selected as the active flight plan, it becomes the basis from which all guidance and advisory data is referenced. The secondary flight plan can have the same terminus or can be completely different with no shared waypoints.

It should be possible to make modifications to the active flight plan and review the impact of those modifications without affecting the active flight plan. For crew review and evaluation, the ~~EFIS~~ ND ~~(optional)~~ should show the modified flight plan together with the unmodified active flight plan, with unique symbology to differentiate between them. ~~Performance (t~~Trajectory~~)~~ predictions should be available on the MCDU for the modified flight plan. During this modification process, all guidance and advisory data is still referenced to the unmodified active flight plan.

This modification process ~~may~~ should use a separate modified flight plan. ~~, or it may make use of the secondary flight plan. If a separate modified flight plan is used, then w~~When all the desired changes have been made, the crew must invoke the modified flight plan to replace the active flight plan. This action will replace the active flight plan and terminate the existence of the modified flight plan. All guidance and advisory data will immediately be referenced to the newly invoked flight plan.

Facilities should be provided to access the independent secondary flight plan and to copy this flight plan into the active flight plan when requested by the crew. ~~These facilities will also be used in modifying the active flight plan if the manufacturer has opted to use this method to preview flight plan changes, rather than having a separate modified flight plan.~~

~~COMMENTARY~~

~~In defining how the FMS should provide the preview capability for the active flight plan, manufacturers should take into account the need to use the secondary flight plan for other purposes. Airlines have expressed a desire to retain the content of this flight plan when flight plans received from Air Traffic Control (ATC) are being previewed.~~

4.3.2.2 Navigation Data Base

The Navigation Data Base (NDB) contains enroute, terminal, and airline custom defined data needed to support the flight management functions. It should be packed in a format to efficiently use available memory and to provide rapid access to the data. The format of the source data for the navigation data base is defined in ARINC 424. The supplier of the data, packing format, and maintenance of the data is to be specified by the supplier.

Section 9.2 of this document provides a more complete description of the content of the navigation data base.

Each navigation data base is valid for a specific effectivity period and is updated typically on a 28-day cycle. The effectivity dates for a set of data are displayed for reference on the system's configuration definition page. The navigation data base effectivity period should be compared automatically with the current date and discrepancies annunciated.

The system should be capable of defining a flight path based on standard ARINC 424 path terminators as shown below:

AF		DME Arc to a Fix
CA		Course to an Altitude
CD		Course to a Distance
CF	*	Course to a Fix
CI		Course to an Intercept
CR		Course to Intercept a Radial
DF	*	Direct to a Fix
FA	*	Course from Fix to Altitude
FC		Course from Fix to Distance
FD		Course from Fix to DME Distance
FM		Course from Fix to Manual Term
HA	*	Hold to an Altitude
HF	*	Hold, Terminate at Fix after 1 Circuit
HM	*	Hold, Manual Termination
IF	*	Initial Fix
PI		Procedure Turn
RF	*	Constant Radius to a Fix
TF	*	Track to Fix
VA		Heading to Altitude
VD		Heading to Distance

VI	Heading to Intercept next leg
VM	Heading to Manual Termination
VR	Heading to Intercept Radial

COMMENTARY

Even though it is expected that in the future only a limited set of these terminator types will be used, as defined (*) above and as specified in ~~the RTCA RNP MASPS~~DO-236(), the advanced system should continue to support this list as long as procedures exist that use these terminator types.

4.3.2.3 Supplemental and Temporary NDB Creation and Management

Besides waypoints and navaids contained in the data base, new waypoints that can be used in flight plan construction may be created in a number of ways.

The system should support creation of new waypoints in the following ways:

- Point Bearing/Distance (PBD)
- Point Bearing/Point Bearing (PB/PB)
- Along Track Fix
- Latitude/Longitude
- Dir-To Abeam Waypoint(s)

The system may support creation of new waypoints in the following ways:

- Latitude/Longitude Crossing
- Unnamed Airway Intersection
- Fix Intersection
- Runway Extension
- FIR/SUA Intersection

These waypoints should be stored in the temporary navigation database.

~~Waypoints may be created using Point Bearing/Distance (PBD), PB/PB, Along Track Offset (ATO), Lat/Long, crossings, airway intersections, runway extensions, or ABEAM facilities, and are stored in the temporary navigation data base. These capabilities are optional as defined below.~~

Optional capability may be provided to allow waypoints, navaids, and airports to be directly created by the crew (or data link function) using a supplemental navigation data base facility. The supplemental NDB is retained indefinitely (until deleted). The temporary data base is retained until flight complete (deleted automatically after touchdown). A supplemental and temporary navigation data base summary facility is provided for the crew to inspect, review, and select the current contents of these data bases.

4.3.2.3.1 PBD Waypoints

Waypoints can be created as bearing/distance off existing named waypoints, navaids or airports.

4.3.2.3.2 PB/PB Waypoints

Waypoints can be created as the intersections of bearings from two defined waypoints.

4.3.2.3.3 ~~ATO~~ Along Track Fix Waypoints

Waypoints can be created by an Along Track ~~Offset (ATO)~~Distance from an existing flight plan waypoint. The waypoint that is created is located at the distance entered and along the current flight plan path from the waypoint used as the fix. A positive distance results in a waypoint after the fix point in the flight plan while a negative distance results in a waypoint before the fix point.

4.3.2.3.4 Lat/Long Waypoints

Waypoints can be created by entering in the latitude/longitude coordinates of the desired waypoint.

4.3.2.3.5 Lat/Long Crossing Waypoints

Waypoints can be created by specifying a latitude or longitude. In this case, a waypoint will be created where the active flight plan crosses that latitude or longitude. Latitude or longitude increments can optionally be specified in which case several waypoints are created that correspond to where the flight plan crosses the specified increments of latitude or longitude.

4.3.2.3.6 Unnamed Airway Intersection ~~of Airways~~

Waypoints can be created as the intersection of two airways. Waypoints will be created at all points where the airways cross.

4.3.2.3.7 Fix Intersection Waypoints

Waypoints can be created by using a Fix Reference MCDU page. Reference information includes creation of abeam waypoints and creation of waypoints where the intersections of a specified radial or distance from a specified fix intersects the current flight plan is computed.

4.3.2.3.8 Runway Extension Waypoints

Runway extension waypoints may be created by selecting a distance from a given destination runway. The new waypoint will be located that distance from the runway threshold along the reciprocal ~~runway~~ of the runway heading.

4.3.2.3.9 Dir-To Abeam Waypoints

If a direct-to is performed, facilities should be provided to retain intervening waypoint information (~~such as~~e.g. speed/altitude constraints, waypoint wind data, etc.). If the abeam facility is selected, then temporary waypoints will be created at their abeam point on the direct to path. Any waypoint information associated with the original waypoint will be transferred to the new waypoints.

COMMENTARY

Care should be exercised in the implementation of the abeam waypoint function since other effects such as inappropriate course changes in the direct-to path and inclusion of abeam points in some data link waypoint lists may be undesirable.

4.3.2.3.10 FIR/SUA Intersection Waypoints

The system should define waypoints at the intersection of Flight Information Region (FIR) boundaries and Special Use Areas (SUA) stored in the navigation data base in constructing flight plans.

Commented [GE3]: Should this be a may or a should?

4.3.2.3.11 Suggested Waypoint Naming Convention

Flight plan waypoints created using the above capabilities should be given flight plan identifiers in accordance with the following conventions:

Place/Bearing/Distance	wptnn
Place-Bearing/Place-Bearing	wptnn
Along Track Waypoint	wptnn
Latitude/Longitude	wxxyzzz or xxwzzzy
Crossing Fix	wxx or yzzz
Airway Intercept	Xawy
Dir-To Abeam Waypoint	wptnn
Radial or abeam intercept	wptnn
Runway extension	RXrwyhdg
FIR/SUA intersection	FIRnn or SUAnn

Upper case indicates actual characters used, and lower case indicates variable content as follows:

nn	FMS-determined sequence number
awy	Full identifier of airway following the intersection
wpt	First 3 characters of the base waypoint identifier
w	N or S as appropriate
y	E or W as appropriate
xx	degrees of latitude
zzz	degrees of longitude
rwyhdg	two-digit nominal runway heading

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<< Advice on avoiding naming convention which results in NDB procedure waypoint names.>>

4.3.2.4 Lateral Flight Planning

4.3.2.4.1 Flight Plan Construction

Flight plans can be constructed in a variety of ways:

- ~~NDB~~ Terminal Area procedures
- Airways
- Pre-stored company routes
- Waypoints
- Navaids
- Runways
- Supplemental/Temporary waypoints
- Combinations thereof

These selections may be strung together by menu selection from the NDB or by specific edit actions. Flight plans can also be constructed and edited through the data link function.

~~Computation of flight plan magnetic courses should utilize an internal magnetic variation model utilizing a magnetic variation data base as defined in Section 9.5.~~

4.3.2.4.2 ~~NDB~~Terminal Area Procedures

The following navigation data~~-~~base procedure types should be supported:

- Standard Instrument Departure (SID)
- Engine-~~o~~Out SID
- Standard Terminal Arrival Route (STAR)
- ~~FMS/Area Navigation (~~RNAV/RNP~~)~~ Approach including LP/LPV (SBAS)
- GPS (GNSS) Approach~~Global Positioning System (GPS)/GNSS~~
- ~~ILS/MLS~~ILS/LOC Approach
- MLS Approach
- GLS (GBAS) Approach
-

The following navigation data~~-~~base approach procedure types may be supported based on individual system or customer requirements:

- RNP Authorization Required (RNP-AR)
- VOR
- ~~Non Directional~~Non-Directional Beacon
- Localizer Directional Aid (LDA)
- Instrument Guidance System (IGS)

- RNAV Visual Flight Procedure (RVFP) / Visual Guidance Approach (VGA)
- Circling Approach
- Visual Prescribed Track (VPT)

COMMENTARY

In the future, with the anticipated widespread introduction of precision FMS and GPS/GNSS approach procedures based on the RNP navigation concept, the use of traditional non-precision approach procedures is expected to diminish.

The following navigation database SID procedure types may be supported based on individual system or customer requirements:

- RNP Authorization Required (RNP-AR)

Some of these procedures may have an associated RNP value to be used for the navigation function while flying these procedures.

4.3.2.4.3 Flight Plan Editing

The flight planning function offers various ways to modify the flight plan at the crew's discretion. These are described in the following sections.

4.3.2.4.3.1 Direct/Intercept Option

The direct/intercept feature allows the crew to select any fixed waypoint as the active waypoint and for the intercept option, to select the desired course into this waypoint. If the direct-to option is selected, the waypoint becomes the active waypoint and the flight plan that results goes direct from the current aircraft position to that waypoint. Any waypoints in the flight plan before that waypoint are deleted from the flight plan. Whenever the intercept option is selected on a given fixed waypoint, either the direct-to course or an entered course can be selected as the course to that waypoint.

4.3.2.4.3.2 Entry of Waypoints

Waypoints may be entered at any point in the flight plan provided it results in a valid leg combination. Refer to ARINC 424 for valid leg combinations. These waypoints may be from the navigation data base, supplemental data base, or temporary data base. It is possible that more than one waypoint uses the same identifier. Therefore, facilities must be provided to display the coordinates for all selections and allow the crew to make the choice, or alternatively to provide logic for automatic selection.

Commented [GE4]: Should this last part be kept?

4.3.2.4.3.3 Flight Plan Linking

Facilities should be provided to select portions of the flight plan and re-link that portion with another portion of the flight plan.

4.3.2.4.3.4 Flight Plan Delete

Facilities should be provided to allow the use of a delete function to remove unwanted portions of a flight plan.

4.3.2.4.3.5 Procedure Selection

Selecting procedures from the data base will replace a previous procedure selection, retaining the active waypoint if it was part of the previous procedure selection and optionally retaining constraints previously sent by the ATC on waypoints part of the selected procedure.

.

4.3.2.4.3.6 Holding Patterns (HM Leg)~~and Procedure Turns~~

Holding patterns ~~and optionally procedure turns~~ can be defined by data base procedure or manually specified at the current position or at a~~ny~~ selected waypoint. All parameters for holding patterns ~~or procedure turns~~ are editable including ~~entry~~ inbound course, turn direction, and leg time/length~~, etc~~. flyover/flyby, hold speed,

<<Add Conventional Hold versus RNP Hold in Lateral Path Construction section and point to DO-283()>>

~~COMMENTARY~~

~~In the future, with the anticipated widespread introduction of precision FMS and GPS/GNSS approach procedures the use of procedure turns as part of traditional approach procedures is expected to diminish.~~

4.3.2.4.3.7 Flight Plan Editing using Data Link

Facilities should be provided to perform flight plan construction and editing using both AOC and ATC data link. If a flight plan data link is received, then a message is issued to the crew of the pending request. Facilities to review and to accept or reject the data link action must be provided.

4.3.2.4.3.8 Flight Plan Editing using a Pointing Device

[Deleted by Supplement 5]

~~Recommendations for this function will be provided in a future Supplement to this Characteristic.~~

4.3.2.4.4 Flight Planning Support for ATM

[Deleted by Supplement 5]

4.3.2.4.5 Missed Approach Procedures

The flight planning function also allows missed approach procedures to be included in the flight plan. These missed approach procedures can either come from the navigation data base where the missed approach is part of a published procedure, in which case they will be automatically included in the flight plan~~.~~. Additional waypoints can be added beyond the MAP to be flown in the event of a missed approach.~~Alternatively, or they a missed approach can be manually constructed by entry through the MCDU. In either case,~~ ~~a~~Automatic guidance will be available upon activation of the missed approach. ~~Use of RNP-based FMS and GPS/GNSS approach procedures may not allow manually constructed missed approach procedures.~~

4.3.2.4.6 Lateral Offset Construction

~~The flight planning function can create a parallel flight plan by specifying a direction (left or right of path) and distance (up to 99 nm). Capability may be optionally provided to allow selection of a start and end waypoint for an active flight plan. A complete lateral path for the offset will be generated to ensure guidance and other advisories, consistent with the requirements for RNP navigation and the RTA function.~~

~~COMMENTARY~~

~~Designers should ensure that flyable offset paths are created. Series of offset waypoints that create course reversals or unflyable paths should be avoided. Transition paths to and from the offset path should also be defined.~~

The flight planning function should support the creation of a parallel offset path via specification of a direction (left or right of path) and distance. For the offset distance, the system should support a maximum value of at least 20 NM with a resolution of 0.1 NM for at least the first 10 NM. Multiple pre-planned parallel offsets may be supported but are not required.

The system should allow initiation of the parallel offset at the current aircraft position or at a specified downpath waypoint.

The system should allow termination of the parallel offset: immediately when commanded by the crew, at a specified downpath waypoint, or automatically:

- at the first fix of an instrument approach procedure (IAF, IF or FAF); or
- when a leg type other than TF, CF, DF, RF is encountered; or
- when the offset path is not flyable (i.e. when a combination of ground speed, track change geometry and waypoint proximity forces course reversals); or
- when reaching a lateral discontinuity

When transitioning to and from the offset path, a 30-degree intercept angle should be used by default. Entry or selection of another intercept angle may be optionally provided.

The system should provide the capability to offset predefined curved paths such as Fixed Radius Transitions (FRT) and optionally, RF legs.

When executing a parallel offset, all performance requirements and constraints of the original path should be applicable to the offset path. Guidance parameters (e.g. cross-track deviation, distance-to-go) should be referenced to the offset path and offset waypoints. The system should provide a means for display of both the parallel offset path and the original path. Display of the transition paths between the original path and the parallel path is highly recommended.

Refer to DO-236() and DO-283() for additional lateral offset requirements.

4.3.2.4.7 Magnetic Variation

The system should have the capability of assigning a magnetic variation (MagVar) at any fix/location when operations are conducted relative to Magnetic North. The MagVar value may be retrieved from the NDB, or in the absence of an NDB-specified value, computed using an internal magnetic reference.

COMMENTARY

DO-283() provides requirements for the treatment of MagVar on terminal procedures, airports, leg types, en route areas and an internal set of magnetic variation tables.

ARINC 424 specifies NDB requirements for MagVar on certain leg types. Additionally, ARINC 424-19 introduced the concept of a Procedure Design MagVar (PDMV) which attempts to relieve the confusion on which MagVar value to use (when the various options conflict) by coding an appropriate MagVar value on the respective instrument procedure or individual procedure legs.

The system should incorporate a hierarchy to determine the use of MagVar sources in the following order (note that 1, 2 and 3 will be coded in the NDB):

1. If the leg is part of a navigation database terminal area procedure, the MagVar to be used is the PDMV for the procedure or individual procedure legs, when available.

2. If the leg is part of a navigation database terminal area procedure and ~~the~~ the PDMV is not specified and a recommended VHF navaid magnetic declination exists for the leg, ~~,~~ the MagVar to be used is the ~~MagVar of record for the airport or the~~ recommended VHF navaid magnetic declination of the leg.

~~, if specified.~~

3. If the leg is part of a navigation database terminal area procedure and the PDMV is not specified and a recommended VHF navaid magnetic declination does not exist for the leg, the MagVar to be used is the MagVar of record for the airport.

4. If the leg is not part of a procedure and the terminating fix is a VOR, the MagVar to be used is the station declination of the VOR.

5. If the leg is not part of a procedure and the terminating fix is not a navaid, the MagVar to be used is defined by the system using an internal model (See Section 9.5).

4.3.2.5 Vertical Flight Planning

Vertical flight planning consists of entry and deletion ~~consists~~ of ~~specification of~~ altitude and speed ~~and altitude~~ constraints at waypoints (Section 4.3.2.5.2 and 4.3.2.5.3) as well as other parameters (listed below) which are used by the Vertical Guidance, Trajectory Predictions, and Performance Calculations functions.

~~including At, At or Above, At or Below, and Window constraints), step climbs, (optional) step descents, (optional) cruise climb, tactical changes of speed and altitude and winds at waypoints, and during descent.~~

~~Facilities~~The system should ~~be~~ provide~~provided~~ for entry and modification of the following performance parameters:~~crew selection and entry of various performance constraints:~~

- Zero Fuel Weight (or Gross Weight)
- Block Fuel
- Cost Index
- Cruise Altitude
- Climb Mode (Section 4.3.4.1.1)
- Cruise Mode (Section 4.3.4.1.2)
- Descent Mode (Section 4.3.4.1.3)
- Hold Pattern ~~Leg Time/Distance/~~Speed
- Airport S~~s~~peed Limit~~Restriction~~
- Thrust Reduction Altitude/Height
- Climb Acceleration Altitude/Height
- ~~Performance correction factors such as Drag~~
- ~~Factor and Fuel Flow Factor~~
- ~~Cost Index~~
- RTA ~~waypoint~~Waypoint, ~~t~~Time, and ~~time~~ To~~to~~lerance (Section 4.3.3.2.4 & 4.3.3.2.5)
- Climb and ~~d~~Descent ~~w~~Winds and ~~/t~~Temperatures (Section 4.3.2.5.1)
- Cruise Wind at Waypoint (Section 4.3.2.5.1)~~waypoint winds/temperatures~~
- ~~Temperature~~
- ~~Tropopause altitude~~Transition Altitude/Level
- Destination QNH

- Takeoff Derate(s)
- Climb Derate

All of these ~~items~~ parameters should be considered in ~~generating~~ the trajectory predictions ~~the vertical trajectory a~~and performance function computations.

The system may provide for entry and modification of the following ~~additional~~ parameters ~~may also be considered in developing the vertical trajectory~~:

- Maneuver Margin
- Min Cruise Time
- Min Rate of Climb (~~Clb~~All-Engine - Max Climb thrust rating)
- Min Rate of Climb (~~Crz~~All-Engine - Max Cruise thrust rating)
- Min Rate of Climb (Engine- ~~o~~Out – Max Continuous thrust rating)
- Drag Factor and Fuel Flow Factor
- Anti-~~i~~Ice ~~b~~Bands
- Tropopause Altitude
- Minimum
- ~~Optimal~~ Step Climb ~~Climb s~~Size and ~~e~~Enterable ~~d~~Default
- Preplanned Cruise Altitude Step(s)
- Optimal Cruise Altitude Step(s)
- Cruise-Climb Block Altitude (Drift-Up Cruise)
- Preplanned Cruise Speed Changes
- Multiple Cruise Winds at Waypoints (Section 4.3.2.5.1)
- Cruise Temperature at Waypoints (Section 4.3.2.5.1)

Commented [BM(AU5]: Clarify

When supported, these parameters should be considered in the trajectory predictions and performance function computations.

4.3.2.5.1 Wind, Temperature, and Atmospheric Model

Wind and temperature may be entered via the MCDU or data link. The wind model for the climb ~~segment~~ phase should be a set of wind magnitudes and bearings that are entered for different altitudes. The value at any altitude is then computed from these values and merged with the current sensed wind.

The temperature model for the climb ~~segment~~ phase should be temperature values entered for different altitudes. The value at any altitude is then computed from these values and merged with the current sensed temperature.

Wind models for use in the cruise ~~segment~~ phase should allow for the entry of one or more winds (altitude, magnitude, and bearing) at a waypoin~~t: a single value or multiple wind/altitude pairs~~t. Systems should merge these entries with current winds obtained from sensor data in a method which gives a heavier weighting to sensed winds close to the aircraft.

Temperature models for use in the cruise ~~segment~~phase may allow for entry of a temperature and altitude at a waypoint or an ISA deviation at a waypoint. As a minimum, the system should allow for entry of a single cruise temperature or ISA deviation value that applies throughout cruise. Systems should merge these entries with current temperature (ISA deviation) obtained from sensor data in a method which gives a heavier weighting to sensed values close to the aircraft.

~~The cruise temperature data may be entered associated with flight plan waypoints and/or as a single value that applies throughout the flightcruise.~~

The wind model used for the descent ~~segment~~ phase should be a set of wind magnitudes and bearings entered for different altitudes. The value at any altitude should then be computed from these values, and merged with the current sensed wind.

The temperature model for the descent ~~segment~~ phase should be temperature values entered for different altitudes. The value at any altitude is then computed from these values and merged with the current sensed temperature.

~~A more advanced representation of wind data in the FMC is the use of a grid wind model which may be up to a four-dimensional definition of wind. The grid winds would not be tied to waypoints in the flight plan, but associated with latitude longitude regions similar to a magnetic variation model. It is expected that grid winds would only be uplinked and not manually entered.~~

Temperature should be based on the International Standard Atmosphere (ISA) with an offset (ΔISA) obtained from pilot entries or the actual sensed temperature. ~~The temperature data may be entered associated with flight plan waypoints or as a single value that applies throughout the flight.~~ Likewise, the tropopause altitude (altitude at which constant temperature begins) may be crew enterable (with 36,089 ft. as default).

4.3.2.5.2 Waypoint Altitude Constraints

The system should allow insertion of AT, AT or ABOVE, AT or BELOW, and WINDOW (i.e. both an AT or ABOVE and AT or BELOW) altitude constraints at waypoints in the flight plan. Waypoint altitude constraints may be inserted directly via crew entry or indirectly via selection of a procedure in the navigation database. The system should allow for entry and modification of WINDOW altitude constraints.

COMMENTARY

Historically, crew entry and modification of WINDOW altitude constraints was not possible on some systems. On such systems, WINDOW constraints could only be inserted via selection of a navigation database procedure. Per DO-236(), the system is required to support crew entry of each type of altitude constraint.

The system should avoid automatic deletion of altitude constraints above cruise altitude.

COMMENTARY

Upon cruise altitude modification or procedure insertion, some systems will automatically delete altitude constraints that are above cruise altitude. This design has led to airline and ATC complaints as it is susceptible to order of operation and situational awareness issues. System designs where altitude constraints are retained and ignored and/or where altitude constraints are retained and the cruise altitude modified are preferable.

The system should designate altitude constraints as either CLIMB constraints or DESCENT constraints. The system should designate an altitude constraint on a waypoint in the departure or missed approach procedure as a CLIMB constraint. The system should designate an altitude constraint on a waypoint in the arrival or approach procedure as a DESCENT constraint. The system may incorporate additional rules to designate an altitude constraint as either a CLIMB or DESCENT constraint when the constraint is on a waypoint which is not part of a procedure listed above.

The system should apply CLIMB constraints to the takeoff and climb phases of flight in accordance with Table 4.3.2.5.2-1 below. The system should apply DESCENT constraints to the descent and approach phases of flight in accordance with Table 4.3.2.5.2-1 below.~~Table 4.3.2.5.2-1 Altitude Constraint Applicability~~

Altitude Constraint Type	Altitude Constraint Phase/Applicability	
	CLIMB	DESCENT
AT or BELOW	Do not exceed PRIOR to and AT	Do not exceed AT and AFTER
AT or ABOVE	Do not go below AT and AFTER	Do not go below PRIOR to and AT
AT	Do not exceed PRIOR to, cross AT, do not go below AFTER	Do not go below PRIOR to, cross AT, do not exceed AFTER
WINDOW	Do not exceed upper bound PRIOR to and AT Do not go below lower bound AT and AFTER	Do not exceed upper bound AT and AFTER Do not go below lower bound PRIOR to and AT

Table 4.3.2.5.2-1 Altitude Constraint Applicability

Field Code Changed

COMMENTARY

PRIOR to, AFTER, and AT in Table 4.3.2.5.2-1 refer to sequence of the waypoint with the altitude constraint.

The descent path is typically constructed using a series of straight line segments. For waypoints with a descent AT constraint, the descent path will typically cross at the specified altitude. When flown using the Vertical Guidance function, some systems may cross above or below the altitude constraint value due to a vertical fly-by transition. DO-236() and DO-283() define the acceptable altitude deviation for a vertical fly-by transition.

Upon procedure selection, most systems combine common waypoints between departure, arrival, and/or approach segments. In rare situations, the altitude constraint coded in one procedure differs from the altitude constraint coded in the other procedure (e.g. STAR and APPROACH). When this occurs, systems may use different logic to meld the altitude constraints; however, upon subsequent selection by the crew of a different procedure (e.g. same approach with a new ~~STAR or runway~~approach transition) where the common waypoint is retained, the system should ensure the altitude constraint on the ~~(former/current)~~ common waypoint originate~~d~~s from one of the currently selected navigation procedures (provided the crew did not modify the altitude constraint).

The system should provide a means to initiate a vertical direct-to to a vertically (altitude) constrained fix.

COMMENTARY

This allows the aircraft to proceed from present altitude direct-to a specified altitude in the flight plan. If there are altitude constraints prior to the vertical direct-to fix, the altitude constraints are deleted.

~~the altitude constraint on the common waypoint should be re-assessed.~~

4.3.2.5.3 Waypoint Speed Constraints

The system should allow insertion of AT, AT or ABOVE, and AT or BELOW speed constraints at waypoints in the flight plan. Waypoint speed constraints may be inserted directly via crew entry or indirectly via selection of a procedure in the navigation database.

The system should designate speed constraints as either CLIMB constraints or DESCENT constraints. The system should designate a speed constraint on a waypoint in the departure or missed approach procedure as a CLIMB constraint. The system should designate a speed constraint on a waypoint in the arrival or approach procedure as a DESCENT constraint. The system

Formatted: Commentary Text, Indent: Left: 0", Right: 0" may incorporate additional rules to designate a speed~~n altitude~~ constraint as either a CLIMB or DESCENT constraint when the constraint is on a waypoint which is not part of a procedure listed above.

The system should apply CLIMB constraints to the takeoff and climb phases of flight in accordance with Table 4.3.2.5.3-1 below. The system should apply DESCENT constraints to the descent and approach phases of flight in accordance with Table 4.3.2.5.3-1 below.

Speed Constraint Type	Speed Constraint Phase/Applicability	
	CLIMB	DESCENT
AT or BELOW	Do not exceed PRIOR to and AT	Do not exceed AT and AFTER
AT or ABOVE	Do not go below AT and AFTER	Do not go below PRIOR to and AT
AT	Do not exceed PRIOR to, cross AT, do not go below AFTER	Do not go below PRIOR to, cross AT, do not exceed AFTER

Field Code Changed

Table 4.3.2.5.3-1 Speed Constraint Applicability

COMMENTARY

PRIOR to, AFTER, and AT in Table 4.3.2.5.3-1 refer to sequence of the waypoint with the altitude constraint.

In accordance with Table 4.3.2.5.3-1, the system should apply ABOVE climb speed constraints after sequence of the speed constraint waypoint until transition to the climb MACH or transition to cruise flight phase. The system should apply ABOVE descent speed constraints upon transition to the descent CAS (from the cruise flight phase or descent MACH) until sequence of the speed constraint waypoint.

BELOW constraints may be applied in cruise flight phase in accordance with Table 4.3.2.5.3-1. This is recommended for missed approach and low(er) cruise altitude scenarios where procedural waypoint speed constraints may operationally be encountered while in cruise.

Upon procedure selection, most systems combine common waypoints between departure, arrival, and/or approach segments. In rare situations, the speed constraint coded in one procedure differs from the speed constraint coded in the other procedure (e.g. STAR and APPROACH). When this occurs, systems may use different logic to select or meld the speed constraints; however, upon subsequent selection by the crew of a different procedure (e.g. same approach with a new approach transition) where the common waypoint is retained, the system should ensure the speed constraint on the common waypoint originates from one of the currently selected navigation procedures (provided the crew did not modify the speed constraint).

~~however, upon subsequent selection by the crew of a different procedure (e.g. STAR or runway transition), the system should ensure the speed constraint on the (former/current) common waypoint originated from the currently selected navigation procedures.~~

4.3.2.5.4 Temperature Compensation

For Baro-VNAV approach operations, unless compensated for temperature, the system can only be used within the temperature limitations (if any) ~~for temperature~~ published on approach procedure charts. To enable baro-VNAV approach operations outside published temperature limits or operations in non-ISA temperature environments, the preferred method is for the system to correct for the effects of temperature on the barometric altitude upon crew entry of a destination temperature. Systems providing automatic temperature compensation to the baro-VNAV guidance must comply with DO-236() ~~a~~Appendix H and DO-283() ~~a~~Appendix H.

COMMENTARY

The barometric altimeter indication is influenced by temperature variations. During cold temperature operations (below ISA), the airplane's true altitude is lower than the indicated altitude. Similarly, during hot temperature operations (above ISA), the airplane's true altitude is higher than the indicated altitude. This results in an aircraft flying a vertical path angle shallower than (or steeper than for hot temperature) the designed vertical path angle (or gradient) without an indication in the flight deck.

Temperature compensation corrects altitude constraints and vertical angles to those intended by the procedure designer. When the aircraft flies the compensated altitudes, the aircraft is actually flying the intended descent/approach path. However, the indicated altitude will be different than the charted value.

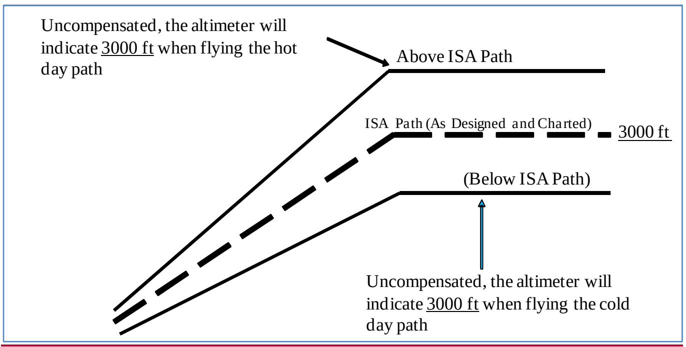


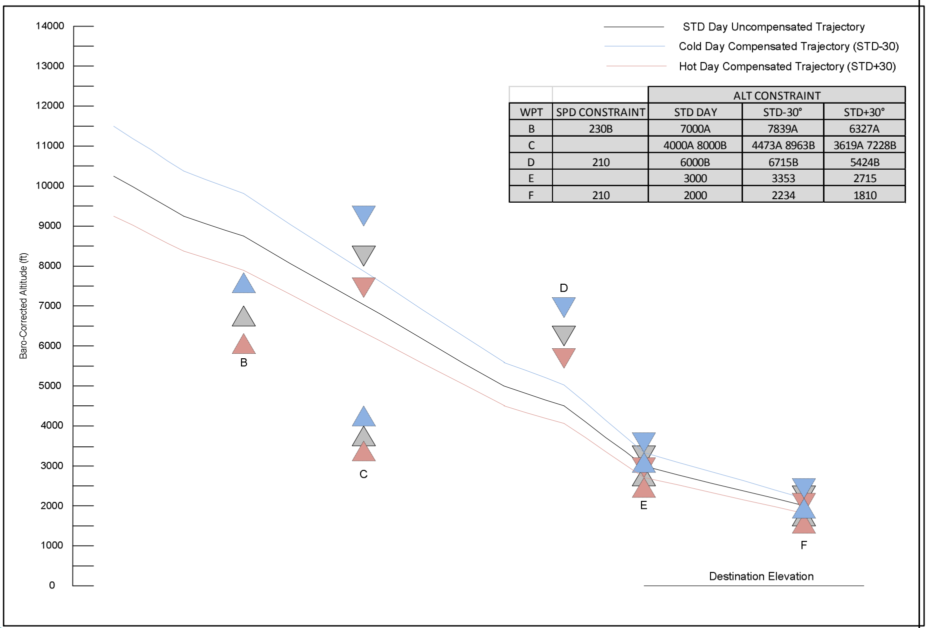
Figure 4.3.2-1~~4.3.2-1~~~~4.3.3-18~~ Temperature Effects on Altimetry

The system should use a flight crew-entered temperature and standard temperature lapse rate to compute altitude and flight path angle corrections accounting for the bias in the barometric altimetry system indications caused by deviations from ISA at the aerodrome's field elevation. The temperature compensation method used should be within 10% of the "accurate method" as described in DO-283(). These corrections should be applied, at a minimum, to the altitudes and flight path angles contained in any approach procedure selected from the navigation database from the initial approach fix (IAF) through the missed approach procedure up to and including the missed approach holding point (MAHP), and including altitude-terminated legs in the missed approach segment. For all approach types (including SBAS, GLS, ILS, MLS) temperature compensation should be applied to all segments where vertical guidance is dependent on barometric altimetry, including the FAF altitude.

When temperature compensation has been applied, altitudes that are manually entered into a procedure by the flight crew should not be temperature compensated. The system should clearly differentiate the display of temperature compensated altitudes from uncompensated altitudes.

Since the MDA/DA is not an assigned altitude, this procedural altitude is eligible for temperature compensation. When the system loads the uncompensated MDA/DA from the database or the flight crew enters it, the system should provide a means to determine and display the temperature compensated MDA/DA.

~~The system should respect all constraints in the uncompensated path while approaching the compensated path.~~ When temperature compensation adjusts the vertical path, the system should ensure that the path construction precludes the insertion of a climb ~~path~~ segment in ~~a~~the descent path. This will typically apply when transitioning from a path segment based upon uncompensated fix altitudes to a path segment whose altitudes have been compensated for temperature. When temperature compensation results in ~~such~~ an altitude conflict, the system should provide an annunciation suitable to prompt flight crew action.



		ALT CONSTRAINT		
WPT	SPD CONSTRAINT	STD DAY	STD-30°	STD+30°
B	230B	7000A	7839A	6327A
C		4000A 8000B	4473A 8963B	3619A 7228B
D	210	6000B	6715B	5424B
E		3000	3353	2715
F	210	2000	2234	1810

Figure 4.3.2-2: Temperature-Compensated Trajectory

When an interface has not provisioned for output of both a compensated and uncompensated altitude constraint value, the compensated altitude constraint value should be output.

COMMENTARY

The ACARS, Intent Bus, ADS-C EPP, and EFIS interfaces are all examples of interfaces that output altitude constraint information.

4.3.3 Lateral and Vertical ~~Navigation~~Guidance

The system should provide fully automatic, performance optimized, guidance along two, three, or four-dimensional paths, defined by the sequence of waypoints specified in the active flight plan. Lateral guidance requires an active flight plan. Vertical guidance requires, as a minimum, an input of gross weight, cost index, and cruise altitude. ATC constraints may

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be entered along the flight plan which in turn will constrain the lateral and vertical flight paths. Guidance commands should be generated and available to drive the Flight Control Computers.

The integrated FMS should provide facilities for the crew to easily override the current guidance commands (without amending the flight plan) for rapid response to tactical situations. Some of the intervention overrides are:

- Altitude target
- Speed target
- Course/Heading target
- Vertical Speed target

This temporary override should replace the applicable guidance output until the override is terminated at which point the internally generated guidance commands should resume.

COMMENTARY

Different autoflight system implementations may allocate these intervention modes to the FMF, while others may accomplish these modes through a combination of FMF and AFCS functions.

4.3.3.1 Lateral ~~Navigation~~Guidance and Path Construction

The lateral guidance of the aircraft is performed using the position data derived by the navigation function and a ~~guidance~~ lateral reference path. For ~~the active plan, generated by the lateral guidance function. T~~the lateral ~~steering~~ guidance function generates a roll command based on the above data to guide the aircraft to ~~straight~~ geodesic leg segments between entered waypoints and to transitional paths at the leg intersections. ~~The roll commands generated are constrained by limits imposed by ATC, the flight plan, the automatic flight control system, and operational flight characteristics of the aircraft.~~ Special procedural paths such as holding patterns (HM), procedure holds (HF), procedure turns (PI), ~~missed approach procedures,~~ and lateral offset paths are automatically flown along with the transitional paths into and out of these procedures.

The aircraft's progress along each path segment is continually monitored to determine when a path transition must be initiated. Direct-to guidance is also available from the aircraft's present position to any waypoint or to intercept a course to ~~or from~~ a waypoint to accommodate modified ATC clearances.

~~**LNAV guidance is provided for enroute, terminal, and approach area operations including Standard Instrument Departures (SIDs) and Standard Terminal Arrival Routes (STARs), approaches, holding patterns, lateral offsets, procedure turns, Direct To a Waypoint, missed approaches, etc.**~~

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4.3.3.1.1 Lateral Reference Path Construction

The lateral function computes independent continuous lateral paths for all existing flight plans. This computation should be fully integrated with the vertical trajectory in that the turn conics should be based on the predicted speeds at the leg transitions. Proper construction for all ARINC 424 defined waypoint/leg types and the corresponding transitional paths between them should be generated and flown by the system.

COMMENTARY

Altitude terminated legs are unique in that the termination criteria for the leg is based on altitude instead of a lateral location. This implies a further coupling to the vertical profile in the construction of the reference path for these leg types.

4.3.3.1.2 Lateral Leg Transitions

Leg-to-leg transitions should provide for a continuous path between legs and generally should be determined by the course change between the legs, the type of next leg, waypoint overfly requirement, bank angle limitations, and the predicted speeds for the transition. Leg transition paths must be constructed within the airspace limitations specified in DO-283() ~~the RNP MASPS~~ for operation within RNP airspace.

Commented [BM(AU7]: Give preference to DO-283 over DO-236

When a lateral path transition cannot be constructed per the leg definition, the system should provide an indication to the crew.

There are three categories of turns recognized in ~~the RNP MASPS~~DO-236():

1. Fly-by turns- Subdivided into 2 categories, high altitude (≥~~>~~FL195) and low altitude (<FL195)
~~2.~~ Fly-over turns~~- Specified as part of leg definition in the NDB, low altitude only (<FL195)~~
2.
3. Fixed radius transitions

COMMENTARY

~~The RNP MSPS~~ DO-283() assumes that course changes at a fly-by fix will not exceed 120 degrees for low altitude operation (<FL195) and 70 degrees for high altitude operation (≥~~>~~FL195). While this assumption is reasonable for a database-defined ~~individual~~ procedure and enroute definitions, flight crew modifications to the route may make this assumption impractical due to factors such as aircraft performance, course, change, and leg length.~~procedure linking and editing make this assumption unenforceable.~~

4.3.3.1.2.1 Fly-By Turns

DO-283() provides the requirements for the fly-by leg transition. DO-283() relates the radius of the turn to ground speed and bank angle and results in a theoretical transition area within which the aircraft should remain throughout the turn. Remaining within the transition area is dependent upon the course change assumptions noted above and the area may not apply if the course change is exceeded. In such exceedance cases, the path to be flown should be displayed to the flight crew. For normal ~~(i.e. course changes less than 135 degrees)~~ fly-by transitions (i.e. course changes less than 135 degrees), the fix should sequence at the lateral bisector.

COMMENTARY

When situations are encountered outside the~~se~~ DO-283() assumptions noted above, the following guidelines are offered:

For fly-by turns with track changes less than 135 degrees, a circular transition path should be constructed tangential to the current and the next legs. The leg transition should occur at the bisector. ~~If the airspace limitation requirements for fly-by turns cannot be met, then the crew should be informed that this condition exists.~~ For track changes greater than 135 degrees, a circular path should be constructed to be tangential to the current leg and a line normal to the current leg emanating from the waypoint. This path should be extended to provide a 40- to 50-degree intercept to the next leg. ~~This construction is similar to fly-over turns. The crew should be informed if this construction is used for a fly-by turn.~~

See Figure 4.3.3-1 below.

The fly-by leg transition reduces track miles while also enhancing ride quality. However, enroute air traffic controllers have noted that some aircraft begin the turn initiation earlier than expected and in some cases have conflicted with other traffic. The criteria specified in DO-283() are minimum requirements and can result in a generous theoretical transition area. It is recommended that equipment manufacturers give ample consideration to airspace consumption when selecting nominal bank angles.

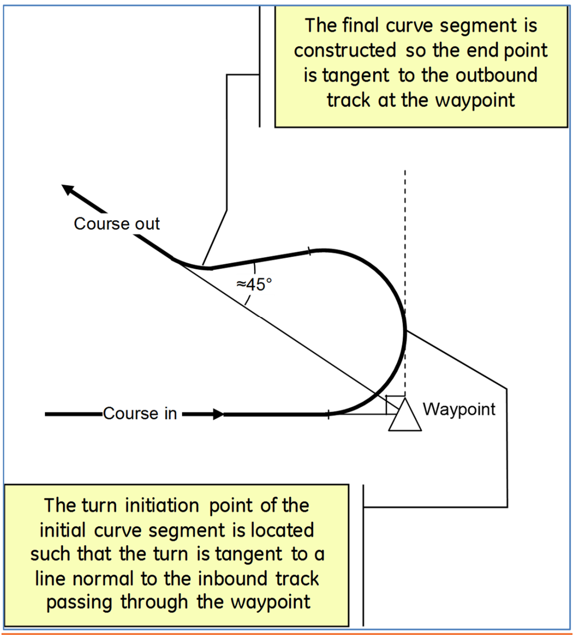

Figure 4.3.3-~~14.3.3-14.3.3-1~~ Fly-By Turn > 135 Degrees

4.3.3.1.2.2 Fly-Over Turns

When a fly-over waypoint is specified, the leg transition should occur at the waypoint prior to transitioning to the next leg. For fly-over waypoints, the next leg type should define the transition path. When the fly-over waypoint is sequenced, the lateral guidance function should command an intercept to capture the next leg. The intercept should be based upon aircraft performance and geometry parameters such as ground speed, leg length, and bank angle limitations.

COMMENTARY

For RNP operations, DO-283() discourages the use of fly-over waypoints since the subsequent path is not repeatable and ~~airspace protection cannot follow the~~ RNP containment cannot be assured~~concept~~. It is recognized, however, that some terminal area operations may require the use of fly-over waypoints followed by a defined leg to the next waypoint.

~~For fly-over waypoints, the next leg should define the transition path. All leg transitions should occur at the fix which is overflown prior to transitioning to~~

~~the next leg. If the airspace limitation requirements for fly-over turns cannot be met, then the crew should be informed that this condition exists.~~

~~In all cases the turn transition conics should be constructed so that the resulting trajectory is flyable by the aircraft.~~

4.3.3.1.2.3 Fix Radius Transitions (FRT)

The FRT is intended to define a fixed radius transition path between airway legs in the enroute sector when parallel routes are closely spaced at the transition waypoint and the fly-by turn is not compatible with separation criteria. DO-283() specifies the geometry and method of computing the fixed turn radius. The FRT is defined in terms of the track change, turn radius, and lead distance. For those enroute airways using an FRT, the turn radius is coded in the ARINC 424 navigation database for the respective airway where the FRT is specified.

COMMENTARY

ICAO Doc 9613:~~,~~ *Performance-Based Navigation Manual*, lists two possible radii, 22.5 NM for high altitude routes (≥FL 195) and 15 NM for low altitude routes. Although these radii are suggested and the actual radii coded in the navigation database could vary, it is expected that airspace designers will abide by these guidelines so that aircraft bank angle limitations in current systems will be respected.

~~4.3.3.1.4~~4.3.3.1.3 Special Lateral Path Construction

All procedural paths such as hold patterns, procedure turns and procedure holds should be continuous paths that allow accurate reference paths to be ~~done~~ constructed for the complete flight plan. The construction of these paths must meet the airspace limitation and path geometry requirements specified in DO-236()~~the RNP MASPS~~.

For hold pattern entries, these paths contain all the ~~straight~~ geodesic and curved segments of the entry (including transition from the prior leg) and may optionally be displayed on the ~~EFIS~~ ND before ~~and during~~ the entry maneuver~~s~~. After the entry is complete, subsequent path updates should account for changes in airspeed, wind speeds and altitude of the airplane. Hold entry paths must conform to the airspace limitations specified in DO-236()~~RNP MASPS~~.

For holding pattern exits which require a sequence of the hold fix, the lateral path should be updated to include the appropriate fly-by transition to the following leg and the paths must conform to the airspace limitations specified in DO-236()~~RNP MASPS~~ for hold exits. For other holding pattern exits (e.g.~~,~~ a direct-to) the lateral path should be updated accordingly, without a return to the hold fix, and should comply with airspace limitations specified in RNP MASPS for those types of maneuvers.

Similar path construction and path prediction techniques are used when procedure turns and procedure holds are part of the flight plan.

~~4.3.3.1.5~~4.3.3.1.4 ~~Autopilot~~ Lateral Guidance Roll Command

Based on the aircraft current state provided by the navigation function and the stored reference path, lateral guidance should ~~produce~~ compute a roll steering command ~~to the autopilot~~ that is both magnitude and rate limited. This roll command is computed to capture and track the ~~straight~~ geodesic and curved path segments that comprise the reference path as displayed on the ~~EFIS~~ND.

~~4.3.3.1.6~~4.3.3.1.5 Lateral Guidance Output Parameters ~~Lateral Path Reference Displays~~

~~Besides generating the roll command, the l~~Lateral guidance~~/lateral steering function~~ should ~~also provide~~ compute and output the following parameters~~outputs~~ relat~~ing~~ed to the active flight plan~~various flight plans for display on the MCDU and the Horizontal Situation Indicator (HSI)/EFIS. Some of these outputs may include~~:

- Roll command
- Distance to go (active waypoint)
- Bearing to go (active waypoint)
- Desired Track~~Commanded course with respect to the leg being flown~~
- ~~Downstream leg distances and courses~~
- ~~Track angle and track angle error~~
- Cross track error

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- Track angle error
- ~~Bearings to various waypoints~~
- ~~Lateral track change alert indicators~~
- ~~This function also supplies data in the form of a complete lateral path to the EFIS such that the flight plan can be displayed in its entirety as defined in Section 7.~~

~~4.3.3.1.7~~4.3.3.1.6 Lateral Capture Path Construction

At engagement, a capture path ~~should~~ may be constructed that guides the airplane to the active leg. This capture path should capture the active guidance leg such that smooth path acquisition occurs without excessive roll activity or turns in the wrong direction.

~~4.3.3.1.8~~4.3.3.1.7 Localizer/MLS Capture

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4.3.3.2 Vertical ~~Navigation~~Guidance and Trajectory Predictions

~~The vertical function should facilitate vertical navigation to a computed aircraft trajectory that includes all phases of flight. This should be accomplished by providing to the crew, the information necessary for them to monitor and control the aircraft vertically as it progresses along the lateral path defined by the flight plan, and (in the case where managed vertical control is selected), providing the flight control computer with the vertical guidance control targets and commands necessary for it to control the aircraft to the flight management computed trajectory.~~

4.3.3.2.1 Trajectory Predictions

The Trajectory Predictions function computes and stores a 4D trajectory which represents a prediction of the aircraft state (e.g. distance, altitude, ~~distance,~~ airspeed, fuel, time) at various points in the flight plan which is used for display and downlink. Trajectory Predictions also computes a reference descent and approach trajectory which is used by Vertical Guidance for control in descent and approach.

The system should compute a complete aircraft trajectory prediction along the specified lateral route. When in preflight and a destination exists in the flight plan, the trajectory should include a takeoff segment, a climb segment, a cruise segment which may include cruise altitude changes (cruise steps), a descent segment, and an approach segment to the destination. When enroute, the trajectory should include segments for the remaining phases of flight. The trajectory may include predictions of the missed approach when included in the flight plan. The trajectory should be continuous from the departure airport (or present position if enroute) to the destination airport. The takeoff, climb, and cruise segments should be a prediction (i.e. model) of how LNAV and VNAV will guide the aircraft from present position along the specified route toward the cruise altitude. The descent and approach segments should be defined in two parts: (a) a reference descent and approach path that defines a Top of Descent location as well as reference altitudes and airspeeds for all points between Top of Descent and the destination and (b) a prediction of how VNAV will guide the aircraft to acquire and track this descent and approach reference path (both altitude and airspeed) once the aircraft is in descent or approach.

COMMENTARY

The descent/approach may be thought of as two separate trajectories, one which is a reference and defines *path* altitudes and speeds (i.e. where the aircraft should be) and one which is a prediction based on the aircraft present position and defines *predicted* altitudes and speeds (i.e. where the aircraft will be if prediction assumptions are valid). It should be noted that some systems display the predicted descent altitudes and speeds while others display the reference path altitudes and speeds.

The system should compute a vertical trajectory for the following flight plans:

- Active
- Modified
- Secondary

For each point in the vertical trajectory predictions, the following data should be computed, stored, and made available to other functions:

- Predicted Altitude
- Predicted Speed
- Estimated Time of Arrival (ETA) or Estimated Time Enroute (ETE)
- Predicted Fuel Remaining

Refer to Section 4.3.3.2.3 for accuracy requirements related to the ETA.

In addition, for each point between Top of Descent and the destination (inclusive), the following data should be computed, stored, and made available to other functions:

- Path Altitude
- Path Speed

The vertical trajectory predictions should include points at:

- the lateral sequence point of each waypoint in the primary flight plan
- speed change points (start and end of an acceleration/deceleration)
- Crossover Altitude
- Top of Climb

- Step Climb
- End of Descent
- Top of Descent
- Intermediate Level-Offs
- Descent Path Intercept Point (when off-path in descent)

COMMENTARY

The above points are the minimum required to support display and datalink requirements including ADS-C Extended Projected Profile. Additional points may be necessary to support specific capabilities or to obtain a desired accuracy via linear interpolation at any arbitrary point in the vertical trajectory.

The vertical trajectory predictions should be based on the following inputs:

- Lateral flight plan elements (Section 4.3.2.4)
- Vertical flight plan elements (Section 4.3.2.5
- Measured and forecast winds/temperatures (Section 4.3.2.5.1)
- Lateral path including curved transitions between legs, holding pattern entries and lateral offsets (Section 4.3.3.1)
- Models of the airframe lift and drag characteristics
- Models of airframe speed and altitude limitations (e.g. stall, buffet, VMO, MMO)
- Models of the engine thrust and fuel flow characteristics
- Aircraft weight and center of gravity
- Crew selected and preselected guidance modes

The vertical trajectory predictions should be updated when an edit is made to a flight plan element or other input into vertical trajectory predictions. Refer to Section 3.4.2 for specific response time requirements related to these modifications.

The vertical trajectory predictions should be updated on a periodic basis to account for tactical interventions as well as wind, temperature, and other modeling errors.

The vertical trajectory should be integrated with the lateral trajectory such that the climb rate and lateral leg distances used to compute the vertical trajectory account for smooth (curved) transitions between lateral legs.

COMMENTARY

The above requirement is not intended to preclude assumptions in the vertical trajectory when lateral discontinuities and manually terminated legs (i.e. HM, VM, and FM legs) are encountered in the flight plan. In these situations, the lateral trajectory is ill-defined and the vertical and lateral trajectory assumptions may differ in order to provide a more reasonable prediction of destination time and fuel. Users of 3D/4D trajectory information should keep these scenarios in mind when using the trajectory information and designing interfaces.

The vertical predictions should comply with all waypoint altitude and speed constraints as specified in Sections 4.3.2.5.2 and 4.3.2.5.3. When this is not possible due to aircraft performance or a conflict in the constraints, appropriate indications should be provided to inform the crew of the specific issue. As with vertical guidance, vertical trajectory predictions should prevent a descending maneuver in a climbing segment in order to satisfy a climb altitude constraint. Likewise, it should prevent an ascending maneuver in a descending segment in order to satisfy a descent altitude constraint. Similarly, vertical predictions should produce a speed profile that is monotonic during a single phase of flight in the presence of speed constraints. The predicted speed profile should remain within the operating envelope of the specific aircraft. It should take into account the aircraft/engine performance, flap configuration changes, selected speed schedules, and speed constraints/limits. The trajectory predictions and associated advisories should be consistent with the vertical guidance when the vertical guidance function is engaged.

Refer to DO-236() and DO-283() for specific VNAV performance and operational requirements.

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4.3.3.2.1.1 Takeoff Phase Predictions

The takeoff phase may be constructed based on a simple model or more complex first principle models using takeoff thrust, flap setting and other vertical flight plan parameters including derated takeoff off thrust, thrust reduction height/altitude and acceleration height/altitude. The takeoff model should support the overall accuracy requirements and system level advisories.

Refer to Climb Phase Predictions for an example of a typical takeoff segment.

4.3.3.2.1.2 Climb Phase Predictions

The climb phase is typically predicted based on climb thrust which may be a derated and/or noise abatement climb thrust and a speed schedule for optimized operations. When constraints are encountered as part of the vertical flight plan, these constraints take precedence over the optimal climb profile. Waypoint altitude constraints are referenced to baro altitude.

Predictions may assume a transition to STD pressure at the transition altitude. AT or BELOW and AT altitude constraints apply as an upper limit altitude before the associated waypoint. AT or ABOVE and AT altitude constraints apply as a lower limit altitude after the associated waypoint. Similarly, waypoint speed constraints are referenced to calibrated airspeed and apply as an upper and/or lower speed limit. AT or BELOW and AT waypoint speed constraints apply as an upper speed limit before the associated waypoint. AT or ABOVE and AT waypoint speed constraints apply as a lower speed limit after the associated waypoint until climb mach is achieved or cruise altitude is captured. A series of identical “AT” speed constraints forms a constant speed segment in the climb speed profile. Altitude associated speed restrictions are referenced to calibrated airspeed and apply below the specified altitude.

Figure 4.3.3-2 depicts an example of a climb phase prediction.

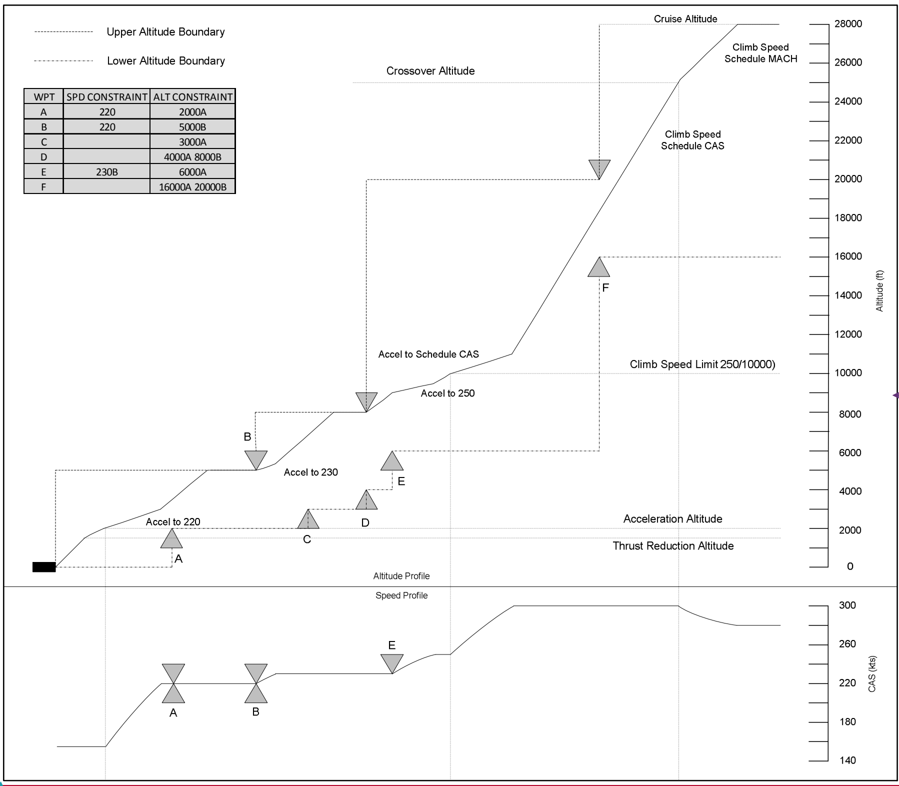

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Figure 4.3.3-24.3.3-24.3.3-2 Climb Phase Prediction Example

COMMENTARY

In this example, the predicted climb profile with the selected thrust limits and climb speeds meets all the ABOVE altitude constraints. However, factors such as aircraft characteristics and actual wind conditions may cause an ABOVE altitude constraint violation. If an ABOVE altitude constraint cannot be satisfied with the selected thrust limits and climb speeds, the crew should be informed of the situation prior to committing to the procedure so a different thrust/speed climb can be attempted. It is assumed that procedure designers will take aircraft performance and meteorological variation into account in the design of departure procedures. It is highly desirable to impose as few constraints and/or ATC interventions as is possible during a departure so the aircraft can perform a Continuous Climb Departure (CCD) for fuel/time efficient climb operation.

4.3.3.2.1.3 Cruise Phase Predictions

The cruise phase is typically predicted based on an optimal speed profile at a specified cruise altitude. When a step climb is active or the aircraft is in cruise below the cruise altitude, the system should predict a climb to cruise altitude assuming engagement of the vertical guidance function. Likewise, when a step descent is active or the aircraft is in cruise above the cruise altitude, the system should predict a descent to cruise altitude assuming engagement of the vertical guidance function. The system may provide for one or more preplanned and/or optimal cruise steps. Preplanned cruise steps may be a climb/descent at a specified waypoint or an optimal step where the system determines the optimal location and/or altitude to change cruise altitude. Similarly, the system may provide for a drift up cruise capability (“cruise/climb mode” in ARINC 660B) which allows the system to perform a drift up maneuver within a specified altitude block to better achieve optimal operation as fuel is burned off and aircraft weight decreases. When present, these preplanned maneuvers should be reflected in the cruise predictions.

The cruise speed is based on the selected cruise performance mode. When an active RTA exists in the flight plan, the cruise speed profile should reflect the speeds that will be flown in an attempt to achieve the RTA. Similar to preplanned cruise steps, the system may provide for one or more preplanned cruise speed or performance mode changes (e.g. constant mach segments). When present, these preplanned cruise speed changes should be reflected in the cruise predictions.

The system should provide an indication when a destination exists in the flight plan and predictions determine the cruise altitude is unachievable due to aircraft performance limitations and/or insufficient route distance.

4.3.3.2.1.4 Descent Phase Path Construction and Predictions

For the descent phase, the system should construct a reference descent path that vertical guidance can use as a target path. During the descent phase, tactical situations may divert the aircraft from the descent reference path, so the system should provide vertical predictions that model how vertical guidance will attempt to capture and track the reference path (altitude and speed).

4.3.3.2.1.4.1 Descent Phase Path Construction

The descent path should be constructed based on idle or near idle thrust and a speed schedule for optimized operations. When altitude constraints are encountered in the vertical flight plan and the idle path does not satisfy one or more constraints, the constraints take precedence over the optimal descent profile and a geometric descent path constructed. The resultant vertical trajectory should be flyable by the aircraft. When this is not possible, appropriate indications should be provided. Waypoint altitude constraints are referenced to baro altitude and apply at the associated waypoint. A series of altitude constraints form a geometric boundary that the descent path must stay within beyond the first constrained waypoint, excluding small excursion for idle path decelerations (see Figure 3). Similarly, waypoint speed constraints are referenced to calibrated airspeed and apply as an upper and/or lower speed limit. AT or BELOW and AT waypoint speed constraints apply as an upper speed limit after the associated waypoint. AT or ABOVE and AT waypoint speed constraints apply as a lower speed limit before the associated waypoint but do not apply to the descent mach and/or extend into the cruise phase. A series of identical AT speed constraints forms a constant speed segment in the descent speed profile. Altitude associated speed restrictions are referenced to calibrated airspeed and apply below the specified altitude. To honor these constraints, the vertical path must anticipate the altitude/speed constraint prior to reaching the associated waypoint/altitude.

When conflicts exist between different types of constraints or the aircraft performance cannot satisfy all constraints, the descent path construction should give priority to one constraint over another as follows:

1. Altitude constraints
2. Vertical angle (FPA) constraints
3. Speed constraints
4. Time constraints (RTA)

COMMENTARY

A conflict between an altitude constraint and an FPA constraint can only exist for an ABOVE altitude constraint. In the case of a BELOW constraint, a level segment should be inserted to satisfy both constraints (see Figure 4.3.3-9). An altitude constraint should never cause construction of the vertical path for the leg to be shallower than the FPA constraint. The above requirement does not preclude insertion of a vertical discontinuity as a means to ensure some measure of speed control and/or minimum deceleration capability.

Figure 4.3.3-3 depicts an example of a descent path construction.

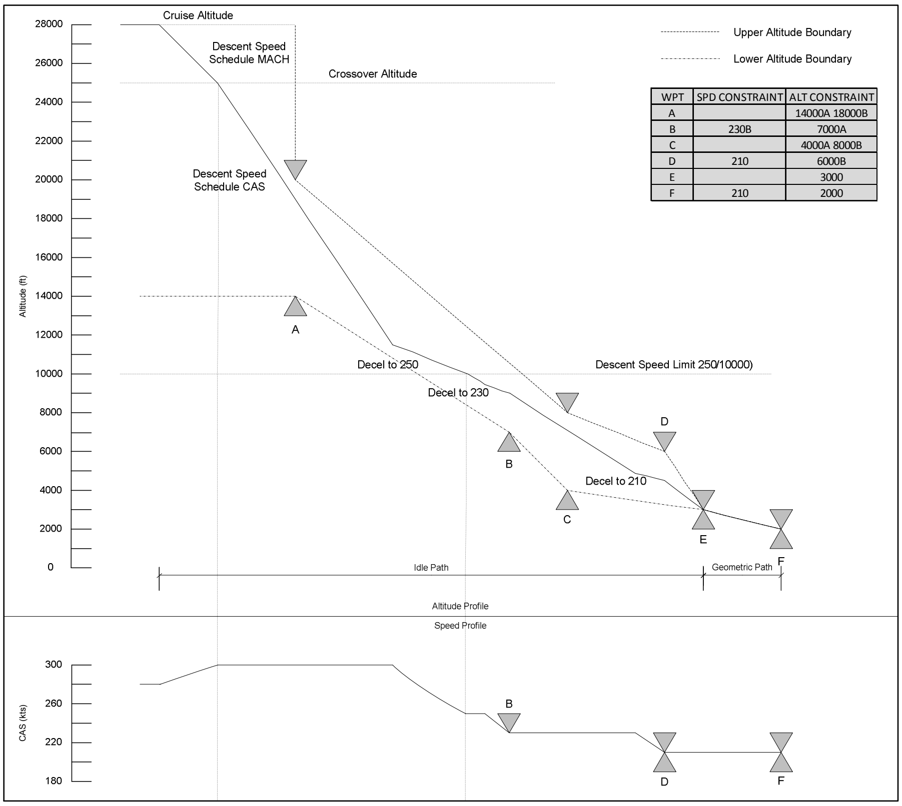

Figure 4.3.3-34.3.3-34.3.3-3 Descent Path Construction Example #1

COMMENTARY

In this example, the descent path fits within the constraint boundaries. There may be procedures or conditions where the descent path follows a boundary. In some cases, factors such as aircraft characteristics and meteorological conditions may dictate if a descent path is flyable (per the rules) for a given aircraft on a given

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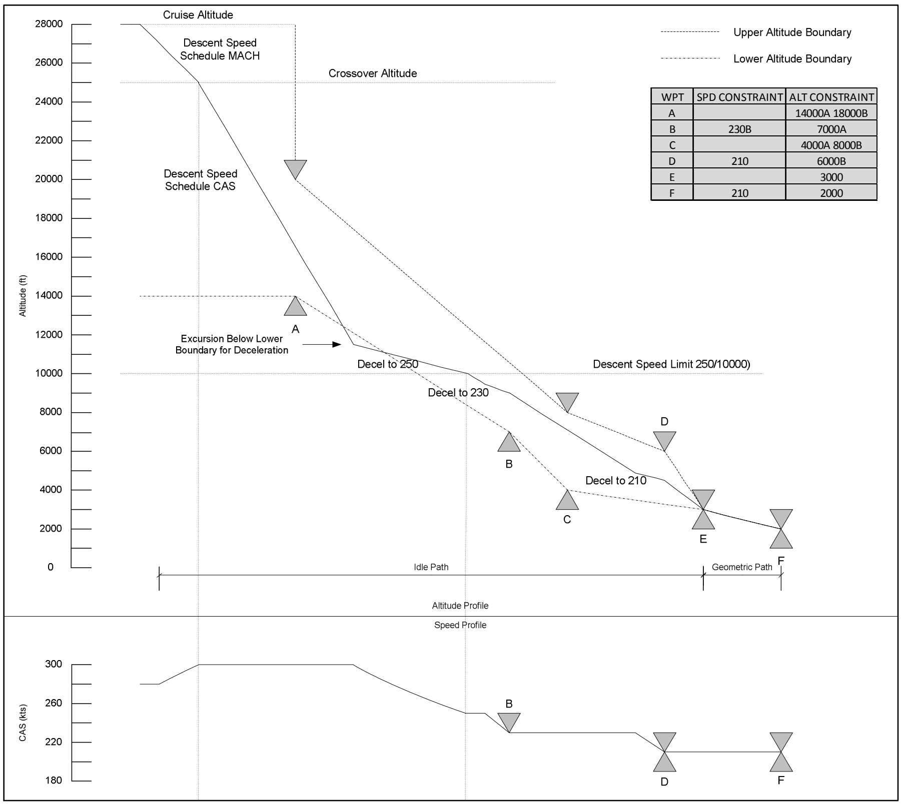
day. When a continuous, flyable descent path which satisfies all constraints cannot be constructed, the system should provide appropriate indications to the crew. It is assumed that procedure designers will take aircraft performance and meteorological variation into account in the design of arrival procedures. It is highly desirable to impose as few constraints and/or ATC interventions as is possible during an arrival so the aircraft can perform a Continuous Descent Operation (CDO) for fuel/time efficient descent operation.



WPT	SPD CONSTRAINT	ALT CONSTRAINT
A		14000A 18000B
B	230B	7000A
C		4000A 8000B
D	210	6000B
E		3000
F	210	2000

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Figure 4.3.3-44.3.3-44.3.3-4 Descent Path Construction Example #2

COMMENTARY

In this example, a shallow idle deceleration segment is constructed to facilitate a short, efficient deceleration to the descent speed limit. Per DO-283(), to facilitate decelerations within curvilinear (idle) paths, small excursions below the lower altitude boundary are allowed and expected when an idle path is constructed to satisfy a series of AT or BELOW, AT or ABOVE, and WINDOW constraints. Excursions below the lower altitude boundary for step-down or dive-and-drive descent path strategies (Figure 4.3.3-5) or above the upper altitude boundary for stay-high descent path strategies (Figure 4.3.3-6) are prohibited.

~~The descent path is typically constructed using a series of straight line segments which comply with the altitude boundary rules as described above. When the descent path is flown using the Vertical Guidance function, systems may cross above or below the altitude constraint value due to a vertical fly-by transition. DO-236() defines the acceptable altitude deviation for a vertical fly-by transition.~~

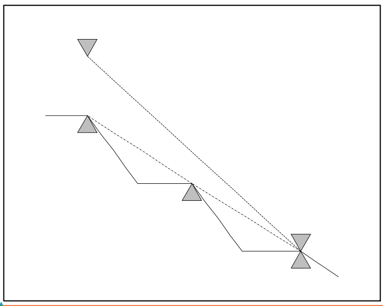

Figure 4.3.3-5~~4.3.3-5~~4.3.3-5 Step-Down Idle Descent (Prohibited)

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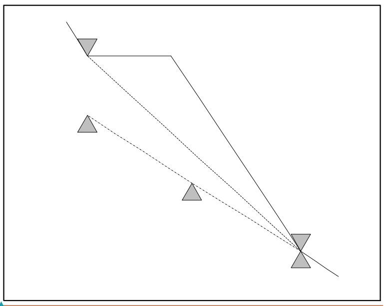

Figure 4.3.3-6~~4.3.3-6~~4.3.3-6 Stay-High Idle Descent (Prohibited)

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The descent path is typically constructed using a series of straight line segments which comply with the altitude boundary rules as described above. When the descent path is flown using the Vertical Guidance function, systems may cross above or below the altitude constraint value due to a vertical fly-by transition. DO-236() defines the acceptable altitude deviation for a vertical fly-by transition.

When the crew initiates a vertical direct-to to a vertically constrained fix, the system should construct a geometric descent path from the aircraft position to the vertically constrained fix.

COMMENTARY

The above requirement is not intended to take precedence over normal geometric path construction rules. In other words, the system is not required to build an unflyable descent path nor one that violates a vertical angle constraint.

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4.3.3.2.1.4.2 Descent Phase Predictions

During the descent phase situations, such as not being cleared to descend at the predicted top of descent, being instructed to descend prior to the top of descent, unforecasted meteorological conditions and flight plan edits can divert the aircraft from the desired reference path/speed profile. The system should provide vertical predictions (altitude, speed, ETA) that model how vertical guidance will attempt to capture and track the descent reference path. These predictions should be available for display and datalink in order to support situational awareness and advisories to the crew. When descent predictions determine that a constraint will be violated, appropriate indications should be given to the crew.

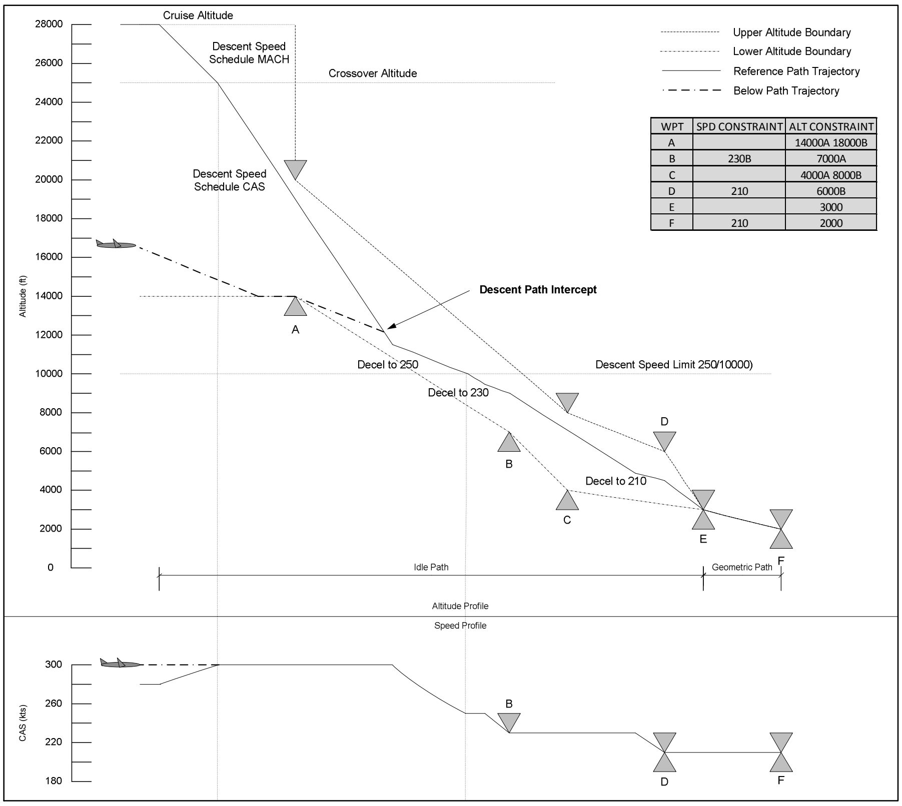

Figure 4.3.3-74.3.3-74.3.3-7 Below-Path Descent Prediction Example

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COMMENTARY

In this descent scenario, predictions model the vertical guidance below-path descent control strategy. A level-off is performed at 14000 feet to honor the ABOVE altitude constraint at WPT A. Upon sequence of WPT A, a partial power descent resumes until intercept of the descent reference path.

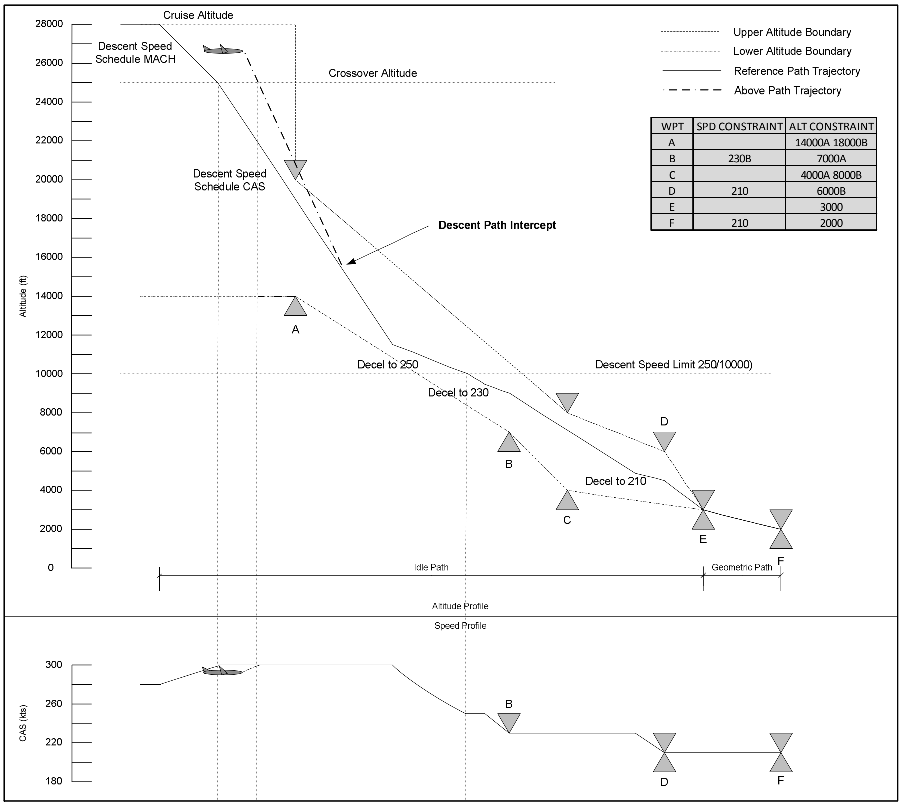

Figure 4.3.3-84.3.3-84.3.3-8 Above-Path Descent Prediction Example

COMMENTARY

In this descent scenario, predictions assume vertical guidance will attempt to recapture the descent reference path by descending steeper than the planned descent rate. The above-path descent predictions predict the aircraft will cross WPT A at 19000 feet and violate the 18000 BELOW constraint.

4.3.3.2.1.5 Approach Phase Path Construction and Predictions

Similar to descent phase, the system should construct an approach path for use by vertical guidance as a reference or target path. As with takeoff, the approach path may be constructed using a simple model or more complex

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first principle models using idle thrust, aeroconfiguration setting, and other vertical flight plan parameters. The approach model should support the overall accuracy requirements and system level advisories.

During approach phase, tactical situations may divert the aircraft from the reference path, so the system should provide vertical predictions that model how vertical guidance will attempt to capture and track the reference path (altitude and speed).

The vertical approach path consists of two portions: ~~-~~an ~~intermediate~~initial approach ~~portion~~path followed by a final approach path. In the initial approach path, ~~where~~ the aircraft decelerates from a flaps-up target speed toward a configured ~~approach~~landing speed. The initial approach path terminates upon reaching the start of the final approach path. ~~until it reaches a final approach capture point followed by a~~ The final approach ~~portion~~path ~~which~~ extends from the final approach capture point (intercept of final approach vertical angle) to the destination and is typically constructed at a constant landing configuration speed and ~~flight path~~vertical angle.

The final approach path should be constructed based on the vertical angle coded on the destination runway, Missed Approach Decision Point (MAP), or Final End Point (FEP). In the case of a MAP beyond the ~~l~~Landing ~~t~~Threshold ~~p~~Point (LTP), the system may compute the FEP and associated angle or may obtain the FEP and angle from navigation database source. Refer to ARINC 424 for additional details and non-precision approach codings. For the final approach ~~or vertical angle leg~~, the system should not construct a vertical path shallower than the specified vertical angle. The system may construct a vertical path steeper than the specified vertical angle(s) in order to satisfy an ABOVE altitude constraint. The above statements are not intended to preclude temperature compensation of the altitude constraints and vertical angle(s). A few typical final approach path geometries are illustrated in Figure 4.3.3-9 and Figure 4.3.3-10 below. A final approach path which ends at a FEP coded in the navigation database is illustrated in Figure 4.3.3-11 below.

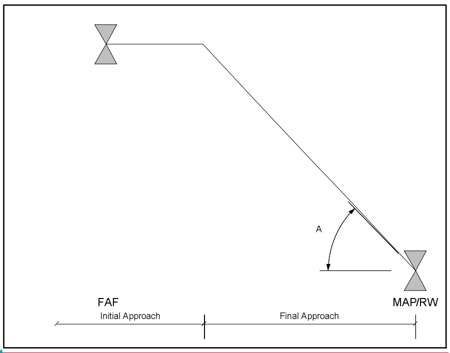

Figure 4.3.3-9~~4.3.3-~~9~~4.3.3-9~~ Typical Final Approach #1

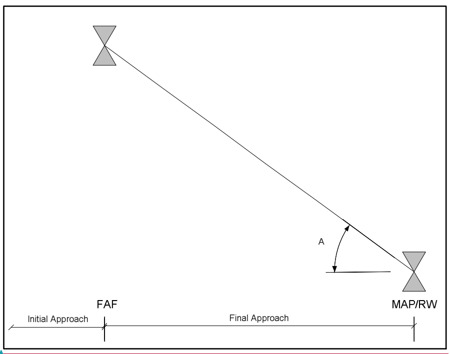

Figure 4.3.3-10~~4.3.3-~~10~~4.3.3-10~~ Typical Final Approach #2

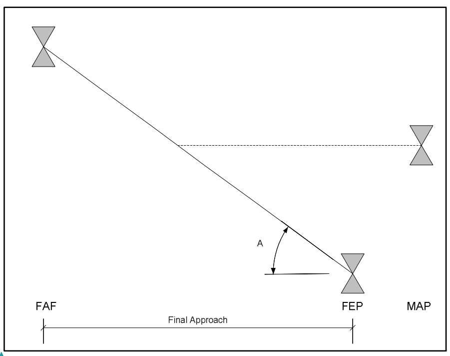

Figure 4.3.3-11~~4.3.3-11~~ MAP Beyond Landing Threshold Point

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In the presence of vertical angle constraint, the initial approach path for the vertical angle leg should be constructed using the vertical angle. The system may construct a vertical path steeper than the specified vertical angle(s) in order to satisfy an ABOVE altitude constraint. The above statements are not intended to preclude temperature compensation of the altitude constraints and vertical angle(s). In the absence of a ~~FPA~~vertical angle constraint~~s~~, the ~~intermediate~~initial approach path may be constructed as a stepdown or “dive and drive” approach in accordance with VFR flight rules as shown in Figure 4.3.3-12~~Figure 4.3.3-12Figure 4.3.3-11~~. However, it is preferable the ~~intermediate~~initial approach path be constructed as a “Continuous Descent Approach” (CDA) path as shown in Figure 4.3.3-13~~Figure 4.3.3-13Figure 4.3.3-12~~ and Figure 4.3.3-14~~Figure 4.3.3-14Figure 4.3.3-13~~. A CDA path is a more stabilized and fuel efficient approach path and generally safer. It aligns with industry recommendations and trends. In either case, when a continuous, flyable approach path which satisfies all constraints cannot be constructed, the system should provide appropriate indications to the crew.

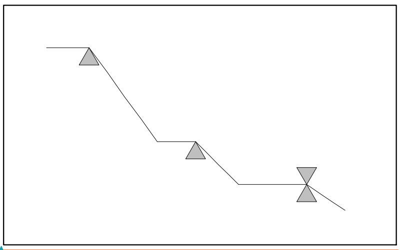

Figure 4.3.3-12~~4.3.3-124.3.3-11~~ Step-Down ~~Intermediate~~Initial Approach

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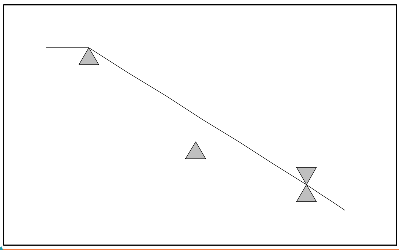

Figure 4.3.3-13~~4.3.3-134.3.3-12~~ Continuous Descent Approach #1

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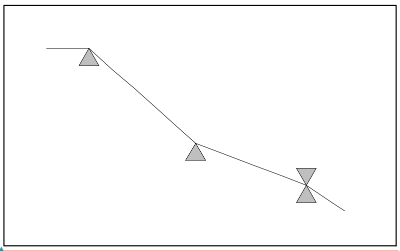

Figure 4.3.3-144.3.3-144.3.3-13 Continuous Descent Approach #2

<< Add Step Down Fixes as an optional feature (according to AC20-138D): Step down fixes are waypoints with an 'at or above' altitude constraint and are part of an

approach procedure defined in the navigation database. Step down fixes are used to avoid obstacles or to prevent the aircraft from descending prematurely in the approach phase. The pilot is not allowed to modify the altitude constraint at the step down fix.

4.3.3.2.1.6 Missed Approach Phase Prediction

The system may provide a missed approach prediction aligned with the lateral missed approach path. If a vertical trajectory is predicted it should be based on go around thrust limits and flap placard speeds and is predicted much like the climb profile. Typically, the prediction starts at the missed approach point or when the crew initiates the missed approach and terminates at an altitude constraint defined in the missed approach procedure. Any remaining descent path altitude and speed constraints are ignored.

COMMENTARY

Typically, the missed approach speed is limited by flap configuration. In the case where the aircraft is in a clean configuration, the speed target should not be released to the airport altitude speed restriction. It is recommended that the speed should be limited to a minimum clean speed or low altitude best hold speed.

4.3.3.2.2 Vertical Guidance

The Vertical Guidance function defines vertical guidance targets and, when in descent, reference parameters to be used by the autopilot and autothrottle to fly the vertical flight plan.

When vertical guidance is engaged, depending on the aircraft architecture, the vertical guidance function should request or select a control mode for the elevator and throttle and generate altitude, airspeed, thrust, vertical speed,

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Formatted: Body Text, Indent: Left: 0", Right: 0" pitch targets, and/or load factors in accordance with the requested and selected control mode(s). An alternative design may provide vertical segment(s) and/or capture trajectory as part of vertical parameters.

Depending on the autopilot interface, these targets and parameters are used by control laws in either the FMS or the autopilot to generate pitch and thrust commands.

In addition, Vertical Guidance is responsible for automatically updating the phase of flight and providing vertical situational awareness in the form of vertical deviation and advisory messages.

When the autopilot interface is a target interface, the system should provide the requested elevator control mode to the autopilot and provide targets for the both the requested and selected (i.e. engaged) elevator control mode. With this interface, vertical guidance requests and targets are analogous to the crew mode and target selections on the AFCS Control Panel.

When the autopilot interface is a pitch command, the system should compute a pitch command in accordance with the selected internal control mode. With this interface, vertical guidance always computes a pitch command whether the internal control mode is speed on elevator, vertical speed, altitude hold, or (descent) path on elevator. When the autopilot interface is a pitch command, the system should also perform the mode transition and path capture of the vertical guidance altitude target.

The system should provide a requested autothrottle control mode along with an EPR/N1 command (if appropriate).

~~When a managed mode of vertical guidance is selected, the flight management system should provide commands of pitch, pitch rate, and thrust control to the parameters of target speeds, target thrusts, target altitudes, and target vertical speeds (or alternately may provide only the targets depending on the selected vertical mode and the flight management/flight control architecture of the particular aircraft). Vertical guidance should also provide mode commands for the flight control computer and thrust management functions as well as automatic flight phase switching. The vertical profile upon which the vertical guidance is based should be the trajectory prediction defined above.~~

~~T~~The vertical guidance function~~s~~ should provide for auto switching of the flight phase during a flight. This flight phase should be used as the basis for altitude, speed, and thrust target selection and should be made available to the ~~flight control computer~~AFCS. At a minimum, the system should provide logic for the automatic transition between flight phases ~~for~~ of preflight, climb, cruise, and descent. The preflight flight phase should apply when the aircraft is on the ground. When in preflight, the system ~~and~~ should allow for access ~~to~~ and entry of all route and performance ~~flight management~~ initialization data. After liftoff, the flight phase should switch to climb and the climb phase should remain active until the aircraft ~~reaches the top of climb~~acquires the initial cruise altitude, at which point the phase should switch to cruise. The flight phase should then switch from cruise to descent when the aircraft reaches the top of descent and the descent phase should remain active for the remainder of the flight.

COMMENTARY

The logic discussed above is general and applies to a minimum set of flight phases. In general, systems will provide ~~more~~ additional flight phases to facilitate specific functionality defined for a particular ~~phase~~ aspect of the aircraft's operation. Some of the additional phases which should be considered are Takeoff, Approach, Go-Around, and Done. The specific logic for the transition between phases is implementation dependent since the conditions are generally application specific and are a function of the flight control system modes, aircraft dynamics and performance characteristics and aircraft operations.

4.3.3.2.2.1 Climb Phase Operation

The system should provide for guidance to the selected performance mode speed schedule applied to the climb trajectory and should provide the appropriate speed target and thrust command (or target) required to achieve the associated trajectory. In addition, an altitude command (or target) for the next target altitude (level off) in the vertical trajectory should be provided. The target altitude should be a function of the flight plan altitude constraints and the crew selected (clearance) altitude. ~~The ETA and distance to the next flight plan altitude constraint should be displayed as advisory information. If the RTA performance mode is selected, then a time error advisory is also displayed. The top of climb point is displayed on the map display.~~ The profiles are constrained by the altitude selected by the pilot on the AFCS ~~controller~~ Control Panel, cruise altitude, and waypoint altitude constraints.

4.3.3.2.2.2 Cruise Phase Operation

The system should provide for guidance to the selected performance speed mode applied to the cruise phase of the flight and should provide the appropriate speed target and altitude command (or target). The target altitude should be the cruise altitude or step altitude. ~~The ETA and distance to the top of descent are displayed as advisory information. If the RTA performance mode is selected, then a time error is displayed.~~ Entry of a higher or lower cruise altitude results in a step climb or step descent respectively, with guidance commands consistent with the selected operation.

The system ~~should~~ may also provide vertical guidance for a drift-up cruise climb mode when ATC has provided a block altitude clearance ~~or when operating in a free flight environment with no altitude constraints~~.

4.3.3.2.2.3 Descent Phase Operation

The system should provide for guidance to the selected performance mode speed schedule applied to the descent trajectory and should provide, through the use of both a path and speed (airmass) mode of control, the appropriate speed target, thrust command (or target), pitch command, or vertical speed command (or target) required to achieve the associated trajectory. In addition, an altitude command (or target) for the next target altitude in the vertical trajectory should be provided. The target altitude should be a function of the flight plan altitude constraints and the crew selected (clearance) altitude.

~~For the case of the economy performance mode, where the vertical trajectory is optimized resulting in a computed path (altitude and speed profile as a function of distance from the destination)~~When tracking the descent path, a pitch command (or target) or vertical speed command (or target) should be computed to allow capture and track of the reference descent path. O~~o~~verspeed protection in the form of vertical mode reversion logic should be provided to enable guidance to switch from path control to speed control if conditions are such that both ~~altitude~~ path and speed cannot be maintained. Annunciation may also be provided prior to mode reversion for predicted overspeed or speed/altitude constraint violations.

~~Should~~ When the crew ~~initiate~~ causes a transition to descent flight phase ~~a descent before~~ prior to reaching the planned ~~t~~Top-of-~~d~~Descent point, the system should default to its ~~early~~ below-path descent ~~scenario~~control strategy. ~~The s~~Systems typically command a shallow rate of descent until the ~~flight plan~~reference descent path is intersected, at which time the originally planned descent profile is resumed.

The system should switch the speed target to the approach speed at a point that is either, constructed in the trajectory and displayed to the crew, or as a result of the crew selection of an approach configuration. Once targeted, the approach speed should be limited to the speed related to the current configuration of the aircraft, switching to the landing speed when landing configuration is selected.

Vertical deviation information based on the difference between the ~~computed vertical~~reference descent/approach ~~trajectory~~ path and the actual aircraft altitude should be provided throughout the descent/approach phase of flight. ~~Also, for three dimensional approach guidance, the system should provide a vertical path deviation in a form suitable for display as a deviation from the pseudo glide slope.~~

4.3.3.2.2.4 Selected Altitude Compliance

Since altitude clearances are difficult to pre-plan using flight plan altitude constraints, a crew selected altitude, usually provided by the flight controls panel, should be used as a tactical altitude limiter by the flight management function. The aircraft, under vertical guidance control, should not be allowed to ascend through the selected altitude during a climb, or descend through the selected altitude during a descent. During approach operations, this general rule may be suspended to allow the crew to pre-select the altitude clearance to arm a missed approach. The selected altitude may also be used to arm an automatic transition to descent or to enable step climbs and descents during cruise phase operations.

4.3.3.2.2.5 Altimeter Barometric Correction for Terminal Area Operations

Generally, altimeter barometric settings are utilized during terminal area operations to account for the local pressure deviation in the air data system, making the barometric altitude a more accurate ground reference~~. The vertical function should not generate a vertical deviation nor related path capture maneuver as a result of this barometric adjustment activity. Any discontinuity in the altitude reference created by this activity should be smoothly applied without violation of specified altitude constraints and limits.~~

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Moreover, the local altitude reference may be either Altimeter sub-scale setting to obtain elevation when on the ground (QNH) or atmospheric pressure at runway (QFE) based (sea level equals zero for QNH, runway elevation equals zero for QFE). Vertical guidance should accept an indication of which reference is being used and apply the appropriate adjustments.

4.3.3.2.2.6 Altitude Constraints

The Vertical Guidance function of the system should prevent the aircraft, when in takeoff or climb and under vertical guidance control, from ascending through the upper bound of a climb AT, AT or BELOW, or WINDOW altitude constraint. Likewise, it should prevent the aircraft, when in descent or approach and under vertical guidance control, from descending through the lower bound of a descent AT, AT or ABOVE, or WINDOW altitude constraint. Aside from altitude captures, it should be a basic philosophy that the Vertical Guidance function should never descend in takeoff or climb flight phase in order to satisfy an altitude constraint; likewise, it should never ascend in descent or approach in order to satisfy an altitude constraint.

Refer to 4.3.2.5.2 for the definition of climb and descent altitude constraints.

COMMENTARY

In takeoff or climb, upon engagement or insertion of a flight plan with an altitude constraint below the aircraft, the Vertical Guidance function may find the aircraft is in violation to (i.e. above) a subsequent BELOW climb altitude constraint. The Vertical Guidance behavior in this situation differs between systems. Some systems will prevent engagement of Vertical Guidance into an altitude constraint violation while others allow engagement into a violation. Some systems prevent engagement into a violation and also disengage when a violation occurs while the Vertical Guidance function is engaged. On those systems where Vertical Guidance can engage or be engaged in a violation condition, some will provide an indication and level-off to minimize the violation of the altitude constraint whereas others will provide an indication and maintain a climbing attitude. An analogous situation exists in descent for ABOVE altitude constraints.

When under vertical guidance control and in violation to an ABOVE constraint, the Vertical Guidance function should level-off to minimize the violation of the altitude constraint as the constraint may exist for obstacle clearance.

Commented [GE10]: Need to make a final decision as a group on whether these should be requirements or recommendations?

When below-path and under vertical guidance control and flying a lateral leg with a procedural vertical angle, the Vertical Guidance function should level-off as the vertical angle may exist for obstacle clearance.

Refer to 4.3.3.2.1 for more details regarding use of altitude constraints in the descent path construction and trajectory predictions.

~~4.3.3.2.2.6~~4.3.3.2.2.7 Speed ~~and Altitude~~ Restrictions

~~Speed and altitude restrictions encountered in the climb should be observed by the vertical function to prevent the aircraft from accelerating or ascending beyond those restriction values until the associated restriction has been passed. At this point the next restriction (if any) should become the limiting case. Restrictions encountered in descent should be handled similarly except that in the case of speed restrictions, sufficient deceleration distance must be provided in order to achieve the restrictive speed prior to passing the associated restriction.~~The system should ~~support~~honor altitude-based speed limits such as airport speed limits (e.g. 250/10000) and ICAO limits for procedure legs. For airport speed limits and other limits which apply to a region or block of airspace, the aircraft airspeed should remain AT or BELOW the speed limit while the aircraft is below the specified altitude. For ICAO limits, the aircraft should remain AT or BELOW the speed limit while the aircraft is both flying the procedure leg and below the specified altitude.

In the case of descent AT and AT or BELOW restrictions, sufficient deceleration distance should be provided in order to cross the speed restriction at or below the restriction speed. Once the descent speed restriction has been sequenced, it should be latched such that the descent target speed does not exceed the restriction speed unless the crew deletes the latched speed restriction or the aircraft transitions back to climb flight phase.

Refer to 4.3.2.5.3 for the definition of climb and descent waypoint speed constraints and their applicability in various flight phases.

In general, the system should compute the target speed at any given point in the flight plan as the speed schedule limited to the lowest AT/BELOW of applicable speed restrictions. This target speed should always be limited to the speed envelope (e.g. VMO, MMO, stall, buffet, and placard limits) of the aircraft for the given or assumed aerodynamic configuration. The Vertical Guidance function of the system should accelerate or decelerate as necessary to capture and track the limited target speed.

COMMENTARY

Historically, all speed constraints in the navigation database and entered by the crew were treated as AT or BELOW speed constraints by the FMS. Indeed, most of the optimizations performed by the FMS were accomplished using speed schedules optimized for some criteria (e.g. fuel, time, cost, maximum angle/rate); the philosophy of the FMS was to reach the optimum speed with speed restrictions preventing it from doing so. DO-236() mandated support for an AT

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Vertical Flight Planning already has a bullet for Airport Speed Restrictions. Is that sufficient? I changed this to "honor" to convey that the guidance requirement is to honor the flight plan constraints. Does that address the comment?

and AT or ABOVE speed constraint capability, and the ARINC 424 source now includes a speed descriptor field with each waypoint speed constraint. While DO-236() defines a minimal set of requirements, it does not provide guidance in terms of what takes precedence when an ABOVE speed constraint conflicts with the speed schedule and other speed constraints and limits. To ensure a measure of interoperability as this capability is incorporated into flight management systems, the following requirements and guidance are offered.

When in conflict, the system should always give priority to altitude-based speed limits over waypoint-based speed constraints.

COMMENTARY

Altitude-based limits are AT or BELOW speed limits which may be lower than a preceding AT or ABOVE climb waypoint speed constraints and/or subsequent AT or ABOVE descent waypoint speed constraint. In such cases, the altitude-based limit(s) should take priority. Airport speed limits are in place to ensure safety with slower moving VFR traffic while ICAO limits ensure aircraft remain within the designated airspace.

When in conflict, the system should give priority to BELOW speed constraints over ABOVE speed constraints.

COMMENTARY

In descent, a deceleration point should occur prior to an ABOVE speed constraint if necessary in order to ensure a safe, continuous deceleration to the landing speed. Moreover, altitude-based limits are BELOW speed constraints that are associated with airspace limitations and thus should take precedence.

The figures below illustrate various conflicts and the speed profiles that result given the rules in this section.

For the descent scenario illustrated in Figure 4.3.3-18~~Figure 4.3.3-18Figure 4.3.3-17~~, an alternative is to insert a speed discontinuity into the theoretical descent path (at AAA) and provide appropriate indications to the crew. This is deemed less preferable as it may lead to unrealistic deceleration assumptions which are only apparent once the ABOVE speed constraint is sequenced. Moreover, in the absence of special considerations, insertion of a speed discontinuity creates an inherent ETA error and may cause poor guidance behavior as the theoretical speed profile is often used as a reference for advisories and mode reversion logic.

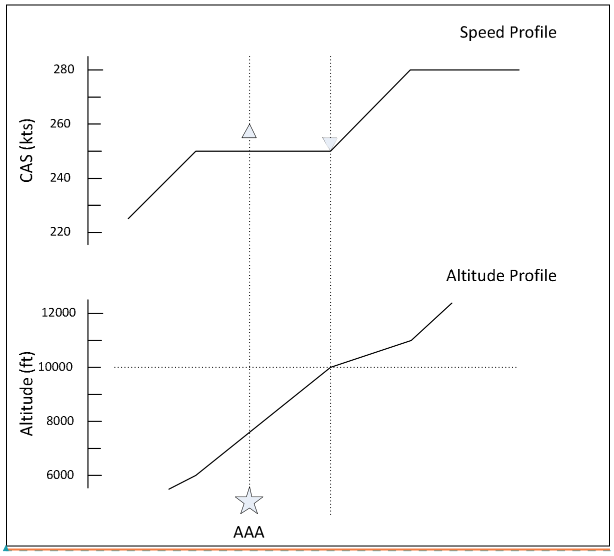

Figure 4.3.3-154.3.3-154.3.3-14 250/10000 takes priority over 260A at AAA (climb)

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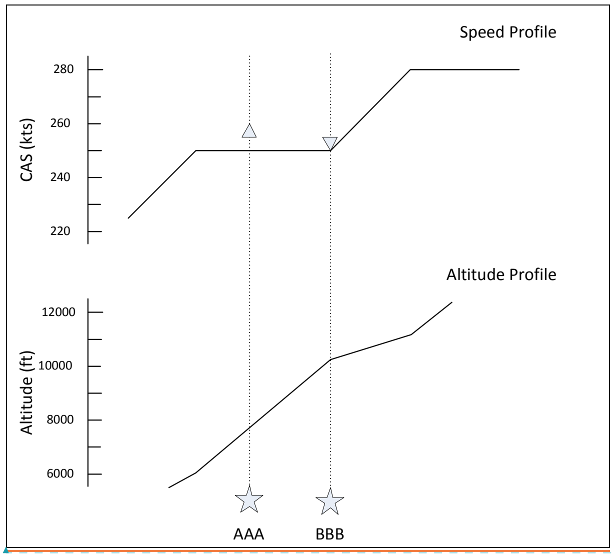

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Figure 4.3.3-164.3.3-164.3.3-15 250B at BBB takes priority over 260A at AAA (climb)

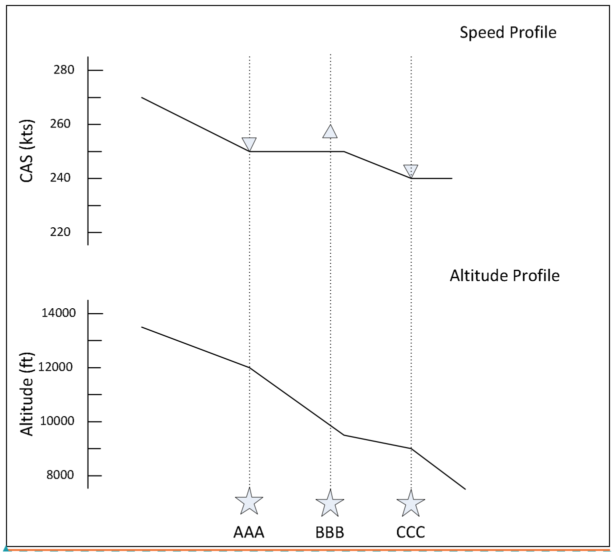

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Figure 4.3.3-174.3.3-174.3.3-16 250B at AAA takes priority over 260A at BBB (descent)

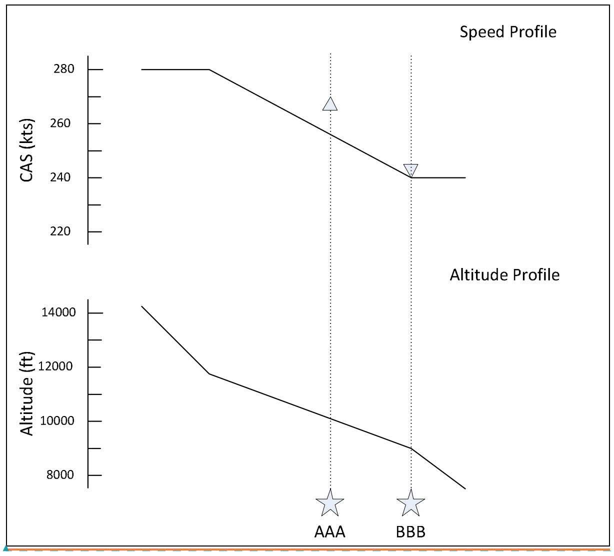

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Figure 4.3.3-184.3.3-184.3.3-17 Decel to 240B AT BBB takes priority over 270A at AAA (descent)

In general, in the absence of edits and tactical speed interventions, the system should produce a speed profile that is monotonic during a single phase of flight. For takeoff and climb, the speed target should continuously increase until reaching the climb speed schedule. For descent and approach, the speed target should continuously decrease from the descent speed schedule until reaching the landing speed. As such, the system should compute a climb speed schedule which is the maximum of the mode-based climb speed and the highest ABOVE climb speed constraint; the system should compute a descent speed schedule which is the maximum of the mode-based descent speed and the highest ABOVE descent speed constraint. This limitation should be applied to both the speed schedule CAS and MACH (when applicable).

COMMENTARY

Without the MACH limitation, a higher ABOVE speed constraint will produce a lower crossover altitude at which point the ABOVE speed constraint will cease to apply. For this reason, it is suggested that the MACH equivalent of the ABOVE speed constraint evaluated at 25000 feet be used as the lower limit MACH value. This ensures that ABOVE speeds are maintained until at least 25000’ for most aircraft.

It is assumed that ABOVE speed constraints would not be applied when in performance modes designed to maximize climb rate or angle.

The system should not apply ABOVE speed constraints to hold speed schedules.

Refer to 4.3.3.2.1 for more details regarding use of speed restrictions in the descent path construction and trajectory predictions.

4.3.3.2.3 Estimated Time of Arrival (ETA)

The system should be capable of providing an ETA for every flight plan fix in the primary flight plan. For modifications to the active flight plan, each flight plan fix ETA should be available within 30 seconds (15 seconds typical) of the completion of entries required to perform the calculations.

The accuracy of the ETA should be within +/- 1 percent of the time of flight remaining to the fix, or +/- 10 seconds, whichever is greater, for the entered conditions.

COMMENTARY

It is understood that additional data is required (e.g. forecast wind and temperature) to improve the operational accuracy of the predicted ETA. Such entries can be made manually by the flight crew or uplinked via data communications.

~~4.3.3.2.3~~4.3.3.2.4 Required Time of Arrival (RTA)~~RTA (Required Time of Arrival)~~

The system should ~~make available~~provide a control mode such that the aircraft will be controlled to arrive at any specified waypoint in the primary flight plan at a specified arrival time (RTA). The system should support a resolution of 1 second for entry and display of the RTA time. Accuracy of this function should be ±30 seconds at enroute fixes and ~~route~~ and ±~~5~~10 seconds at descent fixes~~in the terminal area, as defined in RTCA Task Force 3, Final Report on Free Flight Implementation~~. If the RTA is predicted to be ~~not~~ unachievable, an indication ~~annunciation~~ of this condition ~~the problem to the crew~~ should be provided to the crew. The ~~situation~~ condition should be continually reassessed until such time as the RTA is achievable. ~~While on the ground, the system should compute the takeoff time window that allows an achievable time at the specified RTA waypoint.~~ All RTA calculations should respect the speed envelope ~~restrictions~~ as well as all flight plan constraints. The RTA control band should be designed to limit throttle activity to a minimum.

The~~is~~ RTA function should accommodate ATS data link consistent with industry standards (e.g. DO-258(), DO-350()) ~~of RTA constraints consistent with RTCA DO-219,~~ including constraint types AT, ~~Before~~AT or BEFORE, and AT or AFTER.~~, After, and Between.~~

Systems may provide ~~RTA~~ predictions ~~showing~~ of the earliest and latest arrival times for the candidate RTA waypoint and/or active RTA ~~aircraft may arrive at a~~ waypoint ~~(an RTA window)~~. ~~Also, c~~Consideration of fuel reserves in the prediction of RTA feasibility may be provided.

While in preflight, the system may compute a recommended takeoff time which allows an RTA to be achieved using the crew entered cost index or planned speed schedules. While in preflight, the system may also compute the earliest and latest takeoff times which allow ~~takeoff time window that allows~~ an RTA to be achieved.~~an achievable time at the specified RTA waypoint.~~

4.3.3.2.5 Time of Arrival Control (TOAC)

COMMENTARY

> As detailed in DO-236() and DO-283(), the TOAC function is a performance-based operation that invokes a time accuracy requirement for arriving at a specified RTA waypoint within a range of achievable ETAs in 95% of the attempts. The accuracy requirement is dependent upon current and accurate performance data inputs and uncertainty models. TOAC is intended to support/enable future advanced air traffic management (ATM) operations such as time-based trajectory operations (4DTBO) by providing a performance-based time management capability. The requirement for a performance-based time function that enhances predictability, similar in concept to performance requirements of RNP, is a new model upon which to enable future air traffic sequencing and flow management.

The equipment should provide a Time of Arrival function which supports a specified arrival time (RTA) at the RTA constrained fix within the range of achievable ETAs. The range of achievable ETAs at the specified fix is computed by the system based upon entered aircraft performance parameters, current and forecast environmental conditions, and uncertainty models.

The TOAC function should be operational in both enroute and descent phases of flight.

COMMENTARY

> Additionally, it is expected that procedure designs will implement speed and altitude constraints (when required) that are compatible with a time-based system such as TOAC by not overly constraining the path. For example, a speed-constrained descent and a time-constrained descent may not be compatible except under specific conditions.

The system should be capable of providing the range of achievable ETAs for at least one fix in the primary flight plan for display in the flight deck and communication to the traffic management facility. For fixes after an RTA constrained fix, the range of achievable ETAs should ~~assume~~be based on the ETA at the RTA fix. ~~the RTA will be achieved (when achievable).~~

When the RTA is selected from within the range of achievable ETAs computed by the system, the total time error (TTE), in the presence of the uncertainty model described in DO-283(), should be less than or equal to the required accuracy in 95 percent of the attempts.

The equipment should control to the accuracy requirement while also considering the adverse flight deck effects of large speed and thrust fluctuations.

COMMENTARY

It is expected that the essential information such as current and accurate wind and temperature forecasts are provided and used by the system such that the performance requirements for the TOAC function can be met.

DO-283() specifies the functional requirements of a TOAC function.

4.3.3.3 Three-Dimensional RNAV Approach

[Deleted by Supplement 5]

4.3.4 Performance Calculations Function

The performance function should use information from the flight plan and the performance data base (See Section 9.4) to generate performance related data for display on the MCDU.

4.3.4.1 Performance Modes

One performance mode that should be common to all flight phases is the economy speed mode which should calculate the associated speeds and speed schedules which minimize the total cost of operating the airplane on a given flight. This mode should use a Cost Index, which is the ratio of time-related costs (crew salaries, maintenance, etc.) to fuel cost.

This is expressed as:

$$\text{Cost Index (CI)} = \frac{\text{Time Cost}}{\text{Fuel Cost}}$$

Typical Cost Index entries vary from zero to 999, with the minimum trip fuel cost occurring with the Cost Index set to zero. Cost Index values above zero result in increased trip speeds and varying aircraft vertical trajectories. At the proper Cost Index, the increased fuel cost will be offset by the reduced time cost.

4.3.4.1.1 Climb Mode

Speed modes supported may include:

- Economy CAS/Mach (based on Cost Index) – Lowest cost of operation
- Pilot-entered ~~Computed Air Speed~~CAS ~~(CAS)~~/Mach – Manual selection (or pre-selection)
- Maximum angle climb – Maximum climb rate with respect to distance
- Maximum rate of climb – Maximum climb rate with respect to time
- Required Time of Arrival (RTA) – Variable speed to meet a time constraint

4.3.4.1.2 Cruise Mode

Speed modes supported may include:

- Economy CAS or Mach (based on Cost Index) – Lowest cost of operation
- Pilot-entered CAS or Mach – Manual selection (or pre-selection)
- Maximum endurance – Maximum time endurance
- Long Range Cruise – Maximum range
- Required Time of Arrival (RTA) – Variable speed to meet a time constraint

~~**4.3.4.1.3 Step Climb and Step Descent (for changes in cruise flight level)**~~

~~4.3.4.1.4~~4.3.4.1.3 Descent Mode

Speed modes supported may include:

- Economy CAS/Mach (based on Cost Index) – Lowest cost of operation
- Pilot-entered CAS/Mach – Manual selection (or pre-selection)
- Maximum descent rate – Maximum descent rate with respect to time
- Required Time of Arrival (RTA) – Variable speed to meet a time constraint

~~A descent path should be computed based on the economy speed schedule, manually selected speed schedule and complying with waypoint speed/ altitude constraints where the path is defined as the altitude and speed as a function of the distance from the destination. This path should be~~

~~constructed such that the performance of the aircraft is optimized with respect to the cost index, assuming the aircraft will be allowed to follow the constructed path.~~

4.3.4.2 Maximum and Optimum Altitudes Calculation

The performance function should compute both optimum and maximum altitude for the aircraft/engine type, weight, atmospheric conditions, bleed air settings, and the other vertical flight planning parameters. The optimum altitude algorithm should compute the most cost effective operational altitude and the maximum altitude algorithm should compute the highest attainable altitude (up to maximum certified altitude) while satisfying maneuver margin and minimum climb rate(s) criterion.~~allowing for the specified rate of climb margin.~~ Optimum altitude should be limited by maximum altitude. Consideration should be given in the algorithm design to eliminate the sensitivity and therefore possible erratic behavior that can occur because of the flatness of the performance characteristics. Maximum altitude for engine out should also be computed.

4.3.4.3 Trip Altitude Calculations

The performance function should compute a recommended cruise altitude for a specified route. This altitude may be different from the optimum altitude in that for short trips the optimum altitude may not be achievable because of the trip distance. This algorithm searches for the altitude that satisfies the climb and descent while preserving a minimum cruise time specified by the crew or airline policy. Some designs may elect to integrate this computation as part of the optimum altitude algorithm. All the vertical flight planning parameters should be considered in this algorithm.

4.3.4.4 Alternate Destinations Calculation

The performance function should perform alternate destination calculations. The computations are ~~optionally~~ based on alternate destination flight plan routing, ~~either on~~ a direct route from current position to the alternate destination, or continuing to the current destination~~,~~ followed by execution of a missed approach at the destination and then direct to the alternate destination. Distances, fuel, and ETA, and optionally best trip cruise altitude for selectable alternate destinations should be computed and available for display. Also computed for these alternate destinations are available holding times at the present position and current fuel state versus fuel required to alternates. Besides the alternate destination prediction, this function should provide for the retrieval of the airports nearest the aircraft at crew request.

4.3.4.5 Step Climb/Descent

The performance function should include a prediction of the optimum point(s) at which a step climb/descent maneuver may be initiated to provide for more cost~~-~~effective operation. This algorithm should consider all the vertical flight planning parameters as well as entered wind data. The time and distance to the optimum step point to the specified step altitude should be made available for display. Also, the percent savings penalty for the step climb or descent versus the current flight plan may be computed and displayed.

4.3.4.6 Cruise Climb

The performance function ~~should~~ may compute an optimum or drift-up cruise climb guidance ~~parameters~~which tracks the optimum altitude ~~for all-engine and engine-out conditions~~. This algorithm should take into account fuel burn (weight decrease) and the predicted wind altitude profile. ~~Automatic mode transition to level cruise should occur when an altitude constraint is reached~~.

4.3.4.7 T/C, T/D, Intermediate T/D Advisories

The performance function should compute distances to the top of climb (T/C) and top of descent (T/D) points. This information is based on the stored trajectory prediction and the current state of the aircraft. Also, for the climb and descent phases, performance should compute the distance and ETA to the next altitude constraint. In descent, the distance and ETA is also computed for the next intermediate T/D (where the aircraft will continue its descent after a level off in the descent path caused by an altitude constraint). <<Add Deceleration Points and Intercept, S/C, etc)

4.3.4.8 Thrust Limit Data Calculations

The thrust limits for takeoff, climb, cruise, go around, and continuous modes of operation should be computed (if applicable for the installation) for the current atmospheric conditions and type of engine/aircraft and bleed settings. Moreover, derates for takeoff and climb thrust should be available for selection as well as selected temperature derates for takeoff thrust. The crew can manually select the thrust limit mode that is output as the current thrust limit or an auto mode can be selected that makes the choice based on logic between the flight control computer and the FMC.

COMMENTARY

> In some designs, the thrust limit function is performed by a Thrust Control Computer (TCC). For these designs, the thrust limit computation in the FMC is only required for the purpose of trajectory predictions and support of other performance calculations.

4.3.4.9 Takeoff Reference Data

The performance function should provide for the entry of V1, VR, and V2 speeds. ~~c~~Computation ~~, or entry, of V1, VR, and V2 takeoff~~of V- speeds for selected flap settings and runway, atmospheric, weight, and ~~weight/~~CG conditions may be implemented for the purpose of selection and/or reasonableness checks. The~~se~~ entered or selected V- speeds should be ~~made available for crew selection as~~ output for display on the flight instruments. ~~In addition,~~ Flap/slat retraction ~~takeoff configuration~~ speeds ~~should~~ may optionally be computed and displayed for reference.

4.3.4.10 Approach Reference Data

Landing configuration selection should be provided for each configuration appropriate for the operation of the specific aircraft. The crew should be allowed to select the desired approach configuration and the state of that selection should be made available for output to other systems. Selection of an approach configuration should also result in the computation of a landing speed based on a manually entered wind correction for the destination runway. In addition, approach configuration speeds should be computed and displayed for reference.

4.3.4.11 Reserve Fuel Calculation

When the system supports a default reserve fuel, the default ~~The amount of fuel that can be specified as~~ reserve fuel should be computed based on the estimated fuel burn for the ~~active~~ given flight plan, ~~and~~ the entered~~/~~ or measured total fuel quantity, and additional entered parameters such as assumed fuel flow percent error. ~~This computation may be used as a default reserve fuel value.~~ Manual entry of a reserve fuel quantity ~~to override this computation~~ should be provided and should override the default value (if any). The system should provide an indication to the crew when the predicted fuel at destination is below the reserve fuel.~~.~~

4.3.4.12 Engine-Out Performance Calculation

Systems should provide engine-out performance predictions for the case of the loss of at least one engine. These predictions may include:

- Climb at engine-out climb speed
- Cruise at engine-out cruise speed
- Driftdown to engine-out maximum altitude at driftdown speed
- Use of maximum continuous thrust
- Two-engine-out predictions when applicable on three and four engine aircraft

4.3.4.13 Other Predictions

A number of other predictions and computed performance parameters can be provided by flight management systems. The following are a few of these optional functions:

4.3.4.13.1 Maximum Range Computation

Capability to compute the maximum range of the aircraft based on the entered/measured fuel quantity and the specified reserves should be provided. Both range to reserves and range to empty may be displayed as appropriate.

4.3.4.13.2 Maximum Endurance Computation

The maximum endurance time of the aircraft can be computed based on the entered/measured fuel quantity and the specified reserves. Both endurance time to reserves and time to empty can be provided.

4.3.4.13.3 Descent Energy Circles

For a selected fix point and associated altitude constraint, the distance required to descend from current altitude to the constraint altitude can be computed for both clean and full drag aircraft configurations. This data can be available for display on both the MCDU and as range circles centered on the specified fix on the navigation display.

4.3.5 Printer Functions

Capability may be provided to print various data such as data link messages, flight plans, and maintenance information.

4.3.6 AOC Function

The system should provide for a data link interface with Airline Operations Communication. This interface should allow for uplink and crew controlled insertion of parameters that are enterable through the MCDU. This should include:

- User preferred flight plans defined by the airline dispatch office
- Wind and Temperature ~~profiles~~ entries at multiple altitudes (Section 4.3.2.5.1)
- Waypoints where automatic position reports are required
- Performance initialization data
- Navigation data base amendments

~~NOTAMs~~

Likewise, this interface should provide for the downlink of entered and computed data ~~computed for display on the MCDU~~, including flight plan requests and waypoint reports.

Refer to Section 8.0 and ATTACHMENT 7 for interface details.

4.3.7 ATS Datalink

Air Navigation Service Providers (ANSPs) are implementing, or have plans to implement, Air Traffic Services Datalink functions using existing and future data link systems whose requirements are defined according to the DO-264/ED-78 safety and performance requirements process. These include:

- FANS 1/A+ Interoperability and Accommodation (DO-258 FANS Interoperability, DO~~-~~-305 Accommodation in Domestic Airspace, and DO-306 Oceanic Safety and Performance Requirements)
- Link 2000+ (subset of Baseline 1, DO-280/290/EUROCONTROL spec-0116)
- Baseline 2 Rev A or B (DO-350 through DO-353/ED-229)

COMMENTARY

Rev A is planned for Europe and Rev B is planned for the US

The FMS system should support these datalink systems. FANS 1/A was originally utilized primarily in trans-oceanic ATC environments (mandated in the North Atlantic) but is being expanded into US and European domestic airspace. Link 2000+ is the datalink system in Europe. Baseline 2 is applicable to domestic airspace in North America and will eventually replace Link 2000+ in domestic European airspace. Some aircraft avionics implementations have elected to support multiple ATS datalink systems (oceanic and domestic).

All these ATS datalink systems provide the capability to establish a direct message exchange between the pilots and controllers, using datalink messages instead of voice and may provide other functions such as downlink of position reports and aircraft state and intent information.

The datalink communication architecture on the aircraft has evolved with variation in the allocation of the datalink subfunctions to physical units.

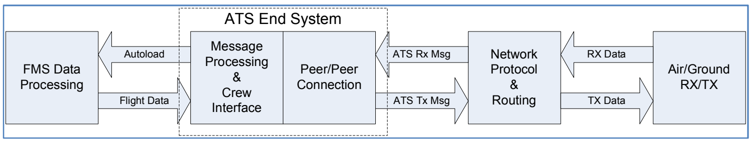

Figure 4.3.7-14.3.7-14.3.7-1 Functional Breakdown of ATS Datalink Airborne Architecture

Some system integrators have chosen to allocate the ATS end system into the FMS, some have chosen to allocate the ATS end system to a different unit and establish a significant data interface with the FMS to support the various datalink functions. Some implementations have a minimal interface with the FMS and depend on the crew to manually support the data needs of the datalink function. The following sections describe all the potential FMS requirements for the datalink functions without regard to the functional allocation of the specific airborne architecture.

It is imperative for stakeholders to understand the specific airborne architecture and which requirements are applicable in their particular architecture.

4.3.7.1 Future Air Navigation System 1/A (FANS 1/A)

The ATS applications used in FANS 1/A are Air Traffic Services Facilities Notification (AFN), Automatic Dependent Surveillance-contract (ADS-C), Controller Pilot Data Link Communication (CPDLC) as defined in DO-258/DO 290 and ARINC 622. These applications enable the following ATS services:

- Data Link Initiation (DLIC)
- ATC Communications Management (ACM)
- Clearance Request and Delivery (CRD)
- ATC Microphone Check (AMC)
- Pre-Departure Clearance
- Information Exchange and Reporting (IER)
- Position Reporting (PR)
- In Trail Procedure (ITP)

4.3.7.1.1 Air Traffic Services Facilities Notification (AFN)

The AFN logon function can only be aircraft initiated. The aircraft system uses the logon function to provide an application name, address, and version number for each application that the aircraft wishes to use, along with the current position as required by the ground system. In response, the ground provides an application name and version number for each application that the ground supports. AFN enables and precedes the use of CPDLC, ADS-C and associated services.

To support auto transfer from one center to the next, the contact function provides a method for the ATS ground system to request the aircraft system to initiate the logon function with the next ATS ground system. The aircraft initiates a logon and provides the information indicating whether or not the requested contact was successful. The AFN logon messages and sequence are detailed in DO-258 and ARINC 622.

For architecture with dual datalink systems (dual stack), the AFN function should support the auto transfer from one datalink system to another datalink system.

4.3.7.1.2 Controller/Pilot Data Link Communication (CPDLC)

The CPDLC specific messages supported should be those defined by ICAO Doc 4444: PANS-ATM ~~4444~~ and DO-258()/ED-100() to enable the following services:

- ATC Communications Management (ACM)
- Clearance Request and Delivery (CRD)
- ATC Microphone Check (AMC)
- Pre-Departure Clearance
- Information Exchange and Reporting (IER)
- Position Reporting (PR)

These messages include some which are loadable and others which are display only. The FMS exchanges these messages with the communication management function which provides for the capability to receive and send these messages over the data link network. The FMS should provide the capability to interface with the network protocol and integrity checking as defined by ARINC 622, These data link messages will be identified with an Imbedded Message Identifier (IMI) of ATx and Message Format Identifier (MFI) of AA/BA to distinguish them from AOC messages and take priority over any other pending data link messages.

Interpretation of the message is based on the CPDLC application defined by RTCA DO-258/290 message element number. Upon receipt of an ATC uplink, the system should annunciate an alerting level message in the primary field of view and set an output discrete that will be used to control an aural warning. The system should also provide for a crew interface that details these messages for crew review along with the appropriate prompts for crew responses such as accept, reject, standby, or response data that may be required.

As a minimum, the FMC functions should provide the capability to load (autoload) the following message types:

- Cross position BEFORE, AT, or AFTER time
- Route Clearances

For all load functions, the changes should be displayed for review by the flight crew. The changes should be initiated and activated by the flight crew.

4.3.7.1.3 Automatic Dependent Surveillance - Contract (ADS-C)

This function should provide for uplink messages to establish the following:

- Periodic Contract
- On Demand Contract
- Event Contract
- Cancel Contract
- Cancel All Contracts

It should also provide Acknowledgment, Negative Acknowledgment, Noncompliance Notification, and data downlink messages as defined in RTCA DO-258.

This function should support at least 5 connections (four typically used for ATC and another for AOC). Each connection is associated with the ATC center address and may have any contract type.

The ADS-C contracts should be established automatically by the contract protocol defined in DO-258 without the need for crew intervention. Each contract specifies the data groups as well as the report interval and other report downlink triggers that are desired. Each contract request can specify the data groups to be transmitted:

- Basic ADS-C
- Flight ID
- Airframe ID
- Air vector
- Ground vector
- Aircraft Intent
- Projected profile
- MET data

All time stamps associated with data groups should be based on the UTC received from the GNSS. UTC based on aircraft clocks should only be used in case of GNSS outage or failure.

4.3.7.2 Link 2000+

The ATN applications used in Baseline 1 Link 2000+ are subsets of context management (CM), and Controller Pilot Data Link Communication (CPDLC), as defined in DO-280/290/EUROCONTROL spec-0116. These applications support the following ATS Services:

- Data Link Initiation (DLIC)

- ATC Communications Management (ACM)
- Air Traffic Clearance (ACL)
- ATC Microphone Check (AMC)

4.3.7.2.1 Context Management (CM)

The Baseline 1 Link 2000+ CM logon function can only be aircraft initiated. The aircraft system uses the logon function to provide an application name, address, and version number for each application that the aircraft wishes to use that can be ground initiated, along with the Origin and Destination airports as required by the ground system. In response, the ground provides an application name and version number for each ground-only initiated requested application.

To support auto transfer from one center to the next, the Link 2000+ CM contact function provides a method for the ATS ground system to request the aircraft system to initiate the logon function with the ATS ground system indicated in the CM contact. The ATS ground system initiates this function with a contact request specifying the ATS ground system CM application address with which to logon. The aircraft initiates a logon and provides the information indicating whether or not the requested contact was successful. The Context Management logon messages and sequence are detailed in the Baseline 1 ATN Interoperability DO-280.

For architecture with dual datalink systems (dual stack), the CM function should support the auto transfer from one datalink system to another datalink system.

4.3.7.2.2 Controller Pilot Data Link Communication (CPDLC)

The Link 2000+ CPDLC is a subset of the ATN Baseline 1 CPDLC as defined in RTCA DO-280/290/ EUROCONTROL spec-0116. The ATN Baseline 1 Link 2000+ controller-pilot message exchange function defines a method for a controller and pilot to exchange information via data link as detailed in DO-280/ 290/EUROCONTROL spec-0116. This function provides messages for the following:

- ATC Communication Management (ACM)
- Air Traffic Clearance (ACL)
- ATC Microphone Check (AMC)

The ATN Baseline 1 Link 2000+ CPDLC message elements encompass level assignments, crossing constraints, lateral deviations, route changes and clearances, speed assignments, radio frequency assignments, and various requests for information. The pilot has the capability to respond to messages, request clearances and report information. An uplink “free text” capability is also provided to exchange information not conforming to defined formats and to append information explaining error reasons. A downlink “free text” capability is provided to append information explaining error reasons.

The Baseline 1 transfer of data authority function provides the capability for the current data authority (CDA) to designate another air traffic service unit

(ATSU) as the next data authority (NDA). A CPDLC connection can be established by the NDA at a time before becoming the CDA. This capability is intended to prevent a loss of communication that would occur if the NDA were prevented from actually setting up a connection with an aircraft system element until it became the CDA.

4.3.7.3 Baseline 2 (B2)

The ATS applications used in Baseline 2 are Context Management (CM), Automatic Dependent Surveillance-Contract (ADS-C) and Controller Pilot Data Link Communication (CPDLC) as defined in DO-350 through DO-353 and ED-229. These applications support the following ATM functions:

- Data Link Initiation (DLIC)
- ATC Communications Management (ACM)
- Clearance Request and Delivery (CRD)
- ATC Microphone Check (AMC)
- Departure Clearance (DCL)
- Data Link Taxi (D-TAXI)
- In Trail Procedure (ITP)
- Advanced Interval Management (A-IM)
- Oceanic Clearance Delivery (OCL)
- Information Exchange and Reporting (IER)
- Position Reporting (PR)
- 4-Dimensional Trajectory Data Link (4DTRAD)
- Dynamic Required Navigation Performance (DRNP)

4.3.7.3.1 Context Management (CM)

The CM logon function can only be aircraft initiated. The aircraft system uses the logon function to provide an application name, address, and version number for each application that the aircraft wishes to use that can be ground initiated, along with the Origin and Destination airports as required by the ground system. In response, the ground provides an application name and version number for each ground-only initiated requested application.

To support auto transfer from one center to the next, CM contact function provides a method for the ATS ground system to request the aircraft system to initiate the logon function with the ATS ground system indicated in the CM contact. The ATS ground system initiates this function with a contact request specifying the ATS ground system CM application address with which to logon. The aircraft initiates a logon and provides the information indicating whether or not the requested contact was successful. The Context Management logon messages and sequence are detailed in DO-350 and ED-229.

For architecture with dual datalink systems (dual stack), the CM function should support the auto transfer from one datalink system to another datalink system.

4.3.7.3.2 Controller Pilot Data Link Communication (CPDLC)

The ATN Baseline 2 controller-pilot message exchange function defines a method for a controller and pilot to exchange information via data link as detailed in DO-350 and ED-229. This function provides messages for the following:

- General information exchange
- Clearance delivery, request, and response
- Departure Clearance
- Taxi Instructions
- Separation Assurance
- Route modification
- Advanced Interval Management
- 4D trajectory based operation
- Dynamic RNP

The aircraft system ~~shall~~ should allow the flight crew to view the message with no more than a single action and allow the flight crew to access the list/queue of unread messages with no more than a single action. The aircraft system should display the messages on a display in the primary field of view.

The aircraft data link system ~~shall~~ should provide the flight crew with the capability to load designated CPDLC uplink messages into the FMS to avoid hazards associated with human entry errors and/or increased workload. The following clearance messages are prone to these hazards:

- A clearance that will require the creation, in the resulting flight plan, of more than one waypoint unless the route is described by a procedure name that can be loaded from the navigation database,
- A clearance that will require the creation, in the resulting flight plan, of one waypoint specified by place-bearing-distance or latitude/longitude with a resolution smaller than whole degrees.

The aircraft data link system will provide the flight crew with assistance to create CPDLC downlink messages to avoid any safety implications (i.e., human entry errors and/or significant increased workload). The following downlink messages are prone to these hazards:

- request messages which contain more than one waypoint
- report messages of the present aircraft position or containing one (or more) waypoint(s) from the FMS active flight plan.

4.3.7.3.3 Automatic Dependent Surveillance (ADS-C)

The ADS-C application provides automatic reports from an aircraft system to an ATSU as detailed in DO-350. The ATSU is capable of requesting the aircraft system to provide the ADS-C reports to the ATSU system in three ways:

- on demand
- on a periodic basis

- when triggered by an event

Only one contract of a given type is permitted at one time per ATSU. When the ATSU sends a contract request to an aircraft system for a periodic or event contract, and either of these two contracts already exists with that aircraft, then the new contract will override the previous contract for that type. Acceptance of an event or periodic contract request implicitly cancels an existing respective event or periodic contract. Since the demand contract is satisfied by sending a single report, any number of demand contracts may be sequentially established with a given aircraft. The ATSU is capable to cancel either a single contract or all contracts in operation that it has established with an aircraft. The ATSU specifies either which contract(s) to cancel by identifying the contract type(s), or specifying to cancel all contracts. The aircraft system acknowledges the cancellation and ceases sending the ADS-C reports for the cancelled contract(s). The aircraft system is capable of providing ADS-C reports to support contract requests. The ADS-C reports content and the conditions under which the report is sent vary depending on the type of contract request and the conditions specified in the request. The aircraft system is capable of supporting contract requests with at least five ground systems simultaneously. In addition, when in emergency mode, the aircraft system provides an emergency/urgency indication as part of each downlink ADS-C messages including the ADS-C report.

Each contract request can specify the data groups to be transmitted:

- Basic ADS-C
- air vector
- ground vector
- projected profile
- MET data
- RTA status data
- extended projected profile
- planned final approach speed
- RNP status

COMMENTARY

The predicted altitudes in ADS reports should be the level at which the aircraft is predicted to sequence the point. When the aircraft is off the vertical reference path this altitude may be different than the predicted reference path altitude.

4.3.8 Airport Surface Guidance

[~~This section d~~Deleted by Supplement 5].

4.3.9 Terrain and Obstacle Data

[~~This section d~~Deleted by Supplement 5].

4.3.10 Electronic Map Interfaces

~~4.3.8.1~~4.3.10.1 Navigation Display Interface

The system should ~~provide for~~support an interface with a Navigation Display (ND) in order to provide ~~an Electronic Flight Instrument System (EFIS or EIS) for the purpose of~~ lateral situational awareness (~~ie.~~eg. aircraft position, lateral ~~route~~trajectory, nearby navaids, etc). Based on the architecture, the FM~~C~~F may provide data for use by an external symbol generator or may provide a series of drawing commands. The EFIS ND interface is detailed in Section 7.0; the CDS interface is in ARINC 661~~supporting navigation data display described in this characteristic. The standard interface between the EFIS and the flight management function, detailing the interface data and formats, etc., may be found in Section 7 of this Characteristic.~~.

In addition to the map background data, the system should supply a number of other data items that are shown on the navigation displays. These may include:

- Wind (either cross wind and headwind components or magnitude and bearing)
- Time and distance to go to the next waypoint
- Ground speed
- Vertical deviation when guiding to the descent path
- Trend vector showing current rate and direction of turn

Independent displays should be provided for the pilot and copilot by each of the two Flight Management ~~Computers~~ Functions (~~FMC~~FMF). Thus, each pilot may select different map ranges, modes, or options.

4.3.10.2 Vertical Situation Display Interface

Commented [BM(AU12]: Add VSD

The system may support an interface with a Vertical Situation Display (VSD) in order to provide vertical situational awareness (e.g. aircraft position, AFCS Control Panel Altitude, altitude constraints, descent reference path, vertical trajectory predictions, terrain, etc). Based on the architecture, the FMF may provide data for use by an external symbol generator or may provide a series of drawing commands. The CDS interface is in ARINC 661.

In addition to the map background data, the system should supply a number of other data items that are shown on the navigation displays. These may include:

- Time to go to the next waypoint
- Vertical speed
- Vertical deviation when guiding to the descent path
- Trend vector showing current flight path angle

Independent displays should be provided for the pilot and copilot by each of the two Flight Management Functions (FMF). Thus, each pilot may select different map ranges, modes, or options.

~~4.3.9~~4.3.11 CMU Interface

The system should provide for an interface with a CMU for the purpose of supporting all data link functionality described in this characteristic. The standard interface between the CMU and the flight management function, detailing the interface data and formats, may be found in Section 8.0 of this characteristic. Message formats for AOC communications are defined in ATTACHMENT 7.

~~4.3.10~~4.3.12 Predictive Receiver Autonomous Integrity Monitoring (RAIM)

Optional capability may be provided for the FMS to transmit the selected destination latitude, longitude, and ETA to the GNSS when a flight plan has been activated ~~4.3.12 Predictive Receiver Autonomous Integrity~~ and predicted. The purpose of this capability is for the prediction of the availability of GNSS satellite coverage for the approach phase of the flight. The GNSS should respond to whether adequate satellite coverage is anticipated. If not, the system should immediately alert the crew. Interface requirements for this capability are defined in ARINC Characteristic 743A, Appendix C.

4.3.13 Precision-Like Approach Guidance

With the advent of advanced navigation sensors and airborne systems, two methods have been developed that allow non-precision approaches to be flown like an ILS, MLS, or GLS precision approach: LP/LPV Approaches and FMS Landing System (FLS)

LP/LPV Approaches are analogous to GLS approaches. Both LP/LPV and GLS are satellite-based operations using an augmented GNSS solution. In a GLS approach, a ground station transmits both (a) corrections to a GNSS signal, and (b) a Final Approach Segment (FAS) Data Block which defines the localizer and glideslope beams. When tuned to the GLS channel number, a receiver onboard the aircraft receives those signals and computes ILS look-alike deviations for use by the autoflight and display systems. In an LP/LPV approach, a receiver onboard the aircraft receives corrections to the GNSS signal from a satellite-based system (SBAS) rather than a ground-based system (GBAS); it typically receives the FAS Data Block from the onboard Flight Management System.

For any non-precision approach, some Flight Management Systems support an FLS guidance mode where the onboard FMS navigation solution may be used to provide the autoflight and display systems with ILS look-alike deviations.

4.3.13.1 ~~Approach Navigation Data Base Exchange~~LP/LPV Approach Guidance

On some installations, the system supports LP/LPV approach capability when used in conjunction with an ARINC 743B GNSS Landing System Sensor Unit (GLSSU) (RTCA DO-229 Delta-4 SBAS receiver) or an ARINC 755 Multi-Mode Receiver (MMR) supporting the GLS function. The GLSSU (or MMR) provides the lateral and vertical deviations (ILS look-alike) and guidance during the final approach segment.

On those installations, upon crew selection of the desired LP/LPV approach, the system should extract the Final Approach Segment (FAS) data block from its navigation database and transmit it to the GLSSU/MMR. The protocol to exchange the FAS data block is described in ARINC 743B Appendix D and ARINC755 Appendix A. The Final Approach Segment (FAS) data block includes a 32-bit Cyclic Redundancy Check (CRC) value ensuring the integrity of the data from the time of the original packet generation.

Upon crew activation of a new approach where the previously selected Final Approach Segment is no longer applicable, the system should invalidate the previously sent Final Approach Segment Data Message (FASDM).

~~One possible implementation of this function provides for the FMC to transmit to the GNSS landing function the final approach path data packet as extracted from the FMC navigation data base when the approach has been selected and the GNSS landing function has been armed for the approach. The final approach data packet would include a 32-bit Cyclic Redundancy Check (CRC) value to ensure the integrity of the packet that was preserved from the time of the original packet generation. Specific recommendations will be provided in a future revision to this document.~~

4.3.13.2 FMS Landing System (FLS)

The system may support a virtual ILS guidance capability which can be used to fly a non-precision final approach segment. This capability is referred to as FMS Landing System (FLS).

When an FLS capability is provided and the crew has selected a non-precision approach, the system should provide a means for the crew to select or de-select FLS guidance for the final approach. When FLS is selected and lateral guidance is not already being provided by a ground-based localizer (if allowed), the system should compute a virtual localizer path. When FLS is selected, the system should compute a virtual glideslope path. For the virtual glideslope path, the anchor point should be located such that the aircraft can maintain a constant vertical angle to the landing threshold point (LTP), even in cases where the MAP is not located at the runway or there is a curved lateral path to the runway. When FLS guidance is selected, the system should interface to the autoflight and/or display systems to allow the virtual localizer and/or glideslope to be flown. When the system cannot support FLS guidance for the selected non-precision approach, the system should prohibit selection of FLS guidance and/or provide an indication to the crew.

COMMENTARY

FLS guidance must comply with the Temperature Compensation Requirements in Section 4.3.2.5.4 ~~4.3.3.2.2.8~~.

~~4.3.11~~4.3.14 Integrity Monitoring and Alerting

~~4.3.11.1~~4.3.14.1 Sensor Status

Sensor warning inputs will be implemented as specified in ARINC Specification 429, Section 2.1, in that validity status is contained within the digital word format.

In all cases of sensor input failure, suitable sensor failure warning and degraded status annunciation should be provided.

~~4.3.11.2~~4.3.14.2 System Status Alert

Any change of status that results in reduced system operational capability or availability should be annunciated to the pilot on, or adjacent to, primary flight instruments. Additional data for use in diagnosing the reason for the change will be of value if it can be displayed on the MCDU or output to an onboard printer of data collection system (e.g., through the data loader interface). Means should be provided to cancel the alert.

COMMENTARY

The system status alert is designed only to attract the attention of the pilot to the fact that something has happened either within the system or to one of the sensors that has degraded or will degrade the operational viability of the system. It will be necessary for the pilot to look for further signs to determine the actual problem and whether or not he can correct it.

System integrity monitoring and failure warning discrete outputs are described in Section 5.3 of this Characteristic. All other such alerts and warnings are included in the transmitted digital word as specified in ARINC Specification 429, Section 2.1.

~~4.3.11.3~~4.3.14.3 Self-Test

The FMC should be designed to perform automatic self-tests of its internal operation, and reasonableness tests on input data during normal operation. The FMC will generate digital output buses which will include malfunction codes to indicate the FMC's assessment of its health, and the status of its interfaces.

~~4.3.11.4~~4.3.14.4 Failure Response

The system should monitor its own health and processing for integrity. When an error is detected, the system should record the failure in a nonvolatile BITE log and attempt to recover from or correct the error if possible. If an attempted fault recovery is unsuccessful, the system should prevent further processing in the affected partition.

COMMENTARY

The airlines desire a high degree of fault tolerance in the FMS. System recovery logic for intermittent faults should be designed to minimize visible flight deck effects and loss of system availability.

4.4 Training Simulator Support Functions

FMS requirements for simulator support functions are defined in ARINC Report 610~~B~~().

5.0 STANDARD INTERFACES

5.1 FMC Digital Data Input Ports

This section describes the digital interfaces to the FMC. It is unlikely that all of these inputs will be employed in a given installation. Those not used in a particular aircraft type need not be implemented in the FMC. However, hardware, software, and computer cycle time capacity should be available to allow all of them to be activated when needed.

COMMENTARY

Data signaling for inputs and outputs to the FMC should be in the ARINC 429 low-speed rates, except where otherwise specified. The data signals are defined in Attachment 4 of this document.

Providing for FMC interchangeability across different aircraft types in a user's fleet may generate the need for the computer to offer more input capacity than needed on any one of those types.

5.1.1 VOR Input Ports

Two ARINC 429 input ports are provided to receive data from dual ARINC 711 VOR receivers.

5.1.2 DME Input Ports

Two ARINC 429 input ports are provided to receive data from dual ARINC 709 DME interrogators.

5.1.3 ILS/MMR Input Port

One ARINC 429 input port will receive data from an ARINC 710 ILS receiver or an ARINC 755 Multi-Mode Landing System Receiver (MMR).

COMMENTARY

These ports are used to support LP/LPV approaches when interfacing to an ARINC 755 MMR

5.1.4 Air Data Input Ports

Two ARINC 429 input ports will receive data from dual ARINC 706 Air Data Systems or ARINC 738 Air Data Inertial Reference Unit (ADIRU).

5.1.5 IRS/AHRS Input Ports

Three ARINC 429 input ports will receive data from ARINC 704 IRS, ARINC 705 AHRS or ARINC 738 ADIRU systems. These are ARINC 429 high-speed inputs.

5.1.6 GNSS Input Ports

Two ARINC 429 input ports should receive data from an ARINC 743A GNSS Sensor. These may be ARINC 429 high-speed or low-speed inputs. The ARINC 743A GNSS Sensor is capable of providing ARINC 429 data in high-speed or low-speed format.

COMMENTARY

These ports are used to support LP/LPV approaches when interfacing to an ARINC 743B GLSSU or an ARINC 755 MMR

5.1.7 Flight Control System Input Ports

One ARINC 429 input port will receive data from an ARINC 701 Flight Control System glare shield controller.

5.1.8 MCDU Input Ports

Two ARINC 429 input ports are provided to receive data from one or two MCDUs. One of these ports is designated the “on-side” port and the other is designated the “off-side” port (see Attachment 3 of this document).

5.1.9 Data Loader Input Ports (ARINC 615)

One ARINC 429 input port is dedicated to receive data to update bulk storage integral to the FMC. This port is intended for an interface with a loading device of the type described in ARINC ~~Report~~ 615. The characteristics of the digital data transmission on this bus are defined to the extent necessary in that document.

5.1.10 Data Link Input Ports

The FMC should provide two ARINC 429 high-speed input ports to receive data from up to two ARINC 758 CMUs.

The FMC should provide two ARINC 429 low-speed input ports to receive data from up to two ARINC 724B ACARS Management Units or to support existing ACARS functionality integrated into the ARINC 758 CMU.

COMMENTARY

Dual ACARS low-speed inputs can be accommodated by using a software selectable speed input for at least one of the CMU inputs.

5.1.11 Intersystem Data Input Port

One ARINC 429 input port provides the intersystem comparison data received from a second FMC.

COMMENTARY

As an alternative to ARINC 429, a faster intersystem data bus may be necessary. Refer also to Sections 5.2.1 and 5.4.

5.1.12 Propulsion/Configuration Data Input Ports

Six ARINC 429 input ports are provided for engine and fuel flow and quantity parameters and data received from the Thrust Control Computer (TCC).

COMMENTARY

It is intended that four of these ports should be assigned for receiving individual engine and fuel flow data from up to four engines or fuel systems. The remaining two ports would normally receive other data such as thrust limit, fuel quantity, and TCC data.

5.1.13 Electronic Flight Instrument System Input Ports

Two ARINC 429 input ports are provided for data from an Electronic Flight Instrument system. This interface may provide interface capability to the Cursor Control Device (CCD). This capability may be provided by a separate input as defined in Section 5.1.19.

5.1.14 Printer

One ARINC 429 input port is provided for data from an ARINC 740 or ARINC 744 airborne printer.

5.1.15 Digital Clock Input

One ARINC 429 input port is provided for data from a digital clock. The clock input may be provided from a GNSS source, in which case the GNSS input is utilized per Section 5.1.6. In this case a dedicated clock input port is not required.

5.1.16 Maintenance Input

One ARINC 429 low-speed input port is provided for interface to an ARINC 604 or 624 maintenance system.

5.1.17 WBS Input

One ARINC 429 input port is reserved for input of data from an ARINC 737 On-Board Weight and Balance System (WBS).

5.1.18 Simulator Input

A serial digital input is required to support ARINC 610B simulator functions. As a manufacturer option, this input may be shared with other interfaces not requiring simultaneous use, such as maintenance or data loader inputs.

5.1.19 Pointing Device

Two high-speed ARINC 429 input ports are reserved for input from dual cockpit pointing devices.

COMMENTARY

These ports are retained for compatibility with unknown systems should they exist. It is expected that all future systems will receive graphical user interface inputs via an ARINC 661 CDS interface.

5.1.20 ASAS Input

One ARINC 429 high-speed port is reserved for input of data from an Aircraft Separation Assurance System (ASAS) system.

5.1.21 Reserved Ports for Growth Inputs

Four ARINC 429 input ports are reserved. These ports should be software selectable as ARINC 429 high-speed or low-speed inputs.

5.2 FMC Digital Data Outputs

Separate buffered ARINC 429 data output ports are provided to drive the MCDUs and other subsystems requiring FMC data.

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5.2.1 FMC Intersystem Output

The FMC should provide an output bus which can be used for intersystem communication from one FMC to another. Section 5.4 of this document provides guidance on intersystem communications.

COMMENTARY

It may be necessary to exchange data at higher data rates than possible on an ARINC 429 data bus. In these cases, an alternative data bus may be used. Any alternative data bus should meet the same EMI requirements of ARINC 429.

5.2.2 General Data Output

Two ARINC 429 outputs provide data to flight instruments, to radio receivers or frequency management unit for tuning, to the Thrust Control Computer System, Flight Control Computer System, and other users. They may also provide initialization data to the IRS. Optionally, they may include the FAS data block to an ARINC 743B GLSSU or ARINC 755 MMR.

COMMENTARY

The amount of data to be carried may require the use of ARINC 429 high-speed buses.

5.2.3 Primary Display Data Output

Two ARINC 429 high-speed outputs are dedicated to supplying data for the Electronic Flight Instrument systems.

COMMENTARY

The specialized design of the FMC/EFI interface makes these outputs unsuitable for supplying other displays such as digital electromechanical instruments. The general data outputs should be used for these purposes. See Section 7.0 of this document.

5.2.4 MCDU Output Ports

Two ARINC 429 outputs provide the means for the FMC to supply data to the MCDUs for the system.

5.2.5 Data Loader Output

One ARINC 429 output is provided for interface to an ARINC 615 data loader.

5.2.6 Data Link Output Ports

One ARINC 429 high-speed output is provided for connection to an ARINC 758 CMU.

One ARINC 429 low-speed output is provided for connection to an ARINC 724B ACARS Management Unit, or to support existing ACARS functionality integrated into the ARINC 758 CMU.

5.2.7 Autothrottle (Reserved)

One ARINC 429 output is reserved to supply data to an Electronic Engine Control (EEC) computer.

5.2.8 Printer

One ARINC 429 high-speed output is reserved for the output of data to an ARINC 740 or ARINC 744 printer.

5.2.9 Onboard Maintenance

One ARINC 429 output is reserved for the output of data to an ARINC 604 or 624 onboard maintenance system.

5.2.10 Programmable Data Output

One ARINC 429 high-speed output is provided to support flight test data collection.

5.2.11 Simulator

A serial digital output is required to support ARINC 610B simulator functions. As a manufacturer option, this output may be shared with other interfaces not requiring simultaneous use, such as maintenance or data loader inputs.

5.2.12 Aircraft State and Intent Path Output (Trajectory Bus)

The FMC should include an ARINC 429 high-speed bus to provide Position Velocity Time (PVT) and intent data from the FMC. This data may be used for surveillance applications such as ADS-B, Terrain Awareness and Warning System (TAWS), Terrain/Obstacle avoidance, and other situational awareness systems. The interface definition is comprised of present aircraft state data that is broadcast at a half second (2 Hz) update rate. The FMS should comply with the requirements of RTCA DO-229C that specifies that the data defining the position shall be output prior to 200 milliseconds after the time of applicability.

Additionally, trajectory intent data for the active flight plan, modified or temporary flight plan, or other specified flight plan, assumed to be flown in FM managed mode, is transmitted as a block data transfer. This data may be used for all types of ATM applications.

As an option, the Aircraft State and Trajectory output may be provided by an ARINC 664 Ethernet interface. In principle, the types of data parameters, refresh rates, etc., are similar. However, the reader is cautioned that specific differences in the data structure and content are intentional. Ethernet state data is not defined herein, as it is expected to be generally available on Ethernet buses. The Trajectory data is specified in Section 5.2.12.2.2. There are no pin assignments in this Characteristic for an ARINC 664 Ethernet bus. These interfaces may be aircraft specific.

The list of ARINC 429 data words used for the broadcast data is included in ARINC Specification 429: Digital Information Transfer System (DITS).

5.2.12.1 Aircraft State Data

The aircraft state data from the FMS should include the parameters in Table 5-1. Trajectory intent status data should be included as an FMC output based on determination if the aircraft is following its FMC specified flight plan. Separate discrete bits (label 270 bits 27, 28, 29) are provided to the user to aid in the interpretation of trajectory data. These discrete bits indicate whether the airplane is being flown to the vertical, lateral, and speed/time targets for the trajectory provided with the appropriate automation engaged, as necessary.

This list of data represents information that is expected to be made available on the Trajectory intent data bus from the FMC to support multiple functions. It is not intended to specify what should be transmitted from the airplane.

Table 5-1 – Aircraft State and Intent Path Output

Label	Parameter	Update Rate
102	FMS Selected Altitude	0.5 sec
103	FMS Selected Airspeed	0.5 sec
106	FMS Selected Mach	0.5 sec
114	FMS Desired Track	0.5 sec
116	Cross Track Distance	0.5 sec
117	Vertical Deviation	0.5 sec
135	Current Vertical Path Perf Limit (Vert RNP)	0.5 sec
136	Current Vertical Path Perf (Vert ANP[(1)])	0.5 sec
150	UTC	0.5 sec
167	Estimated Position Uncertainty (or ANP)	0.5 sec
171	Current RNP	0.5 sec
233-237	Flight ID	0.5 sec
310	Present Position Latitude	0.5 sec
311	Present Position Longitude	0.5 sec
312	Ground Speed	0.5 sec
313	Track Angle True	0.5 sec
314	True Heading	0.5 sec
315	Wind Speed	0.5 sec
316	Wind Direction	0.5 sec
320	Magnetic Heading (pass through from IRS)	0.5 sec
325	Roll Data (pass through from IRS)	0.5 sec
335	Track Angle Rate (pass through from IRS)	0.5 sec
365	Inertial Vertical Velocity (pass through from IRS)	0.5 sec
366	N/S Velocity	0.5 sec
367	E/W Velocity	0.5 sec
270	Intent Status bit 29-speed/time controlled bit 28-lateral controlled bit 27-vertical controlled bit 26-no active flight plan intent data bit 25-desired track mag/true ref (1 = true) bit 24-indicates when bus is guidance master	0.5 sec

Note 1: Vertical ANP is applied to baro-corrected altitude when below transisiton altitude. Vertical ANP is applied to transition flight level and barometric altitude when above transition altitude.

COMMENTARY

Table 5-1 provides FMS data parameters for surveillance and fully recognizes that other data parameters necessary for surveillance transmit processing are provided by other systems (e.g., GPS, inertial system, air data system, Flight Controls system).

For example, data available from the air data system is not included in the Aircraft State and Intent Path Output, as the surveillance transmitter (e.g., ATC transponder for ADS-B) would interface directly to the air data system.

The integrity data is Estimated Position Uncertainty and Current Vertical Path Performance. It is expected that surveillance systems using this data to transmit an integrity parameter outside the airplane would use these data items (or the appropriate integrity parameters when using data from another source, such as GPS) to compute the requisite integrity parameter as specified by the RTCA MOPS for that particular surveillance application.

5.2.12.2 Trajectory Intent Data

In addition to the aircraft state data defined above, the FMC should provide an output of the flight path trajectory for each flight plan, for example, active, modified, secondary, and ATC flight plans. This may be used to support predictive functions such as real time traffic conflict probes, airspace traffic situational awareness, strategic traffic coordination, and terrain/obstacle avoidance. The data should consist of a string of points that describe the predicted trajectory of the aircraft along with the point type and data associated with the flight path transition. This data forms the basis for a using function to be able to unambiguously reconstruct the predicted flight trajectory. This block transmission is for the entire flight trajectory even though a using function may only be interested in a part of the active trajectory. For the active flight plan, this data should be updated under the following events:

- Whenever an active flight plan change occurs.
- When a lateral waypoint is passed.
- When a defined period has elapsed (on the order of one minute) since the last transmission.

COMMENTARY

Other events might require data to be updated. For example, it may be desirable to update the data when there has been a significant change to the predicted trajectory caused by tactical operations or unforecast environmental conditions.

For the modified, secondary and data link flight plans, this data should be updated when such a plan is created, deleted or a change is made to these plans.

5.2.12.2.1 A429 Trajectory Intent File Transfer Format

Refer to Attachment 8 for coding examples of the Trajectory Intent Data File Format.

Table 5-2 – A429 Trajectory Intent File Transfer Format

Word Type Bits 31, 30	Parameter	Bit 29	Format Bits 28-9	Label Bits 8-1
Start Of Transmission 1 1	-------	0	Bits 28-25 (Note 4) Bits 24-17 word count Bits 16-9 LDU sequence	232 for Active Intent (Note 5)

Word Type Bits 31, 30	Parameter	Bit 29	Format Bits 28-9		Label Bits 8-1
Full Data Word 0 1 (frame start)	Data Descriptor	Bits 29-22 Pad 0 Bits 21-16 Data Type (Note 6a) Bits 15-13 Geometry (Note 6b) Bits 12-9 Version/Compatibility (Note 6c)			232
Full Data Word 0 0	Characteristics	Bits 29-9 Characteristic (Note 7)			232
Full Data Word 0 0	Point Latitude	Same as label 310			232
Full Data Word 0 0	Point Longitude	Same as label 311			232
Full Data Word 0 0	Point Altitude	Same as label 361 (Note 2) (less than -2000 feet = NCD)			232
Full Data Word[1] 0 0	Point ETA UTC	0 = valid 1 = NCD	Same as label 150		232
Full Data Word 0 0	Path RNP	0 = valid 1 = NCD	Same as label 171		232
Full Data Word[1] 0 0	Point CAS or Point Mach[3]	0 = valid 1 = NCD	Same as label 103 (CAS) or Same as label 106 (Mach)		232
Full Data Word[1] 0 0	Wind Speed	0 = valid 1 = NCD	Same as label 315		232
Full Data Word[1] 0 0	True Wind Direction	Same as label 316			232
Full Data Word[1] 0 0	Point name	Bits 29-23 Char #3	Bits 22-16 Char #2	Bits 15-9 Char #1	232
Full Data Word[1] 0 0	Point name	Bits 29-23 Char #6	Bits 22-16 Char #5	Bits 15-9 Char #4	232
Full Data Word[1] 0 0	Point name	Bits 29-23 Pad 0	Bits 22-16 Pad 0	Bits 15-9 Char #7	232
Full Data Word[1] 0 0	Named Point Ref Latitude	Same as label 310			232
Full Data Word[1] 0 0	Named Point Ref Longitude	Same as label 311			232
Full Data Word[1] 0 0	Altitude Constraint Lower Bound	Same as label 361 (less than zero feet = no lower bound)			232
Full Data Word[1] 0 0	Altitude Constraint Upper Bound	Same as label 361 (more than 50000 feet = no upper bound)			232
Full Data Word[1] 0 0	Earliest ETA UTC	0 = valid 1 = NCD	Same as label 150		232
Full Data Word[1] 00	Latest ETA UTC	0 = valid 1 = NCD	Same as label 150		232
Full Data Word[2] 0 0	Turn Radius	Sign negative = left	Bits 28-13 range ± 512 nm resolution = 0.0078125 nm		232
Full Data Word[2] 0 0	Turn Center Latitude	Same as label 310			232
Full Data Word[2] 0 0	Turn Center Longitude	Same as label 311			232
Repeat Full Data Word group starting with frame start (01) as necessary to the end of trajectory. After 253 Full Data Words a new LDU must be started.					
End Of Transmission 1 1		1	Bits 28-26 0 0 0 Bits 25 final LDU = 1 Bits 24-9 CRC		232

Word Type Bits 31, 30	Parameter	Bit 29	Format Bits 28-9	Label Bits 8-1
(1) Full Data Word only included as specified in Data Type table (Note 6a) (2) Only included if arc to point (Geometry code 010) (3) Parameter defined by Characteristics bit 12				

Notes:

1. Only point types that are implemented need to be encoded. This provides for different levels of FMS implementation.
2. Refer to Section 4.3.3.2.1, Trajectory Predictions, where altitude reference is described. By definition, altitude is flight level above the transition altitude/level, and MSL is below.
3. Because of multiple users (sink) of this file, no RTS, CTS, ACK, or NAK protocol is provided. Receivers must be capable of handling the block file transfer when the transmitter sends it.
4. Start of transmission word, Bits 28-25 describe provisions for alternate content.
5. The following labels are used for different flight plan types:

Label	Flight Plan Type
232	Active
242	Modified
252	Secondary
262	Data Link

6a. Data Type codes are as follows:

Bits 21-16 Data Type Integer Value	Data Includes ETA	Data Includes point speed, wind speed, wind direction	Data Includes point name, ref latitude, ref longitude	Data Includes lower altitude constraint, upper altitude constraint	Data includes earliest ETA, latest ETA
0					
1	YES				
2	YES	YES			
3			YES		
4	YES		YES		
5	YES	YES	YES		
6			YES	YES	
7	YES		YES	YES	
8	YES	YES	YES	YES	
9	YES	YES	YES		YES
10	YES	YES	YES	YES	YES
11-63 SPARE					

Point name corresponds to a flight plan waypoint crossing location where the point lies on the trajectory and not necessarily the waypoint location. The identifier is provided as part of the data set for this point.

6b. Geometry codes are as follows:

Bits 15-13	Geometry
000	Start point
001	Line to point
010	Arc to point
---	Reserved for growth
111	Reserved for growth

6c. Version/Compatibility codes are as follows:

Bits 12-9	Version
0000	ARINC 702A-2 (2005)
0001	ARINC 702A-3 (2006)[1]
0010	ARINC 702A-4 (2014)[1]
0011	Reserved
----	Reserved
1111	Reserved

Note

1. The definition of Aircraft State and Intent Path Output (Trajectory Bus) (Section 5.2.12) is identical in ARINC 702A-3 and ARINC 702A-4.

7. Characteristic codes are as follows:

Bits 29-9	Characteristics	Description
29	Start of climb	The point where the trajectory will begin a climb segment following a level (intermediate or cruise) segment.
28	Top of climb	Where the trajectory arrives at the cruise flight level. There will be one top-of-climb point for each cruise flight level (step climbs).
27	Top of descent	The point where the trajectory begins a descent from the cruise flight level.
26	End of descent	The point in the trajectory where the descent procedure ends. Subsequent points will correspond to an approach procedure or may include a vertical discontinuity if the approach is undefined.
25	Level-off	The point in climb where an intermediate level-off occurs (i.e., not including top-of climb) or in descent where a level segment begins.
24	Crossover altitude	The point in climb or descent where the airplane will transition between Mach and IAS control.
23	Transition altitude/level	Where the trajectory reaches the transition altitude (in climb) or transition level (in descent).
22	Speed change	The point where the airplane will begin accelerating or decelerating as a result of a speed constraint or limit, or reaches the target speed.
21	Reserved	
20	Reserved	
19	Unnamed fix	A point inserted between other FMS trajectory points, not corresponding to any other specific point type, so as to provide more complete definition of the trajectory. The unnamed fix includes any vertical points not specifically identified by other characteristics necessary to describe the vertical trajectory.
18	Aircraft projection	Indicates that the point corresponds to the projection of the airplane's present position onto the current flight plan leg.
17	Non-flyable	Indicates that the trajectory from the previous point to this one is unflyable.
16	Discontinuity	Indicates that the trajectory from the previous point to this one is undefined.
15	Runway	Indicates that the point corresponds to a runway.
14	Start of descent	The point where the trajectory begins a descent from intermediate level segments.
13	RTA point	The first point with a Required Time of Arrival (RTA) constraint.
12	Speed is Mach	Point speed is Calibrated Air Speed (CAS) if zero. Mach if one.
11	Clearance Altitude Level-off	Indicates the point where the aircraft will level off at selected altitude.
10	Current or next leg	Indicates that the segment belongs at least partially to the active or the next leg.
9	Reserved	

5.2.12.2.2 Ethernet Trajectory Intent File Transfer Format

The format of the trajectory data uses blocks containing a header, body, and footer. All elements shall be coded in big endian mode.

Table 5-3 – Ethernet Trajectory Intent File Transfer Format

HEADER			
Data	**Type**	**Size (bits)**	**Comments**
Start_of_block		8	Start of application block. Code hx53
Flight Plan type	Integer	8	(Note 1)
Trajectory_sequence_number	Integer	8	From 1 to 255 (0 reserved for special use)
Header_size	Integer	8	Size in byte of the header including pad
Trajectory_file_size	Integer	32	Size in byte of the file (does not include header nor footer)
Block_number	Integer	8	Number of application block starting with “0”
Number_of_blocks	Integer	8	Total number of application blocks for the transmitted file
Pad		16	hx0000
Block_size	Integer	32	Size in byte of application block including header and footer
Transition_altitude	Signed Integer	32	Initial climb transition altitude in feet (Note 6)
Climb_baro_setting	Float	32	Climb baro setting in hPa. (Note 6)
Transition_FL	Signed Integer	32	Descent transition FL in feet (converted by FL x 100) (Note 6)
Descent_baro_setting	Float	32	Descent baro setting in hPa (Note 6)
BODY			
Data	**Type**	**Size (bits)**	**Comments**
Geometry	Integer	3	Always included. (Note 2)
Data Type	Integer	5	Always included. (Note 3)
Characteristics	Integer	24	Always included. (Note 4)
Path RNP	Float	32	Always included. (Note 6) RNP in NM.
Point Latitude	Float	32	Always included. (Note 6) Latitude in degrees.
Point Longitude	Float	32	Always included. (Note 6) Longitude in degrees.

Turn Radius	Float	32	Only included if geometry is arc to point. (Note 6) Radius in NM.
Turn Center Latitude	Float	32	Only included if geometry is arc to point. (Note 6) Latitude in degrees.
Turn Center Longitude	Float	32	Only included if geometry is arc to point. (Note 6) Longitude in degrees
Point Altitude	Signed Integer	32	Always included. See bit 1 and 2 of characteristics (Note 4, Note 5) for altitude reference. (Note 6) Altitude in feet.
Point ETA	Integer	32	Only included as specified in Data Type Table. (Note 3, Note 6) ETA in seconds (UTC)
Point Speed	Float	32	Only included as specified in Data Type Table. (Note 3, Note 6) Mach if value between 0-10 CAS in kt if value greater than 10
Wind Speed	Float	32	Only included as specified in Data Type Table. (Note 3, Note 6) Speed in kt.
Wind Direction	Float	32	Only included as specified in Data Type Table. (Note 3, Note 6) Direction in degrees.
Point Name	String	m * 32	Only included as specified in Data Type Table. (Note 3, Note 6, Note 7)
Ref Latitude	Float	32	Only included as specified in Data Type Table. (Note 3, Note 6) Latitude in degrees.
Ref Longitude	Float	32	Only included as specified in Data Type Table. (Note 3, Note 6) Longitude in degrees.
Altitude Constraint, Lower Bound	Signed Integer	32	Only included as specified in Data Type Table. (Note 3, Note 6) Altitude in feet.
Altitude Constraint, Upper Bound	Signed Integer	32	Only included as specified in Data Type Table. (Note 3, Note 6) Altitude in feet.
Earliest ETA	Integer	32	Only included as specified in Data Type Table. (Note 3, Note 6) ETA in seconds (UTC).
Latest ETA	Integer	32	Only included as specified in Data Type Table. (Note 3, Note 6) ETA in seconds (UTC).
FOOTER			
Data	**Type**	**Size (bits)**	**Comments**
End of block		8	End of application block. Code hx45
Pad		24	hx000000

4349

4350 Notes:

4351 1. The following coding is used for different flight plan types:

Integer Value	Flight Plan Type
0	Reserved
1	Partial Portion of Active
2	Active
3	Secondary
4	Data Link
5	Modified/Temporary
6- 255	Spare

4352 2. Geometry codes are as followed:

Integer Value	Geometry
0	d
1	nt 3D
2	oint 3D
3	iint 3D
4 to 7	

4353 3. Data Type codes are as follows:

Data Type Integer Value	Data Includes ETA	Data Includes point speed, wind speed, wind direction	Data Includes point name, ref latitude, ref longitude	Data Includes lower altitude constraint, upper altitude constraint	Data includes earliest ETA, latest ETA
0					
1	YES				
2	YES	YES			
3			YES		
4	YES		YES		
5	YES	YES	YES		
6			YES	YES	
7	YES		YES	YES	
8	YES	YES	YES	YES	
9	YES	YES	YES		YES
10	YES	YES	YES	YES	YES
11-31 SPARE					

4354 4. Characteristic codes are as follows:

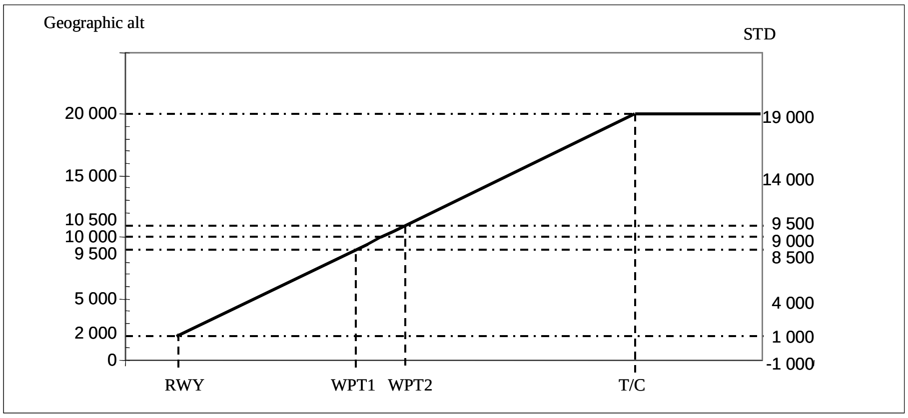
Bits 1-24	Characteristics	Description
1	Start of climb	The point where the trajectory will begin a climb segment following a level (intermediate or cruise) segment.
2	Top of climb	Where the trajectory arrives at the cruise flight level. There will be one top-of-climb point for each cruise flight level (step climbs).
3	Top of descent	The point where the trajectory begins a descent from the cruise flight level.

Bits 1-24	Characteristics	Description
4	End of descent	The point in the trajectory where the descent procedure ends. Subsequent points will correspond to an approach procedure or may include a vertical discontinuity if the approach is undefined.
5	Reserved	
6	Runway	Indicates that the point corresponds to a runway.
7	Reserved	
8	Reserved	
9	Aircraft projection	Indicates that the point corresponds to the projection of the airplane's present position onto the current flight plan leg.
10	Discontinuity	Indicates that the trajectory from the previous point to this one is undefined.
11	Non-flyable	Indicates that the trajectory from the previous point to this one is unflyable.
12	Clearance Altitude Level-off	Indicates the point where the aircraft will level off at selected altitude.
13	Current or next leg	Indicates that the segment belongs at least partially to the active or the next leg.
14	Reserved	
15	Reserved	
16	Unnamed fix	A point inserted between other FMS trajectory points, not corresponding to any other specific point type, so as to provide more complete definition of the trajectory. The unnamed fix includes any vertical points not specifically identified by other characteristics listed that are necessary to describe the vertical trajectory.
17	Baro ref 1	Note 5
18	Baro ref 2	Note 5
19	Crossover altitude	The point in climb or descent where the airplane will transition between Mach and IAS control.
20	Reserved	
21	Speed change	The point where the airplane will begin accelerating or decelerating as a result of a speed constraint or limit, or reaches the target speed.
22	Reserved	
23	Reserved	
24	Reserved	

5. Altitude Reference

Baro ref 1 (bit1)	Baro ref 2 (bit2)	Description
0	0	Reserved
0	1	The altitude is baro referenced for a segment in climb with baro correction = Climb_baro_setting (if available)
1	0	The altitude is baro referenced for a segment in descent with baro correction = Descent_baro_setting correction (if available)
1	1	The altitude is STD referenced

Note that two codings may be used to code the same trajectory:



Example of trajectory with CLB QNH = 1049 hPa, transition altitude = 10 000 ft and standard temperature.

Note: Geographic altitude is true height above the earth (tape measure), with Mean Sea Level as the "0" reference. Geographic altitude is independent of atmospheric pressure or temperature.

				Coding with "STD" only			Mixed coding with "STD" and "Baro" references		
	Geo Altitude	Std Altitude (1013 hPa)	ATC Altitude	Altitudes coded in "format"	Baro_ref1	Baro_ref2	Altitudes coded in "format"	Baro_ref1	Baro_ref2
T/C	20 000	19 000	FL 190	9 000	1	1	19 000	1	1
WPT2	10 500	9 500	FL 095	9 500	1	1	9 500	1	1
Trans ALT	10 000	9 000	10 000 ft	9 000	1	1	10 000	0	1
WPT1	9 500	8 500	9 500 ft	8 500	1	1	9 500	0	1
RWY	2 000	1 000	2 000 ft	1 000	1	1	2 000	0	1
	0	-1 000	N/A	N/A	N/A	N/A	N/A	N/A	N/A

6. hxFF 80 00 00 code is reserved to indicate invalid / undefined parameter.

7. Strings are defined as the sequence of n (numbered 1 through n) ASCII characters, 8-bits encoded. Number n is encoded as a 16-bits unsigned integer, and is immediately followed by the n bytes of the string. Padding for 32-bits word shall be filled with 0's (zeroes).

5.2.13 Reserved Ports for Growth

Four ARINC 429 output ports should be reserved for growth. These ports should be programmable for high-speed or low-speed operation.

5.3 Discrete Inputs and Outputs

Digital discrete inputs may be provided by discrete program pins or by coded digital configuration inputs, such as a configuration data base or Airplane Personality Module (APM). Discrete program pins are defined in Attachment 2-3.

5.4 FMC/FMC Intersystem Communications

FMC-to-FMC intersystem communications are not defined in this document. The formats and data content should be optimized by the system implementer to support system synchronization, including, but not limited to, the following:

Navigation Cross Check – used to monitor independent navigation calculation and improve the integrity of the navigation solution.

Data Entry Transfer – used to ensure that data entries and selections are reflected in all FMCs.

Radio Tuning Coordination – used to ensure that each FMC tunes a different set of radio sensors (if possible) to ensure navigation independence.

Status Information – used to synchronize mode of operation such as phase of flight, active flight plan leg, navigation status and other events.

Sensor Data – used to transfer data from some inputs, cross check discretes, confirm sensor faults, etc.

Crossloading of data bases and software - intersystem communications can be utilized to facilitate data loading in a dual FMS installation.

5.5 Ethernet Interface (ARINC 646)

Commented [BM(AU15)]: Double-Check

Two ARINC 646 Ethernet interfaces are provided for dual interface capability to peripheral devices such as ARINC 615A data loader, ARINC 744A printer, and ARINC 758 CMU. This should not be confused with ARINC 664 Ethernet operating in a switched network topology (typical).

6.0 CONTROL DISPLAY UNIT INTERFACE

6.1 General

The Control Display Unit (CDU) design should be a Multi-Purpose Control and Display Unit (MCDU) in accordance with ARINC 739 or ARINC 739A.

COMMENTARY

It is expected that the MCDU installed in this configuration will provide a shared control and display resource used by both the FMC and the data link management unit. This is especially true where ATC data link communications are used. Depending on the chosen architecture for ~~CNS/ATM~~ATS Datalink (see Section 4.3.7~~4.3.7.1.3~~), an ARINC 739A MCDU one key access to the Communications Management Unit (CMU) may be required as opposed to the standard log-on/log-off menu style selection.

6.2 Standby Navigation

In order to initialize the MCDU flight plan for standby navigation, the FMC should provide the MCDU with an ordered list defining the current active flight plan legs. Any leg whose type is not compatible with the MCDU flight plan, as described in ARINC 739, should be replaced with a flight plan discontinuity. This initialization should occur as required to ensure the MCDU has current data at the time of transition to standby navigation.

6.3 Self-Test

The MCDU may include a pilot confidence test, initiated by a control on the MCDU, which will provide a visual indication that the display and any status annunciators are operating correctly. This test should in no way affect the on-line performance, navigation and guidance computations, or the FMC interfaces.

6.4 MCDU Annunciators

The ARINC 739 MCDU may have several annunciator lights located on the unit front panel. The purpose of these annunciators is to alert the pilot's attention for possible required action. Specific annunciator definitions and associated logic is installation dependent and is not defined in this document; however, typical annunciator usage may include the following:

- MSG (Message) – illuminates when FMC generated messages are displayed in the MCDU scratchpad
- DSPY (Display) – illuminates when the current display is not related to the active flight plan leg or the currently operational performance mode
- FAIL – illuminates in case of selected FMC failure
- OFST (Offset) – illuminates when a parallel offset is in use
- IND (Independent) – illuminates in case of independent dual system operation
- MENU – illuminates when the FMC is the active subsystem and a non-active subsystem requests MCDU access

6.5 MCDU Alerting

The MCDU may display a number of messages on the bottom line of the display known as the scratchpad. These messages may be of several types, indicating different priorities or originating conditions. Specific message definitions, classes, and display logic are dependent on overall flight deck display/annunciation design and operational philosophy, and are not specified in this document. The following paragraphs provide a description of typical message classes and logic design considerations.

High priority messages, referred to as Alerting or Type I messages, are typically displayed in response to a significant status change or operational condition of the system. Lower priority messages may be referred to as Advisory, Type II, or Entry Error messages, and usually indicate a condition of lesser importance, or prompt the pilot to enter required data or correct a previous entry through the MCDU.

Considerations for design of MCDU alerting include the following:

- Priority of scratch pad messages over other classes of messages and MCDU scratchpad alpha-numeric data entries
- Relationship of scratchpad messages to EFIS messages or other dedicated annunciators in the pilot’s forward field of view
- Message clearing logic. Messages may be cleared by keyboard action, or automatically by a change in system status
- Inhibition of MCDU messages during critical flight phases
- Stack operation of multiple messages

6.6 MCDU Color and Font Usage

The MCDU may utilize variation in display color and character font size to convey additional information to the flight crew. Designers should consider priority of the displayed information and consistency with color usage on other display devices in defining MCDU color usage standards. Character font size may be used to indicate data attributes such as computed versus pilot-entered data.

7.0 ELECTRONIC FLIGHT INSTRUMENT SYSTEM INTERFACE

7.1 Introduction

The navigation data base stored in the ARINC 702A Advanced Flight Management Computer may, together with computed guidance data, be used to support the operation of a map display on an electronic horizontal situation indicator or other electronic display in the cockpit. This section of this Characteristic describes interface standards which will enable any manufacturer's FMC to be used with any manufacturer's electronic display. The term Electronic Flight Instrument (EFI) will be used to describe such displays generically.

7.2 FMC Outputs to EFI

Two high-speed ARINC 429 data output ports are provided on the FMC for instrumentation supply. All of the map background and position updating (dynamic) data for two EFIS will be supplied from both of these ports. In an installation comprising one FMC and two EFIS, the FMC's #1 Instrumentation Output should be connected to the captain's EFI, and its #2 Instrumentation output to the first officer's EFI. A possible interconnection scheme in an installation comprising two FMCs and two EFIS is to connect the #1 output of FMC #1 and the #2 output of FMC #2 to the captain's EFI and the #1 output of the FMC #2 to the #2 output of FMC #1 to the first officer's EFI.

COMMENTARY

The foregoing data output arrangements permit one FMC to supply independently organized data to each of two EFIS. While the word formats of the individual data elements crossing the interface are not map scale dependent, the total number of data words needed to construct the map does vary with the map scale selected. The FMC can thus accommodate the generation of maps on both sides of the cockpit even when the captain and the first officer have selected different scales.

7.3 FMC Inputs from EFI

The FMC provides two low-speed ARINC 429 data input ports through which map mode, scale and symbol option selections are transferred from the EFIS to the FMC.

~~Interface provisions are provided to the FMC from a pointing device.~~

~~**7.4 COMMENTARY**~~

~~**7.5 Functional and architectural requirements for the pointing device will be provided in a future Supplement to this Characteristic.**~~

~~7.6~~7.4 EFI Design Features

The following EFI design features impact the design of the FMC/EFI interface.

~~7.6.1~~7.4.1 Map

The EFI will generate a dynamic map positioned relative to the aircraft. The map may be oriented with respect to aircraft track or heading.

~~7.6.2~~7.4.2 Plan

The EFI may also generate a north-oriented static map positioned relative to reference points selected at the FMC Multi-Purpose Control Display Unit (MCDU). This may be used by the flight crew to verify the correct insertion of flight plan waypoints and other data.

~~7.6.3~~7.4.3 HSI Mode

The FMC/EFI interface may provide outputs of desired track (course), track angle error, drift angle, and lateral and vertical deviations to support the generation of a HSI (rose mode) type of display. If provided, the lateral and vertical deviation outputs should support the use of variable sensitivities (full scale deflection) in accordance with the requirements of RTCA/EUROCAE SC-181/WG-13 RNP MASPS.

Commented [GE16]: What is the correct reference here?

~~7.6.4~~7.4.4 Map Scales

EFI map scales for map and plan modes will be a compatible subset of the ARINC 708A Weather Radar, which has selectable ranges, from 5 to 640 nautical miles of look-ahead. Additional low range capability may be required for incorporation of surface map display capability.

~~7.6.5~~7.4.5 Map Projection

The EFI will transform earth coordinate data received from the FMC into flat plane coordinates for the map display. The accuracy of this transformation will be such that the EFI can be used as a primary instrument for guiding the aircraft along ~~great circle~~geodesic and circular transition flight paths, and provide accurate registration of planar weather radar data on the map display. The map projection method chosen is expected to permit worldwide EFI usage without latitude restrictions.

The EFI will also ensure that vector lines and conics which cross display editing boundaries are correctly terminated to ensure a continuous and accurate presentation on the display. The EFI will translate the map background to account for aircraft motion between map background data block transmissions based on aircraft position and angular data received from the FMC and other systems.

~~7.6.6~~7.4.6 Option Selection

The EFI will provide for symbology option selections, including weather radar data overlay on the map. These will allow the flight crew to declutter the map by selectively removing different categories of data, e.g., Navaids, Airfields, Geographic Reference Points, Waypoint Definition Data, etc.

~~7.6.7~~7.4.7 Symbol Repertoire

Each category of data shipped from the FMC for display on the EFI will call for a distinctive symbol on the display. A list of potential data categories includes, but is not necessarily limited to, the following:

- ~~Primary~~ Active flight plan path
- Secondary flight plan path
- Modified flight plan path
- Altitude Intercepts

- RTA symbology
- Waypoints
- Waypoint data (altitude, speed, time)
- Origin and destination airports

- FIR boundaries
- Special reference points (T/D, B/D, energy circles)
- Runway Data
- Marker Beacons
- Tuned Navaids
- Navaids, including (co-Located VOR and TACAN (VORTAC), VOR, DME/ TACAN (high altitude and low altitude)
- VOR radials
- Airports
- Geographic reference points
- Non-directional beacons
- Navigation data (e.g., sensor positions)
- Terrain/obstacle data (MSA, MEA, MORA)
- Special use airspace

The data available for display in a particular installation will depend on the navigation data base content of the FMC. The above data categories fall into the following general symbology types, each of which requires different data parameters for definition via the FMC/EFI interface.

- Vectors (~~straight~~geodesic lines)
- Conics (circular arc lines)
- Upright symbols
- Rotated symbols
- Dynamic symbols
- Alpha/numeric data readouts

~~7.6.8~~7.4.8 EFI Data Conditioning

The EFI will perform any input data filtering needed to produce a smoothly changing map display, and will condition data used to update readouts on the display.

~~7.6.9~~7.4.9 Pointing Device

[Deleted by Supplement 5]

~~Functional and architectural requirements for the pointing device will be provided in a future Supplement to this Characteristic.~~

~~7.6.10~~7.4.10 Surface Map Mode

[Deleted by Supplement 5]

~~The surface map mode will provide a scaled representation of the airport surface for assistance in aircraft taxi and ramp movement. Functional recommendations will be provided in a future Supplement to this Characteristic.~~

~~7.7~~7.5 FMC Design Features

The following FMC design features impact the design of the FMC/EFI interface.

~~7.7.1~~7.5.1 Flight Plans

As part of its guidance function, the FMC will have flight plans assembled in its guidance buffers by pilot data entry or data link and selection through the MCDU. Such flight plans will define paths in the sky in two, three and ultimately four dimensions. Accurate representation of aircraft position with respect to the flight plan path is essential when the EFI is used as the primary instrument by which the flight crew controls the aircraft laterally and vertically with respect to a three-dimensional path, and along that path to make good assigned times at waypoints.

Flight plan paths can be presented on the EFI as sequences of lines and conics representing ~~great circle~~geodesic paths between waypoints and curved transitions between path legs. Circular path legs consisting of DME arcs, RF legs, holding patterns, and procedure turns can also be displayed. The FMC generates the necessary data to define four-dimensional flight plans in its guidance buffers. The guidance algorithms in the FMC calculate the position, speed and time differences between the aircraft state vector and the flight plan, and hence generate the guidance commands to the automatic flight control system (including the auto-throttle) to make good the flight plan.

The guidance data can be used to define the vector lines and conics needed to represent the flight plan path and other guidance symbology on the EFI.

~~7.7.2~~7.5.2 Map Display Edit Areas

The FMC should, to the extent of the limitations imposed by the size of the data block (see Section 7.6.2), supply map background data for an area large enough to preclude the appearance of blank screen between transmissions. The EFI will limit the data displayed to that needed for the viewing window. This limit operation will include vector clipping to ensure the correct display of vector data and associated text.

7.5.3 Pointing Device

[Deleted by Supplement 5]

~~COMMENTARY~~

~~It is expected that future systems will incorporate a pointing device in the FMC/EFI interface. Functional and architectural requirements for the pointing device will be provided in a future Supplement to this Characteristic.~~

~~7.8~~7.6 Interface Design

The design of the FMC/EFI interface is described in the following paragraphs.

~~7.8.1~~7.6.1 General

Map background data and position updating and other dynamic data should be interleaved on the FMC instrumentation output buses. The FMC should specify the data type to be displayed and the associated positioning and rotation data. The EFI will control symbology color, size, brightness, blinking and related parameters, and transform map position data received from the FMC into screen coordinates.

The FMC should extract the information necessary for the map background from its navigation data base and flight plan buffers. Position data transmitted to the EFI should be in latitude and longitude coordinates. The types of data transmitted should respond to mode symbology options and display range selected by the flight crew on the EFI control panel. The order of the data on the bus should be in general accordance with the priority in which it is to be displayed.

The FMC/EFI dynamic data interface should be designed to permit updating of the map background data positions between background data block transmissions without the need for a hand-shaking relationship between the FMC and the EFI symbol generator. FMC/EFI dynamic data is defined in Attachment 4.

The FMC/EFI interface design and map background and dynamic data bus implementation should be such that the EFI can provide a valid map display if map background data transmissions are lost or invalid for periods of up to 10 seconds duration.

The display mechanization should accommodate a worldwide map projection. This may result in the need to provide additional and/or special software to project map data in the vicinity of the earth's poles.

~~7.8.2~~7.6.2 Map Data Updating

The FMC should supply map data to the EFI in alternating 64-word blocks of background and dynamic data until a complete map background data block has been transmitted (see Attachment 6, Figure 2). The maximum size of the background data block should be programmable up to a maximum of 1023 words. After completion of the map background data transmission, the dynamic data should continue to be updated at a rate of 20 times per second (nominal) until a new map background data block is to be transmitted. Map background data should be updated and transmitted once every three seconds (nominal), except that when a mode, scale or option change is made on the EFI, the FMC should update and transmit new map background data within one second (maximum).

COMMENTARY

Dynamic data update at a rate greater than 16 times per second is needed to avoid undesirable visual effects on the display.

~~7.8.3~~7.6.3 Background Data Prioritizing

To ensure that writing time or other internal data processing limitations in the EFI do not result in most wanted map background data not appearing on the display, the FMC should prioritize the information as follows. The EFI should truncate the data, if necessary, in the reverse order of this prioritization.

1. Flight plan data
    a. ~~Primary~~ Active flight plan
    b. Secondary flight plan

   c. Flight plan changes
   d. Waypoints
   e. Waypoint data
   f. Offsets
   g. Altitude intercepts
   h. Flight plan events
   i. RTA symbology
2. Selected reference points
3. Runway Data (may be edited out in some flight phases but should not disappear because of truncation of the data stream)
4. Origin and destination airports
5. Tuned navaids
6. Navigation data (may be dynamic rather than background)

7. Non flight plan navaids
8. General reference points (position ordered)

~~7.8.4~~7.6.4 Background Data Editing

An example of the background data editing process is shown in Attachment 6, Figure 1. The FMC should, as a minimum, transmit data for the displayed area plus the area which could appear on the display as a result of aircraft translation and rotation between map background data updates.

Because the density of data needed for terminal operations could saturate the display at the higher map scales and the volume of data within the edit area overload the EFI symbol generator buffers, the FMC should determine the amount of data it supplies to the EFI from an analysis of the map scale and mode selection information it receives from the EFI.

Typically, the high map scales are used in cruise and the low map scales are used for terminal area operations. Therefore, only high altitude chart data need be transferred across the interface for the larger map scales.

~~7.8.5~~7.6.5 Mode Change Response

The FMC should respond to a mode, scale or symbology option selection change received from the EFI such that the desired data transmission occurs within one second maximum.

COMMENTARY

Airlines desire the overall (FMC and EFI) response time of a practical system to be less than two seconds.

~~7.8.6~~7.6.6 Map Translation and Rotation Data

The FMC should provide the following data to the EFI to support map projection and rotation functions:

Map Projection

Map background data

- Map reference latitude (plan mode only)
- Map reference longitude (plan mode only)
- Map mode/scale

Map Position Data

- Aircraft present latitude
- Aircraft present longitude

Map Rotation

Map Position Data

- Track (true)
- Track (magnetic)

~~7.8.7~~7.6.7 Resolution

The resolution of data used to position symbology on the display should be such that a change of binary state of the least significant bit of a position data word produces no visible step movement on the display.

~~7.8.8~~7.6.8 Interface Data Errors

The mechanization of the FMC/EFI interface should minimize the visual effects on the map display of occasional data errors.

~~7.8.9~~7.6.9 FMC-to-EFI Data Transfer Protocol

Because the FMC/EFI interface is dedicated to the transfer of data between the FMC and the EFI symbol generator(s), not all of the formatting and protocol standards of ARINC Specification 429: Digital Information Transfer System (DITS) will be applied. The following sections indicate where these departures from ARINC 429 have been made. Although not mentioned hereafter, the electrical and timing standards set forth in ARINC 429 for high-speed operation (100 kbps) and the standard broadcast protocol do apply.

~~7.8.9.1~~7.6.9.1 Data Block Format

The first word of each 64-word data block should be a Start of Transmission word containing octal code 301 in its label field (bits 1 through 8) if the block contains map background data and octal code 303 in this field if the block contains dynamic data. Bits 9 through 13 of each map background data block Start of Transmission word should contain a binary number indicating the position of the block in the sequence of such blocks into which the transmission is divided. In addition, the first such Start of Transmission word of a transmission should contain in bits 20 through 29 a binary count of the total number of usable background data words to be contained in the transmission. (This count should not include Start of Transmission, End of Transmission, or fill-in words.) This field should contain binary zeros in all subsequent background data block Start of Transmission words of the transmission. All background data block Start of Transmission words should contain binary zeros in bits 14 through 19, while bits 30 and 31 should contain the control word code defined in Section 7.6.9.2 and bit 32 should be set to render word parity odd.

The Start of Transmission word of each dynamic data block should contain binary zeros in bits 9 through 29 and the control word code defined in Section 7.6.9.2 in bits 30 and 31. Bit 32 should be set to render word parity odd.

The last word of each 64-word map background data block should be an End of Transmission word containing octal code 302 in its label field. Bits 9 through 29 of this word should contain binary zeros. Bits 30 and 31 should contain the control word code defined in Section 7.6.9.2 and bit 32 should be set to render word parity odd.

The 62 usable data words of each map background data block should contain the positional, character, and control information used by the EFI to construct the map background. The label codes and word formats defined in Attachment 6 to this document should be used. Bits 30 and 31 should be encoded to indicate word type per Section 7.6.9.2 and bit 32 should be set to render word parity odd. If the final block of the transmission contains less than 62 useful words, it should be padded to this length with fill-in words (binary zeros in bit positions 1 through 32) and terminated with the End of Transmission word at position 64.

Dynamic data blocks should be interleaved with map background data blocks as described in Section 7.6.2. Dynamic data blocks should contain data words labeled and formatted per ARINC Specification 429.

COMMENTARY

The interleaving on the same bus of blocks of data labeled per ARINC 429 standards and blocks of data labeled per other standards requires the EFI to be capable of changing from one set of standards to the other at appropriate instants during the data transmissions. The EFI is expected to make use of the two Start of Transmission words and the background data block End of Transmission word in deciding when to make these changes.

~~7.8.9.2~~7.6.9.2 Data Type Word Formats

The general word format defined in ARINC Specification 429 should be employed. Words transmitted by the FMC for which standards are defined in ARINC 429 should employ those standards and their ARINC 429 labels. Formats of symbol word groups, vector word groups, map reference word groups, and dynamic symbol words should differ from ARINC 429 standards in that the label field should be used to encode data type and the sign/status matrix to designate multiple word records within a data type group as follows:

BIT		
31	**30**	**WORD DESCRIPTION**
0	1	First word of data type group
0	0	Intermediate positional, character words
1	1	Control words (symbol rotation and vector conics)
1	0	Last word of data type group

Attachment 6 to this document sets forth the formats of these FMC-specific ARINC 429 words.

~~7.8.10~~7.6.10 EFI-to-FMC Data Transfer

The data sent from the EFI to the FMC will consist of the map mode, scale and symbol option selections made by the flight crew at the EFI control panel. These selections will be encoded into one or more discrete words, as defined in ARINC Specification 429, Part 2 and in ARINC Characteristic 725: Electronic Flight Instruments (EFI).

8.0 COMMUNICATIONS MANAGEMENT UNIT INTERFACE

8.1 General

The Communications Management Unit (CMU) interface is defined in ARINC Characteristic 758: Communications Management Unit (CMU) Mark 2. Specific details are implementation dependent.

9.0 DATA BASE STORAGE CONSIDERATIONS

9.1 Introduction

The FMC will contain a number of data bases and configuration tables which provide the data and definitions required to support the functions defined in Section 4. The data bases are stored in non-volatile memory and may be periodically updated or modified via the data loader. The individual data bases should be separately loadable. Designers should provide significant growth capacity when sizing data base memory storage. Mechanisms should be provided to ensure the integrity of the stored data.

9.2 Navigation Data Base

The navigation data base is stored in non-volatile memory in two parts: a body of active permanent data which is effective until a specified expiration date and a set of data revisions or active data for the next period of effectivity. The effectivity dates for both sets of data are displayed for reference on the system's configuration definition page. Data base updates are to be accomplished at appropriate intervals by loading the next cycle via means of a data base loader.

The navigation data base contains all current information required for operation in a specified geographic area. The data base should be consistent with the requirements of **RTCA DO-201A:** *Standards for Aeronautical Data*. It includes the following data:

- VOR, ILS, DME, VORTAC, and TACAN navigation aids
- NDBs
- Waypoints
- Airports and runways
- Standard Instrument Departures (SIDs)
- Standard Terminal Arrival Routes (STARs)
- Enroute airways
- Charted holding patterns
- Approaches (GNSS, ILS, VOR, NDB, LOC, LDA, etc., types)
- Approach and departure transitions
- Final Approach Segment (FAS) Data Block (for LP/LPV approaches)
- Company route structure
- Terminal gates
- Alternates
- Minimum Safe Altitude (MSA)
- Minimum Enroute IFR Altitude (MEA)
- Minimum Obstruction Clearance Altitude (MOCA)
- Grid Minimum Off-Route Altitudes (MORAs)
- FIR/Upper Flight Information Region (UIR) Boundaries
- Special Use Airspace
- Effectivity dates

- Airline customized data
- RNP

The data base is capable of supplying all of the information required for the assembly of a complete flight plan for the selected route via MCDU data entry and selection.

9.3 Airline Modifiable Information (AMI) Data Base

The Airline Modifiable Information data base is capable of defining those items which may be individually selectable by the airline operator. These may include the following:

- Performance management options
- Airport speed restrictions
- AOC data link parameters
- Tailorable CDU page formats
- Flight test bus definitions

The Airline Modifiable Information may also contain: special operations information, trigger events, special airline specific messages, and/or parameters.

9.4 Performance Data Base

The performance data base will contain the data necessary to allow the FMS to provide the vertical trajectory predictions (Section 4.3.3.2.1), performance calculations (Section 4.3.4), and vertical guidance (Section 4.3.3.2.2) functions. The data will consist of tables, coefficient for polynomials or any other convenient means of representing the data, but will not include any executable code. The data contained in the Performance Data base may include elements of the following:

- Aerodynamic Data
  - Drag polars (clean and high-lift)
  - Reynolds number drag correction
  - Compressibility drag
  - Trim drag (clean and high-lift)
  - Windmill drag
  - Spoiler/speed brake drag
  - Buffet onset mach number/lift coefficients
  - Stall speeds (clean and high-lift)
  - Bank angle limits
- Propulsion Data
  - Data to compute each thrust limit (Takeoff, Max Continuous, Max Cruise)
  - Data to compute de-rate and flex take-off rating
  - Bleed effects
  - Idle thrust setting

    - Relationship between thrust, fuel flow, ram drag and thrust setting parameter (EPR or N1)
- Performance Data
    - Economy climb speed data (all-engine and one engine inoperative)
    - Economy cruise speed data (all-engine and one engine inoperative)
    - Economy descent speed data (all-engine and one engine inoperative)
    - Drift-down speed data
    - Hold speed data
    - Maximum endurance speed data
    - Long Range Cruise (LRC) speed data
    - Maximum angle climb speed data
    - Maximum rate of climb speed data
    - Flap/slat/gear placard speeds
    - Maximum altitude (all engine and one engine inoperative)
    - Take-off time, fuel, distance data
    - Go-around time, fuel, distance data
    - Alternate flight plan time, fuel, distance data
    - Optimum altitude/optimum step weight data
    - Relationship between fuel weight/C.G.
- Take-off/approach data
    - Data to compute V1, VR, and V2
    - Approach speed data
    - Climb-out speed data

This is not an all-inclusive list. Some of the data in the list may not be applicable to a specific airplane/system and some additional data may be necessary in some applications, particularly as additional capability is added to the system. The format of the data is not specified in this document, but manufacturers are encouraged to use a standard format that will allow use of the FMS across multiple airplane types.

Data for the Performance data base is developed from data supplied by the airplane manufacturer, and may include off-line data reduction and modeling before loading into the FMS. It should be consistent with the data contained in that airplane's Airplane Flight Manual (AFM) and Flight Crew Operations Manual (FCOM).

The data base should contain sufficient data to allow identification of its part number and to which airplane model(s) it is applicable. Loading and use of the data in the FMS should include positive means of verifying that the appropriate data has been loaded, and that data pertaining to a particular model airplane is not being used on an airplane to which it does not apply.

A particular data base may contain data for more than one airplane model. In this case, positive means to preclude the wrong data being used should be provided.

9.5 Magnetic Variation Data Base

The magnetic variation data base will support the determination of magnetic variation for any Lat/Long, Navaid, Waypoint, Airport, etc. The format of the data stored in this data base is a manufacturer option, but should be flexible to accommodate periodic update of the magnetic variation data reference.

COMMENTARY

The use of current MagVar throughout the flight deck is desired to minimize confusion. However, for those aircraft configurations which cannot be updated, system designers should give consideration to providing a means to harmonize MagVar tables with other aircraft equipment, such as the inertial reference system, to provide a consistent display of magnetic bearings in the flight deck.

9.6 Terrain and Obstacle Data

[~~This section d~~Deleted by Supplement 5].

9.7 Airport Surface Map Data

[~~This section d~~Deleted by Supplement 5].

9.8 Configuration Data Base

The configuration data base defines parameters specific to an individual system application or installation.

COMMENTARY

These items are type certification driven. Changes to these items will require re-certification.

These items may include the following:

- Tables containing ATS data link parameters
- Transport and network protocols
- FMS configuration
- Available functional options
- Interface variations
- CMU specific configuration variations
- Optional maintenance configurations
- Weight variants definitions

10.0 BUILT-IN TEST AND MAINTENANCE PROVISIONS

10.1 General Discussion

Since the FMC may be the primary means of navigation on some aircraft, the utmost attention should be paid to the need for reliability and maintainability in all phases of system design, production, and installation.

COMMENTARY

It is also important to remember that all aspects of the testing program (BITE, ramp, and shop testing) contribute to the reliability and profitable operation of a system by the end users. The ability of the program to identify faults, and facilitate their repair, has a profound affect on maintainability and overall reliability. Attention to a close relationship between aircraft faults and shop testing will help in reducing the number of unscheduled removals.

10.2 Fault Detection and Reporting

10.2.1 General

The FMC should support at least one of the following Built-In Test Equipment (BITE) capabilities defined by AEEC:

- **ARINC Report 624:** Design Guidance for Onboard Maintenance System
- **ARINC Report 604:** Guidance for Design and Use of Built-In Test Equipment

MCDU maintenance pages should contain a fault log formatted in accordance with ARINC Report 624 or ARINC 604. This maintenance log should be able to be printed on the cockpit printer via selection on the MCDU.

COMMENTARY

The option used should be compatible with the aircraft in which the FMC will be installed.

BITE in the FMC should be capable of detecting at least 95% of the faults or failures which can occur within the FMS, and as many faults as possible associated with other interfaces.

Where possible, optional functions present in the FMS that are not activated by the operator should be excluded from all on-board testing. The intent is to eliminate unnecessary removals.

BITE should closely relate to bench testing. Error modes encountered on the aircraft should be reproducible in the shop. Error messages recorded by BITE should assist bench testing.

No failure occurring in the BITE subsystem should interfere with the normal operation of the FMC.

10.2.2 Self-Monitoring

The self-contained fault detection should incorporate nonvolatile memory and logic to identify true hardware faults based on the historical trends. This includes a flight hour monitor as well as air-ground logic to monitor installed time on the aircraft.

10.2.3 Debugging Tools

FMC complexity is such that it may sometimes exhibit operational anomalies for which the root cause(s) are difficult to identify. To provide for quick in-service observation/evaluation of the FMC software anomalies, the FMC should provide password accessible MCDU pages for BITE, view latched fail code(s), memory contents, etc. This feature would be usable by supplier/operator engineers as a debugging tool. Access to these pages should be categorized and leveled for line maintenance or engineering use, as appropriate. This should be a certified configuration so as to allow engineering evaluations in-flight during revenue operations of the system.

10.2.4 Failure Rate Monitor

Reasonable failure rate thresholds for some significant faults should be incorporated such that the FMC would optionally set a flag when these thresholds are exceeded.

COMMENTARY

Some hardware faults that would be reset during a ground check or power interruption may not be repeated immediately. This condition may allow the unit to remain on board the aircraft. A threshold exceedance monitor would detect and set the flag when one of these transient faults exceeds an acceptable rate of occurrence. Some airlines may choose to deactivate such a monitor.

10.2.5 Fault Messaging

The FMC will have a go/no-go light or indicator indicating overall unit performance ability. BITE fault messages (MCDU display, code lights or otherwise) will be as descriptive as possible (English language fault descriptions). When an external or internal fault occurs, the FMC will alert maintenance personnel to the status of the specific system components, either as a displayed list, or on request.

System faults should be classified based on their effect on the system as debilitating or non-debilitating. Fault displays should also indicate the most probable correction of the problem.

A system debilitating failure is any non-recoverable failure which prohibits the FMC from performing any basic required function: navigation, performance computations, flight planning, etc. Cockpit and/or LRU failure annunciation is provided for a system debilitating failure. A system debilitating failure will be logged in BITE memory. If recoverable, crew action may be necessary.

A non-system-debilitating failure is any BITE-detected failure which is auto-recoverable within specified/acceptable operational limitations (of short duration and requiring no crew action for recovery) and which has no adverse impact on the required functions of the FMC. A non-system-debilitating failure will be logged in BITE memory, but need not be cockpit and/or LRU annunciated.

10.3 Ramp Maintenance

10.3.1 Return to Service Testing

When an FMC is installed on an air transport aircraft, some form of end to end testing should be available for two primary reasons:

- To provide an operational verification of the system function prior to return to service.
- To reduce unnecessary removals of the FMC when the fault was actually in another part of the system.

As an end-to-end test, the procedure should verify integrity of the LRU as well as interfaces with other systems. This maintenance test will provide test values on the digital outputs with the appropriate status matrix code for the test condition as defined in ARINC Specification 429. This test can also exercise internal monitoring and diagnostic routines and provide test formats on the MCDU and on a multifunction display.

COMMENTARY

The airlines prefer test results to indicate the probable cause of failure. Emphasis on end to end system testing will lead to a desirable increase in the MTBUR, especially for removals that were not related to LRU faults.

Means should be provided for initiating this maintenance test either through an externally supplied discrete input or an MCDU prompt. The FMC may also have the capability, via a switch on the front of the FMC, for initiating the maintenance test. If this switch is provided, an indicator should also be mounted on the FMC front panel to show the result of the test.

10.3.2 Programmable Data Bus Interface

The system should provide output data to be recorded for analysis of system performance, including in-service operation. A list of available parameters, scaling, and label assignments should be determined by the manufacturer and made available for selection by the aircraft operator as required.

10.3.3 Data Loading

It is expected that operational software (manufacturer and airline controlled software or tables) and data bases (e.g., navigation data, performance data) will be on-board loadable. The FMC should accept this data from a data loader in accordance with ARINC 615 or ARINC 615A. The standard interface from the data loader to the FMC is high-speed ARINC 429. The return interface to the data loader is low-speed ARINC 429. The FMC should also support high-speed data loading via Ethernet interface defined in ARINC 615A.

COMMENTARY

It is recognized that some minimal level of boot software must be non-loadable to provide the basic loading interface.

The FMC should provide compatibility testing to ensure that loadable software and data are compatible with the FMC hardware configuration. Mechanisms should be provided to ensure the integrity of the loaded data.

10.3.4 Cross Loadable Software

All loadable software and data bases should be selectively cross loadable between two FMCs in a dual installation via the intersystem bus.

COMMENTARY

The objective of the cross loading capability is to reduce loading times. Since mixed cases of cross loadable and non-cross loadable software present many problems, operators prefer that all of the software be cross loadable.

10.3.5 Data Loading Fault Recovery

In all cases, when loading or cross loading software or data, the procedure must provide a method for recovering from faults. The FMC should be able to abort a software or data base loading process without a major disruption of the system (disruption requiring removal of the FMC from the aircraft).

10.4 Provisions for Automatic Test Equipment

10.4.1 General

To enable Automatic Test Equipment (ATE) to be used in the bench maintenance, internal circuit functions not available at the unit service connector and considered by the equipment manufacturer necessary for automatic test purposes may be brought to pins on an auxiliary connector of a type selected by the equipment manufacturer. This connector should be fitted an adequate number of contacts needed to support the ATE functions. The connector should be provided with a protective cover suitable to protect these contacts from damage, contamination, etc. while the unit is installed in the aircraft. The manufacturer should observe ARINC Specification 600 for unit projections, etc., when choosing the location for this auxiliary connector.

10.4.2 ATE Testing

The FMC should be ATE testable and should have a test program written using the ATLAS language specified in **ARINC Specification 626:** *Standard ATLAS Subset for Modular Test*. Development of the test program set should consider and apply the quality characteristics set forth in ARINC Specification 625.

COMMENTARY

The airlines desire that the ATLAS test procedure be demonstrated to execute without modification on Automatic Test Systems defined in **ARINC Specification 608A:** *Automatic Test Equipment Standards*.

ATTACHMENT 1 FLIGHT MANAGEMENT SYSTEM

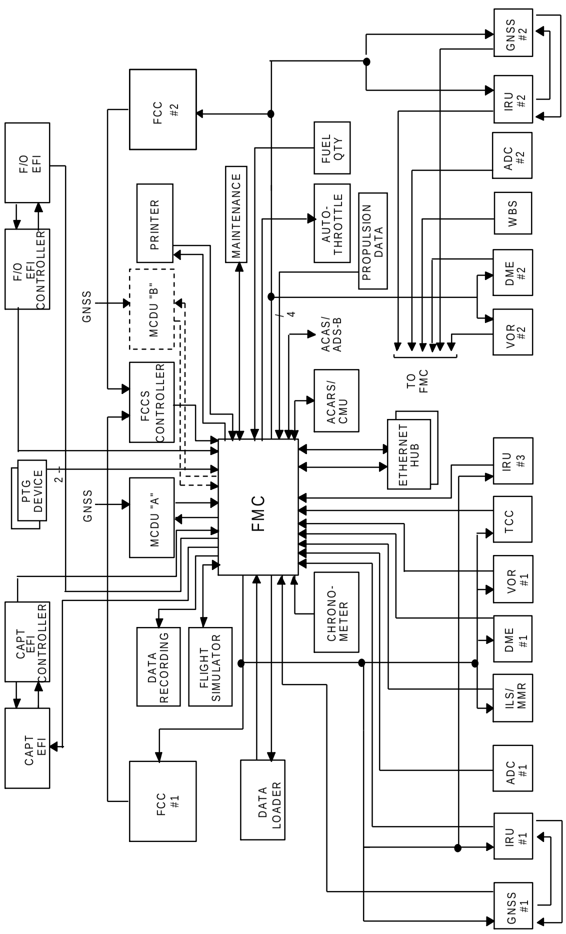
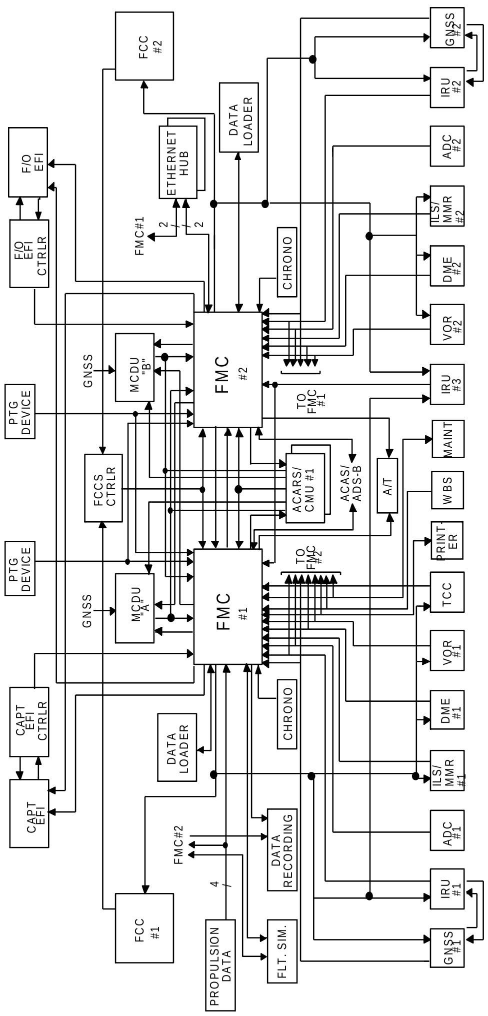


Figure 1-1 –

Configuration 1 – Single FMC Installation and

Configuration 2 – Single FMC/Dual CDU Installation

ATTACHMENT 1
FLIGHT MANGEMENT SYSTEM

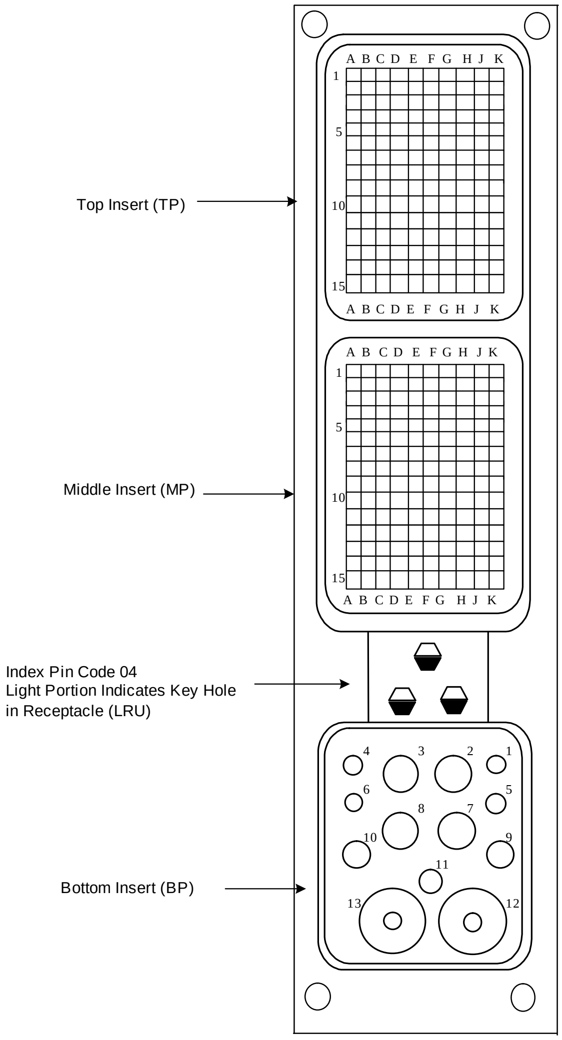


5171
5172 **Figure 2-2 – Configuration 3 – Dual FMC CDU Intallation**

ATTACHMENT 2 FMC CONNECTOR AND INTERWIRING

~~ATTACHMENT 2-1~~

ATTACHMENT 2-1 FMC CONNECTOR POSITIONING



ATTACHMENT 2-2

Figure 2-1 – View from Rear of Connector

ATTACHMENT 2-2
STANDARD INTERWIRING

ATTACHMENT 2-3 STANDARD INTERWIRING

ATTACHMENT 2-3

FUNCTION		FMC PIN	1 2 SOURCE/SINKS	NOTES
ARINC 429 Input	A	TP1A	ARINC 711 VOR #1	
ARINC 429 Input	B	TP1B	ARINC 711 VOR #1	
Spare		TP1C		
ARINC 429 Input	A	TP1D	ARINC 709 DME #1	
ARINC 429 Input	B	TP1E	ARINC 709 DME #1	
Spare		TP1F		
ARINC 429 Input	A	TP1G	ARINC 710 ILS	
ARINC 429 Input	B	TP1H	ARINC 710 ILS	
Spare		TP1J		
Discrete Input		TP1K	Oleo Strut Switch	
ARINC 429 Output	A	TP2A	ARINC 758 CMU	
ARINC 429 Output	B	TP2B	ARINC 758 CMU	
Spare		TP2C		
ARINC 429 Output	A	TP2D	Trajectory Bus	
ARINC 429 Output	B	TP2E	Trajectory Bus	
Spare		TP2F		
ARINC 429 Output	A	TP2G	Spare	
ARINC 429 Output	B	TP2H	Spare	
Spare		TP2J		
Spare		TP2K		
ARINC 429 Input	A	TP3A	ARINC 704A IRS	
ARINC 429 Input	B	TP3B	or ARINC 705 AHRS #1	
Spare		TP3C		
ARINC 429 Input	A	TP3D	ARINC 743A/755 GNSS #1	
ARINC 429 Input	B	TP3E	ARINC 743A/755 GNSS #1	
Spare		TP3F		
ARINC 429 Input	A	TP3G	ARINC 737 Weight and Balance System	
ARINC 429 Input	B	TP3H	ARINC 737 Weight and Balance System	
Spare		TP3J		
Discrete Input		TP3K	Self Test Switch	
Spare		TP4A		
Spare		TP4B		
Spare		TP4C		
ARINC 429 Output	A	TP4D	Spare	
ARINC 429 Output	B	TP4E	Spare	
Spare		TP4F		
ARINC 429 Input	A	TP4G	ARINC 762 TAWS	
ARINC 429 Input	B	TP4H	ARINC 762 TAWS	
Spare		TP4J		
Discrete Input		TP4K	Mag/True Input #1	
ARINC 429 Input	A	TP5A	EFI Data Source #1	
ARINC 429 Input	B	TP5B	EFI Data Source #1	
Spare		TP5C		
ARINC 429 Input	A	TP5D	ARINC 611 Fuel Quantity Data Source	
ARINC 429 Input	B	TP5E	ARINC 611 Fuel Quantity Data Source	
Spare		TP5F		
ARINC 429 Input	A	TP5G	ARINC 703 TCC	
ARINC 429 Input	B	TP5H	ARINC 703 TCC	

ATTACHMENT 2-2
STANDARD INTERWIRING

Spare	TP5J		
Discrete Input	TP5K	MCDU Select Switch	3
		1 2	

FUNCTION	FMC PIN	SOURCE/SINKS	NOTES
Spare	TP6A		
Spare	TP6B		
Spare	TP6C		
ARINC 429 Output A	TP6D	Spare	
ARINC 429 Output B	TP6E	Spare	
Spare	TP6F		
ARINC 429 Output A	TP6G	ARINC 739A Offside MCDU	
ARINC 429 Outpu B	TP6H	ARINC 739A Offside MCDU	
Spare	TP6J		
Discrete Input	TP6K	Reserved Spare	
ARINC 429 Input A	TP7A	Propulsion Data	
ARINC 429 Input B	TP7B	Source #3	
Spare	TP7C		
ARINC 429 Input A	TP7D	ARINC 706	
ARINC 429 Input B	TP7E	Air Data System #1	
Spare	TP7F		
ARINC 429 Input A	TP7G	ARINC 701	
ARINC 429 Input B	TP7H	Glare Shield Controller	
Spare	TP7J		
Discrete Input	TP7K		
Spare	TP8A		
Spare	TP8B		
Spare	TP8C		
Spare	TP8D		
Spare	TP8E		
Spare	TP8F		
Spare	TP8G		
Spare	TP8H		
Spare	TP8J		
Spare	TP8K		
ARINC 429 Input A	TP9A	ARINC 739A Onside MCDU	
ARINC 429 Input B	TP9B	ARINC 739A Onside MCDU	
Spare	TP9C		
ARINC 429 Input A	TP9D	ARINC 615 Data Loader	6
ARINC 429 Input B	TP9E	ARINC 615 Data Loader	
Discrete Input	TP9F		
ARINC 429 Output A	TP9G	Data Utilization	
ARINC 429 Output B	TP9H	Devices	
Spare	TP9J		
Discrete Input	TP9K	Man/Autotune Input #1	4
Spare	TP10A o		
Spare	TP10B o		
Spare	TP10C o		
Spare	TP10D o		
Spare	TP10E o		
Spare	TP10F o		
Spare	TP10G o		
Spare	TP10H o		
Spare	TP10J o		
Spare	TP10K o		

ATTACHMENT 2-2
STANDARD INTERWIRING

FUNCTION		FMC PIN	SOURCE/SINKS [1] [2]	NOTES
ARINC 429 Output	A	TP11A	EF/Instruments	
ARINC 429 Output	B	TP11B	EF/Instruments	
Spare		TP11C		
ARINC 429 Input	A	TP11D	ARINC 739A Offside MCDU	
ARINC 429 Input	B	TP11E	ARINC 739A Offside MCDU	
Spare		TP11F		
ARINC 429 Output	A	TP11G	ARINC 615 Data Loader	6
ARINC 429 Outpu t	B	TP11H	ARINC 615 Data Loader	
Spare		TP11J		
Discrete Input		TP11K	Man/Autotune Input #2	4
Spare		TP12A		
Spare		TP12B		
Spare		TP12C		
Spare		TP12D		
Spare		TP12E		
Spare		TP12F		
Spare		TP12G		
Spare		TP12H		
Spare		TP12J		
Spare		TP12K		
ARINC 429 Output	A	TP13A	Other ARINC 702A FMC	
ARINC 429 Output	B	TP13B	Other ARINC 702A FMC	
Spare		TP13C		
ARINC 429 Output	A	TP13D	ARINC 739A Onside MCDU	
ARINC 429 Output	B	TP13E	ARINC 739A Onside MCDU	
Spare		TP13F		
ARINC 429 Output	A	TP13G	Test Data Recording	
ARINC 429 Output	B	TP13H	Test Data Recording	
Spare		TP13J		
Discrete Output		TP13K	Alert Annunicator	
Spare		TP14A		
Spare		TP14B		
Spare		TP14C		
Ethernet Interface #1 6	A	TP14D	615A Data Loader, 758 CMU,	
Ethernet Interface #1	B	TP14E	and/or 744A Printer via Ethernet Hub	
Ethernet Interface #1 6	C	TP14F	615A Data Loader, 758 CMU,	
Ethernet Interface #1	D	TP14G	and/or 744A Printer via Ethernet Hub	
Ethernet Interface #1 6	E	TP14H	615A Data Loader, 758 CMU, and/or 744A Printer via Ethernet Hub	
Spare		TP14J		
Spare		TP14K		

ATTACHMENT 2-2
STANDARD INTERWIRING

FUNCTION		FMC PIN	SOURCE/SINKS [1] [2]	NOTES
ARINC 429 Input	A	TP15A	ARINC 758 CMU #1	
ARINC 429 Input	B	TP15B	ARINC 758 CMU #1	
Spare		TP15C		
ARINC 429 Input	A	TP15D	ARINC 704A IRS or	
ARINC 429 Input	B	TP15E	ARINC 705 AHRS #3	
Spare		TP15F		
ARINC 429 Input	A	TP15G	Propulsion Data Source #1	
ARINC 429 Input	B	TP15H	Propulsion Data Source #1	
Spare		TP15J		
Discrete Output		TP15K		
ARINC 429 Input	A	MP1A	Propulsion Data	
ARINC 429 Input	B	MP1B	Source #4	
Spare		MP1C		
ARINC 429 Input	A	MP1D	ARINC 711 VOR #2	
ARINC 429 Input	B	MP1E	ARINC 711 VOR #2	
Spare		MP1F		
ARINC 429 Input	A	MP1G	Other ARINC 702A FMC	
ARINC 429 Input	B	MP1H	Other ARINC 702A FMC	
Spare		MP1J		
Discrete Input		MP1K	SDI Code Input #1 [5]	
ARINC 429 Output		MP2A	Autothrottle System	
ARINC 429 Output		MP2B	Autothrottle System	
Spare		MP2C		
ARINC 429 Output		MP2D	ARINC 624 Maintenance System	
ARINC 429 Output		MP2E	ARINC 624 Maintenance System	
Spare		MP2F		
ARINC 429 Output		MP2G	ARINC 740/744A Printer	
ARINC 429 Output		MP2H	ARINC 740/744A Printer	
Spare		MP2J		
Discrete Input		MP2K		
ARINC 429 Input	A	MP3A	ARINC 704A IRS or	
ARINC 429 Input	B	MP3B	ARINC 705 AHRS #2	
Spare		MP3C		
ARINC 429 Input	A	MP3D	ARINC 731 Digital Clock	
ARINC 429 Input	B	MP3E	ARINC 731 Digital Clock	
Spare		MP3F		
ARINC 429 Input	A	MP3G	ARINC 724B ACARS	
ARINC 429 Input	B	MP3H	ARINC 724B ACARS	
Spare		MP3J		
Discrete Input		MP3K	SDI Input #2	5
Spare		MP4A		
Spare		MP4B		
Spare		MP4C		
ARINC 429 Output	A	MP4D	Spare	
ARINC 429 Output	B	MP4E	Spare	
Spare		MP4F		
ARINC 429 Input	A	MP4G	ASAS Bus	
ARINC 429 Input	B	MP4H	ASAS Bus	

ATTACHMENT 2-2
STANDARD INTERWIRING

Spare	MP4J
Spare	MP4K

FUNCTION		FMC PIN	SOURCE/SINKS [1] [2]	NOTES
ARINC 429 Input	A	MP5A	Propulsion	
ARINC 429 Input	B	MP5B	Data Source #2	
Spare		MP5C		
ARINC 429 Input	A	MP5D	ARINC 706	
ARINC 429 Input	B	MP5E	Air Data System #2	
Spare		MP5F		
ARINC 429 Input	A	MP5G	ARINC 740/744A Printer	
ARINC 429 Input	B	MP5H	ARINC 740/744A Printer	
Spare		MP5J		
Discrete Input		MP5K	SDI Code Input #3	5
ARINC 429 Input	A	MP6A	ARINC 624 Maintenance System	
ARINC 429 Input	B	MP6B	ARINC 624 Maintenance System	
Spare		MP6C		
ARINC 429 Input	A	MP6D	ARINC 758 CMU #2	
ARINC 429 Input	B	MP6E	ARINC 758 CMU #2	
Spare		MP6F		
ARINC 429 Input	A	MP6G	ARINC 724B ACARS #2	
ARINC 429 Input	B	MP6H	ARINC 724B ACARS #2	
Spare		MP6J		
Discrete Output		MP6K		
ARINC 429 Input	A	MP7A	ARINC 743A/755 GNSS #2	
ARINC 429 Input	B	MP7B	ARINC 743A/755 GNSS #2	
Spare		MP7C		
ARINC 429 Output	A	MP7D	Data Utilization	
ARINC 429 Output	B	MP7E	Devices	
Spare		MP7F		
ARINC 429 Input	A	MP7G	ARINC 709 DME #2	
ARINC 429 Input	B	MP7H	ARINC 709 DME #2	
Spare		MP7J		
Discrete Output		MP7K		
ARINC 429 Input	A	MP8A	Spare	
ARINC 429 Input	B	MP8B	Spare	
Spare		MP8C		
ARINC 429 Input	A	MP8D	Spare	
ARINC 429 Input	B	MP8E	Spare	
Spare		MP8F		
ARINC 429 Input	A	MP8G	Spare	
ARINC 429 Input	B	MP8H	Spare	
Spare		MP8J		
Spare		MP8K		
ARINC 429 Output	A	MP9A	ARINC 724B ACARS Data Link	
ARINC 429 Output	B	MP9B	ARINC 724B ACARS Data Link	
Spare		MP9C		
ARINC 429 Input	A	MP9D	EFIS	
ARINC 429 Input	B	MP9E	EFIS	
Discrete Input		MP9F		

ATTACHMENT 2-2
STANDARD INTERWIRING

ARINC 429 Output	A	MP9G	EFI Instrumentation	
ARINC 429 Output	B	MP9H	EFI Instrumentation	
Spare		MP9J		
Spare		MP9K		

FUNCTION		FMC PIN	SOURCE/SINKS (1 2)	NOTES
Spare		MP10A		
Spare		MP10B		
Spare		MP10C		
Ethernet Interface #2	A	MP10D	615A Data Loader, 758 CMU,	
Ethernet Interface #2	B	MP10E	and/or 744A Printer via Ethernet Hub	
Ethernet Interface #2	C	MP10F	615A Data Loader, 758 CMU,	
Ethernet Interface #2	D	MP10G	and/or 744A Printer via	
Ethernet Interface #2	E	MP10H	Ethernet Hub	
Spare		MP10J		
Spare		MP10K		
Discrete Input		MP11A	Data Loader Interface	6
Discrete Input		MP11B	Connector	
Discrete Input		MP11C	Reserved for Application-	
Discrete Input		MP11D	Unique Discrete Inputs	
Discrete Input		MP11E	Reserved for Application-	
Discrete Input		MP11F	Unique Discrete Inputs	
Discrete Input		MP11G	Reserved for Application-	
Discrete Input		MP11H	Unique Discrete Inputs	
Discrete Input		MP11J	Reserved for Application-	
Discrete Input		MP11K	Unique Discrete Inputs	
Spare		MP12A		
Spare		MP12B		
Spare		MP12C		
Spare		MP12D		
Spare		MP12E		
Spare		MP12F		
Spare		MP12G		
Spare		MP12H		
Spare		MP12J		
Spare		MP12K		
Discrete Input		MP13A	Reserved for Application-	
Discrete Input		MP13B	Unique Discrete Inputs	
Discrete Input		MP13C	Reserved for Application-	
Discrete Input		MP13D	Unique Discrete Inputs	
Discrete Input		MP13E	Reserved for Application-	
Discrete Input		MP13F	Unique Discrete Inputs	
Discrete Input		MP13G	Reserved for Application-	
Discrete Input		MP13H	Unique Discrete Inputs	
Discrete Input		MP13J	Reserved for Application-	
Discrete Input		MP13K	Unique Discrete Inputs	
Spare		MP14A		
Spare		MP14B		
Spare		MP14C		
Spare		MP14D		
Spare		MP14E		

ATTACHMENT 2-2
STANDARD INTERWIRING

Spare	MP14F		
Spare	MP14G		
Spare	MP14H		
Spare	MP14J		
Spare	MP14K		

1 2

FUNCTION	FMC PIN	SOURCE/SINKS	NOTES
Discrete Input	MP15A	Reserved for Application-	
Discrete Input	MP15B	Unique Discrete Inputs	
Discrete Input	MP15C	Reserved for Application-	
Discrete Input	MP15D	Unique Discrete Inputs	
Discrete Input	MP15E	Reserved for Application-	
Discrete Input	MP15F	Unique Discrete Inputs	
Discrete Input	MP15G	Reserved for Application-	
Discrete Input	MP15H	Unique Discrete Inputs	
Reserved	MP15J		
Reserved	MP15K		
115 Vac Primary Power (Hot)	BP1	115 Vac 5 A C/B	
Spare	BP2		
Spare	BP3		
Spare	BP4		
Spare	BP5		
Spare	BP6		
115 Vac Primary Power (Cold)	BP7	ac Ground	
Chassis Ground	BP8	dc Ground	
Spare	BP9		
Spare	BP10		
Spare	BP11		
Spare	BP12		
Spare	BP13		

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ATTACHMENT 2-3
NOTES APPLICABLE TO THE STANDARD INTERWIRING

ATTACHMENT 2-4 NOTES APPLICABLE TO THE STANDARD INTERWIRING

~~ATTACHMENT 2-4~~ATTACHMENT 2-5

1. The standard interwiring shown in this Attachment is for a single FMC installation comprised of one FMC and one CDU. For the sake of completeness; however, wiring is also shown to enable the FMC to operate with a second CDU and one for a cross-talk bus between this FMC and another one.

Commented [BM(AU17]: Looks like something got messed up.

2. Because of the variety of interwiring characteristics of aircraft installations utilizing the 702A FMC, this attachment does not standardize detailed interwiring in the traditional sense. Connector pin assignments are standardized with respect to input/output signal types only. While nominal signal functions are provided, manufacturers are encouraged to utilize programmable I/O design approaches which allow for variations in aircraft interfaces and installations.
3. Shield Grounds
4. Digital data bus shield grounds should be grounded to aircraft structure at both ends.
5. Off-Side CDU Enable Discrete
6. This discrete tells the FMC which CDU has control of data entry in dual CDU installations in which either may perform this function. When an open circuit is sensed by the FMC, its prime CDU has control. When the wire is connected to ground by means of a cockpit-located switch, or equivalent, the other CDU has control.
7. FMC Master/Slave and Manual Autotune Discrete
8. The Master/Slave discrete may be used in dual FMC installations to tell the FMCs which unit should be considered as master for dual system synchronism and redundancy management purposes as described in Section 3.5. The manual/autotune discretes provide information to the FMCs on VOR/DME turning status. When in autotune mode, these radios accept tuning commands from the FMC.
9. Source/Destination Identifier (SDI) Encoding
10. Pins MP1K, MP3K, and MP5K are assigned for encoding the location of the FMC in the aircraft (i.e., system number) per Section 2.1.4 of ARINC Specification 429. If the SDI function is used, the following encoding scheme should be employed, the pins designated being either left open circuit or connected, on the aircraft-mounted half of the connector, to pin MP5K. The wiring of these pins should cause bit numbers 9 and 10 of each digital word transmitted by the FMC to take on the binary states defined in ARINC Specification 429. When the SDI function is not used, both pins MP1K and MP3K should be left open circuit such that bit numbers 9 and 10 are always binary zeros.

FMC No.	Connector Pin	
	MP1K	MP3K
Not Applicable	Open	Open
1	Open	To MP5K
2	To MP5K	Open
3	To MP5K	To MP5K

11. The foregoing describes the SDI function performed by a data source. ARINC Specification 429 also discusses the data identification function to be performed by

ATTACHMENT 2-3
NOTES APPLICABLE TO THE STANDARD INTERWIRING

sinks whose system numbers are encoded in this way. In summary, the FMC should recognize and accept data words in which bit numbers 9 and 10 are either both zeros or form the code defined by pins MP1K and MP3K. All other data may be discarded.

12. Data Loader Interface

13. It is expected that the airframe manufacturers will provide, at some convenient location on the aircraft, a connection point for an external data loader of the type described in ARINC ~~Report~~ 615 and 615A.

14.

ATTACHMENT 2-4
CONNECTOR INSERT LAYOUT

ATTACHMENT 2-6 CONNECTOR INSERT LAYOUT

~~ATTACHMENT 2-5~~ATTACHMENT 2-7

TOP INSERT

	A	B	C	D	E	F	G	H	J	K
1	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	o DISC INPUT
2	ARINC 429 OUTPUT o A	o B	SPARE o	ARINC 429 OUTPUT o A	o B	SPARE o o	ARINC 429 OUTPUT o A	o B	SPARE o	SPARE o
3	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	o DISC INPUT
4	SPARE o	SPARE o	SPARE o	ARINC 429 OUTPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	o DISC INPUT
5	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	o DISC INPUT
6	SPARE o	SPARE o	SPARE o	ARINC 429 OUTPUT o A	o B	SPARE o	ARINC 429 OUTPUT o A	o B	SPARE o	o DISC INPUT
7	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	o DISC INPUT
8	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o
9	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	o DISC INPUT	ARINC 429 OUTPUT o A	o B	SPARE o	o DISC INPUT
10	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o
11	ARINC 429 OUTPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	ARINC 615 OUTPUT o A	o B	SPARE o	o DISC INPUT
12	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o
13	ARINC 429 OUTPUT o A	o B	SPARE o	ARINC 429 OUTPUT o A	o B	SPARE o	ARINC 429 OUTPUT o A	o B	SPARE o	o DISC OUTPUT
14	SPARE o	SPARE o	SPARE o	ETHERNET INTERFACE #1 o A	o B	o C	o D	o E	SPARE o	SPARE o
15	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	ARINC 429 INPUT o A	o B	SPARE o	o DISC OUTPUT

ATTACHMENT 2-4
CONNECTOR INSERT LAYOUT

MIDDLE INSERT

	A	B	C	D	E	F	G	H	J	K
1	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	S D I C O D E I N P U T # 1 o
2	ARINC 429 OUTPUT o o A B		S P A R E o	ARINC 429 OUTPUT o o A B		S P A R E o	ARINC 429 OUTPUT o o A B		S P A R E o	o D I S C I N P U T
3	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	o D I S C I N P U T
4	S P A R E o	S P A R E o	S P A R E o	ARINC 429 OUTPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	S P A R E o
5	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	o D I S C I N P U T
6	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	ARINC 429 INPUT o o A B		S P A R E o	o D I S C

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ATTACHMENT 2-4
CONNECTOR INSERT LAYOUT

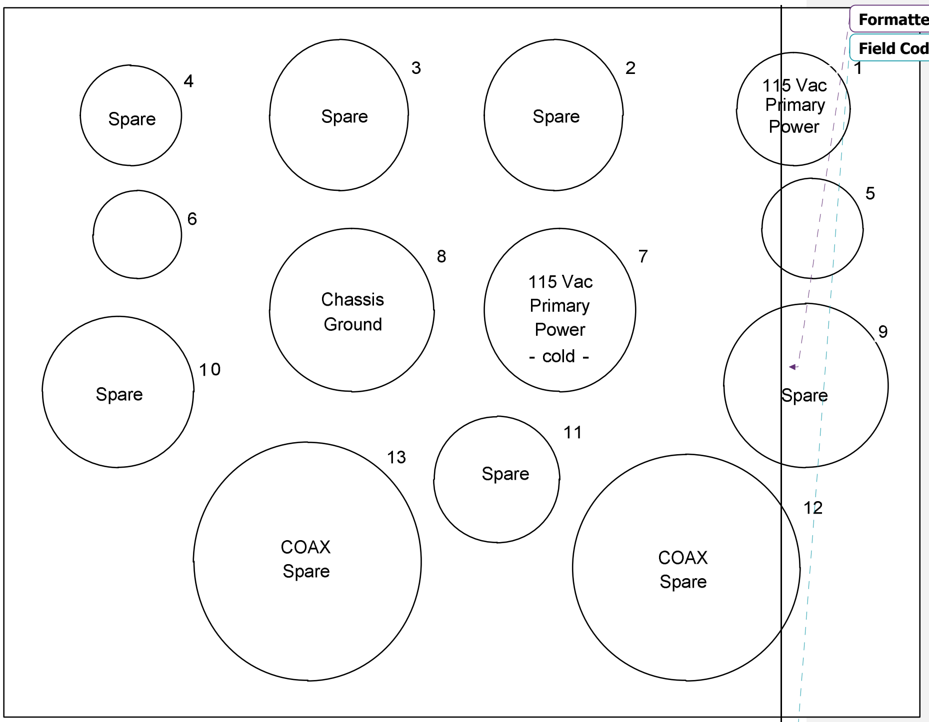
										OUTPUT
7	ARINC 429 INPUT o o A B		SPARE o	ARINC 429 OUTPUT o o A B		SPARE o	ARINC 429 INPUT o o A B		SPARE o	o DISC INPUT
8	ARINC 429 INPUT o o A B		SPARE o	ARINC 429 INPUT o o A B		SPARE o	ARINC 429 INPUT o o A B		SPARE o	SPARE o
9	ARINC 429 OUTPUT o o A B		SPARE o	ARINC 429 INPUT o o A B		o DISC INPUT	ARINC 429 OUTPUT o o A B		SPARE o	SPARE o
10	SPARE o	SPARE o	SPARE o	ETHERNET INTERFACE #2 o o o o o A B C D E					SPARE o	SPARE o
11	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT
12	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o

ATTACHMENT 2-4
CONNECTOR INSERT LAYOUT

13	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT
14	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o	SPARE o
15	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o DISC INPUT	o RSVD	o RSVD

ATTACHMENT 2-4
CONNECTOR INSERT LAYOUT

BOTTOM INSERT



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ATTACHMENT 3

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5246 **ATTACHMENT 4 DATA INPUT/OUTPUT FMC OUTPUTS**

FUNCTION	LABEL		MCDU	GENERAL	EFI	ACARS	PRINTER	AUTO THROTTLE	TRAJECTORY
DISTANCE TO GO	001	BCD		X	X				
TIME TO GO	002	BCD			O				
PRESENT POSITION LATITUDE	010	BCD		O					
PRESENT POSITION LONGITUDE	011	BCD		O					
GROUND SPEED	012	BCD		O	X				
SELECTED RUNWAY HEADING	017	BCD		O					
SELECTED N1/EPR (BCD)	021	BCD							
TACAN SELECTED COURSE (BCD)	027	BCD		O					
ILS FREQUENCY	033	BCD		O					
VOR/ILS FREQUENCY #1	034	BCD		O					
VOR/ILS FREQUENCY #2	034	BCD		O					
DME FREQUENCY #1	035	BCD		O					
DME FREQUENCY #2	035	BCD		O					
MLS FREQUENCY/CHANNEL	036	BCD		O					
SET LATITUDE	041	BCD		X					
SET LONGITUDE	042	BCD		X					
SET MAGNETIC HEADING	043	BCD		X					
FAS DATA BLOCK MESSAGE START (see ARINC 743B/755 for details)	045	BLK		O					
FAS DATA BLOCK MESSAGE DATA	046	BLK		O					
ETA (ACTIVE WAYPOINT)	056	BCD			X				
ACMS INFORMATION	061	BNR		O					
ACMS INFORMATION	062	BNR		O					
ACMS INFORMATION	063	BNR		O					
LONGITUDINAL (ACTIVE WAYPOINT) CENTER OF GRAVITY (BCD)	066	BCD		O					
REFERENCE AIRSPEED (VREF)	070	BNR		O	O				
TAKE-OFF CLIMB AIRSPEED (V2)	071	BNR		O	O				
ROTATION SPEED (VR)	072	BNR		O	X				
CRITICAL ENGINE FAILURE SPEED VI	073	BNR		X					
ZERO FUEL WEIGHT	074	BNR		O					
GROSS WEIGHT	075	BNR		X				O	
TARGET AIRSPEED	077	BNR		O					
SELECTED COURSE #1	100	BNR		O					
SELECTED ALTITUDE	102	BNR		O					X
SELECTED AIRSPEED	103	BNR		O				O	X
SELECTED VERTICAL SPEED	104	BNR		O					
SELECTED RUNWAY HEADING	105	BNR		O					
SELECTED MACH	106	BNR		O					X
SELECTED CRUISE ALTITUDE	107	BNR		O					
DESIRED TRACK	114	BNR		O	X				X

ATTACHMENT 4
DATA INPUT/OUTPUT FMC OUTPUTS

FUNCTION	LABEL		MCDU	GENERAL	EFI	ACARS	PRINTER	AUTO THROTTLE	TRAJECTORY
WAYPOINT BEARING	115	BNR		X	X				
CROSS TRACK DISTANCE	116	BNR		O	X				
VERTICAL DEVIATION	117	BNR		O	O				
RANGE TO ALTITUDE	120	BNR			X				
HORIZONTAL COMMAND SIGNAL	121	BNR		X					
VERTICAL COMMAND SIGNAL	122	BNR		O					
THROTTLE COMMAND SIGNAL	123	BNR					O	O	
UNIVERSAL COORDINATED TIME (UTC)	125	BCD		X					
VERTICAL DEVIATION (WIDE)	126	BNR		O					
SELECTED LANDING ALTITUDE	127	BNR		X					
CURRENT VERTICAL PATH PERF LIMIT	135	BNR							X
CURRENT VERTICAL PATH PERF	136	BNR							X
GREENWICH MEAN TIME (UTC)	150	BNR		X	X			O	X
LOCALIZER BEARING (TRUE)	151	BNR		O					
MAXIMUM ALTITUDE	153	BNR		X					
RUNWAY HEADING (TRUE)	154	BNR		X					
ESTIMATED POSITION UNCERTAINTY	167	BNR							X
CURRENT RNP	171	BNR							X
DRIFT ANGLE	200	BCD		O					
ENERGY MANAGEMENT (CLEAN)	202	BNR			O				
ENERGY MANAGEMENT SPEED BRAKES	203	BNR			O				
UTILITY AIRSPEED	204	BNR		O	O				
BARO ALTITUDE	204	BNR							
SBAS FAS DATABLOCK WORD #1 (see ARINC755 for details)	205	BLK		O					
COMPUTED AIRSPEED	206	BNR							
SBAS FAS DATABLOCK WORD #2	206	BLK		O					
SBAS FAS DATABLOCK WORD #3	207	BLK		O					
TOTAL AIR TEMPERATURE	211	BNR					O	O	
SBAS FAS DATABLOCK WORD #4	211	BLK		O					
ALTITUDE RATE	212	BNR							
STATIC AIR TEMPERATURE	213	BNR					O	O	
SBAS FAS DATABLOCK WORD #5	213	BLK		O					
SBAS FAS DATABLOCK WORD #6	215	BLK		O					
GEOMETRIC VERTICAL RATE	217	BNR							
SBAS FAS DATABLOCK WORD #7	217	BLK		O					
MCDU #1 ADDRESS LABEL	220		X						
~~MCDU #1 ADDRESS LABEL~~	~~220~~		~~X~~						
SBAS FAS DATABLOCK WORD #8	220	BLK		O					
MCDU #2 ADDRESS LABEL	221		X						

ATTACHMENT 4
DATA INPUT/OUTPUT FMC OUTPUTS

FUNCTION	LABEL		MCDU	GENERAL	EFI	ACARS	PRINTER	AUTO THROTTLE	TRAJECTORY
SBAS FAS DATABLOCK WORD #9	221	BLK		O					
MCDU #3 ADDRESS LABEL	222		O						
CDU DATA (PER ARINC 739)			X						
PRINTER #1 ADDRESS LABEL	223						O		
SBAS FAS DATABLOCK WORD #10	223	BLK		O					
PRINTER #2 ADDRESS LABEL	224						O		
SBAS FAS DATABLOCK WORD #11	224	BLK		O					
MINIMUM MANEUVERING AIR SPEED	225	BNR			O				
SBAS FAS DATABLOCK WORD #12	225	BLK		O					
MINIMUM OPERATING FUEL TEMP.	226	BNR		O					
MCDU #4 ADDRESS LABEL	230			X					
SBAS FAS DATABLOCK WORD #13	225	BLK		O					
ACTIVE TRAJ INTENT DATA BLOCK	232								X
ACMS INFORMATION	233								X
ACMS INFORMATION	234								X
ACMS INFORMATION	235								X
ACMS INFORMATION	236								X
ACMS INFORMATION	237								X
MIN. AIRSPEED FOR FLAP EXTENSION	241	BNR			O				
MODIFIED INTENT DATA BLOCK	242								X
SBAS FAS DATABLOCK WORD #14	242	BLK		O					
SBAS FAS DATABLOCK WORD #15	244	BLK		O					
MINIMUM AIRSPEED	245	BNR		O					
GENERAL MAX SPEED (VCMAX)	246	BNR		O					
SBAS FAS DATABLOCK WORD #16	246	BLK		O					
CONTROL MINIMUM SPEED (VCMIN)	247	BNR		O					
CONTINUOUS N1 SPEED	250	BNR	O				O		
GO-AROUND N1 LIMIT	253	BNR		X					
CRUISE N1 LIMIT	254	BNR		X					
CLIMB N1 LIMIT	255	BNR		X					
TIME FOR CLIMB	256	BNR		O					
TIME FOR DESCENT	257	BNR		O					
DATE/FLIGHT LEG	260	BCD		X				O	
FLIGHT NUMBER (BCD)	261	BCD		O					
DOCUMENTARY DATA (PER ARINC 619)	262	BNR				O			
MIN. AIRSPEED FOR FLAP RETRACTION	263	BNR			O				
NDB EFFECTIVITY	263			O					
TIME TO TOUCHDOWN	264	BNR		O	O				
MIN. BUFFET AIRSPEED	265	BNR		O					

ATTACHMENT 4
DATA INPUT/OUTPUT FMC OUTPUTS

FUNCTION	LABEL		MCDU	GENERAL	EFI	ACARS	PRINTER	AUTO THROTTLE	TRAJECTORY
MAX. MANEUVER AIRSPEED	267	BNR		O	O				
INTENT STATUS	270	DISC							X
STATUS DISCRETES	270	DISC		X					
DISCRETE DATA #1	270	DISC			X				
DISCRETE DATA #2	271	DISC		X	X				
DISCRETE DATA #3	272	DISC		O	O				
DISCRETE DATA #6	275	DISC		O	O				
DISCRETE DATA #7	276	DISC		O	O				
APPLICATION DEPENDENT	301				O				
APPLICATION DEPENDENT	302				O				
APPLICATION DEPENDENT	303				O				
PRESENT POSITION LATITUDE	310	BNR		O	X				X
PRESENT POSITION LONGITUDE	311	BNR		O	X				X
GROUND SPEED	312	BNR		O	X				X
TRACK ANGLE TRUE	313	BNR		O	X				X
TRUE HEADING	314	BNR							X
WIND SPEED	315	BNR			X				X
WIND DIRECTION (TRUE)	316	BNR			X				X
TRACK ANGLE MAGNETIC	317	BNR		O	X				
MAGNETIC HEADING	320	BNR							X
DRIFT ANGLE	321	BNR		O	X				
FLIGHT PATH ANGLE	322	BNR			O				
GEOMETRIC ALTITUDE	323	BNR							
TRACK ANGLE RATE	335	BNR							X
N1 OR EPR COMMAND	341	BNR		X			O	O	
N1 BUG DRIVE	342	BNR		X			O	O	
MAINTENANCE DATA #5	354			O					
ISO ALPHABET #5 MESSAGE	357	ISO-5			O				
FLIGHT INFORMATION	360	BNR		O	O				
N/S VELOCITY	366	BNR							X
E/W VELOCITY	367	BNR							X
EQUIPMENT ID	377			X					

Notes:

~~2.~~4. X = Basic or Baseline

~~3.~~5. O = Optional

ATTACHMENT 5 ENVIRONMENTAL TEST CATEGORIES

ENVIRONMENT	RTCA DO-160 SECTION	CATEGORY RTCA DO-160C/D
Temperature and Altitude	4	Category A2/W
Temperature Variation	5	Category A
Humidity	6	Category B
Shock	7	
Vibration	8	Category B'
Explosion	9	Category X
Waterproofness	10	Category X
Hydraulic Fluid	11	Category X
Sand and Dust	12	Category X
- Fungus	13	Category F
- Salt Spray	14	Category X
Magnetic Effects	15	Category Z
Power Input	16	Category A
Voltage Spikes	17	Category A
Audio Frequency		
- Conducted Susceptibility	18	Category Z
Electromagnetic Compatibility		Category A
- Induced Signal Susceptibility	19	Category Z
- Radio Frequency Susceptibility	20	Category W
- Emission of Radio Frequency Energy	21	Category Z
- Lightning	22	600v/120a

ATTACHMENT 6 FMC/EFI INTERFACE

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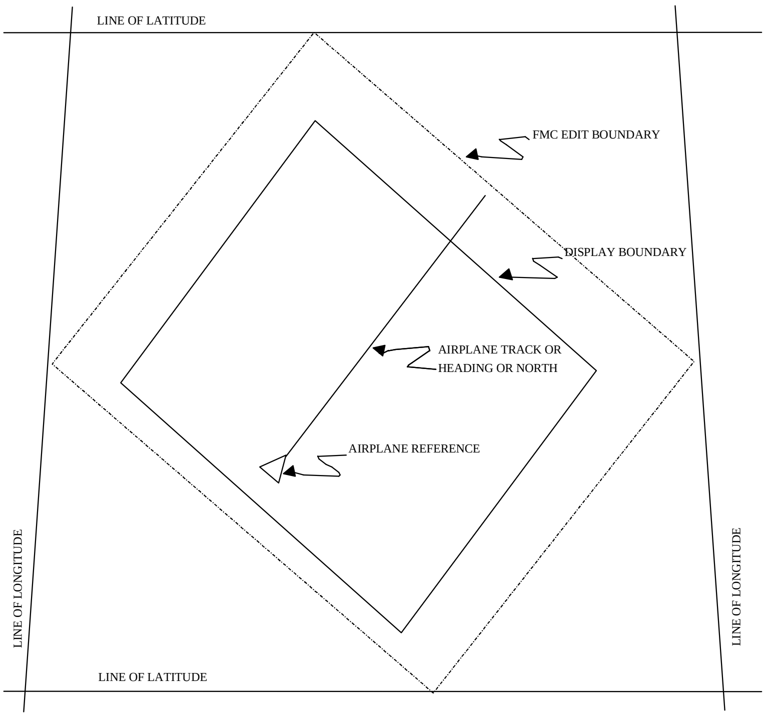
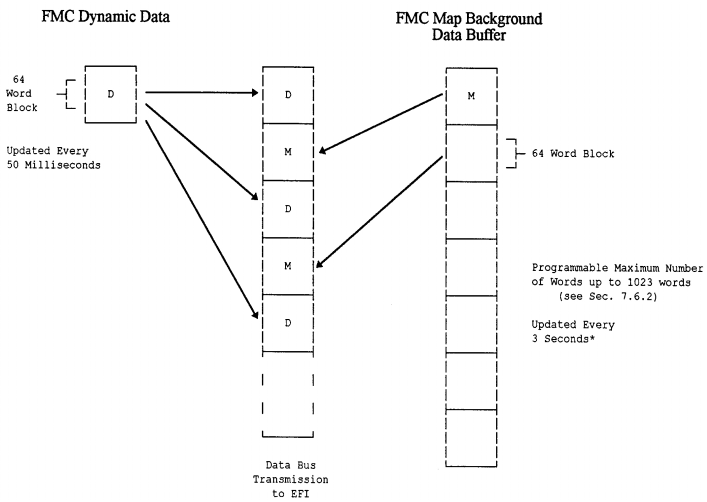


Figure 6-1 – Map Edit Area
North-Up Orientation Used in Plan Mode

ATTACHMENT 6
FMC/EFI INTERFACE



Note: Updated and transmitted within 1 second after either a mode, scale or option change.

Figure 6-2 – FMC/EFI Data Transmission Format

ATTACHMENT 6
FMC/EFI INTERFACE

Table 6-1 – FMC/EFI Data Type Identification Codes

OCTAL LABEL	BIT POSITION								PARAMETER
	1	2	3	4	5	6	7	8	
301	1	1	0	0	0	0	0	1	START OF TRANSMISSION (SOT) (BACKGROUND)
303	1	1	0	0	0	0	1	1	START OF TRANSMISSION (SOT) (DYNAMIC)
100	0	1	0	0	0	0	0	0	VECTOR - Active Flight Plan
300	1	1	0	0	0	0	0	0	- Active Flight Plan Changes
040	0	0	1	0	0	0	0	0	- Inactive Flight Plan
240	1	0	1	0	0	0	0	0	- Inactive Flight Plan Changes
140	0	1	1	0	0	0	0	0	- Radial
340	1	1	1	0	0	0	0	0	- Runway Center Line
020	0	0	0	1	0	0	0	0	- Offset Path
220	1	0	0	1	0	0	0	0	undefined
120	0	1	0	1	0	0	0	0	undefined
320	1	1	0	1	0	0	0	0	undefined
060	0	0	1	1	0	0	0	0	undefined
260	1	0	1	1	0	0	0	0	undefined
160	0	1	1	1	0	0	0	0	VECTOR IDENTIFIERS
360	1	1	1	1	0	0	0	0	undefined
010	0	0	0	0	1	0	0	0	undefined
210	1	0	0	0	1	0	0	0	undefined
110	0	1	0	0	1	0	0	0	undefined
310	1	1	0	0	1	0	0	0	undefined
050	0	0	1	0	1	0	0	0	undefined
250	1	0	1	0	1	0	0	0	SYMBOLS - VORTAC + Identifier
150	0	1	1	0	1	0	0	0	- Tuned VORTAC + Identifier
350	1	1	1	0	1	0	0	0	- VOR + Identifier
030	0	0	0	1	1	0	0	0	- Tuned VOR + Identifier
230	1	0	0	1	1	0	0	0	- DME/TACAN + Identifier
130	0	1	0	1	1	0	0	0	- Tuned DME/TACAN + Identifier
330	1	1	0	1	1	0	0	0	- Waypoint + Identifier
070	0	0	1	1	1	0	0	0	- Active Waypoint + Identifier
270	1	0	1	1	1	0	0	0	- Airfield + Identifier
170	0	1	1	1	1	0	0	0	- Origin/Destination Airfield Ident
370	1	1	1	1	1	0	0	0	- GRP + Identifier
004	0	0	0	0	0	1	0	0	- Altitude Profile Point + Identifier
204	1	0	0	0	0	1	0	0	- Selected Reference Point
104	0	1	0	0	0	1	0	0	undefined
304	1	1	0	0	0	1	0	0	undefined
044	0	0	1	0	0	1	0	0	undefined
244	1	0	1	0	0	1	0	0	undefined
144	0	1	1	0	0	1	0	0	undefined
344	1	1	1	0	0	1	0	0	undefined
024	0	0	0	1	0	1	0	0	undefined
224	1	0	0	1	0	1	0	0	TEXT - Type 1: Navigation Advisory
124	1	0	0	1	0	1	0	0	- Type 2: Maintenance Test
324	1	1	0	1	0	1	0	0	- Type 3
064	0	0	1	1	0	1	0	0	- Type 4
264	1	0	1	1	0	1	0	0	MAP REFERENCE GROUP - Latitude

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FMC/EFI INTERFACE

OCTAL LABEL	BIT POSITION 1	2	3	4	5	6	7	8	PARAMETER
164	0	1	1	1	0	1	0	0	-Longitude
364	1	1	1	1	0	1	0	0	DISCRETE WORD - Map Mode
014	0	0	0	0	1	1	0	0	- Range
214	1	0	0	0	1	1	0	0	undefined
114	0	1	0	0	1	1	0	0	undefined
314	1	1	0	0	1	1	0	0	undefined
054	0	0	1	0	1	1	0	0	ROTATED SYMBOLS - Runway + Identifier
254	1	0	1	0	1	1	0	0	- Airport + Runway + Identifier
154	0	1	1	0	1	1	0	0	- Marker Beacon
354	1	1	1	0	1	1	0	0	- Holding Pattern – R
034	0	0	0	1	1	1	0	0	- Holding Pattern – L
234	1	0	0	1	1	1	0	0	- Procedure Turn – R
134	0	1	0	1	1	1	0	0	- Procedure Turn – L
334	1	1	0	1	1	1	0	0	undefined
074	0	0	1	1	1	1	0	0	undefined
274	1	0	1	1	1	1	0	0	undefined
174	0	1	1	1	1	1	0	0	undefined
374	1	1	1	1	1	1	0	0	undefined
302	1	1	0	0	0	0	1	0	END OF TRANSMISSION (EOT)
000	0	0	0	0	0	0	0	0	FILL-IN WORDS

ATTACHMENT 7 FMC/DATALINK INTERFACE

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Part A
Text-Imbedded Error Check For Ground Computer/Airborne Computer Messages

Section 1
End-to-End Error Check

The FMC should provide the facility to perform an “end-to-end” error check on messages received and transmitted via ACARS. This is accomplished by designating the four characters preceding the suffix character (ETX) of the final block of the message as the “text-imbedded” error control field. This field will be used to verify successful transfer of each message to which the end-to-end error check applies.

The allowable character set on which the end-to-end check is performed is defined in Attachment 10 to this Characteristic, entitled “ISO Alphabet No. 5 Subset for Ground Computer/Airborne Computer Message Exchange Via ACARS.” In addition, bit patterns of the characters appended to the message by the error checking procedure should be encoded per this ISO subset.

The pad bit for each 7-bit character in the message is set to a binary zero prior to encoding or decoding of the error check.

The error check to be used in the verification of end-to-end message integrity is a Cyclic Redundancy Check (CRC), described in Section 3 of this attachment, “Character-oriented CRC Calculation.” The CRC generator polynomial is the same CCITT polynomial introduced into ARINC Specification 429 by Supplement 12.

COMMENTARY

The end-to-end error check provides an assurance that a message composed on the ground has been correctly reconstructed by the FMC (and vice versa for messages originated by the FMC). It supplements the message integrity assurance provisions which are employed at various levels during the transfer of data from originator (e.g., the host airline computer) to the FMC. The normal message integrity checks which, onboard the aircraft, include BCS, word count check, parity check, etc., should continue to be exercised in accordance with the appropriate ACARS Characteristic (ARINC 597, 724, or 724B) and this Characteristic.

Encoding the CRC at the Message Source

The procedure specifying the application of the CRC by the source on the message text is as follows. (See Section 3 of this attachment, Character-Oriented CRC Calculation, for a detailed description and example of this procedure.)

- The CRC is to be applied to the message text beginning with the first character of the IMI, and ending with the last text character of the message.

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- When ordering bits in the message to be CRC'd, the Most Significant Bit (MSB) of the message is the least significant bit of the first character of the IMI. The Least Significant Bit (LSB) of the message is the most significant bit of the last text character of the message (excluding the ETX character).
- After the source has been determined the CRC code from the 16-bit "remainder," four hexadecimal characters representing these 4-bit bytes will be encoded as ISO #5 characters for the CRC field. The hexadecimal characters are determined by assigning 4 bits at a time in the order specified by the table in Section 2 of this attachment. The resulting four characters are placed at the end of the original message text to be transmitted, in the same transmission order as message text characters; i.e., the LSB of each character is transmitted first.
- For character-oriented file transfer protocols, an ETX character follows the last character of the CRC code.

Decoding the CRC at the Message Sink

- Upon the receipt of a message which is error-free in accordance with the link level protocol, the sink will begin verification of the received message.
- In order to verify the value of the CRC, the sink should first ensure each 7-bit ISO #5 character of the message text has the associated pad bit set to a binary zero, such that each character can be assumed to be 8 bits in length. The sink should also ensure any intermediate "end-of-block" characters have been deleted from the message text.
    - The sink then operates on the four characters representing the CRC code to translate them back to the original 16-bit binary value calculated by the source; i.e., the reverse of the procedure specified above is performed. Finally, the sink verifies the integrity of the message text by applying either of the verification procedures specified for the receiving system in the following section on Character-Oriented CRC Calculation.
- If the CRC confirms message integrity, the sink should accept the message. If message integrity is not confirmed (the CRC fails), the sink should discard the message. Further action will be defined by the user and will depend on the application of the message.

COMMENTARY

This CRC scheme is only compatible with uncorrupted messages from the host airline computer to the FMC and vice versa. No intermediate systems may be allowed to modify the message text portion of the transmission by character substitution or insertion (such as line feeds, carriage returns, etc.).

Section 2
ISO #5 Representation of Hexadecimal Characters for Binary Data Transmission

This document states that ISO #5 representation of hexadecimal characters should be used for the interchange of binary information between ground-based and airborne computers via ACARS. The following example illustrates the binary-to-ISO character conversion process.

TRANSMISSION ORDER = =>								
	LSB						**MSB**	
1. BINARY DATA STREAM	1 0 1 1		0 1 0 0		0 0 0 0		0 0 1 1	
2. 4 BIT BYTES STREAM	1 0 1 1		0 1 0 0		0 0 0 0		0 0 1 1	
3. HEX CHARACTER VALUE	B		4		0		3	
4. ISO CHARACTER (COLUMN, ROW)	4,2		3,4		3,0		3,3	
5. ISO BIT VALUES (P = PAD BIT)	P	1 0 0 0 0 1 0	P	0 1 1 0 1 0 0	P	0 1 1 0 0 0 0	P	0 1 1 0 0 1 1
6. ISO BITS TRANSMITTED (PAD BITS set to 0)	0	1 0 0 0 0 1 0	0	0 1 1 0 1 0 0	0	0 1 1 0 0 0 0	0	0 1 1 0 0 1 1
7. CHARACTER TX ORDER	CHAR 4		CHAR 3		CHAR 2		CHAR 1	

ATTACHMENT 7
FMC/DATALINK INTERFACE

Binary representation of ISO #5 hexadecimal characters is illustrated in the table below.

BIT 7 ------------------------>					0	0	0	0	1	1	1	1
BIT 6 -------------------------------------->					0	0	1	1	0	0	1	1
BIT 5 -->					0	1	0	1	0	1	0	1
BIT 4	**BIT 3**	**BIT 2**	**BIT 1**	**Col → Row ↓**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
0	0	0	0	0	00 NUL	10 DLE	20 SP	30 0	40 @	50 P	60 '	70 p
0	0	0	1	1	01 SOH	11 DC1	21 !	31 1	41 A	51 Q	61 a	71 q
0	0	1	0	2	02 STX	12 DC2	22 "	32 2	42 B	52 R	62 b	72 r
0	0	1	1	3	03 ETX	13 DC3	23 #	33 3	43 C	53 S	63 c	73 s
0	1	0	0	4	04 EOT	14 DC4	24 $	34 4	44 D	54 T	64 d	74 t
0	1	0	1	5	05 ENQ	15 NAK	25 %	35 5	45 E	55 U	65 e	75 u
0	1	1	0	6	06 ACK	16 SYN	26 &	36 6	46 F	56 V	66 f	76 v
0	1	1	1	7	07 EL	17 ETB	27 ’	37 7	47 G	57 W	67 g	77 w
1	0	0	0	8	08 BS	18 CAN	28 (	38 8	48 H	58 X	68 h	78 x
1	0	0	1	9	09 HT	19 EM	29)	39 9	49 I	59 Y	69 i	79 y
1	0	1	0	10	0A LF	1A SUB	2A *	3A :	4A J	5A Z	6A j	7A z
1	0	1	1	11	0B VT	1B ESC	2B +	3B ;	4B K	5B [	6B k	7B {
1	1	0	0	12	0C FF	1C FS	2C ,	3C <	4C L	5C \	6C l	7C ¦
1	1	0	1	13	0D CR	1D GS	2D /	3D =	4D M	5D]	6D m	7D }
1	1	1	0	14	0E SO	1E RS	2E .	3E >	4E N	5E ^	6E n	7E ~
1	1	1	1	15	0F SI	1F US	2F /	3F ?	4F O	5F _	6F o	7F DEL

Section 3
Character-Oriented CRC Calculation

Generation of the CRC Code

This CRC calculation method is based on the premise that a message may be represented as the coefficients of a polynomial, G(x), having k terms, where k is the number of bits in the message.

COMMENTARY

The notation used to describe the CRC is based on the property of cyclic codes that a code vector such as 1000000100001 can be represented by a polynomial G(x) = x12 + x5 + 1. The elements of a k element code vector are thus the coefficients of a polynomial of order k - 1. In this application, these coefficients can have the value 0 or 1, and all polynomial operations are performed modulo 2.

To create the polynomial G(x) representing the message, the terms are ordered as follows:

- The coefficient of the most significant bit of G(x), (xk-1), is the LSB of the first character of the message.
- The coefficient of the least significant bit of G(x), (x0), is the MSB of the last character of the message.

For example, if the message, G(x), is ‘FPR’, the first character is ‘F’ which is represented by the code 46 hex or 01000110 binary. The rightmost bit of ‘F’, 0 in this example, is therefore the most significant bit of G(x). Similarly, the last character, ‘R’, is represented by the code 52 hex or 01010010 and the least significant bit of G(x) is the leftmost bit of ‘R’, which is 0. The message FPR has 24 bits so k has a value of 24.

The actual transmission order for the message is MSB to LSB as follows:

Note slashes (/) are used for octet separation only.

Transmission Order ==>		
LSB		MSB
01010010	01010000	01000110
R	P	F

In order to illustrate the mathematical procedure, the entire message is transposed for representation as a bit stream with the MSB at the left and the LSB at the right to yield:

Transmission Order ==>		
MSB		LSB
01100010	00001010	01001010

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Expressing the bit stream for this example as a polynomial, G(x), yields:

$$G(x) = x^{22} + x^{21} + x^{17} + x^{11} + x^{9} + x^{6} + x^{3} + x^{1}$$

To generate the CRC code the generator polynomial is defined as:

$$P(x) = x^{16} + x^{12} + x^{5} + 1$$

The CRC code is the one's complement of the remainder obtained from the modulo 2 division of:

$$\frac{x^{16} G(x) + x^{k} (x^{15} + x^{14} + x^{13} + \ldots + x^{2} + x + 1)}{P(x)} = Q(x) + \frac{R(x)}{P(x)}$$

where Q(x) is the quotient and R(x) is the remainder.

Note: The addition of X^{16}G(x) and xk(x^{15} + x^{14} +x^{13} + ... x^2 + x + 1) is modulo 2 and is equivalent to inverting the 16 most significant bits of G(x) and appending a bit string of 16 zeroes to the lower order end of G(x).

If the 16-bit binary CRC code were appended to the original G(x) the resulting message, M(x), would be of length n, where n = k + 16. This is equivalent to the following operation:

$$M(x) = x^{16} G(x) + (16 \text{-} bit) CRC\ (Modulo\ 2).$$

1

Commented [GE18]: Looks like something got messed up here …

When the 16-bit binary CRC is transformed into four ISO #5 characters (8 bits each), the final message to be transmitted, M*(x) is now of length N* = k + 32, and so

$$M^*(x) = x^{32} G(x) + (32 \text{-} bit) CRC\ (Modulo\ 2).$$

2

Using the above example with ‘FPR’ as G(x), the CRC calculation gives a remainder of 00111111/11010010, where the left-hand 0 is the most significant bit and the right-hand 0 is the least significant bit (see Appendix 7 of ARINC Specification 429, Mathematical Example of CRC Encoding/Decoding, for a detailed example of the mathematical operations involved to arrive at this remainder).

The CRC code is the one’s complement of the remainder, or 11000000/00101100. This CRC code is converted to a four character (ISO #5) code and appended to the end of the message over which the CRC code was calculated by applying steps 1 through 7 in Section 2 as follows:

1. Because the message was transposed in this illustration to generate the CRC code, the resultant CRC code should also be transposed from left to right. Transposing 11000000/00101101 yields 10110100/00000011. This operation returns the CRC code to the same transmission order as the original message, with the MSB to the right and the LSB to the left.

2-3. Separating the 16-bit transposed value into 4-bit segments and expressing it in hex yields B403.

4-7. The four characters representing this value are coded as ISO #5 characters and appended to the message in the order: MS to LS character. For this example, the order is 3, 0 4, B.

The complete message plus CRC code for this example (read left to right) is:

FPR304B

The transmission order of this message is right to left, as:

B403RPF ==>

Section 4
Verification (Decoding) of the CRC Code

At the receiving system, the four characters representing the CRC code are converted back into the original binary CRC code; i.e., the steps in Section 2 are performed in reverse order. At this point, verification (decoding) of the CRC is accomplished by either of the following methods:

1. After conversion back to the binary CRC code, the 16-bit binary CRC is appended to the message G(x) (in the same transmission order as the message) resulting in the message M(x), of length n, where n = k + 16 and

$$M(x) = x^{16} G(x) + (16\text{-}bit)CRC\ (Modulo\ 2).$$

3

M(x) is multiplied by X^{16}, added to the product $x^n(x^{15} + x^{14} + x^{13} + ... + x^2 + x + 1)$, and divided by P(x) as follows (where n = k + 16):

4

This CRC procedure is designed to create a constant remainder for error free messages. If the transmission of the serial incoming bits plus CRC code (i.e., M(x)) is error free, then the remainder, Rr(x) is always:

Transmission Order ==>	
MSB	LSB
00011101	00001111

(coefficients of x^{15} through x^0, respectively).

2. An alternate procedure for the receiving system, which will ensure the same data integrity, is to recompute the CRC code on the received message less the four CRC characters (using the same generator polynomial). The generated CRC code is then compared with the one received. The following steps are performed:

- The received message, M*(x), is stripped of the four CRC characters, leaving only G(x). The four characters representing the CRC code are converted back into the original binary 16-bit CRC code; that is, the steps in Section 2 are performed in reverse order.
- A binary CRC code is generated for G(x) using the same encoding method described for the message source.
- The generated binary CRC code is compared with the 16-bit binary CRC code stripped from the message and if they are identical, the message is assumed to be free of errors and exactly represents the message transmitted by the source.

Part B
Table-Based Formats for FMC IMI/IEI Messages

Section 1
Definition of Terms Used In Data Link Messages

All uplink and downlink messages are formatted using a consistent set of syntax rules. The following definitions are used to describe parts of a message:

IMI (Imbedded Message Identifier)

The IMI is a three alphanumeric character identifier. An IMI is placed at the beginning of the text to identify the relative message content. Only one IMI is used per message. The same IMI can be used for both uplinks and downlinks.

Examples of IMIs are: FPN, PER, LDI, POS, REJ, etc.

IEI (Imbedded Element Identifier)

The IEI is a two alpha character identifier that is used to group one or more elements.

Examples of IEIs are: FN, RP, RM, CG, RW, etc.

Element

An element is the smallest omissible part of an uplink or downlink message. It can be a single parameter, or a number of parameters. A single parameter element is defined as either fixed length or variable length with a defined maximum number of characters. Directional elements are single parameter elements that must contain either a single alpha character preceding one or more numeric characters, or one or more numeric characters followed by an alpha character. The alpha character indicates the direction (or qualifier) that is associated with the numeric value. Directional elements can be fixed or variable length.

A multi-parameter element is used to group similar or related information. Multi-parameter elements can be fixed length, variable length or a combination of fixed and variable length. However, only one field within a multi-parameter element can be of variable length. There is no delimiter between single data elements within a multi-parameter element.

Example:

OAT: P23	Single parameter element OAT is +23 ºC.
V1VRV2: 131139147	Multi-parameter element is composed of:
	V1 = 131 knots
	VR = 139 knots
	V2 = 147 knots

Parameter

A parameter is an element or part of an element that has the following attributes:

1. Type - Variable or Fixed
2. Element Type - Alpha (A - Z)
3. Alphanumeric (A - Z, 0 - 9, dash)
4. Numeric (0 - 9)
5. Character Length - Number of Characters
6. Scaling Factor - Identifies the multiplication factor
7. Units - Identifies The Parameter Units

List

A list is a repeatable group of elements within a data link message. Each list contains one or more elements.

Message Format Example

The following is an example of a Predicted Wind Information uplink message (the IMI for this message is PWI, the IEI is DD for Descent Wind Data and the IEI DS is for Descent Wind Temperature).

Example:
PWI/DD350270060.310270045.140260040/DS320M50.250M30.100M10.010P10:060,,,M04,1013

Altitude/Wind List (up to ten allowed):	
Altitude	**Wind**
FL350	270/060 kts
FL310	270/045 kts
14000	260/040 kts

Altitude/Temperature List (up to ten allowed):	
Altitude	**Temperature**
FL320	- 50 ºC
FL250	- 30 ºC
FL100	- 10 ºC
1000ft	+10 ºC

Remaining Elements:	
TAI On Altitude	6000 ft
TAI On/Off Altitude	(Missing Data)
Des Transition Altitude	(Missing Data)
Descent ISA Deviation	-4 ºC
QNH	1013 Hectopascals

Flight Plan Definition

Each independent part of a flight plan is called a Flight Plan Element (FPE). Each FPE is preceded by a Flight Plan Element Identifier (FPEI) which identifies the group of data that follows. These FPEs are used in combination to fully define the FMC flight plan in both the uplinks and downlinks. The flight plan definition is used to create a flight plan (either active or inactive) or modify an existing flight plan.

FPEI (Flight Plan Element Identifier)

FPEIs are used to identify special elements, which are used in the (Flight Plan) Route IEIs of RP, RI, RM, and RA. Examples of Flight Plan Element Identifiers are :H:, :V:, “.”, “..”, “DA”, etc.

FPE (Flight Plan Element)

A Flight Plan Element (FPE) is a special type of variable or fixed length element (or group of elements) used in RP, RI, RM, or RA IEIs.

Examples of FPEs (and their corresponding FPEIs) are shown below:

FPE	FPEI	Example
Departure Airport	:DA:	KJFK
Arrival Airport	:AA:	KLAX
Company Route	:CR:	JFKLAX07
Waypoint Spd/Alt/Time	:V:	N47W125,250,AT1250
Direct to Waypoint	..	BLAKO
Departure Runway	:R:	04O
Airway VIA	.	J36
Arrival Procedure	:A:	DOWNE
Arrival Transition	.	HECTR
Arrival Runway	(XXX)	(04O)

The last four items in the table illustrate the dual role of the special character “.” which is context dependent. It can be used as a “VIA” indicator for an airway, or as a transition indicator if it is preceded by an “:A:” (or an “:AP:” or a :D:), as in DOWNE.HECTR(04O).

Example: F P N / R M..N I A . J 4 8 . B E N N Y , N 3 3 2 4 0 W 1 1 6 2 5 0 : A T : N I A - M0400,280,AT1400:A:BENE3.NIA:AP:ILS32R.EDD

- IMI (FPN) followed by
- IEI (RM) followed by
- Direct to waypoint NIA
- Followed by a via airway J48
- To waypoint BENNY with optional lat/lon definition
- Then an along track offset definition of NIA -40.0 with an associated speed restriction of 280 at 14,000 feet
- Followed by a standard arrival BENE3 with a NIA transition and the standard approach of ILS32R with an EDD transition.

Uplink and Downlink Delimiters

When constructing an uplink or a downlink message, delimiters are used to consistently identify the information in the message. The delimiters supersede each other in the order given (i.e., ‘/’ has the highest priority).

IEI Delimiter '/' solidus, Character 2/15

This character precedes each Imbedded Element Identifier which identifies the beginning of predefined group of elements. This delimiter is always followed by two alpha characters.

List Terminator ':' colon, Character 3/10

The colon is an end of list control character. This character is used to terminate a repetitive list structure.

List Entry Terminator '.' period, Character 3/11

The period is a list entry terminator. This character is used to terminate each list entry (group of elements). List entries are groups of parameters or elements that are repeated one or more times.

Element Terminator ',' comma, Character 2/12

Commas are used to separate elements (unless they have been separated by or terminated with another control character; i.e., '/', ':', '.' or another FPEI in the case of RI, RM, RP, or RAs). Missing elements are denoted by consecutive commas.

Request Messages

To allow the receiving system to recognize the difference between a message that is transmitting data and a message that is requesting data, a special IMI has been reserved for requests. This IMI ('REQ' is the default) precedes any request message. The data that follows this IMI depends on whether the message is an uplink or a downlink.

Uplink Request A Downlink

The request IMI is followed by an element which contains the IMI of the "reply." This is optionally followed by a comma (element terminator), which is optionally followed by a list of elements that define the IEIs to be included in the downlink (all separated by a list entry terminator). An IMI, or IEIs following the REQ are considered elements in the uplink.

Example: REQPRG,DT.FN

This example is a request from the ground for the current destination and current flight number which results in a downlink of:

PRG/DTKSEA/FNSFOSEA001

Downlink Requesting An Uplink

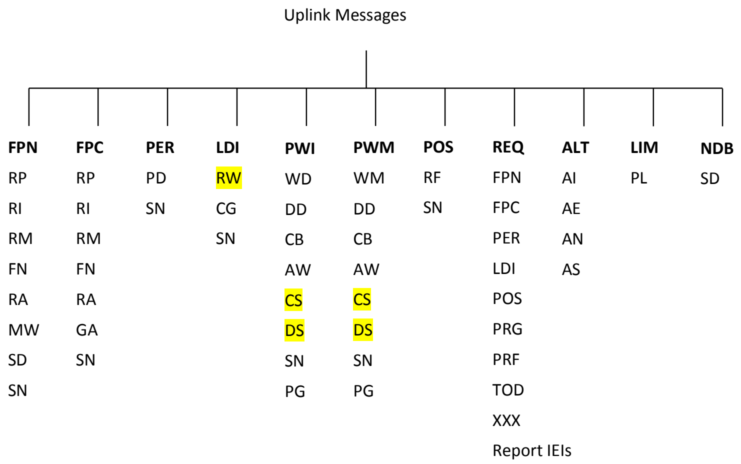
In a downlink request, the request IMI is followed by the requested information.

Example: REQFPN/COKSEAKSFO02

This example is a request from the FMC for a flight plan, the request includes the entered company route as a data element.

Section 2
IMI/IEI Relationships

This section identifies the IEIs normally associated with IMIs that have been defined. This section will be updated as the need for new IMIs and IEIs is identified. Users are requested to advise the AEEC staff when such a need arises. The basic IEIs are listed in bold text, the dependent IEIs are listed in italics and the extended IEIs are listed as normal text.



Note that XXX may be an unrecognizable IMI that is followed by recognizable IEIs.

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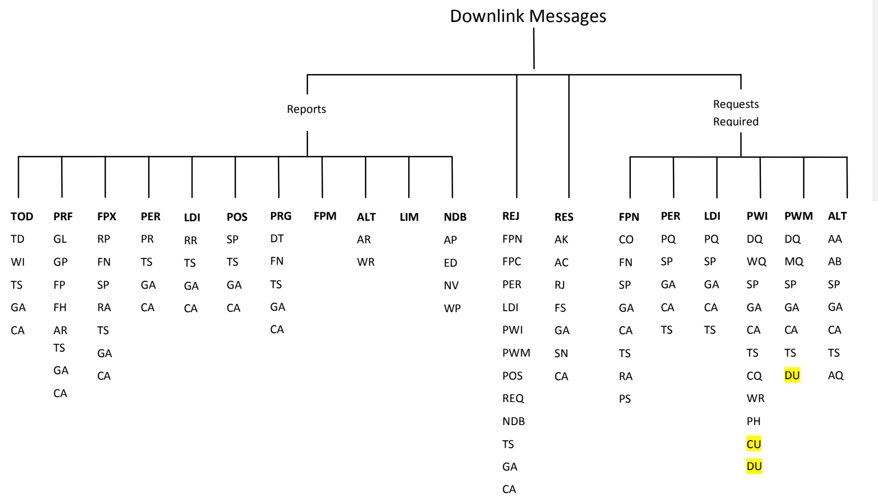

Note that FPX represents FPN and FPC.

Section 3
Uplink IMI Definitions

This section lists the currently defined uplink IMIs and provides a brief description of the associated message content. This section will be updated as the need for new IMIs is identified. Users are requested to advise the AEEC staff when such a need arises.

IMI	DESCRIPTION	DEFINITION
ALT	ALTERNATE DATA	Contains alternate airport information generated by the airline.
FPC	FLIGHT PLAN	Flight plan information supplied by ATC.
FPN	FLIGHT PLAN	Flight plan information generated by the airline.
LDI	LOAD INFORMATION	Contains load information for takeoff generated by the airline.
LIM	PERFORMANCE LIMITS DATA	Contains performance limits data that is provided by the airline.
NDB	AIRLINE DATABASE	Contains supplemental Navigation Data Base, Effectivity Date, Supplemental Navigation Airport, Navaid, and Waypoint definitions generated by the airline.
PER	PERFORMANCE INITIALIZATION	Contains performance initialization data generated by the airline.
POS	POSITION	Contains specified triggers for automatic position report information generated by the airline.
PWI	PREDICTED WIND DATA	Contains climb, alternate, enroute, descent wind and/or temperature information that is to be applied to the flight plan. Generated by the airline.
PWM	PREDICTED WIND MODIFICATION	Contains alternate, enroute, descent wind and/or temperature information that is to be applied to the modified active flight plan. Descent winds and temperatures data may be applied regardless of the route status. Generated by the airline ground station.
REQ	REQUEST	Contains a type of request (FPN/FPC, PER, LDI, POS, PRG, PRF, TOD, XXX) for information generated by the airline.
TAC	RESERVED	
TAR	RESERVED	

Section 4
Downlink IMI Definitions

This section lists the currently defined downlink IMIs and provides a brief description of the associated message content. This section will be updated as the need for new IMIs is identified. Users are requested to advise the AEEC staff when such a need arises.

IMI	DESCRIPTION	DEFINITION
ALT	ALTERNATE DATA	Provides the airline with alternate airport information.
FPC	FLIGHT PLAN	Provides flight plan report to ATC.
FPM	FLIGHT PLAN	Provides flight plan modification information to the airline.
FPN	FLIGHT PLAN	Provides flight plan information to the airline.
LDI	LOAD INFORMATION	Provides the airline with a load information data report for a single runway.
LIM	PERFORMANCE LIMITS DATA	Provides the airline with the current FMC performance limits.
NDB	AIRLINE DATA BASE	Provides the contents of the supplemental data base to the airline.
PER	PERFORMANCE INITIALIZATION	Provides performance initialization data report to the airline.
POS	POSITION	Provides the airline with current position report information.
PRF	PREFLIGHT	Provides preflight report to the airline.
PRG	PROGRESS (ETA) REPORT	Provides the airline with progress report data in response to a trigger.
PWI	PREDICTED WIND DATA	Provides the airline with climb, enroute, descent wind and/or temperature information that is to be applied to the flight plan.
PWM	PREDICTED WIND MODIFICATION	Provides the airline with enroute, descent wind and/or temperature information that is to be applied to the modified active flight plan. Descent wind data may be applied regardless of the route status.
REJ	DOWNLINK REJECTION	Provides ATC or the airline with information referencing a rejected uplink message.
REQ	REQUEST	Requests (FPN/FPC, PER, LDI, PWI/PWM) information from the airline or ATC.
RES	DOWNLINK RESPONSE	Provides a response to an uplink message.
TAC	RESERVED	
TAR	RESERVED	
TOD	TOP OF DESCENT	Provides top of descent data to the airline.

Section 5
Uplink IEIs

This section lists the currently defined uplink IEIs. This section will be updated as the need for new IEIs is identified. Users are requested to advise the AEEC staff when such a need arises.

IEI	DESCRIPTION
AE	COMPANY PREFERRED ALTERNATES DATA
AI	ALTERNATE INFORMATION DATA
AN	ALTERNATES INHIBIT DATA
AW	ALTERNATE WIND DATA
AS	ALTERNATES FLIGHT LIST DATA
CA	COMPANY DISTRIBUTION
CB	CLIMB WIND DATA
CG	TAKEOFF CENTER OF GRAVITY
CS	CLIMB TEMPERATURE DATA
DD	DESCENT FORECASTS
DS	DESCENT TEMPERATURE DATA
FN	FLIGHT NUMBERS
GA	GROUND ADDRESS
MW	MEAN WIND DATA
PD	PERFORMANCE INITIALIZATION DATA
PG	PAGE INFO
PL	PERFORMANCE LIMITS
RA	ALTERNATE ACTIVE/INACTIVE ROUTE
RF	POSITION REPORT FIX
RI	INACTIVE ROUTE
RM	ROUTE MODIFICATION
RP	ACTIVE ROUTE
RT	REQUIRED TIME OF ARRIVAL
RW	RUNWAY DATA
SD	SUPPLEMENTAL NAVIGATION DATABASE
SN	MESSAGE SEQUENCE NUMBER
TS	TIME STAMP
WD	ENROUTE WIND DATA
WE	WIND VECTOR MAGNITUDE DIFFERENCE
WL	WAYPOINT LIST
WM	ENROUTE WIND MODIFICATION

Section 6
Downlink IEIs

This section lists the currently defined downlink IEIs. This section will be updated as the need for new IEIs is identified. Users are requested to advise the AEEC staff when such a need arises.

IEI	DESCRIPTION
AA	COMPANY PREFERRED ALTERNATES REQUEST
AB	ALTERNATES FLIGHT LIST REQUEST
AC	ACCEPT
AK	ACKNOWLEDGE
AP	SUPPLEMENTAL NAV DATA BASE AIRPORTS
AQ	WEATHER REQUEST
AR	ALTERNATE INFORMATION REPORT
CA	COMPANY DISTRIBUTION
CO	COMPANY ROUTE REQUEST
CQ	CLIMB FORECAST REQUEST
CU	CLIMB TEMPERATURE REQUEST
DI	DOWNLINK TIME INFORMATION
DQ	DESCENT FORECAST REQUEST
DT	DESTINATION REPORT
DU	DESCENT TEMPERATURE REQUEST
ED	SUPPLEMENTAL EFFECTIVITY DATE
FH	FLIGHT PLAN HISTORY
FN	FLIGHT NUMBER
FP	FUEL PLANNING
GA	GROUND ADDRESS
GL	GENERAL DATA
GP	GENERAL DIRECTIONS
MQ	MOD WIND REQUEST
NV	SUPPLEMENTAL NAV DATA BASE NAVAIDS
PH	FLIGHT PHASE
PL	PERFORMANCE LIMITS
PQ	PERFORMANCE INITIALIZATION REQUEST
PR	PERFORMANCE INITIALIZATION REPORT
PS	POSITION REPORT
RA	ALTERNATE ACTIVE/INACTIVE ROUTE
RJ	REJECT
RP	ACTIVE ROUTE
RQ	RUNWAY DATA REQUEST
RR	RUNWAY DATA REPORT
SN	MESSAGE SEQUENCE NUMBER
SP	SCRATCHPAD
TD	TOP OF DESCENT REPORT
TS	TIME STAMP
WI	WAYPOINT INFORMATION
WQ	WIND REQUEST
WP	SUPPLEMENTAL NAV DATA BASE WAYPOINTS
WR	ALTERNATE AIRPORT WEATHER REQUEST

Section 7
IEI and Associated Elements

This section provides a guideline for relating elements to IEIs and defines the default text for all IEIs. This section is separated into basic IEIs (also dependent IEIs) and their associated elements, extended IEIs and their associated elements, and IMIs and their associated elements. The default IEI content and structure is indicated by 'IEI CONTENT'. The content and order of list entries are indicated by 'LIST ENTRY'. Examples are provided to clarify the default text.

BASIC IEIs AND ASSOCIATED ELEMENTS

AC	ACCEPT EXAMPLE: /AC12345,451 IEI CONTENT MESSAGE SEQUENCE NUMBER STIMULUS CODE	Consists of a variable length field defining the message sequence number and stimulus code.
AK	ACKNOWLEDGE EXAMPLE: /AK12345,451 IEI CONTENT MESSAGE SEQUENCE NUMBER STIMULUS CODE	Consists of a variable length field defining the message sequence number and stimulus code.
CA	COMPANY DISTRIBUTION EXAMPLE: /CAFLTOPS IEI CONTENT COMPANY DISTRIBUTION	Consists of an airline internal distribution identifier.
CG	TAKEOFF CENTER OF GRAVITY EXAMPLE: /CG200 IEI CONTENT TAKEOFF CENTER OF GRAVITY	Consists of a variable length field.
CO	COMPANY ROUTE REQUEST EXAMPLE: /COKBFIKSFO01 IEI CONTENT COMPANY ROUTE	Consists of a variable length field.
DD	DESCENT FORECAST EXAMPLE: /DD350270060.310270045.140260040.100230020.06030. 180.M04.1013 IEI CONTENT LIST ENTRY: ALTITUDE AND WIND TAI ON ALTITUDE TAI ON/OFF ALTITUDE DESCENT TRANSITION ALTITUDE DESCENT ISA DEVIATION QNH	Consists of a list of up to ten altitude wind entries, followed by the additional descent forecast elements.
DQ	DESCENT FORECAST REQUEST EXAMPLE: /DQ390 IEI CONTENT TOP OF DESCENT ALTITUDE	Consists of a single parameter element defining the top of descent altitude.
DS	DESCENT TEMPERATURE	Consists of a list of up to ten altitude temperature entries

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BASIC IEIs AND ASSOCIATED ELEMENTS

	EXAMPLE: /DS320M50.250M30.010P10 IEI CONTENT LIST ENTRY: ALTITUDE AND OAT	
DU	DESCENT TEMPERATURE REQUEST EXAMPLE: /DU370 IEI CONTENT TOP OF DESCENT ALTITUDE	Consists of a single parameter element defining the top of Descent Altitude.
DT	DESTINATION REPORT EXAMPLE: /DTKSFO,28L,0234,190023,003 IEI CONTENT ARRIVAL AIRPORT IDENT DESTINATION RUNWAY IDENT PREDICTED FUEL REMAINING ETA AT DESTINATION REPORT STIMULUS	Consists of a fixed format, fixed order field.
FN	FLIGHT NUMBER EXAMPLE: /FNUAL1633A IEI CONTENT FLIGHT NUMBER	Consists of a variable length field.
GA	GROUND ADDRESS EXAMPLE: /GATULDDAA.HEQXESA IEI CONTENT LIST ENTRY: GROUND ADDRESS	Consists of a list of addresses. A copy of the network address not directly used for message routing purposes.
PD	PERFORMANCE INITIALIZATION DAT. EXAMPLE: /PD2113,,270,,0150,23,,,,P12,M34 IEI CONTENT ZERO FUEL WEIGHT CRUISE CENTER OF GRAVITY CRUISE ALTITUDE PLAN OR BLOCK FUEL RESERVE FUEL COST INDEX CRUISE WIND TOC OR CRUISE TEMPERATURE CLIMB TRANSITION ALTITUDE FUEL FLOW FACTOR DRAG FACTOR PERF FACTOR IDLE FACTOR TROPOPAUSE ALTITUDE TAXI FUEL ZERO FUEL WEIGHT CENTER OF GRAVITY MINIMUM FUEL TEMPERATURE	Consists of a fixed format, fixed order field
PQ	PERFORMANCE INITIALIZATION REQUEST EXAMPLE: /PD2113,,270,,0150,23,,,,P12,M34 IEI CONTENT ZERO FUEL WEIGHT CRUISE CENTER OF GRAVITY CRUISE ALTITUDE PLAN OR BLOCK FUEL	Consists of a fixed format, fixed order field.

BASIC IEIs AND ASSOCIATED ELEMENTS

	RESERVE FUEL COST INDEX CRUISE WIND TOC OR CRUISE TEMPERATURE CLIMB TRANSITION ALTITUDE FUEL FLOW FACTOR DRAG FACTOR PERF FACTOR IDLE FACTOR TROPOPAUSE ALTITUDE TAXI FUEL ZERO FUEL WEIGHT CENTER OF GRAVITY MINIMUM FUEL TEMPERATURE	
PR	PERFORMANCE INITIALIZATION REPORT EXAMPLE: /PR2633,,270,0520,,0150,23,,,,P12,M34 IEI CONTENT CURRENT GROSS WEIGHT CRUISE CENTER OF GRAVITY CRUISE ALTITUDE FUEL REMAINING PLAN OR BLOCK FUEL RESERVE FUEL COST INDEX CRUISE WIND TOC OR CRUISE TEMPERATURE CLIMB TRANSITION ALTITUDE FUEL FLOW FACTOR DRAG FACTOR PERF FACTOR IDLE FACTOR TROPOPAUSE ALTITUDE TAXI FUEL ZERO FUEL WEIGHT ZERO FUEL WEIGHT CENTER OF GRAVITY MINIMUM FUEL TEMPERATURE	Consists of a fixed format, fixed order field.
RF	POSITION REPORT FIX EXAMPLE: /RFORTIN.SEA.N3545W090256 IEI CONTENT LIST ENTRY: WAYPOINT SEQUENCE	Consists of a list of reporting points which when sequenced in flight, trigger the position report.
RI	INACTIVE ROUTE :DA: DEPARTURE AIRPORT IDENT :AA: ARRIVAL AIRPORT IDENT :CR: COMPANY ROUTE :R: DEPARTURE RUNWAY IDENT :D: DEPARTURE PROCEDURE :F: FLIGHT PLAN SEGMENT PUBLISHED IDENT LATITUDE/LONGITUDE	A variable length field that consists of flight plan elements that replace the inactive route. These flight plan elements define a flight plan in approximately the same fashion as ATC clearance language.

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BASIC IEIs AND ASSOCIATED ELEMENTS

	PLACE BEARING/PLACE BEARING PLACE BEARING DISTANCE :ON: START OF DESIGNATED FLIGHT PLAN SEGMENT :A: ARRIVAL PROCEDURE :AP: APPROACH PROCEDURE (): ARRIVAL RUNWAY IDENT :V: WAYPOINT SPEED/ALTITUDE/TIME :H: HOLD AT WAYPOINT :WS: WAYPOINT STEP CLIMB :AT: ALONG TRACK WAYPOINT :RP: REPORTING POINTS .. DIRECT FIX . TRANSITION OR AIRWAY VIA :F:. AIRWAY INTERCEPT :IC: INTERCEPT COURSE FROM	
RJ	REJECT EXAMPLE: /RJ12345,451 IEI CONTENT MESSAGE SEQUENCE NUMBER STIMULUS CODE	Consists of a variable length field defining the message sequence number and the stimulus code.
RP	ACTIVE/INACTIVE ROUTE THE FORMAT IS THE SAME AS DESCRIBED FOR THE RI IEI DESCRIPTION.	A variable length field that consists of flight plan elements. These flight plan elements define a flight plan in approximately the same fashion as ATC clearance language.
RQ	RUNWAY DATA REQUEST EXAMPLE: /RQKSEA,31L,A9,,,156,2613,,P15,140012,1,15,2,,P40 IEI CONTENT LIST ENTRY: DEPARTURE AIRPORT IDENT	Consists of a fixed-list format, fixed order field consisting of data for up to two runway/intersection combinations. TAKEOFF RUNWAY IDENT RUNWAY INTERSECTION POSITION SHIFT RUNWAY LENGTH REMAINING TAKEOFF CENTER OF GRAVITY CURRENT GROSS WEIGHT REFERENCE TAKEOFF GROSS WEIGHT OAT OR SAT TAKEOFF RUNWAY WIND TAKEOFF RUNWAY CONDITION TAKEOFF FLAPS TAKEOFF THRUST RATING VTR PERCENTAGE SELECTED TEMPERATURE BARO SETTING FLAP/SLAT CONFIGURATION THRUST REDUCTION ALTITUDE ACCELERATION ALTITUDE ENGINE-OUT ACCELERATION ALTITUDE
RT	REQUIRED TIME OF ARRIVAL EXAMPLE: /RTVAMPS,143000 IEI CONTENT	Consists of a fixed format, fixed order field

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BASIC IEIs AND ASSOCIATED ELEMENTS

RTA WAYPOINT IDENT
RTA TIME
OPTIONAL RTA CONSTRAINT

RW — RUNWAY DATA — Consists of a fixed-list entry format field consisting of data for up to six runway/intersection combinations followed by a departure airport

EXAMPLE: /RW13R,A9,PO9,,0,1125,2613,2850,P23,U05,250015,1,15,1,08,P38,131139147,0,15,1135,,130137145.31L,ETC:KBFI

IEI CONTENT

LIST ENTRY:

- TAKEOFF RUNWAY IDENT
- RUNWAY INTERSECTION
- POSITION SHIFT
- RUNWAY LENGTH REMAINING
- INVALID FLAG
- TRIM
- REFERENCE TAKEOFF GROSS WEIGHT
- STANDARD LIMIT TAKEOFF GROSS WEIGHT
- OAT OR SAT
- TAKEOFF RUNWAY SLOPE
- TAKEOFF RUNWAY WIND
- TAKEOFF RUNWAY CONDITION
- TAKEOFF FLAPS
- TAKEOFF THRUST RATING
- VTR PERCENTAGE
- ASSUMED TEMPERATURE
- TAKEOFF SPEEDS
- ALTERNATE THRUST RATING
- ALTERNATE FLAPS
- ALTERNATE TRIM
- ALTERNATE LIMIT TAKEOFF GROSS WEIGHT
- ALTERNATE TAKEOFF SPEEDS
- ALTERNATE ASSUMED TEMPERATURE
- FLAP/SLAT CONFIGURATION
- ALTERNATE FLAP/SLAT CONFIGURATION
- ALTERNATE VTR PERCENTAGE

DPARTURE AIRPORT IDENT
BARO SETTING
THRUST REDUCTION ALTITUDE
ACCELERATION ALTITUDE
ENGINE-OUT ACCELERATION ALTITUDE
NOISE ABATEMENT END ALTITUDE
NOISE ABATEMENT SPEED
NOISE ABATEMENT DERATE THRUST
NOISE ABATEMENT THRUST
NOISE ABATEMENT START ALTITUDE

SN — MESSAGE SEQUENCE — Consists of a variable length format field defining the message sequence number.

EXAMPLE: /SN12345

IEI CONTENT

MESSAGE SEQUENCE NUMBER

SP — SCRATCHPAD — Consists of a variable length field that contains the contents of the CDU scratch pad.

EXAMPLE: /SPSCRATCHPADMESSAGE

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BASIC IEIs AND ASSOCIATED ELEMENTS

	IEI CONTENT SCRATCHPAD	
TS	TIME STAMP EXAMPLE: /TS152533,200290 IEI CONTENT GREENWICH MEAN TIME DATE	Consists of a fixed length field.
WD	ENROUTE WIND DATA EXAMPLE: /WD310,SEA,120015,350M35, N04030W120,130090 IEI CONTENT WIND ALTITUDE LIST ENTRY: WAYPOINT NAME OR POSITION WAYPOINT WIND WAYPOINT ALTITUDE/OAT	Consists of an altitude and a variable length list of entries that include the waypoint, the waypoint winds that apply to that altitude and the waypoint temperature.
WQ	WIND REQUEST EXAMPLE: /WQ350.370.390.410:SEA.N4030W110.ORD.ETC IEI CONTENT LIST ENTRY: WIND LEVEL ALTITUDE LIST ENTRY: WIND LEVEL WAYPOINT	Consists of a list of elements defining altitudes for which winds are requested, followed by a list of elements defining waypoints in the route for which the request is being made.
POS	POSITION REPORT EXAMPLE: POSN47261W122185,SEA,093118,350,ORTIN,093436,BARRO,M32,120015,0485,784 CURRENT POSITION (CROSSED) WAYPOINT IDENT GREENWICH MEAN TIME CURRENT ALTITUDE GOTO (NEXT) WAYPOINT IDENT ETA AT GOTO WAYPOINT GOTO+1 (FOLLOWING) WAYPOINT IDENT STATIC AIR TEMPERATURE (SAT) ACTUAL WIND FUEL REMAINING TARGET MACH	Consists of elements used to define a position report.
REJ	REJECT REJPWI,HHMMSS,103,,006,CB/.108,,CB,/CB.109,,001,NOVALIDIEI/TShhmmss,mmddyy UPLINKED IMI TIME UPLINK RECEIVED LIST ENTRY: ERROR TYPE CODE ERROR DATA CODE LITERAL ERROR DATA EXTENDED REJECTION DATA	Consists of the uplinked IMI, time uplink is received and a list of error codes.
RES	RESPONSE EXAMPLE:	Consists of the uplinked IMI, time uplink is received and a list of error codes. RESFPN/AC,073
AA	COMPANY PREFERRED ALTERNATES REQUEST EXAMPLE: /AAN47261W122185,BOE123,KSEA,KSFO,SEASFO CURRENT POSITION	

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BASIC IEIs AND ASSOCIATED ELEMENTS

	FLIGHT NUMBER DEPARTURE AIRPORT IDENT ARRIVAL AIRPORT IDENT COMPANY ROUTE	
AB	<u>ALTERNATES FLIGHT LIST REQUEST</u> EXAMPLE: /ABN47261W122185,BOE123,KSEA,KSFO, SEASFO CURRENT POSITION FLIGHT NUMBER DEPARTURE AIRPORT IDENT ARRIVAL AIRPORT IDENT COMPANY ROUTE	

AE	<u>COMPANY PREFERRED ALTERNATES DATA</u>
	EXAMPLE:/aeksea,1,09020,350P10,HUMPP,KM.WH,2,080100,300M5,ELN:300,1290
	LIST ENTRY
	    COMPANY PREFERRED ALTN IDENT
	    COMPANY PREFERRED ALTN PRIORITY
	    COMPANY PREFERRED ALTN WIND
	    COMPANY PREFERRED ALTN ALTITUDE/OAT
	COMPANY PREFERRED ALTN ALTITUDE
	COMPANY PREFERRED ALTN SPEED
	COMPANY PREFERRED ALTN OFFSET	

AI	<u>ALTERNATE INFORMATION DATA</u>
	EXAMPLE: /AIKSFO,D,1423,230,120045,M15.KLAX,M,1700,310,325020,P34
	<u>IEL CONTENT</u>
	LIST ENTRY:
	    ALTERNATE IDENT
	    ALTERNATE TYPE
	    DISTANCE TO ALTERNATE
	    ALTITUDE TO ALTERNATE
	    ESTIMATED WIND TO ALTERNATE
	    TEMPERATURE AT ALTERNATE
		Consists of a variable length list of entries consisting of alternate information

AN	<u>ALTERNATES INHIBIT DATA</u> EXAMPLE: /ANKPAE.KSEA LIST ENTRY: ALTN INHIBIT	

AP	<u>SUPPLEMENTAL NDB AIRPORTS</u>
	EXAMPLE:
	/APKABC,N39152W121185,01740,E10.K
	DEF,N37440W119118,00900,W12
	<u>IEI CONTENT</u>
	LIST ENTRY:
	    AIRPORT IDENT
	    AIRPORT LAT/LON
	    AIRPORT ELEVATION
	    AIRPORT MAGVAR
		Consists of a list of airports to be included in the supplemental navigation data base

AQ	<u>WEATHER REQUEST</u>
	EXAMPLE: /AQKSFO.KLAX.KONT:KPHX
	LIST ENTRY:
	    COMPANY PREFERRED ALTN IDENT
	    ARRIVAL AIRPORT IDENT	

AR	<u>ALTERNATE INFORMATION REPORT</u> EXAMPLE: /ARKSFO,D,132456,0120,0123,310,310050.KLAX,D,142523,0109,0206,325,340100	Consists of a variable length list consisting of alternate destination data.

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BASIC IEIs AND ASSOCIATED ELEMENTS

	<u>IEI CONTENT</u> LIST ENTRY ALTERNATE IDENT ALTERNATE TYPE ETA AT ALTERNATE DESTINATION FUEL REMAINING AT ALTERNATE DISTANCE TOALTERNATE ALTITUDE TO ALTERNATE CRUISE WIND TO ALTERNATE	
AS	<u>ALTERNATES FLIGHT LIST DATA</u> EXAMPLE: /ASKDEN,18030,350M5.KLAX,02040,350P10 LIST ENTRY: ALTN FLIGHT LIST IDENT ALTN FLIGHT LIST WIND ALTN FLIGHT LIST ALTITUDE/OAT	
AW	<u>ALTERNATE WIND DATA</u> EXAMPLE: /AW220035040 <u>IEI CONTENT</u> ALTITUDE AND WIND	Consists of a multi-parameter element defining the altitude and wind.
CB	<u>CLIMB WIND DATA</u> EXAMPLE: /CB350270060.310270045.140260040.100230020 <u>IEI CONTENT</u> LIST ENTRY: ALTITUDE AND WIND	Consists of a list of up to ten altitude wind entries.
CQ	<u>CLIMB FORECAST REQUEST</u> EXAMPLE: /CQ370 IEI CONTENT CRUISE ALTITUDE	Consists of a single parameter element defining the top of climb altitude.
CS	<u>CLIMB TEMPERATURE DATA</u> EXAMPLE: /CS120P05.250M30.300M40 <u>IEI CONTENT</u> LIST ENTRY: ALTITUDE AND OAT	Consists of a list of up to ten altitude temperature entries.
CU	<u>CLIMB TEMPERATURE REQUEST</u> EXAMPLE: /CS370 IEI CONTENT CRUISE ALTITUDE	Consists of a single parameter element defining the top of climb altitude.
DI	<u>DOWNLINK TIME INFORMATION</u> EXAMPLE: /D1051632.-51635.051636 <u>IEI CONTENT</u> TRIGGER TRIPPED TIME DOWNLINK GENERATION TIME GREENWICH MEAN TIME	Consists of a fixed format, fixed order field containing time information.
ED	<u>SUPPLEMENTAL EFFECTIVITY DATE</u> EXAMPLE: /EDJAN0191/ <u>IEI CONTENT</u> EFFECTIVITY DATE/	Consists of a fixed length field defining the effectivity date of the supplemental navigation data base.
FH	<u>FLIGHT PLAN HISTORY</u> EXAMPLE: /FHLACRE,132034,240K,0700,0197,P23,132016,235,Y,150,012,ILS32R,1100,etc <u>IEI CONTENT</u>	Consists of a variable length list of parameters that are linked to the different waypoints of the flight plan.

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BASIC IEIs AND ASSOCIATED ELEMENTS

LIST ENTRY:
ETA AT PREDICTED WAYPOINT
PREDICTED WAYPOINT IDENT
PREDICTED AIRSPEED
ALTITUDE TO PREDICTED WAYPOINT
FUEL REMAINING AT PREDICTED WAYPOINT
OAT AT PREDICTED WAYPOINT
WIND AT PREDICTED WAYPOINT
TAS AT PREDICTED WAYPOINT
PROCEDURE INDICATOR
COURSE INTO PREDICTED WAYPOINT
DISTANCE TO PREDICTED WAYPOINT
PROCEDURE IDENTIFIER
CURRENT GROSS WEIGHT

FP FUEL PLANNING — Consists of a fixed format, fixed order field.
EXAMPLE: /FP1605,1100,12,220,08,140,110,P26,360
IEI CONTENT
TAKEOFF GROSS WEIGHT
LANDING GROSS WEIGHT
TAXI FUEL
TRIP FUEL
RESERVE FUEL
ALTERNATE FUEL
FINAL FUEL
EXTRA FUEL
PLAN OR BLOCK FUEL

GL GENERAL DATA — Consists of a fixed order field.
EXAMPLE: /GL290690,757-200,,BE49005001,NWA105,BFMWH01,KBFI,KMWH,10,1750, PW2040,KPDX,BFIMWO02.230.255
IEI CONTENT
DATE
AIRCRAFT TYPE
ENGINE THRUST
NAVIGATION DATA BASE IDENT
FLIGHT NUMBER
COMPANY ROUTE
DEPARTURE AIRPORT IDENT
ARRIVAL AIRPORT IDENT
COST INDEX
ZERO FUEL WEIGHT
ENGINE TYPE
ALTERNATE DESTINATION
ALTERNATE COMPANY ROUTE
CRUISE ALTITUDE
CENTER OF GRAVITY

GP GENERAL PREDICTIONS — Consists of a fixed format, fixed order field.
EXAMPLE: /GPKBFI,140000,0201,0280,230,2700,2180,,,,,,,255,KSEA,0140,14033,206,230
IEI CONTENT
ARRIVAL AIRPORT IDENT
ETA AT DESTINATION
DISTANCE TO DESTINATION
PREDICTED DESTINATION FUEL
~~PRIMARY~~ ACTIVE CRUISE ALTITUDE

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BASIC IEIs AND ASSOCIATED ELEMENTS

	TAKEOFF GROSS WEIGHT LANDING GROSS WEIGHT TOTAL FUELFOB PLAN OR BLOCK FUEL TRIP FUEL RESERVE FUEL EXTRA FUEL FINAL FUEL CENTER OF GRAVITY ALTERNATE DESTINATION ALTERNATE FUEL ALTERNATE TIME DISTANCE TO ALTERNATE ALTERNATE CRUISE ALTITUDE	
MQ	MOD WIND REQUEST EXAMPLE: /MQ350.370.390.410:SEA.N4030W110.ORD.ETC IEI CONTENT LIST ENTRY: WIND LEVEL ALTITUDE LIST ENTRY: WIND LEVEL WAYPOINT	Consists of a list of elements defining altitudes for which winds are requested, followed by a list of elements defining waypoints in the modified route for which the request is being made.
MW	MEAN WIND DATA EXAMPLE: /MWKBFI,KMWH,P045 IEI CONTENT DEPARTURE AIRPORT IDENT ARRIVAL AIRPORT IDENT MEAN WIND	Consists of a fixed order, fixed format field.
NV	SUPPLEMENTAL NDB NAVAIDS EXAMPLE: /NVABCD,N25131W108473,11300,VTH,01250,W11 IEI CONTENT LIST ENTRY: NAVAID IDENT NAVAID LAT/LON FREQUENCY CLASS OF NAVAID NAVAID ELEVATION NAVAID MAGVAR	
PG	PAGE INFO EXAMPLE: /PG13 PAGE INFO	
PH	FLIGHT PHASE EXAMPLE: /PH2 IEI CONTENT FLIGHT PHASE	Consists of a fixed format field defining FMC flight phase.
PL	PERFORMANCE LIMITS EXAMPLE: /PL25,210340,220340,240320,500820,650820,500780 IEI CONTENT TIME ERROR TOLERANCE CLIMB CAS LIMITS CRUISE CAS LIMITS DESCENT CAS LIMITS CLIMB MACH LIMITS CRUISE MACH LIMITS DESCENT MACH LIMITS	Consists of a fixed format, fixed order field.

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BASIC IEIs AND ASSOCIATED ELEMENTS

PS	<u>POSITION REPORT</u> EXAMPLE: /PSN47261W122185,SEA,093118,350,ORTIN,093436,BARRO,M32,120015,0485,789,ECON CURRENT POSITION CROSSED WAYPOINT IDENT GREENWICH MEAN TIME CURRENT ALTITUDE GOTO (NEXT) WAYPOINT IDENT ETA AT GOTO WAYPOINT GOTO + 1 (FOLLOWING) WAYPOINT IDENT STATIC AIR TEMPERATURE (SAT) ACTUAL WIND FUEL REMAINING TARGET MACH CRUISE SPEED MODE ENGINE OUT STATUS ZERO FUEL WEIGHT	
RA	<u>ALTERNATE ROUTE</u> EXAMPLE: THE FORMAT IS THE SAME AS DESCRIBED FOR THE RI IEI DESCRIPTION.	A variable length field that consists of flight plan elements that replace the inactive route. These flight plan elements define a flight plan in approximately the same fashion as ATC clearance
RM	<u>ROUTE MODIFICATION</u> THE FORMAT IS THE SAME AS DESCRIBED FOR THE RI IEI DESCRIPTION WITH THE ADDITION OF THE FOLLOWING: LO: LATERAL OFFSET	A variable length field that that consists of flight plan elements that replace the inactive route. These flight plan elements define a flight plan in approximately the same fashion as ATC clearance language. The RM cannot contain the CR: or :DA: flight plan element identifiers.
RR	<u>RUNWAY DATA REPORT</u> EXAMPLE: /RRKBFI,13R,A9,P09,,155,1125,2855,,P25,U35,250015,1,15,2,,P40,108119126 <u>IEI CONTENT</u> DEPARTURE AIRPORT IDENT TAKEOFF RUNWAY IDENT RUNWAY INTERSECTION POSITION SHIFT RUNWAY LENGTH REMAINING TAKEOFF CENTER OF GRAVITY TRIM CURRENT GROSS WEIGHT REFERENCE TAKEOFF GROSS WEIGHT OAT OR SAT TAKEOFF RUNWAY SLOPE TAKEOFF RUNWAY WIND TAKEOFF RUNWAY CONDITION TAKEOFF FLAPS TAKEOFF THRUST RATING VTR PERCENTAGE SELECTED TEMPERATURE TAKEOFF SPEEDS BARO SETTING FLAP/SLAT CONFIGURATION THRUST REDUCTION ALTITUDE ACCELERATION ALTITUDE ENGINE-OUT ACCELERATION ALTITUDE	Consists of a fixed format, fixed order field.

ATTACHMENT 7
FMC/DATALINK INTERFACE

BASIC IEIs AND ASSOCIATED ELEMENTS

SD	SUPPLEMENTAL NAVIGATION DATA BASE EXAMPLE: /SDJAN0190,KABC,N45240W119235,00911,W23.KJLL,etc:ABC,N45354W122506,11550, VTH,00530,W21.SEE,etc:ABCDE,N45354W122506,,, ,W22.WPT01,etc:05L,LFBO,N33125E010259,005,131,11125.02R,etc IEI CONTENT EFFECTIVITY DATA LIST ENTRY: AIRPORT IDENT AIRPORT LAT/LON AIRPORT ELEVATION AIRPORT MAGVAR LIST ENTRY: NAVAID IDENT NAVAID LAT/LON FREQUENCY CLASS OF NAVAID NAVAID ELEVATION NAVAID MAGVAR LIST ENTRY: WAYPOINT IDENT WAYPOINT LAT/LON REFERENCE IDENT REFERENCE LAT/LON RADIAL/DISTANCE WAYPOINT MAGVAR LIST ENTRY: RUNWAY IDENT REFERENCE AIRPORT IDENT RUNWAY LAT/LON RUNWAY COURSE RUNWAY ELEVATION RUNWAY LENGTH	Consists of an effectivity date and four separate lists that define the supplemental data base airport, navaid, waypoint and runway elements in that order.
TD	TOP OF DESCENT REPORT EXAMPLE: /TD134230,N59151W132251,3153,001 IEI CONTENT TOP OF DESCENT ETA TOP OF DESCENT LOCATION CURRENT GROSS WEIGHT STIMULUS CODE	Consists of top of descent time and location, and current weight.
WE	WIND VECTOR MAGNITUDE DIFFERENCE EXAMPLE: /WE020 IEI CONTENT WIND VECTOR MAGNITUDE DIFFERENCE	Consists of a fixed length field used to define the downlink trigger threshold for wind discrepancies.
WI	WAYPOINT INFORMATION EXAMPLE: /WIBDX,143205.CGC,144510.N33E010,153512 IEI CONTENT LIST ENTRY: WAYPOINT NAME OR POSITION ETA AT PREDICTED WAYPOINT	Contains a list of waypoints and their ETAs.

ATTACHMENT 7
FMC/DATALINK INTERFACE

BASIC IEIs AND ASSOCIATED ELEMENTS

WL	WAYPOINT LIST EXAMPLE: /WLBDX.CGC.NSG.N33E010 <u>IEI CONTENT</u> LIST ENTRY: WAYPOINT NAME OR POSITION	Contains a list of waypoints for which data is to be included in a top of descent downlink.
WM	ENROUTE WIND MODIFICATION EXAMPLE: /WM310,SEA,120075,350M35.N04030W120,130090 <u>IEI CONTENT</u> WIND ALTITUDE LIST ENTRY: WAYPOINT NAME OR POSITION WAYPOINT WIND WAYPOINT ALTITUDE/OAT	Consists of an altitude and a variable length list of entries that include the waypoint, the waypoint winds that apply to that altitude and the waypoint temperature.
WP	<u>SUPPLEMNTAL NDB WAYPOINTS</u> EXAMPLE: /WPEFGH,N21421W101113,SRP,1090020,W09 <u>IEI CONTENT</u> LIST ENTRY: WAYPOINT IDENT WAYPOINT LAT/LON REFERENCE IDENT RADIAL/DISTANCE WAYPOINT MAGVAR	Consists of a list of waypoints to be included in the supplemental navigation data base.
WR	<u>ALTERNATE AIRPORT WEATHER REQUEST</u> EXAMPLE: /WRKLAX.KSFO.KPHX <u>IEI CONTENT</u> LIST ENTRY: DESTINATION AND ALTERNATE IDENTS	Consists of a variable length list of entries defining destination and alternate identifiers.

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Section 8
Element Definitions

Formatted: Numbering: Continuous

This section contains an alphabetical table of defined elements indicating the formats and attributes of each element. This section will be updated as the need for new elements is identified. Users are requested to advise the AEEC staff when such a need arises.

Notes:

1. This element may require one or more elements to completely define the desired data.
2. Some implementations require that this element be uplinked in a fixed length format of maximum character length.
3. See Section 10 for further definition of codes.
4. Millibars = Hectopascals = 100 newton/meter2

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
ACARS CONFIG IDENT NUMBER	V	S	AN	10			
ACCELERATION ALTITUDE	V	S	N	5	1	Feet	
ACT PLAN CRUISE ALTITUDE	V	S	N	3	100	Feet	
ACTIVE CRZ WAYPOINT	V	S	AN	13			
ACTIVE CRZ WAYPOINT/WIND	V	S	AN	13			
ACTIVE DESCENT WIND	V	M	N	9			
ALTITUDE	F	S	N	3	100	Feet	
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	2
ACTUAL WIND	V	M	N	6			
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	
AIRCRAFT TYPE	V	S	AN	11			
AIRPORT ELEVATION	V	S	N	5	1	Feet	
AIRPORT IDENT	V	S	AN	4			
AIRPORT LAT/LON	F	S	AN	13			

V = VARIABLE | S = SINGLE PARAMER | A = ALPHA | N = NUMERIC
F = FIXED | M = MULTIPARAMETER | AN = ALPHANUMERIC | D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
AIRPORT MAGVAR	V	S	AN	3			
DIRECTIONAL	F		A	1		E=East	
						W=West	
MAGNITUDE	V		N	2	1	Degrees	
ALTERNATE ASSUMED TEMPERATURE	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
ALTERNATE COMPANY ROUTE	V	S	AN	10			
ALTERNATE CRUISE ALTITUDE	V	S	N	3	100	Feet	
ALTERNATE DESTINATION	V	S	AN	4			1
ALTERNATE FLAP/SLAT							
CONFIGURATION	F	S	N	1			
ALTERNATE FLAPS	V	S	N	2	1	Degrees	
ALTERNATE FUEL	V	S	N	5	0.1	Klbs	
ALTERNATE IDENT	V	S	AN	10			
ALTERNATE LIMIT TAKEOFF							

V = VARIABLE   S = SINGLE PARAMER   A = ALPHA   N = NUMERIC
F = FIXED   M = MULTIPARAMETER   AN = ALPHANUMERIC   D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
GROSS WT	V	S	N	5	0.1	Klbs	
ALTERNATE TAKEOFF SPEEDS	F	M	N	9			
V1	F	S	N	3	1	Knots	
VR	F	S	N	3	1	Knots	
V2	F	S	N	3	1	Knots	
ALTERNATE THRUST RATING	F	S	N	1		0 = No derate 1 = Derate 1 2 = Derate 2 | 9 = Derate 9	
ALTERNATE TIME	F	M	N	6			1
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
SECONDS	F	S	N	2	1	Second	
ALTERNATE TRIM	V	D	AN	5			
DIRECTIONAL	F		A	1		P=Plus M=Minus	
MAGNITUDE	V		N	4	0.01	Degrees	
ALTERNATE TYPE	F	S	A	1		M=Missed Appr D=Dir to from	1

V = VARIABLE
F = FIXED
S = SINGLE PARAMER
M = MULTIPARAMETER
A = ALPHA
AN = ALPHANUMERIC
N = NUMERIC
D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						Present Pos	
ALTERNATE VTR PERCENTAGE	V	S	N	2	1	Percent	
ALTERNATE WIND	V	M	N	9			
ALTITUDE	F	S	N	3	100	Feet	
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	
ALTITUDE AND WIND	V	M	N	9			
ALTITUDE	F	S	N	3	100	Feet	
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	
ALTITUDE TO ALTERNATE	V	S	N	3	100	Feet	1
ALTITUDE TO PREDICTED WPT	V	S	N	4	10	Feet	
ALTN FLIGHT LIST ALT/OAT	V	M	AN	6			
ALTITUDE	F	S	N	3	100		
DIRECTIONAL	F	D	A	1			
MAGNITUDE	V		N	2	1		
ALTN FLIGHT LIST IDENT	V	S	AN	4			
ALTN FLIGHT LIST WIND	V	D	N	6			
DIRECTIONAL	F		N	3	1		
MAGNITUDE	V		N	3	1		
ALTN INHIBIT	V	S	AN	4			
ARRIVAL AIRPORT IDENT	V	S	AN	4			
ASSUMED TEMPERATURE	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
BARO SETTING	V	D	AN	5			
DIRECTIONAL	F		A	1		H=QNH	
						E=QFE	
MAGNITUDE	V		N	4	1	Hecto-pascals	4
CENTER IRS POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
CENTER OF GRAVITY	V	S	N	3	0.1	Percent	
CLASS OF NAVAID	V	S	A	7			
CLIMB CAS LIMITS	F	M	N	6			
MINIMUM CLB CAS	F	S	N	3	1	Knots	
MAXIMUM CLB CAS	F	S	N	3	1	Knots	
CLIMB MACH LIMITS	F	M	N	6			
MINIMUM CLB MACH	F	S	N	3	0.001	Mach	
MAXIMUM CLB MACH	F	S	N	3	0.001	Mach	
CLIMB TRANSITION ALTITUDE	V	S	N	3	100	Feet	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
CLIMB WIND	V	M	N	9			
ALTITUDE	F	S	N	3	100	Feet	
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	
COMPANY DISTRIBUTION	V	S	AN	10			
COMPANY PREFERRED ALTN ALTITUDE	V	S	N	3	100	Feet	
COMPANY PREFERRED ALTN ALT/OAT	V	M	AN	6			
ALTITUDE	F	S	N	3	100		
DIRECTIONAL	F	D	A	1			
MAGNITUDE	V		N	2	1		
COMPANY PREFERRED ALTN IDENT	V	S	AN	4			
COMPANY PREFERRED ALTN OFFSET	V	D	AN	3			
DIRECTIONAL	F		A	1			
DISTANCE	V		N	2	1		
COMPANY PREF ALTN OVERHEAD FIX	V	S	AN	13			
COMPANY PREFERRED ALTN PRIORITY	F	S	N	1			
COMPANY PREFERRED ALTN SPEED	V	M	N	4			
TYPE	F	S	N	1			
SPEED VALUE	V	S	N	S	1, 0.001		
COMPANY PREFERRED ALTN WIND	V	M	N	6			
DIRECTIONAL	F	S	N	3	1		
MAGNITUDE	V	S	N	3	1		
COMPANY ROUTE	V	S	AN	10			
COST INDEX	V	S	N	4			
COURSE IN	F	S	N	3	1	Degrees	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
COURSE INTO PREDICTED WAYPOINT	V	S	N	3	1	Degrees	1
CROSS TRACK DEVIATION	V	D	AN	4			
DIRECTIONAL	F		A	1		L or R	
DISTANCE	V		N	3	0.1	NM	
CROSSED WAYPOINT IDENT	V	S	AN	13			
CRUISE ALTITUDE	V	S	N	3	100	Feet	
CRUISE CAS LIMITS	F	M	N	6			
MINIMUM CRZ CAS	F	S	N	3	1	Knots	
MAXIMUM CRZ CAS	F	S	N	3	1	Knots	
CRUISE CENTER OF GRAVITY	V	S	N	3	0.1	Percent	
CRUISE MACH LIMITS	F	M	N	6			
MINIMUM CRZ MACH	F	S	N	3	0.001	Mach	
MAXIMUM CRZ MACH	F	S	N	3	0.001	Mach	
CRUISE SPEED MODE	V	S	AN	17		Active Cruise Page Title	
CRUISE WAYPOINT WIND	V	M	N	6			
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	2
CRUISE WIND	V	M	N	6			
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	2
CRUISE WIND TO ALTERNATE	V	M	N	6			1
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
CURRENT ALTITUDE	V	S	N	3	100	Feet	
CURRENT CALIBRATED AIRSPEED	F	D	AN	4	1 or		
SPEED VALUE CAS/MACH	F		N	3	0.001	Knots, Mach	
UNIT IDENTIFIER	F		A	1		K or M	
CURRENT GROSS WEIGHT	V	S	N	5	0.1	Klbs	
CURRENT GROSS WEIGHT AT PRED WPT	V	S	N	5	0.1	Klbs	
CURRENT GROUND SPEED	F	S	N	3	1	Knots	
CURRENT POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
CURRENT TRUE AIRSPEED	F	D	AN	4	1 or		
SPEED VALUE CAS/MACH	F		N	3	0.001	Knots, Mach	
UNIT IDENTIFIER	F		A	1		K or M	
CURRENT VERTICAL SPEED	V	D	AN	5			
DIRECTIONAL	F		A	1		U or D	
SPEED VALUE	V		N	4	1	Feet/min	
DATE	F	M	N	6			
DAY	F	S	N	2		Day	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
MONTH	F	S	N	2		Month	
YEAR	F	S	N	2		Year	
DEPARTURE AIRPORT IDENT	V	S	AN	4			
DESCENT CAS LIMITS	F	M	N	6			
MINIMUM DES CAS	F	S	N	3	1	Knots	
MAXIMUM DES CAS	F	S	N	3	1	Knots	
DESCENT ISA DEVIATION	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
DESCENT MACH LIMITS	F	M	N	6			
MINIMUM DES MACH	F	S	N	3	0.001	Mach	
MAXIMUM DES MACH	F	S	N	3	0.001	Mach	
DESCENT TRANSITION ALTITUDE	V	S	N	3	100	Feet	
DESCENT WIND	V	M	N	9			
ALTITUDE	F	S	N	3	100	Feet	2
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	
DESIRED TRACK	V	S	N	3	1	Degrees	
DESTINATION AND ALTERNATE IDENTS	V	S	AN	10			
DESTINATION RUNWAY IDENT	F	D	AN	3			
RUNWAY NUMBER	F		N	2			
RUNWAY SUFFIX	F		A	1		L=Left	
						C=Center	

V = VARIABLE S = SINGLE PARAMER A = ALPHA N = NUMERIC
F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						R=Right	
						O=None	
DISTANCE TO ALTERNATE	V	S	N	4	1	NM	
DISTANCE TO DESTINATION	V	S	N	4	1	NM	
DISTANCE TO PREDICTED WAYPOINT	V	S	N	4	1	NM	1
DISTANCE TO WAYPOINT	V	S	N	4	1	NM	
DOWNLINK GENERATION TIME	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1		
DRAG FACTOR	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	0.1	Percent	
EFFECTIVITY DATE	F	M	AN	7			
MONTH	F	S	A	3		Month	
DAY	F	S	A	2		Day	
YEAR	F	S	N	2		Year	
ENGINE-OUT ACCELERATION							
ALTITUDE	V	S	N	5	1	Feet	
ENGINE-OUT STATUS	V	S	N	1		0=All Engine	
						1=Engine Out	
ENGINE THRUST	F	S	N	3	0.1	Klbs	
ENGINE TYPE	V	S	AN	15			

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
ENTERED IRS HEADING	F	S	N	3	1	Degrees	
ERROR DATA CODE	F	S	N	3			3
ERROR TYPE CODE	F	S	N	3			3
ESTIMATED WIND TO ALTERNATE	V	M	N	6			1
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	2
ETA AT ALTERNATE DESTINATION	F	M	N	6			1
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
SECONDS	F	S	N	2	1	Second	
ETA AT DESTINATION	F	M	N	6			
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
SECONDS	F	S	N	2	1	Second	
ETA AT GOTO WAYPOINT	F	M	N	6			1
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
SECONDS	F	S	N	2	1	Second	
ETA AT PREDICTED WAYPOINT	F	M	N	6			
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
SECONDS	F	S	N	2	1	Second	
ETA CHANGE VARIABLE	F	S	N	1	1	Minutes	
EXTENDED REJECTION DATA	V	S	AN	25			

V = VARIABLE　S = SINGLE PARAMER　A = ALPHA　N = NUMERIC
F = FIXED　M = MULTIPARAMETER　AN = ALPHANUMERIC　D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
EXTRA FUEL	V	D	AN	6			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	5	0.1	Klbs	
FINAL FUEL	V	S	N	5	0.1	Klbs	
FLAP/SLAT CONFIGURATION	F	S	N	1			
FLIGHT NUMBER	V	S	AN	10			
FLIGHT PATH ANGLE	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
ANGLE	V		N	2	0.1	Degrees	
FLIGHT PHASE	F	S	N	1		0= Preflight	
						1=Takeoff	
						2=Climb	
						3=Cruise	
						4= Descent	
						5= Approach	
						6=Go Around	
						7=Done	
FMC BEST POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
FMC POSITION PRIOR TO POS UPDATE	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
FMC SOFTWARE PART NUMBER	F	S	N	10			
FMC SYSTEM DATE	F	M	N	6			
DAY	F	S	N	2	1		
MONTH	F	S	N	2	1		
YEAR	F	S	N	2	1		
FMC SYSTEM TIME	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
FREQUENCY	F	S	N	5	0.01	MHz	1
FUEL AT DESTINATION	V	S	N	5	0.1	Klbs	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
FUEL FLOW FACTOR	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	0.1	Percent	
FUEL REMAINING	V	S	N	5	0.1	Klbs	
FUEL REMAINING AT ALTN DEST	V	S	N	5	0.1	Klbs	1
FUEL REMAINING AT PREDICTED WPT	V	S	N	5	0.1	Klbs	1
GOTO (NEXT) WPT IDENT	V	S	AN	13			
GOTO+1 (FOLLOWING) WPT IDENT	V	S	AN	13			
GREENWICH MEAN TIME	F	M	N	6			
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
SECONDS	F	S	N	2	1	Seconds	
GROUND ADDRESS	V	S	AN	7			
HOLD EFC TIME	F	M	N	4			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
IDLE FACTOR	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	0.1	Percent	
INACTIVE COMPANY ROUTE	V	S	AN	10			
INVALID FLAG	F	S	N	1		Nothing	
						0=Valid	
						1=Invalid	

V = VARIABLE   S = SINGLE PARAMER   A = ALPHA   N = NUMERIC
F = FIXED   M = MULTIPARAMETER   AN = ALPHANUMERIC   D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
IRS-C MODE	F	S	N	1		1=Align	
						2=Nav	
						3=Attitude	
IRS-L MODE	F	S	N	1		1=Align	
						2=Nav	
						3=Attitude	
IRS-R MODE	F	S	N	1		1=Align	
						2=Nav	
						3=Attitude	
IRS MONITOR	F	M	N	9			
LEFT IRS DRIFT	F	S	N	3	0.1	NM/hour	
CENTER IRS DRIFT	F	S	N	3	0.1	NM/hour	
RIGHT IRS DRIFT	F	S	N	3	0.1	NM/hour	
LABEL CODE	F	S	N	3			
LANDING GROSS WEIGHT	V	S	N	5	0.1	Klbs	
LEFT DME DISTANCE	V	S	N	4	0.1	NM	
LEFT DME FREQUENCY	F	S	N	5	0.01	MHz	
LEFT GNSS POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	

V = VARIABLE S = SINGLE PARAMER A = ALPHA N = NUMERIC
F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
MINUTES	F		N	3	0.1	Minutes	
LEFT ILS FREQUENCY	F	S	N	5	0.01	MHz	
LEFT IRS POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
LEFT VOR BEARING	F	S	N	4	0.1	Degrees	
LEFT VOR FREQUENCY	F	S	N	5	0.01	MHz	
LITERAL ERROR DATA	V	S	AN	13			
LOCALIZER DEVIATION	V	D	AN	4		DDM	
DIRECTIONAL	F		A	1		L = Left	
						R = Right	
MAGNITUDE	V		N	3	0.001		
MANEUVER MARGIN	V	S	N	3	0.01		
MAXIMUM CLIMB CAS	F	S	N	3	1	Knots	
MAXIMUM CLIMB MACH	F	S	N	3	0.001	Mach	
MAXIMUM CRUISE CAS	F	S	N	3	1	Knots	
MAXIMUM CRUISE MACH	F	S	N	3	0.001	Mach	
MAXIMUM DESCENT CAS	F	S	N	3	1	Knots	
MAXIMUM DESCENT MACH	F	S	N	3	0.001	Mach	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
MEAN WIND	V	D	AN	4			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	3	1	Knots	
MESSAGE SEQUENCE NUMBER	V	S	AN	10			
MINIMUM CLIMB CAS	F	S	N	3	1	Knots	
MINIMUM CLIMB MACH	F	S	N	3	0.001	Mach	
MINIMUM CRUISE CAS	F	S	N	3	1	Knots	
MINIMUM CRUISE MACH	F	S	N	3	0.001	Mach	
MINIMUM CRUISE TIME	F	S	N	1	1	Minutes	
MINIMUM DESCENT CAS	F	S	N	3	1	Knots	
MINIMUM DESCENT MACH	F	S	N	3	0.001	Mach	
MINIMUM FUEL TEMPERATURE	V	D	AN	3		P=Plus	
DIRECTIONAL	F		A	1		M=Minus	
MAGNITUDE	V		N	2	1	ºC	
MINIMUM R/C - CLB	V	S	N	3	1	Feet/min	
MINIMUM R/C - CRZ	V	S	N	3	1	Feet/min	
MINIMUM R/C - ENG OUT	V	S	N	3	1	Feet/min	
MOD CRZ WAYPOINTS	V	S	AN	13			
MOD PLAN CRUISE ALTITUDE	V	S	N	3	100	Feet	
MONITOR CODE	F	S	N	2			
NAVAID ELEVATION	V	S	N	5	1	Feet	
NAVAID IDENT	V	S	AN	4			
NAVAID LAT/LON	F	S	AN	13			1

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
NAVAID MAGVAR	V	D	AN	3			1
DIRECTIONAL	F		A	1		E=East	
						W=West	
MAGNITUDE	V		N	2	1	Degrees	
NAVAID TYPE	F	S	A	1		D=DME	
						V=VOR	
NAVIGATION DATA BASE IDENT	V	S	AN	10			
NETWORK ADDRESS	V	S	AN	7			
NOISE ABATEMENT AND ALTITUDE	V	S	V	5	1	Feet	
NOISE ABATEMENT SPEED	F	S	N	3	1	Knots	
NOISE ABATEMENT DERATE THRUST	F	S	N	1		N=as required	
						N=0 (no noise derate Thrust)	
						N=1 (Derate 1)	
						N=2 (Derate 2)	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						N=3 (Max Climb)	
NOISE ABATEMENT THRUST	V	M	AN	6			
THRUST TYPE	F	S	A	1		n=n1	
						N=N1	
						E=EPR	
THRUST VALUE	V	S	N	S	0.01	PERCENT OR EPR	
NOISE ABATEMENT START ALTITUDE	V	S	N	S	1	Feet	
OAT OR SAT	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
OAT AT PREDICTED WAYPOINT	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
PAGE ID	V	M	AN	3			
PAGE NUMBER	V		N	2	1		
LAST PAGE FLAG	F		N	1		Blank= Page	
						to Follow	
						E=End	
PAGE INFO	F	M	N	2			
PAGE NUMBER	F	S	N	1			
NUMBER OF PAGES	F	S	N	1			

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
PERF DEFAULTS CONFIG NO.	V	S	A	10			
PERF FACTOR	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	0.1	Percent	
PLAN OR BLOCK FUEL	V	S	N	5	0.1	Klbs	
POSITION SHIFT	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
SHIFT	V		N	2	100	Feet	
PREDICTED AIRSPEED	F	D	AN	4			1
SPEED	F		N	3	1 or		
TYPE	F		A	1	0.001	K=Knot	
						M=Mach	
PREDICTED DESTINATION FUEL	V	S	N	5	0.1	Klbs	1
PREDICTED FUEL REMAINING	V	S	N	5	0.1	Klbs	1
PREDICTED WAYPOINT IDENT	V	S	AN	13			
~~PRIMARY~~ ACTIVE CRUISE ALTITUDE	V	S	N	3	100	Feet	
PROCEDURE INDICATOR	F	S	A	1		Y=	1
						Proc.mbr.	
						N=Not	
						Proc.mbr.	
PROCEDURE IDENT	V	S	AN	6			1
PROCEDURE WAYPOINT	F	S	A	1		Y or N	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
QNH	V	S	N	4	1	Hecto pascals	4
QRH T/O SPD CONFIG NUM	V	S	A	10			
RADIAL/DISTANCE	F	M	AN	7			1
RADIAL	F	S	N	3	1	Degrees	
DASH	F	S	AN	1			
DISTANCE	F	S	N	3	1	NM	
RADIO MEASUREMENT	V	S	N	4	0.1	NM or degrees	
REFERENCE AIRPORT IDENT	V	S	AN	4			
REFERENCE CRZ WAYPOINT IDENT	V	S	AN	13			
REFERENCE IDENT	V	S	AN	5			1
REFERENCE LAT/LON	F	S	AN	13			1
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
REFERENCE RTA WAYPOINT IDENT	V	S	AN	13			
REFERENCE TAKEOFF GROSS WEIGHT	V	S	N	5	0.1	Klbs	
REPORT STIMULUS	F	S	N	3			3
RESERVE FUEL	V	S	N	5	0.1	Klbs	
RIGHT DME DISTANCE	V	S	N	4	0.1	NM	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
RIGHT DME FREQUENCY	F	S	N	5	0.01	MHz	
RIGHT GPS POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
RIGHT ILS FREQUENCY	F	S	N	5	0.01	MHz	
RIGHT IRS POSITION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
RIGHT VOR BEARING	F	S	N	4	0.1	Degrees	
RIGHT VOR FREQUENCY	F	S	N	5	0.01	MHz	
RTA CONSTRAINT	F	S	A	2		AA=AT or AFTER AB=AT or BEFORE	

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F = FIXED	M = MULTIPARAMETER	AN = ALPHANUMERIC	D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						AT =AT	
RTA COST INDEX	V	D	AN	5			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
COST INDEX	V		N	4	1		
RTA TAKEOFF WINDOW TIMES	F	M	N	12			
FIRST HOURS	F	S	N	2	1	Hours	
FIRST MINUTES	F	S	N	2	1	Minutes	
FIRST SECONDS	F	S	N	2	1	Seconds	
LAST HOURS	F	S	N	2	1	Hours	
LAST MINUTES	F	S	N	2	1	Minutes	
LAST SECONDS	F	S	N	2	1	Seconds	
RTA TIME	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
RTA TIME ERROR TOLERANCE	V	S	N	2	1	Seconds	
RTA WAYPOINT IDENT	V	S	AN	13			
RTA WINDOW TIMES	F	M	N	12			
FIRST HOURS	F	S	N	2	1	Hours	
FIRST MINUTES	F	S	N	2	1	Minutes	
FIRST SECONDS	F	S	N	2	1	Seconds	
LAST HOURS	F	S	N	2	1	Hours	
LAST MINUTES	F	S	N	2	1	Minutes	
LAST SECONDS	F	S	N	2	1	Seconds	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
RUNWAY COURSE	V	S	N	3	1	Degrees	
RUNWAY ELEVATION	V	S	N	6	1	Feet	
RUNWAY IDENT	F	D	AN	3			
RUNWAY NUMBER	F		N	2			
RUNWAY SUFFIX	F		A	1		L=Left	
						C=Center	
						R=Right	
						O=None	
RUNWAY INTERSECTION	V	S	AN	3			
RUNWAY LAT/LON	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
RUNWAY LENGTH	V	S	N	5	1	Feet	
RUNWAY LENGTH REMAINING	V	S	N	3	100	Feet	
SCRATCHPAD	V	S	AN	24			
SELECTED TEMPERATURE	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	

V = VARIABLE   S = SINGLE PARAMER   A = ALPHA   N = NUMERIC
F = FIXED   M = MULTIPARAMETER   AN = ALPHANUMERIC   D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
STANDARD LIMIT TAKEOFF GR WT	V	S	N	5	0.1	Klbs	
STATIC AIR TEMPERATURE (SAT)	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
STEADY/INTERMITTENT	F	S	A	1	S or I		
STIMULUS CODE	F	S	N	3			3
SYSTEM CODE	F	S	N	2			
TAI ON ALTITUDE	V	S	N	3	100	Feet	
TAI ON/OFF ALTITUDE	F	M	N	6			
TAI ON ALTITUDE	F	S	N	3	100	Feet	
TAI OFF ALTITUDE	F	S	N	3	100	Feet	
TAKEOFF CENTER OF GRAVITY	V	S	N	3	0.1	Percent	
TAKEOFF FLAPS	V	S	N	2	1	Degrees	
TAKEOFF GROSS WEIGHT	V	S	N	5	0.1	Klbs	
TAKEOFF RUNWAY CONDITION	F	S	N	1		1=Wet	
						2=Dry	
						3=1/4 water	
						4=1/2 water	
						5=1/4 slush	
						6=1/2 slush	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						7=compact snow	
						8= wet skid resist	
TAKEOFF RUNWAY IDENT	F	D	AN	3			
RUNWAY NUMBER	F		N	2			
RUNWAY SUFFIX	F		A	1		L=Left	
						C=Center	
						R=Right	
						O=None	
TAKEOFF RUNWAY SLOPE	V	D	AN	3			
DIRECTIONAL	F		A	1		U=Up	
						D=Down	
MAGNITUDE	V		N	2	0.1	Percent	
TAKEOFF RUNWAY WIND	V	M	N	6			
DIRECTIONAL	F	S	N	3	1	Degree	
MAGNITUDE	V	S	N	3	1	Knots	2
TAKEOFF SPEEDS	F	M	N	9			
V1	F	S	N	3	1	Knots	
VR	F	S	N	3	1	Knots	
V2	F	S	N	3	1	Knots	2
TAKEOFF THRUST RATING	F	S	N	1		0= No derate	
						1= Derate 1	

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
						2= Derate 2	
						|	
						|	
						8=Bump	
						9=Derate	
TAKEOFF TIME							
HOURS	F	S	N	2	1	Hour	
MINUTES	F	S	N	2	1	Minute	
TARGET MACH	V	S	N	3	.001	Mach	
TAS AT PREDICTED WAYPOINT	V	S	N	3	1	Knots	1
TAXI FUEL	V	S	N	5	0.1	Klbs	
TEMPERATURE AT ALTERNATE	V	D	AN	3			1
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
THRUST REDUCTION ALTITUDE	V	S	N	5	1	Feet	
TIME DETERMINED	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
TIME ERROR TOLERANCE	V	S	N	2	1	Seconds	
TIME TO GO TO DESTINATION 1	V	S	N	3	1	Minutes	
TIME TO GO TO DESTINATION 2	V	S	N	3	1	Minutes	
TIME TO GO TO DESTINATION 3	V	S	N	3	1	Minutes	

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F = FIXED　　M = MULTIPARAMETER　　AN = ALPHANUMERIC　　D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
TIME TO GO TO DESTINATION 4	V	S	N	3	1	Minutes	
TIME TO GO TO DESTINATION 5	V	S	N	3	1	Minutes	
TIME TO GO TRIGGER	V	S	N	3	1	Minutes	
TIME UPLINK IS RECEIVED	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
TOC OR CRUISE TEMPERATURE	V	D	AN	3			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	2	1	°C	
TOP OF DESCENT ALTITUDE	V	S	N	3	100	Feet	
TOP OF DESCENT ETA	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
TOP OF DESCENT LOCATION	F	S	AN	13			
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	

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ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
TOTAL FUEL/FOB	V	S	N	5	0.1	Klbs	
TRACK ANGLE MAG	F	S	N	3	1	Degrees	
TRIGGER NUMBER	F	S	N	3	1		
TRIGGER TRIPPED TIME	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
TRIGGER UPLINK TIME	F	M	N	6			
HOURS	F	S	N	2	1	Hours	
MINUTES	F	S	N	2	1	Minutes	
SECONDS	F	S	N	2	1	Seconds	
TRIM	V	D	AN	5			
DIRECTIONAL	F		A	1		P=Plus	
						M=Minus	
MAGNITUDE	V		N	4	0.1	Degrees	
TRIP FUEL	V	S	N	5	0.1	Klbs	
TROPOPAUSE ALTITUDE	F	S	N	5	1	Feet	
UPLINKED IMI	F	S	A	3			
VERTICAL DEVIATION	V	D	AN	6			
DISTANCE	V		N	5	1	Feet	
DIRECTIONAL	F		A	1		H or L	
VTR PERCENTAGE	V	S	N	2	1	Percent	
WAYPOINT ALTITUDE/OAT	V	M	AN	6			1
ALTITUDE	F	S	N	3	100	Feet	

V = VARIABLE S = SINGLE PARAMER A = ALPHA N = NUMERIC
F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
OAT DIRECTIONAL	F	D	N	1		P=Plus	
						M=Minus	
OAT MAGNITUDE	V		N	2	1	°C	
WAYPOINT BEARING	F	S	N	3	1	Degrees	1
WAYPOINT IDENT	V	S	AN	5			
WAYPOINT LAT/LON	F	S	AN	13			1
DIRECTIONAL	F		A	1		N=North	
						S=South	
DEGREES	F		N	2	1	Degrees	F
MINUTES	F		N	3	0.1	Minutes	
DIRECTIONAL	F		A	1		E=East	
						W=West	
DEGREES	F		N	3	1	Degrees	
MINUTES	F		N	3	0.1	Minutes	
WAYPOINT MAGVAR	V	D	AN	3			1
DIRECTIONAL	F		A	1		E=East	
						W=West	
MAGNITUDE	V		N	2	1	Degrees	
WAYPOINT NAME OR POSITION	V	S	AN	13			
WAYPOINT SEQUENCE	V	S	AN	13			
WAYPOINT WIND	V	M	N	6			
DIRECTIONAL	F	S	N	3	1	Degrees	1
MAGNITUDE	V	S	N	3	1	Knots	2
WIND ALTITUDE	V	S	N	3	100	Feet	

V = VARIABLE | S = SINGLE PARAMER | A = ALPHA | N = NUMERIC
F = FIXED | M = MULTIPARAMETER | AN = ALPHANUMERIC | D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

Element Description	Type	Length Type	Elem Type	Char Length	Scale	Units	Notes
WIND AT PREDICTED WAYPOINT	V	M	N	6			1
DIRECTIONAL	F	S	N	3	1	Degrees	
MAGNITUDE	V	S	N	3	1	Knots	
WIND LEVEL ALTITUDE	V	S	N	3	100	Feet	
WIND LEVEL WAYPOINT	V	S	AN	13			
WIND VECTOR MAGNITUDE							
DIFFERENCE	V	S	N	3	1	Knots	
ZERO FUEL WEIGHT	V	S	N	5	0.1	Klbs	
ZERO FUEL WEIGHT CG	V	S	N	3	0.1	Percent	

Section 9
Flight Plan Element Definitions

This section contains the flight plan element identifiers and a complete description of each flight plan element.

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
:DA:	DEPARTURE AIRPORT							
		AIRPORT IDENTIFIER	V	S	AN	4		
:AA:	ARRIVAL AIRPORT							
		AIRPORT IDENTIFIER	V	S	AN	4		
:CR:	COMPANY ROUTE							
		COMPANY ROUTE	V	S	AN	10		
:R:	DEPARTURE RUNWAY							
		RUNWAY IDENTIFIER	F	D	AN	3		
		RWY NUMBER			N	2		

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F = FIXED	M = MULTIPARAMETER	AN = ALPHANUMERIC	D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
		RWY SUFFIX			A	1		L=LEFT
								C=CENTER
								R=RIGHT
	SUFFIX							O=NO
:D:	DEPARTURE PROCEDURE							
		PROCEDURE IDENT	V	S	AN	10		
:F:	FLIGHT PLAN SEGMENT							
	PUBLISHED IDENT							
		FIX IDENTIFIER	V	S	AN	5		
		OPTIONAL INTRO.(,)						
		OPTIONAL LAT/LON	F	M	AN	13		
		DIRECTIONAL			A	1		N OR S
		DEGREES			N	5		
		DIRECTIONAL			A	1		E OR W
		DEGREES			N	6		
	LAT/LON							
		LATITUDE/ LONGITUDE	V	M	AN	13		
		DIRECTIONAL			A	1		N OR S
		DEGREES			N	5		
		DIRECTIONAL			A	1		E OR W
		DEGREES			N	6		
	PB/PB							
		FIX IDENTIFIER	V	S	AN	5		

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ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
		OPTIONAL INTRO.(,)						
		OPTIONAL LAT/LON	F	M	AN	13		
		DIRECTIONAL			A	1		N OR S
		DEGREES			N	5		
		DIRECTIONAL			A	1		E OR W
		DEGREES			N	6		
		OPTIONAL TERM.(,)						
		BEARING	F	S	N	3	1	DEGREES
		DASH						
		FIX IDENTIFIER	V	S	AN	5		
		OPTIONAL INTRO.(,)						
		OPTIONAL LAT/LON	F	M	AN	13		
		DIRECTIONAL			A	1		N OR S
		DEGREES			N	5		
		DIRECTIONAL			A	1		E OR W
		DEGREES			N	6		
		OPTIONAL TERM.(,)						
		BEARING	F	S	N	3	1	DEGREES
	PBD							
		FIX IDENTIFIER	V	S	AN	5		
		OPTIONAL INTRO.(,)						
		OPTIONAL LAT/LON	F	M	AN	13		
		DIRECTIONAL			A	1		N OR S
		DEGREES			N	5		
		DIRECTIONAL			A	1		E OR W

V = VARIABLE   S = SINGLE PARAMER   A = ALPHA   N = NUMERIC
F = FIXED   M = MULTIPARAMETER   AN = ALPHANUMERIC   D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
		DEGREES			N	6		
		OPTIONAL TERM.(,)						
		BEARING	F	S	N	3	1	DEGREES
		DASH						
		DISTANCE	F	S	N	4	0.1	NM
:ON:	START OF DESIGNATED FLIGHT PLAN SEGMENT	SAME AS :F:						
:OF:	END OF DESIGNATED FLIGHT PLAN SEGMENT	SAME AS :F:						
..	DIRECT FIX	SAME AS :F:						
:A:	ARRIVAL PROCEDURE							
		PROCEDURE IDENT	V	S	AN	10		
:AP:	APPROACH PROCEDURE							
		PROCEDURE IDENT	V	S	AN	10		
()	ARRIVAL RUNWAY							
		RUNWAY IDENTIFIER	F	M	AN	3		
		RWY NUMBER		S	N	2		
		RWY SUFFIX		S	A	1		L=LEFT
								C=CENTER
								R=RIGHT
	SUFFIX							O=NO
:V:	WAYPOINT SPD/ALT/TIME							
		FIX IDENTIFIER	V	S	AN	13		

V = VARIABLE S = SINGLE PARAMER A = ALPHA N = NUMERIC
F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
		COMMA (,)						
		OPTIONAL* SPEED	F	S	N	3	1	KNOTS
		COMMA (,)						
		OPTIONAL* ALTITUDE	V	D	AN	6		
		DIRECTIONAL	F		A	2		AA=AT OR ABOVE
								AB=AT OR BELOW
								AT=AT
		ALTITUDE	V		N	4	10	FEET
		COMMA (,)						
		OPTIONAL ALTITUDE	V	D	AN	6		
		DIRECTIONAL	F		A	2		AA=AT OR ABOVE
								AB=AT OR BELOW
								AT=AT
		ALTITUDE	V		N	4	10	FEET
		COMMA (,)						
		OPTIONAL TIME*	V	D	AN	6		
		DIRECTIONAL	F		A	2		AA=AT OR AFTER
								AB=AT OR BEFORE
								AT=AT

V = VARIABLE　　S = SINGLE PARAMER　　A = ALPHA　　N = NUMERIC
F = FIXED　　M = MULTIPARAMETER　　AN = ALPHANUMERIC　　D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
		TIME	F		N	4	1	HOURS MINUTES UTC (HHMM)
		* For speed-only, altitude-only, or time-only constraints						
		Note: Either speed, altitude or time, or any combination must be included.						
	:H:	HOLD AT WAYPOINT						
		FIX IDENTIFIER	V	S	AN	13		
		COMMA (,)						
		SPEED	F	S	N	3	1	KNOTS
		COMMA (,)						
		ALTITUDE	V	D	AN	6		
		DIRECTIONAL	F		A	2		AA=AT OR ABOVE AB=AT OR BELOW AT=AT
		ALTITUDE	V	S	N	4	10	FEET
		COMMA (,)						
		TARGET SPEED	F	S	N	3	1	KNOTS
		COMMA (,)						
		TURN DIRECTION	F	S	A	1		L=LEFT R=RIGHT
		COMMA (,)						
		INBOUND COURSE	F	S	N	3	1	DEGREES
		COMMA (,)						

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F = FIXED   M = MULTIPARAMETER   AN = ALPHANUMERIC   D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
		EFC TIME	F	M	N	4		
		HOURS	F	S	N	2	1	00-24 HOURS
		MINUTES	F	S	N	2	1	MINUTES
		COMMA (,)						
		LEG TIME	F	S	N	2	0.1	MINUTES
		COMMA (,)						
		LEG DISTANCE	V	S	N	3	0.1	NM
:WS:	WAYPOINT STEP CLIMB							
		FIX IDENTIFIER	V	S	AN	13		
		COMMA (,)						
		ALTITUDE	V	S	N	3	100	FEET
:AT:	ALONG TRACK WAYPOINT							
		FIX IDENTIFIER	V	S	AN	5		
		DASH (-)						
		DISTANCE	V	D	AN	5	0.1	NM
		DIRECTIONAL	F		A	1		P=PLUS
								M=MINUS
		DISTANCE	V		N	4	0.1	NM
		COMMA (,)						
		SPEED	F	S	N	3	1	KNOTS
		COMMA (,)						
		ALTITUDE	V	D	AN	6		
		DIRECTIONAL	F		A	2		AA=AT OR ABOVE

V = VARIABLE S = SINGLE PARAMER A = ALPHA N = NUMERIC
F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
								AB=AT OR
								BELOW
								AT=AT
		ALTITUDE	V	S	N	4	10	FEET
		COMMA (,)						
		OPTIONAL ALTITUDE	V	D	AN	6		
		DIRECTIONAL	F		A	2		AA=AT OR
								ABOVE
								AB=AT OR
								BELOW
								AT=AT
		ALTITUDE	V	S	N	4	10	FEET
:RP:	REPORTING POINTS							
	LATITUDE RP	LATITUDE	V	M	AN	3		
		DIRECTIONAL	F	S	A	1		N=NORTH
								S=SOUTH
		DEGREES	V	S	N	2		DEGREES
		OPTIONAL DASH						
		DEGREE INCREMENT	V	S	N	2		
	LONGITUDE RP	LONGITUDE	V	M	AN	4		
		DIRECTIONAL	F	S	A	1		E=EAST
								W=WEST
		DEGREES	V	S	N	3		DEGREES
		OPTIONAL DASH						
		DEGREE INCREMENT	V	S	N	2		

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F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
	TRANSITION							
		TRANSITION IDENT	V	S	AN	5		
.	AIRWAY VIA/EXIT VIA							
	AIRWAY VIA							
		AIRWAY IDENTIFIER	V	S	AN	5		
.	AIRWAY EXIT VIA							
		FIX IDENTIFIER	V	S	AN	6		
:LO:	LATERAL OFFSET	OFFSET	V	D	AN	3		
		DIRECTIONAL	F		A	1		L=LEFT R=RIGHT
		DISTANCE	V/F		N	~~2~~2/3	1/0.1	NM
		For backward compatibility, DISTANCE is either variable length (0-2 numerics) with a resolution of 1 NM or a fixed length of 3 numerics with a resolution of 0.1 NM. Older systems may not support 0.1 NM resolution.						
		OPTIONAL COMMA (,)						
		OPTIONAL START FIX IDENTIFIER	V	S	AN	13		
		OPTIONAL COMMA (,)						
		OPTIONAL END FIX IDENTIFIER	V	S	AN	13		
		OPTIONAL COMMA (,)						
		OPTIONAL INTERCEPT ANGLE	V	S	N	3		DEGREES
:F:.	AIRWAY INTERCEPT							
		AIRWAY IDENTIFIER	V	S	AN	5		

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ATTACHMENT 7
FMC/DATALINK INTERFACE

FPEI	Description	Element Description	Length Type	Elem Type	Char Type	Length	Scale	Units
:IC:	INTERCEPT COURSE FROM							
		PUBLISHED IDENT, PB/PB or PBD as defined in the :F: FLIGHT PLAN FPE, followed by a COMMA (,) and COURSE:						
		COURSE	V	S	N	3	1	DEG
:CS:	CRUISE SPEED SEGMENT							
	FIX IDENTIFIER		V	S	AN	13		
	COMMA (,)							
	SPEED TARGET		V	S	AN	3		Mach 000-999
								E=Econ
								L=LRC
	OPTIONAL COMMA (,)							
	OPTIONAL ALTITUDE		F	S	N	3	100	FT
	OPTIONAL COMMA (,)							
	OPTIONAL FIX IDENTIFIER	V	S	AN	13			
	OPTIONAL COMMA (,)							
	OPTIONAL SPEED TARGET	V	S	AN	3		Mach 000-999	
								E=Econ
								L=LR

V = VARIABLE S = SINGLE PARAMER A = ALPHA N = NUMERIC
F = FIXED M = MULTIPARAMETER AN = ALPHANUMERIC D = DIRECTIONAL

ATTACHMENT 7
FMC/DATALINK INTERFACE

V = VARIABLE	S = SINGLE PARAMER	A = ALPHA	N = NUMERIC
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Section 10
Codes and Triggers

10.1 Error Type Codes

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Error type codes are listed as decimal and hexadecimal values. Depending on implementation, this code may be downlinked as either a decimal or hexadecimal value.

DEC CODE	HEX CODE	DESCRIPTION
001	001	END TO END CRC
002	002	INVALID ATC
003	003	SYNTAX ERROR
004	004	MISSING ELEMENT
005	005	RESERVED FOR DEFINITION (B-737)
006	006	N/A FOR IN AIR
007	007	MISSING ALL DATA FOR DEPENDENT ELEMENT
008	008	INCOMPATIBLE DATA
009	009	FMC DOWNMODE
010	00A	REFERENCE MISMATCH
011	00B	NOT IN NDB
012	00C	DUPLICATE WAYPOINT
013	00D	ROUTE FULL ERROR
014	00E	DATA BASE FULL ERROR
015	00F	ENTRY SLOT UNAVAILABLE
016	010	DUPLICATE SUPPLEMENT NDB DEFINITION
017	011	RESERVED FOR DEFINITION (B-737)
018	012	RESERVED FOR DEFINITION (B-737)
019	013	RESERVED FOR DEFINITION (B-737)
020	014	RESERVED FOR DEFINITION (B-737)
021	015	NO MINIMUM FLIGHT PLAN
022	016	NO ACTIVE ROUTE FOR DOWNLINK
023	017	UNSOLICITED UPLINK
024	018	DATA NOT ALLOWED IN TAKEOFF PHASE
025	019	DATA NOT ALLOWED IN CLIMB PHASE
026	01A	DATA NOT ALLOWED IN CRUISE PHASE
027	01B	DATA NOT ALLOWED IN DESCENT PHASE
028	01C	INCOMPATIBLE RANGE
029	01D	DEPARTURE AIRPORT DOES NOT EXIST
030	01E	DESTINATION AIRPORT DOES NOT EXIST
031	01F	ATO DISTANCE IS ENTERED OVER AN INVALID LEG
032	020	NEGATIVE ATO IS ENTERED OVER MOD DIRECT TO WPT
033	021	ATO DISTANCE IS GREATER THAN LEG LENGTH
034	022	INITIAL FIX IS FLOATER OR PPOS
035	023	PBPB WAYPOINT WITH NO VALID INTERSECTION
036	024	DIRECT WPT AFTER INTERCEPT WAYPOINT
037	025	HOLD ENTERED ON NON-HARD WAYPOINT

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
038	026	ALTITUDE RESTRICTION ON ALT ONLY WAYPOINT
039	027	TO FIX EQUALS FROM ON ROUTE PAGE
040	028	RESERVED FOR DEFINITION (B-737)
041	029	TO FIX IS NOT ON AIRWAY
042	02A	TO FIX CAUSES CHANGE OF DIRECT ON AIRWAY
043	02B	FROM AND TO NOT ON ENTERED AIRWAY
044	02C	CRUISE ALTITUDE LESS THAN MIN CRUISE ALT
045	02D	EPC MORE THAN 6 HOURS PAST HOLD FIX ETA
046	02E	RUNWAY REMAINING GREATER THAN RUNWAY LENGTH
047	02F	RESERVED FOR DEFINITION (B-737)
048	030	UNSOLICITED MOD WIND BECAUSE OF LONG DELETE
049	031	INAPPROPRIATE DATA TYPE
050	032	RESERVED FOR DEFINITION (B-737)
051	033	UNSOLICITED MOD WIND
052	034	CRUISE WIND IN DESCENT
053	035	DATA NOT ALLOWED IN PHASE
054	036	HOLD ENTERED ON HOLD EXIT WITH EXIT ARMED
055	037	VIA TYPE OF PROCEDURE TO FIX ENTRY NOT ALLOWED
056	038	ENTERED AIRPORT ID – DIRECT
057	039	VIA ENTERED FOR FIRST ROUTE SEGMENT
058	03A	AIRWAY UNPACK WAS UNSUCCESSFUL
059	03B	COMPANY ROUTE UNPACK UNSUCCESSFUL
060	03C	N/A FOR AIRCRAFT STATE
061	03D	PROCEDURE NOT FOUND (FOR ENROUTE AFTER)
062	03E	N/A FOR AIRCRAFT INSTALLATION
063	03F	DATA ELEMENT NOT ALLOWED ON GROUND
064	040	NO OFFSET EXISTS
065	041	NO OFFSET AT LEG
066	042	OFFSET IS ACTIVE
067	043	OFFSET DATA INCOMPATIBLE
068	044	NO OFFSETABLE LEG EXISTS
069	045	IMI LOST DUE TO WARM START
070	046	IMI LOST DUE TO OVERFLOW
071-100	047-064	RESERVED FOR DEFINITION (B-737)
101	065	BUFFER FULL
102	066	INCOMPATIBLE IEI
103	067	INVALID IEI FORMAT
104	068	INVALID IMI FORMAT
105	069	NOT ALLOWED ON GROUND
106	06A	INVALID REQUEST LABEL
107	06B	NO IEIs IN MESSAGE
108	06C	NO DATA IN ELEMENT TEXT
109	06D	INVALID FORMAT AND/OR RANGE
110	06E	NOT ALLOWED WHEN AIRBORNE

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
111	06F	NO APPLICABLE ROUTE
112	070	NO APPLICABLE IEI
113	071	NO REPORTING POINTS CREATED
114	072	ZERO FUEL WEIGHT CAUSES INVALID GROSS WEIGHT
115	073	PRIORITY MESSAGE PENDING
116	074	MULTIPLE ROUTE IEI
117	075	NO ROUTE IEI
118	076	NO FLIGHT PLAN ELEMENTS
119	077	NO ACTIVE ROUTE
120	078	FIRST FLIGHT PLAN ELEMENT INVALID
121	079	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
122	07A	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
123	07B	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
124	07C	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
125	07D	MULTIPLE DIRECT TO FIX
126	07E	MULTIPLE OF FLIGHT PLAN ELEMENT NOT ALLOWED
127	07F	FROM FIX IS NOT ON AIRWAY
128	080	AIRWAY/AIRWAY INTERSECTION NOT FOUND
129	081	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
130	082	NO FIX MATCH IN ROUTE
131	083	MULTIPLE HOLD AT FIX
132	084	BASE PROCEDURE UNDEFINED
133	085	LAT/LON REPORTING POINT NOT FOUND
134	086	CURRENT FLIGHT PLAN CONDITIONS INVALID FOR OFFSET
135	087	FPEI INCOMPATIBLE WITH IEI
136	088	NO COMPATIBLE RUNWAYS
137	089	AIRWAY FLIGHT PLAN ELEMENT IS NOT CLOSED
138	08A	NO FROM FIX FOR AIRWAY FLIGHT PLAN ELEMENT
139	08B	SPARE
140	08C	EXCEEDS CHARACTER LIMIT
141	08D	DERATE OPTION NOT SELECTED
142	08E	PAGES OUT OF SEQUENCE
143	08F	TIMED OUT
144	090	NO VALID RWY RECORDS
145-200	091-0C8	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
201	0C9	DEPENDENT IMI REJECTED
202	0CA	DUPLICATE IEIs
203	0CB	REPORT NOT ALLOWED WITH INVALID A/C POSITION
204	0CC	BLOCK NOT SUFFICIENT FOR TAXI AND ROUTE RESERVE
205	0CD	WINDOW ALTITUDE CONSTRAINT NOT ALLOWED
206	0CE	NOT ALLOWED FOR ALTERNATE FLIGHT PLAN
207	0CF	DESTINATION DOES NOT MATCH ORIGIN OF ALTERNATE
208	0D0	PILOT DEFINED STORE IS FULL
209-300	0D1-12C	RESERVED FOR DEFINITION (AIRBUS AIRCRAFT)

10.2 Error Data Codes

Error codes are listed as decimal and hexadecimal values. Depending in implementation, this code may be downlinked as either a decimal or hexadecimal value.

DEC CODE	HEX CODE	DESCRIPTION
001	001	RTA WAYPOINT DATA CODE
002	002	RTA TIME DATA CODE
003	003	ALTERNATE AIRPORT ID DATA CODE
004	004	ALTERNATE AIRPORT TYPE DATA CODE
005	005	ALTERNATE AIRPORT DISTANCE DATA CODE
006	006	ALTERNATE AIRPORT ALTITUDE DATA CODE
007	007	ALTERNATE AIRPORT WIND DATA CODE
008	008	CLEAR FLIGHT PLAN DATA CODE
009	009	FLIGHT NUMBER DATA CODE
010	00A	COST INDEX DATA CODE
011	00B	CRUISE ALTITUDE DATA CODE
012	00C	CRUISE (TOC) TEMP DATA CODE
013	00D	ZERO FUEL WEIGHT DATA CODE
014	00E	CRUISE WIND DATA CODE
015	00F	RESERVE FUEL DATA CODE
016	010	CRUISE CENTER OF GRAVITY DATA CODE
017	011	CLIMB TRANSITION ALTITUDE DATA CODE
018	012	TAKEOFF DEPARTURE RUNWAY ID DATA CODE
019	013	RUNWAY INTERSECTION DATA CODE
020	014	RUNWAY POSITION SHIFT DATA CODE
021	015	RUNWAY LENGTH REMAINING DATA CODE
022	016	T/O RUNWAY INVALID FLAG DATA CODE
023	017	TRIM DATA CODE
024	018	TAKEOFF REFERENCE GROSS WEIGHT DATA CODE
025	019	TAKEOFF FLAPS DATA CODE
026	01A	V1 SPEED DATA CODE
027	01B	V2 SPEED DATA CODE
028	01C	VR SPEED DATA CODE
029	01D	TAKEOFF SEL TEMP DATA CODE (ASSUMED TEMP)
030	01E	T/O RUNWAY SLOPE DATA CODE
031	01F	T/O RUNWAY WIND DATA CODE
032	020	T/O RUNWAY CONDITION DATA CODE
033	021	TAKEOFF DERATE DATA CODE
034	022	RESERVED FOR DEFINITION (B-737)
035	023	OUTSIDE AIR TEMP DATA CODE
036	024	DESCENT WIND ALT DATA CODE
037	025	DESCENT WIND DIR/MAG DATA CODE
038	026	TAKEOFF CENTER OF GRAVITY DATA CODE
039	027	RESERVED FOR DEFINITION (B-737)

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
040	028	BLOCK FUEL DATA CODE (PLAN FUEL)
041	029	DESCENT TRANSITION ALTITUDE DATA CODE
042	02A	TAI ON DATA CODE
043	02B	TAI ON/OFF ALTITUDE DATA CODE
044	02C	DESCENT ISA DEV DATA CODE
045	02D	QNH DATA CODE
046	02E	TIME ERROR TOLERANCE DATA CODE
047	02F	MIN CLB CAS DATA CODE
048	030	MIN CLB MACH DATA CODE
049	031	MIN CRZ CAS DATA CODE
050	032	MIN CRZ MACH DATA CODE
051	033	MIN DES CAS DATA CODE
052	034	MIN DES MACH DATA CODE
053	035	MAX CLB CAS DATA CODE
054	036	MAX CLB MACH DATA CODE
055	037	MAX CRZ CAS DATA CODE
056	038	MAX CRZ MACH DATA CODE
057	039	MAX DES CAS DATA CODE
058	03A	MAX DES MACH DATA CODE
059	03B	DEPARTURE AIRPORT DATA CODE
060	03C	DESTINATION AIRPORT DATA CODE
061	03D	COMPANY ROUTE DATA CODE
062	03E	DEPARTURE RUNWAY DATA CODE
063	03F	DEPARTURE BASE PROCEDURE DATA CODE
064	040	DEPARTURE TRANSITION PROCEDURE DATA CODE
065	041	AIRWAY VIA DATA CODE
066	042	INITIAL FIX WAYPOINT DATA CODE
067	043	INITIAL FIX PBD DATA CODE
068	044	INITIAL FIX PBPB DATA CODE
069	045	INITIAL FIX LAT/LON DATA CODE
070	046	DIRECT WPT AFTER SID DATA CODE
071	047	DIRECT PBD AFTER SID DATA CODE
072	048	DIRECT PBPB AFTER SID DATA CODE
073	049	DIRECT LAT/LON AFTER SID DATA CODE
074	04A	DIRECT WAYPOINT AFTER STAR DATA CODE
075	04B	DIRECT PBD AFTER STAR DATA CODE
076	04C	DIRECT PBPB AFTER STAR DATA CODE
077	04D	DIRECT LAT/LON AFTER STAR DATA CODE
078	04E	DIRECT WAYPOINT AFTER APPROACH DATA CODE
079	04F	DIRECT PBD AFTER APPROACH DATA CODE
080	050	DIRECT PBPB AFTER APPROACH DATA CODE
081	051	DIRECT LAT/LON AFTER APPROACH DATA CODE
082	052	DIRECT TO WAYPOINT DATA CODE
083	053	DIRECT TO PBD DATA CODE

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
084	054	DIRECT TO PBPB DATA CODE
085	055	DIRECT LAT/LON DATA CODE
086	056	ENROUTE WAYPOINT DATA CODE
087	057	DIRECT WAYPOINT DATA CODE
088	058	DIRECT PBD DATA CODE
089	059	DIRECT PBPB DATA CODE
090	05A	DIRECT LAT/LON DATA CODE
091	05B	RESERVED FOR DEFINITION (B-737)
092	05C	REF WAYPOINT 2 LAT/LON DATA CODE
093	05D	STAR BASE PROCEDURE DATA CODE
094	05E	STAR TRANS PROCEDURE DATA CODE
095	05F	APPROACH BASE PROCEDURE DATA CODE
096	060	APPROACH TRANSITION PROCEDURE DATA CODE
097	061	DESTINATION RUNWAY DATA CODE
098	062	HOLD ID AND ALT RESTRICTION DATA CODE
099	063	HOLD TARGET SPEED DATA CODE
100	064	HOLD TURN DIRECTION DATA CODE
101	065	HOLD INBOUND COURSE DATA CODE
102	066	HOLD EFC TIME DATA CODE
103	067	HOLD LEG TIME DATA CODE
104	068	HOLD LEG DISTANCE DATA CODE
105	069	ATO WAYPOINT INFORMATION DATA CODE
106	06A	UPLINK REQUESTING DOWNLINK DATA CODE
107	06B	WAYPOINT SPD/ALT RESTRICTION DATA CODE
108	06C	NETWORK ADDRESS DATA CODE
109	06D	COMPANY ROUTING ADDRESS DATA CODE
110	06E	MESSAGE SEQUENCE NUMBER DATA CODE
111	06F	REFERENCE CRUISE WIND ALT DATA CODE
112	070	ENROUTE WIND WAYPOINT ID DATA CODE
113	071	ENROUTE WIND DIR/MAG DATA CODE
114	072	SUPP EFFECT DATE DATA CODE
115	073	SUPP AIRPORT ID DATA CODE
116	074	SUPP AIRPORT LAT DATA CODE
117	075	SUPP AIRPORT LON DATA CODE
118	076	SUPP AIRPORT ELEVATION DATA CODE
119	077	SUPP AIRPORT MAG VAR DATA CODE
120	078	SUPP NAVAID ID DATA CODE
121	079	SUPP NAVAID LAT DATA CODE
122	07A	SUPP NAVAID LON DATA CODE
123	07B	SUPP NAVAID ELEVATION DATA CODE
124	07C	SUPP NAVAID MAG VAR DATA CODE
125	07D	SUPP NAVAID FREQUENCY DATA CODE
126	07E	SUPP NAVAID CLASS DATA CODE
127	07F	SUPP WAYPOINT ID DATA CODE

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
128	080	SUPP WAYPOINT LAT DATA CODE
129	081	SUPP WAYPOINT LON DATA CODE
130	082	SUPP WAYPOINT MAG VAR DATA CODE
131	083	SUPP REF WAYPOINT ID DATA CODE
132	084	SUPP REF WAYPOINT REF LAT/LON DATA CODE
133	085	SUPP REF WAYPOINT RADIAL DATA CODE
134	086	SUPP REF WAYPOINT DISTANCE DATA CODE
135	087	WIND VECTOR MAGNITUDE DIFFERENCE DATA CODE
136	088	WAYPOINT SEQUENCE ID DATA CODE
137	089	ETA CHANGE DATA CODE
138	08A	ETA TO DEST 1 DATA CODE
139	08B	ETA TO DEST 2 DATA CODE
140	08C	ETA TO DEST 3 DATA CODE
141	08D	ETA TO DEST 4 DATA CODE
142	08E	ETA TO DEST 5 DATA CODE
143	08F	RESERVED FOR DEFINITION (B-737)
144	090	RESERVED FOR DEFINITION (B-737)
145	091	ROUTE BUILDING PARAMETER DATA CODE
146	092	ROUTE DATA TYPE CODE
147	093	PERF INIT DATA TYPE CODE
148	094	TAKEOFF REF DATA TYPE CODE
149	095	RTA DATA TYPE CODE
150	096	ALTERNATE INFO DATA TYPE CODE
151	097	SUPP NDB DATA TYPE CODE
152	098	AUTO INSERT DATA TYPE CODE
153	099	ACTIVE WIND DATA TYPE CODE
154	09A	MOD WIND DATA TYPE CODE
155	09B	DESCENT FORECAST DATA TYPE CODE
156	O9C	PERF LIMITS DATA TYPE CODE
157	09D	SPARE DATA TYPE CODE
158	09E	LATERAL OFFSET DIST DATA CODE
159	09F	LATERAL OFFSET START WPT DATA CODE
160	0A0	LATERAL OFFSET END WPT DATA CODE
161-200	0A1-0C8	RESERVED FOR DEFINITION (B-737)
201	0C9	FUEL FLOW FACTOR DATA CODE
202	0CA	DRAG FACTOR DATA CODE
203	0CB	LIMIT TAKEOFF GROSS WEIGHT DATA CODE
204	0CC	THRUST RATING DATA CODE
205	0CD	VTR PERCENTAGE DATA CODE
206	0CE	ALTERNATE FLAPS DATA CODE
207	0CF	ALTERNATE TRIM DATA CODE
208	0D0	ALTERNATE LIMIT TAKEOFF GROSS WEIGHT DATA CODE
209	0D1	TAKEOFF SPEEDS DATA CODE
210	0D2	ALTERNATE TAKEOFF SPEEDS DATA CODE

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
211	0D3	WAYPOINT ALTITUDE/OAT DATA CODE
212	0D4	LATERAL OFFSET DATA CODE
213	0D5	ALONG TRACK OFFSET DATA CODE
214	0D6	WAYPOINT STEP CLIMB DATA CODE
215	0D7	LAT/LON REPORTING POINT DATA CODE
216	0D8	GROUND ADDRESS DATA CODE
217	0D9	DIRECT FIX DATA CODE
218	0DA	HOLD SPEED RESTRICTION DATA CODE
219	0DB	POSITION REPORTING POINT DATA CODE
220	0DC	ENROUTE WIND SEGMENT DATA CODE
221	0DD	ENROUTE SEGMENT DATA CODE
222	0DE	OPEN ENDED AIRWAY DATA CODE
223	0DF	ALTERNATE THRUST RATING DATA CODE
224	0E0	SEQUENCE NUMBER DATA CODE
225	0E1	MINIMUM FUEL TEMPERATURE DATA CODE
226	0E2	COMPANY PREFERRED AIRPORT IDENT DATA CODE
227	0E3	COMPANY PREFERRED PRIORITY DATA CODE
228	0E4	COMPANY PREFERRED WIND DATA CODE
229	0E5	COMPANY PREFERRED ALT/OAT DATA CODE
230	0E6	COMPANY PREFERRED OVERHEAD FIX DATA CODE
231	0E7	COMPANY PREFERRED ALTITUDE DATA CODE
232	0E8	COMPANY PREFERRED SPEED DATA CODE
233	0E9	COMPANY PREFERRED OFFSET DATA CODE
234	0EA	FLIGHT LIST AIRPORT IDENT DATA CODE
235	0EB	FLIGHT LIST WIND DATA CODE
236	0EC	FLIGHT LIST ALT/OAT DATA CODE
237	0ED	ALTERNATE INHIBIT AIRPORT IDENT DATA CODE
238	OEE	ALTERNATE TAKEOFF VTR PERCENTAGE DATA CODE
239	0EF	THRUST REDUCTION ALTITUDE DATA CODE
240	0F0	ACCELERATION ALTITUDE DATA CODE
241	0F1	ENGINE-OUT ACCELERATION ALTITUDE DATA CODE
242	0F2	PAGING DATA CODE
243	0F3	INTERCEPT COURSE FROM IDENT DATA CODE
244	0F4	INTERCEPT COURSE FROM COURSE DATA CODE
245	0F5	CRUISE SPEED SEGMENT START WAYPOINT DATA CODE
246	0F6	CRUISE SPEED SEGMENT END WAYPOINT DATA CODE
247	0F7	CRUISE SPEED SEGMENT SPEED DATA CODE
248	0F8	CRUISE SPEED SEGMENT ALTITUDE DATA CODE
249-300	0F9-12C	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
301	12D	PERF FACTOR DATA CODE
302	12E	TAXI FUEL DATA CODE
303	12F	ZERO FUEL WEIGHT CG DATA CODE
304	130	TROPOPAUSE ALTITUDE DATA CODE
305	131	IDLE FACTOR DATA CODE

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
306	132	MEAN WIND DATA CODE
307	133	CLIMB WIND ALTITUDE DATA CODE
308	134	CLIMB WIND DIR/MAG DATA CODE
309	135	ALTERNATE DESTINATION WIND ALTITUDE DATA CODE
310	136	ALTERNATE DESTINATION WIND DIR/MAG DATA CODE
311	137	STAR/ENROUTE TRANSITION DATA CODE
312	138	THRUST REDUCTION ALTITUDE DATA CODE
313	139	ACCELERATION ALTITUDE DATA CODE
314	13A	ENGINE-OUT ACCELERATION ALTITUDE DATA CODE
315	13B	ALTERNATE ASSUMED TEMP DATA CODE
316-400	13C-190	RESERVED FOR DEFINITION (AIRBUS AIRCRAFT)
401	191	NOISE ABATEMENT END ALTITUDE DATA CODE
402	192	NOISE ABATEMENT SPEED DATA CODE
403	193	NOISE ABATEMENT DERATED THRUST DATA CODE
404	194	HOLD ALTITUDE DATA CODE
405	195	NOISE ABATEMENT THRUST DATA CODE
406	196	NOISE ABATEMENT START ALTITUDE DATA CODE
407	197	SUPP REF AIRPORT DATA CODE
408	198	SUPP RUNWAY DATA CODE
409	199	SUPP RUNWAY LAT DATA CODE
410	19A	SUPP RUNWAY LON DATA CODE
411	19B	SUPP RUNWAY COURSE DATA CODE
412	19C	SUPP RUNWAY ELEVATION DATA CODE
413	19D	SUPP RUNWAY LENGTH DATA CODE
414	19E	CLIMB TEMPERATURE ALTITUDE DATA CODE
415	19F	CLIMB TEMPERATURE DATA CODE
416	1A0	DESCENT TEMPERATURE ALTITUDE DATA CODE
417	1A1	DESCENT TEMPERATURE DATA CODE

10.3 Extended Error Codes

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Extended error codes are listed as decimal and hexadecimal values. Depending on implementation, this code may be downlinked as either a decimal or hexadecimal value.

DEC CODE	HEX CODE	DESCRIPTION
001	001	ALL OF MESSAGE TEXT DISCARDED
002	002	REMAINDER OF MESSAGE TEXT DISCARDED
003	003	ALL OF DATA TYPE DISCARDED
004	004	REMAINDER OF DATA TYPE DISCARDED
005	005	ALL OF ELEMENT TEXT DISCARDED
006	006	REMAINDER OF ELEMENT TEXT DISCARDED
007	007	ALL OF LIST DISCARDED
008	008	REMAINDER OF LIST DISCARDED
009	009	ALL OF LIST ELEMENT DISCARDED
010	00A	ALL OF MULTI-PARAMETER ELEMENT DISCARDED
011	00B	ALL OF ROUTE BUILDING PARAMETER DISCARDED
012	00C	ALL APPROACH PROCEDURE RELATED DATA DISCARDED
013	00D	ALL DEPARTURE AIRPORT RELATED DATA DISCARDED
014	00E	ALL ARRIVAL AIRPORT RELATED DATA DISCARDED
015	00F	ALL SID RELATED DATA DISCARDED
016	010	ALL STAR RELATED DATA DISCARDED
017	011	NEXT AIRWAY DISCARDED
018	012	SINGLE ELEMENT DISCARDED
019-100	013-064	RESERVED FOR DEFINITION (B-737)
101	065	ALL OF LIST ENTRY DISCARDED
102	066	ALL OF ENROUTE SEGMENT DISCARDED
103	067	ALTERNATE RUNWAY DATA DISCARDED
104	068	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
105	069	ALL OF ELEMENT TEXT DISCARDED
106-200	06A-0C8	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
201-300	0C9-12C	RESERVED FOR DEFINITION (AIRBUS AIRCRAFT

10.4 Triggers, Stimulus Code, and Report Stimulus Codes

Triggers, stimulus codes and report stimulus codes are listed as decimal and hexadecimal values. Depending on implementation, this code may be downlinked as either a decimal or hexadecimal value.

DEC CODE	HEX CODE	DESCRIPTION
001	001	4R INIT REF
002	002	4L SUPP NAV DATA INDEX
003	003	4R SUPP NAV DATA INDEX
004	004	5R PERF INIT
005	005	5L PERF LIMITS
006	006	5R PERF LIMITS
007	007	4L TAKEOFF REF 1/2
008	008	6R MOD LEGS EXTENDED DATA
009	009	6L ALTERNATE DEST
010	00A	1L DATA LINK
011	00B	2L DATA LINK
012	00C	3L DATA LINK
013	00D	4L DATA LINK
014	00E	5L DATA LINK
015	00F	1R DATA LINK
016	010	2R DATA LINK
017	011	3R DATA LINK
018	012	4R DATA LINK
019	013	5R DATA LINK
020	014	6R DATA LINK
021	015	1R MAINT BITE INDEX
022	016	2R MAINT BITE INDEX
023	017	3R MAINT BITE INDEX
024	018	4R MAINT BITE INDEX
025	019	5R MAINT BITE INDEX
026	01A	6R MAINT BITE INDEX
027	01B	6R FMCS BITE INDEX
028	01C	6R FMCS SENSOR STATUS 2/2
029	01D	6R FMCS ANALOG DISCRETES
030	01E	6R IRS MONITOR
031	01F	6R FMCS INFLIGHT FAULTS 3/3
032	020	6R FMCS FLIGHT SELECT
033	021	6R FMCS FLIGHT ‘N’
034	022	3R ROUTE
035	023	6R ACT LEGS EXTENDED DATA
036	024	5L PROGRESS 3/3
037	025	5R PROGRESS 3/3
038	026	6L PROGRESS 3/3
039	027	6R PROGRESS 3/3

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
040	028	DES FORECAST
041	029	TIME TO DESTINATION 1
042	02A	TIME TO DESTINATION 2
043	02B	TIME TO DESTINATION 3
044	02C	TIME TO DESTINATION 4
045	02D	TIME TO DESTINATION 5
046	02E	CHANGE IN DESTINATION ETA
047	02F	CHANGE IN DESTINATION AIRPORT
048	030	CHANGE IN ARRIVAL RUNWAY
049	031	EFC ENTRY
050	032	WIND DISCREPANCY
051	033	WAYPOINT SEQUENCE
052	034	POS SHIFT TO IRS LEFT
053	035	POS SHIFT TO IRS RIGHT
054	036	POS SHIFT TO IRS CENTER
055	037	POS SHIFT TO RADIO
056	038	POS SHIFT TO GPS LEFT
057	039	POS SHIFT TO GNSS RIGHT
058	03A	VERIFY POSITION MESSAGE
059	03B	INSUFFICIENT FUEL MESSAGE
060	03C	MOD PLAN EXECUTION
061	03D	CRUISE ALTITUDE CHANGE
062	03E	RTA UNACHIEVABLE MESSAGE
063	03F	HOLDING PATTERN EXIT
064	040	HOLDING PATTERN ENTRY
065	041	FMC FAULT
066	042	SENSOR FAILURE
067	043	BAD NAVAID
068	044	INAIR
069	045	COMPANY UPLINK TEXT ERROR
070	046	ATC UPLINK TEXT ERROR
071	047	COMPANY UPLINK ACKNOWLEDGE
072	048	ATC UPLINK ACKNOWLEDGE
073	049	COMPANY ROUTE DATA ACCEPTED
074	04A	ATC ROUTE DATA ACCEPTED
075	04B	COMPANY ROUTE DATA ACCEPTED WITH EDIT
076	04C	ATC ROUTE DATA ACCEPTED WITH EDIT
077	04D	COMPANY ROUTE DATA REJECTED
078	04E	ATC ROUTE DATA REJECTED
079	04F	COMPANY RTA DATA ACCEPTED
080	050	ATC RTA DATA ACCEPTED
081	051	COMPANY RTA DATA ACCEPTED WITH EDIT
082	052	ATC RTA DATA ACCEPTED WITH EDIT
083	053	COMPANY RTA DATA REJECTED

ATTACHMENT 7
FMC/DATALINK INTERFACE

DEC CODE	HEX CODE	DESCRIPTION
084	054	ATC RTA DATA REJECTED
085	055	COMPANY WIND TEMP DATA ACCEPTED
086	056	ATC WIND DATA ACCEPTED
087	057	COMPANY WIND TEMP DATA ACCEPTED WITH EDIT
088	058	ATC WIND DATA ACCEPTED WITH EDIT
089	059	COMPANY WIND TEMP DATA REJECTED
090	05A	ATC WIND DATA REJECTED
091	05B	COMPANY DESCENT FORECAST DATA ACCEPTED
092	05C	ATC DESCENT FORECAST DATA ACCEPTED
093	05D	COMPANY DESCENT FORECAST DATA ACCEPTED WITH EDIT
094	05E	ATC DESCENT FORECAST DATA ACCEPTED WITH EDIT
095	05F	COMPANY DESCENT FORECAST DATA REJECTED
096	060	ATC DESCENT FORECAST DATA REJECTED
097	061	COMPANY PERF INIT DATA ACCEPTED
098	062	ATC PERF INIT DATA ACCEPTED
099	063	COMPANY PERF INIT DATA ACCEPTED WITH EDIT
100	064	ATC PERF INIT DATA ACCEPTED WITH EDIT
101	065	COMPANY PERF INIT DATA REJECTED
102	066	ATC PERF INIT DATA REJECTED
103	067	COMPANY PERF LIMIT DATA ACCEPTED
104	068	ATC PERF LIMIT DATA ACCEPTED
105	069	COMPANY PERF LIMIT DATA ACCEPTED WITH EDIT
106	06A	ATC PERF LIMIT DATA ACCEPTED WITH EDIT
107	06B	COMPANY PERF LIMIT DATA REJECTED
108	06C	ATC PERF LIMIT DATA REJECTED
109	06D	RESERVED FOR DEFINITION (B-737)
110	06E	RESERVED FOR DEFINITION (B-737)
111	06F	RESERVED FOR DEFINITION (B-737)
112	070	RESERVED FOR DEFINITION (B-737)
113	071	RESERVED FOR DEFINITION (B-737)
114	072	RESERVED FOR DEFINITION (B-737)
115	073	UPLINK REQUESTING A DOWNLINK
116	074	TIME TO TOP OF DESCENT 1
117	075	TIME TO TOP OF DESCENT 2
118	076	TIME TO TOP OF DESCENT 3
119	077	TIME TO TOP OF DESCENT 4
120	078	TIME TO TOP OF DESCENT 5
121-200	079-0C8	RESERVED FOR DEFINITION (B-737)
201-300	0C9-12C	RESERVED FOR DEFINITION (BOEING AIRCRAFT)
301	12D	MULTI-LEVEL WIND TEMP DATA ACCEPTED
302	12E	MULTI-LEVEL WIND TEMP DATA REJECTED
303-400	12F-190	RESERVED FOR DEFINITION (AIRBUS AIRCRAFT)

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ATTACHMENT 8 CODING EXAMPLES OF TRAJECTORY INTENT DATA FILES

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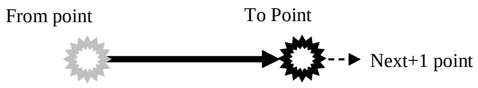
EXAMPLE 1

Line to Point (Straight), No Vertical Change

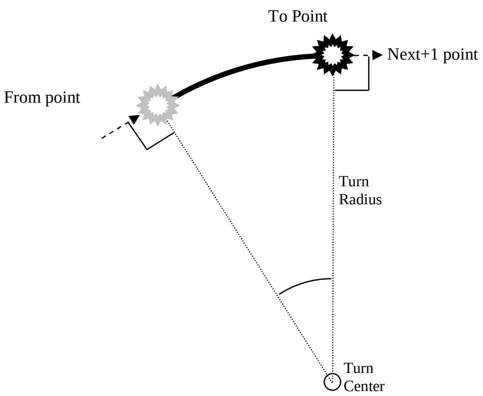


Word Type Bits 31-30	Bit 29	Parameter Bits 28-9				Label Bits 8-1
Full Word 01	Pad 29-22 00000000	Data Type 21-16 000010	Geometry 15-13 001	Version 12-9 0001		Active Intent 10011010
Full Word 00	Characteristics bits 29-9 000000000000000000000					Active Intent 10011010
Full Word 00	Point Latitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point Longitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point Altitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point ETA					Active Intent 10011010
	Valid x	Hours xxxxx	Minutes xxxxxx	Seconds xxxxxx	UTC/Pad x00	
Full Word 00	Valid x	Path RNP xxxx xxxx xxxx xxxx 0000				Active Intent 10011010
Full Word 00	Valid x	Point CAS xxxx xxxx xxx0 0000 0000				Active Intent 10011010
Full Word 00	Valid x	Point Wind Speed xxxx xxxx 0000 0000 0000				Active Intent 10011010
Full Word 00	Point True Wind Direction x xxxx xxxx 0000 0000 0000					Active Intent 10011010

ATTACHMENT 8
CODING EXAMPLES OF TRAJECTORY INTENT DATA FILES

EXAMPLE 2

Arc to Point (Curve), No Vertical Change

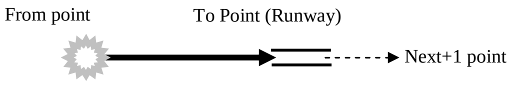


Word Type Bits 31-30	Bit 29	Parameter Bits 28-9	Label Bits 8-1
Full Word 01	Pad 29-22 00000000	Data Type 21-16 000010 | Geometry 15-13 010 | Version 12-9 0001	Active Intent 10011010
Full Word 00	Characteristics bits 29-9 000000000000000000000		Active Intent 10011010
Full Word 00	Point Latitude x xxxxxxxxxxxxxxxxxx 00		Active Intent 10011010
Full Word 00	Point Longitude x xxxxxxxxxxxxxxxxxx 00		Active Intent 10011010
Full Word 00	Point Altitude x xxxxxxxxxxxxxxxxxx 00		Active Intent 10011010
Full Word 00	Point ETA Valid x	Hours xxxxx | Minutes xxxxxx | Seconds xxxxxx | UTC/Pad x00	Active Intent 10011010
Full Word 00	Valid x	Path RNP xxxx xxxx xxxx xxxx 0000	Active Intent 10011010
Full Word 00	Valid x	Point CAS xxxx xxxx xxx0 0000 0000	Active Intent 10011010
Full Word 00	Valid x	Point Wind Speed xxxx xxxx 0000 0000 0000	Active Intent 10011010
Full Word 00	Point True Wind Direction x xxxx xxxx 0000 0000 0000		Active Intent 10011010
Full Word 00	Turn Radius x xxxxxxxxxxxxxxx 0000		Active Intent 10011010
Full Word 00	Turn Center Latitude x xxxxxxxxxxxxxxxxxx 00		Active Intent 10011010
Full Word 00	Turn Center Longitude x xxxxxxxxxxxxxxxxxx 00		Active Intent 10011010

ATTACHMENT 8
CODING EXAMPLES OF TRAJECTORY INTENT DATA FILES

<u>EXAMPLE 3</u>

Line to Runway



<table>
<tr><th>Word Type Bits 31-30</th><th>Bit 29</th><th colspan="4">Parameter Bits 28-9</th><th>Label Bits 8-1</th></tr>
<tr><td>Full Word 01</td><td>Pad 29-22 00000000</td><td>Data Type 21-16 000010</td><td>Geometry 15-13 001</td><td colspan="2">Version 12-9 0001</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td colspan="5">Characteristics bits 29-9 000000000000001000000</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td colspan="5">Point Latitude x xxxxxxxxxxxxxxxxxx 00</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td colspan="5">Point Longitude x xxxxxxxxxxxxxxxxxx 00</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td colspan="5">Point Altitude x xxxxxxxxxxxxxxxxxx 00</td><td>Active Intent 10011010</td></tr>
<tr><td rowspan="2">Full Word 00</td><td colspan="5">Point ETA</td><td rowspan="2">Active Intent 10011010</td></tr>
<tr><td>Valid x</td><td>Hours xxxxx</td><td>Minutes xxxxxx</td><td>Seconds xxxxxx</td><td>UTC/Pad x00</td></tr>
<tr><td>Full Word 00</td><td>Valid x</td><td colspan="4">Path RNP xxxx xxxx xxxx xxxx 0000</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td>Valid x</td><td colspan="4">Point CAS xxxx xxxx xxx0 0000 0000</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td>Valid x</td><td colspan="4">Point Wind Speed xxxx xxxx 0000 0000 0000</td><td>Active Intent 10011010</td></tr>
<tr><td>Full Word 00</td><td colspan="5">Point True Wind Direction x xxxx xxxx 0000 0000 0000</td><td>Active Intent 10011010</td></tr>
</table>

ATTACHMENT 8
CODING EXAMPLES OF TRAJECTORY INTENT DATA FILES

EXAMPLE 4

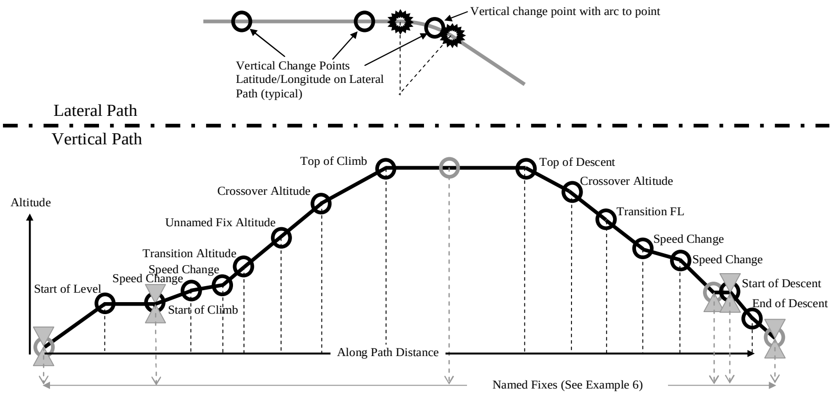
Lateral Discontinuity to Point

<table>
<tr><th>Word Type
Bits 31-30</th><th>Bit 29</th><th colspan="5">Parameter Bits 28-9</th><th>Label Bits 8-1</th></tr>
<tr><td>Full Word
01</td><td>Pad 29-22
00000000</td><td colspan="2">Data Type 21-16
000010</td><td colspan="2">Geometry 15-13
001</td><td>Version 12-9
0001</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td colspan="6">Characteristics bits 29-9
000000000000010000000</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td colspan="6">Point Latitude
x xxxxxxxxxxxxxxxxx 00</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td colspan="6">Point Longitude
x xxxxxxxxxxxxxxxxx 00</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td colspan="6">Point Altitude
x xxxxxxxxxxxxxxxxx 00</td><td>Active Intent
10011010</td></tr>
<tr><td rowspan="2">Full Word
00</td><td colspan="6">Point ETA</td><td rowspan="2">Active Intent
10011010</td></tr>
<tr><td>Valid
x</td><td>Hours
xxxxx</td><td>Minutes
xxxxxx</td><td colspan="2">Seconds
xxxxxx</td><td>UTC/Pad
x00</td></tr>
<tr><td>Full Word
00</td><td>Valid
x</td><td colspan="5">Path RNP
xxxx xxxx xxxx xxxx 0000</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td>Valid
x</td><td colspan="5">Point CAS
xxxx xxxx xxx0 0000 0000</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td>Valid
x</td><td colspan="5">Point Wind Speed
xxxx xxxx 0000 0000 0000</td><td>Active Intent
10011010</td></tr>
<tr><td>Full Word
00</td><td colspan="6">Point True Wind Direction
x xxxx xxxx 0000 0000 0000</td><td>Active Intent
10011010</td></tr>
</table>

ATTACHMENT 8
CODING EXAMPLES OF TRAJECTORY INTENT DATA FILES

EXAMPLE 5

Various Vertical Change Points



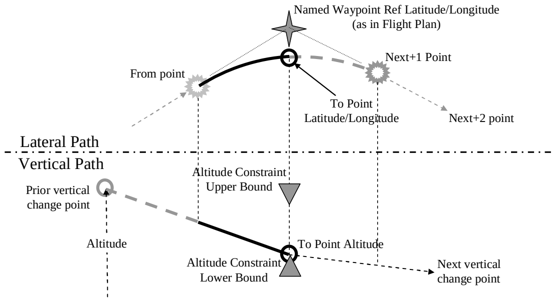
Word Type Bits 31-30	Bit 29	Parameter Bits 28-9					Label Bits 8-1
Full Word 01	Pad 29-22 00000000	Data Type 21-16 000010		Geometry 15-13 001 if line to point 010 if arc to point		Version 12-9 0001	Active Intent 10011010
Full Word 00	Characteristics bits 29-9 xxxxxxxx0000000x00000						Active Intent 10011010
Full Word 00	Point Latitude x xxxxxxxxxxxxxxxxxx 00						Active Intent 10011010
Full Word 00	Point Longitude x xxxxxxxxxxxxxxxxxx 00						Active Intent 10011010
Full Word 00	Point Altitude x xxxxxxxxxxxxxxxxxx 00						Active Intent 10011010
Full Word 00	Point ETA: Valid x	Hours xxxxx	Minutes xxxxxx	Seconds xxxxxx	UTC/Pad x00		Active Intent 10011010
Full Word 00	Valid x	Path RNP xxxx xxxx xxxx xxxx 0000					Active Intent 10011010
Full Word 00	Valid x	Point CAS xxxx xxxx xxx0 0000 0000					Active Intent 10011010
Full Word 00	Valid x	Point Wind Speed xxxx xxxx 0000 0000 0000					Active Intent 10011010
Full Word 00	Point True Wind Direction x xxxx xxxx 0000 0000 0000						Active Intent 10011010
Full Word* 00	Turn Radius x xxxxxxxxxxxxxxx 0000						Active Intent 10011010
Full Word* 00	Turn Center Latitude x xxxxxxxxxxxxxxxxxx 00						Active Intent 10011010
Full Word* 00	Turn Center Longitude x xxxxxxxxxxxxxxxxxx 00						Active Intent 10011010

*Included if arc to point

ATTACHMENT 8
CODING EXAMPLES OF TRAJECTORY INTENT DATA FILES

EXAMPLE 6

Arc to Named Fix (Fly-by Waypoint with Turn and Altitude Constraint)

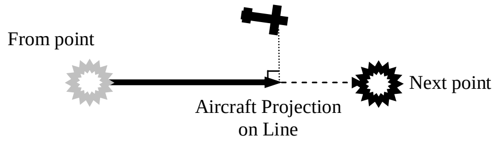


Word Type Bits 31-30	Bit 29	Parameter Bits 28-9				Label Bits 8-1
Full Word 01	Pad 29-22 00000000		Data Type 21-16 001000	Geometry 15-13 010	Version 12-9 0001	Active Intent 10011010
Full Word 00	Characteristics bits 29-9 000000000100000000000					Active Intent 10011010
Full Word 00	Point Latitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point Longitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point Altitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point ETA Valid x	Hours xxxxx	Minutes xxxxxx	Seconds xxxxxx	UTC/Pad x00	Active Intent 10011010
Full Word 00	Valid x	Path RNP xxxx xxxx xxxx xxxx 0000				Active Intent 10011010
Full Word 00	Valid x	Point CAS xxxx xxxx xxx0 0000 0000				Active Intent 10011010
Full Word 00	Valid x	Point Wind Speed xxxx xxxx 0000 0000 0000				Active Intent 10011010
Full Word 00	Point True Wind Direction x xxxx xxxx 0000 0000 0000					Active Intent 10011010
Full Word 00	Point Name xxxxxxx xxxxxxx xxxxxxx					Active Intent 10011010
Full Word 00	Point Name xxxxxxx xxxxxxx xxxxxxx					Active Intent 10011010
Full Word 00	Point Name 0000000 0000000 xxxxxxx					Active Intent 10011010
Full Word 00	Named Point Ref Latitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Named Point Ref Longitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Altitude Constraint Lower Bound x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Altitude Constraint Upper Bound x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Turn Radius x xxxxxxxxxxxxxxx 0000					Active Intent 10011010

Full Word 00	Turn Center Latitude x xxxxxxxxxxxxxxxxxx 00	Active Intent 10011010
Full Word 00	Turn Center Longitude x xxxxxxxxxxxxxxxxxx 00	Active Intent 10011010

EXAMPLE 7

Line to Aircraft Projection, No Vertical Change



Word Type Bits 31-30	Bit 29	Parameter Bits 28-9				Label Bits 8-1
Full Word 01	Pad 29-22 00000000	Data Type 21-16 000010		Geometry 15-13 001	Version 12-9 0001	Active Intent 10011010
Full Word 00	Characteristics bits 29-9 000000000001000000000					Active Intent 10011010
Full Word 00	Point Latitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point Longitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point Altitude x xxxxxxxxxxxxxxxxxx 00					Active Intent 10011010
Full Word 00	Point ETA					Active Intent 10011010
	Valid x	Hours xxxxx	Minutes xxxxxx	Seconds xxxxxx	UTC/Pad x00	
Full Word 00	Valid x	Path RNP xxxx xxxx xxxx xxxx 0000				Active Intent 10011010
Full Word 00	Valid x	Point CAS xxxx xxxx xxx0 0000 0000				Active Intent 10011010
Full Word 00	Valid x	Point Wind Speed xxxx xxxx 0000 0000 0000				Active Intent 10011010
Full Word 00	Point True Wind Direction x xxxx xxxx 0000 0000 0000					Active Intent 10011010

APPENDIX A REFERENCE DOCUMENTS

The latest versions of the following documents apply:

1. **ARINC Specification 413A**: *Guidance for Aircraft Electrical Power Utilization and Transient Protection*

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~~1.~~2. **ARINC Specification 424:** *Navigation System Data Base*
~~2.~~3. **ARINC Specification 429:** *Digital Information Transfer System (DITS)*
~~3.~~4. **ARINC Specification 600**: *Air Transport Avionics Equipment Interfaces*
~~4.~~5. **ARINC Report 604:** *Guidance for Design and Use of Built-In Test Equipment (BITE)*
6. **ARINC Report 607:** *Design Guidance for Avionic Equipment*
~~5.~~7. **ARINC Report 608A:** *Design Guidance for Avionics Test Equipment*
~~6.~~8. **ARINC Report 610B:** *Guidance for Use of Avionics Equipment and Software in Simulators*
~~7.~~9. **ARINC Specification 615:** *Airborne Computer High Speed Data Loader*
~~8.~~10. **ARINC Specification 615A:** *Software Data Loader with High Density Storage Medium*
~~9.~~11. **ARINC Specification 618:** *Air-Ground Character-Oriented Protocol Specification*
~~10.~~ **ARINC Specification 622:** *ATS Data Link Applications Over ACARS Air-Ground Network*
12. ~~**ARINC Specification 623:** *Character-Oriented Air Traffic Services (ATS) Applications*~~
13. **ARINC Report 624:** *Design Guidance for Onboard Maintenance System*
14. **ARINC Report 625:** *Industry Guide for Component Test Development and Management*
15. **ARINC Report 626:** *Standard ATLAS Language for Modular Test*
~~11.~~
~~12.~~16. **ARINC Specification 646:** *Ethernet Local Area Network (ELAN)*
~~13.~~17. **ARINC Report 651:** *Design Guidance for Integrated Modular Avionics*
~~14.~~18. **ARINC Specification 653:** *Avionics Application Software Standard Interface*
~~15.~~19. **ARINC Report 660B:** *CNS/ATM Avionics Architectures Supporting NextGen/SESAR Concepts*
~~16.~~20. **ARINC Specification 661:** *Cockpit Display System Interfaces to User Systems*
21. **ARINC Specification 664:** *Aircraft Data Network*
~~17.~~22. **ARINC Characteristic 701:** *Flight Control Computer System*
~~18.~~23. **ARINC Characteristic 704**: *Inertial Reference System*
~~19.~~24. **ARINC Characteristic 705:** *Attitude and Heading Reference System*
~~20.~~25. **ARINC Characteristic 706:** *Subsonic Air Data System*
~~21.~~26. **ARINC Characteristic 708A:** *Airborne Weather Radar with Forward Looking Windshear Detection Capability*
~~22.~~27. **ARINC Characteristic 709:** *Airborne Distance Measuring Equipment*
28. **ARINC Characteristic 710:** *Mark 2 Airborne ILS Receiver*
~~23.~~29. **ARINC Characteristic 711:** *Mark 2 Airborne VOR ILS Receiver*
~~24.~~30. **ARINC Characteristic 724B:** *Aircraft Communication Addressing and Reporting System (ACARS)*
~~25.~~31. **ARINC Characteristic 725:** *Electronic Flight Instruments (EFI)*
~~26.~~32. **ARINC Characteristic 737:** *On-Board Weight and Balance System*
~~27.~~33. **ARINC Characteristic 738:** *Air Data and Inertial Reference System (ADIRS)*

APPENDIX A
REFERENCE DOCUMENTS

~~28.~~34. **ARINC Characteristic 739A:** *Multi-Purpose Control and Display Unit*
~~29.~~35. **ARINC Characteristic 740:** *Multiple-Input Cockpit Printer*
~~30.~~36. **ARINC Characteristic 743A:** *GNSS Sensor*
~~31.~~37. **ARINC Characteristic 743B:** *GNSS Landing System Sensor Unit (GLSSU)*
~~32.~~38. **ARINC Characteristic 744:** *Full-Format Printer*
~~33.~~39. **ARINC Characteristic 744A:** *Full-Format Printer with Graphics Capability*
~~34.~~40. **ARINC Characteristic 745:** *Automatic Dependent Surveillance*
~~35.~~41. **ARINC Characteristic 755:** *Multi-Mode Landing System – Digital*
~~36.~~42. **ARINC Characteristic 756:** *GNSS Navigation and Landing Unit (GNLU)*
~~37.~~43. **ARINC Characteristic 758:** *Communications Management Unit (CMU) Mark 2*
~~38.~~44. **ARINC Characteristic 760:** *GNSS Navigation Unit (GNU)*
45. **EUROCONTROL SPEC-0116:** *EUROCONTROL Specification on Data Link Services (DLS)*
46. **ICAO Doc 4444:** *Procedures for Air Navigation Services - Air Traffic Management*
47. **ICAO Doc 9613:** *Performance-Based Navigation Manual*
~~39.~~48. **RTCA DO-160/EUROCAE ED-14:** *Environmental Conditions and Test Procedures for Airborne Equipment*
49. **RTCA DO-178/EUROCAE ED-12:** *Software Considerations in Airborne Systems and Equipment Certification*
50. **RTCA DO-200/EUROCAE ED-76:** *Standards for Processing Aeronautical Data*
~~40.~~51. **RTCA DO-201/EUROCAE ED-77:** *Standards for Aeronautical Information*
~~41. **RTCA DO-212:** *Minimum Operational Performance Standards for Airborne Automatic Dependent Surveillance (ADS) Equipment*~~
52. **RTCA DO-219:** *Minimum Operational Performance Standards for ATC Two-Way Data Link Communications*
53. **RTCA DO-229:** *Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment*
~~42.~~54. **RTCA DO-236/EUROCAE ED-75:** *Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation*
~~43.~~55. **RTCA DO-258/EUROCAE ED-100:** *Interoperability Requirements for ATS Applications Using ARINC 622 Data Communications*
56. **RTCA DO-264/EUROCAE ED-78:** *Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications*
57. **RTCA DO-280/EUROCAE ED-110:** *Interoperability Requirements Standard for Aeronautical Telecommunication Network Baseline 1*
~~44.~~58. **RTCA DO-283:** *Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation*
59. **RTCA DO-290/EUROCAE ED-120:** *Safety and Performance Requirements Standard for Air Traffic Data Link Services in Continental Airspace*
~~45.~~60. **RTCA DO-305/EUROCAE ED-154:** *Future Air Navigation Systems 1/A – Aeronautical Telecommunication Network Interoperability Standard (FANS 1/A ATN B1 Interop Standard)*
~~46.~~61. **RTCA DO-306/EUROCAE ED-122:** *Safety and Performance Standard for Air Traffic Data Link Services in Oceanic and Remote Airspace (Oceanic SPR Standard)*

APPENDIX A
REFERENCE DOCUMENTS

~~47.~~62. **RTCA DO-308:** *Operational Services and Environment Definition (OSED) for Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services*

~~48.~~63. **RTCA DO-324:** *Safety and Performance Requirements (SPR) for Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services*

~~49. **RTCA DO-328/EUROCAE ED-195:** *Safety, Performance and Interoperability Requirements Document for Airborne Spacing – Flight Deck Interval Management (ASPA-FIM)*~~

~~50. **RTCA DO-340:** *Concept of Use for Aeronautical Information Services (AIS) and Meteorological (MET) Data Link Services*~~

64. **RTCA DO-350/EUROCAE ED-229:** *Safety and Performance Standard for Baseline 2 ATS Data Communications*

65. **RTCA DO-353/EUROCAE ED-231:** *Interoperability Requirements Standard for Baseline 2 ATS Data Communications*

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APPENDIX B ACRONYMS

~~AAC~~	~~Aeronautical Administrative Control~~
~~AAC~~	~~Airline Administrative Communication~~
ACARS	Aircraft Communications Addressing and Reporting System
ACK	Acknowledgement
ADC	Air Data Computer
ADIRS	Air Data/Inertial Reference System
ADIRU	Air Data/Inertial Reference Unit
ADS	Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance – Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AEEC	Airlines Electronic Engineering Committee
AF	Arc to a Fix
AFM	Airplane Flight Manual
AFN	ATS Facilities Notification
AFCS	Auto Flight Control System
AHRS	Altitude Heading Reference System
AMI	Airline Modifiable Information
ANP	Actual Navigation Performance
AOC	Airline Operational Communication
APM	Airplane Personality Module
~~APC~~	~~Airline Passenger Communication~~
ASAS	Aircraft Separation Assurance System
ATC	Air Traffic Control
~~ATIS~~	~~Automatic Terminal Information Service~~
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Services
ATO	Along Track Offset
ATS	Air Traffic Services
BITE	Built-In Test Equipment
BP	Bottom Plug
CAS	Computed Air Speed
~~CDTI~~	~~Cockpit Display of Traffic Information~~
CDA	Continuous Descent Approach
CDO	Continuous Descent Operation
CDU	Control Display Unit
CF	Course to a Fix
CMU	Communications Management Unit
CNS	Communications, Navigation and Surveillance

APPENDIX B
ACRONYMS

CPDLC	Controller/Pilot Data Link Communication
CRC	Cyclic Redundancy Check
CTS	Clear to Send
DA	Decision Altitude
~~DG~~	~~Directional Gyro~~
~~DGNSS~~	~~Differential Global Navigation Satellite System~~
DITS	Digital Information Transfer System
DLIC	Data Link Initiation of Communications
DME	Distance Measurement Equipment
EFIS	Electronic Flight Information System
EIS	Electronic Information System
ELAN	Ethernet Local Area Network
EPU	Estimated Position Uncertainty
ETA	Estimated Time of Arrival
ETE	~~End-to-End~~Estimated Time Enroute
ETOPS	Extended-range Twin-engine Operations
EUROCAE	European Organization for Civil Aviation Electronics
FAF	Final Approach Fix
FANS	Future Air Navigation System
FAS	Final Approach Segment
FASDM	Final Approach Segment Data Message
FCOM	Flight Crew Operations Manual
FEP	Final End Point
FIR	Flight Information Region
~~FIS~~	~~Flight Information Services~~
FLS	FMS-based Landing System
FMC	Flight Management Computer
FMCS	Flight Management Computer System
FMF	Flight Management Function
FMS	Flight Management System
FRT	Fixed Radius Transition
GBAS	Ground Based Augmentation System
~~GFI~~	~~General Format Identifier~~
~~GIU~~	~~Gatelink Interface Unit~~
GLS	GNSS-based Landing System
GLSSU	GPS/SBAS Landing System Sensor Unit
~~GLU~~	~~GNSS-based Landing Unit~~
GNLU	GNSS-based Navigation and Landing Unit
GNSS	Global Navigation Satellite System
GNSSU	Global Navigation Satellite System Unit
GPS	Global Positioning System

APPENDIX B
ACRONYMS

HSI	Horizontal Situation Indicator
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
IF	Initial Fix
IFR	Instrument Flight Rules
IGS	Instrument Guidance System
ILS	Instrument Landing System
~~IMC~~	~~Instrument Meteorological Conditions~~
IMI	Imbedded Message Identifier
IPC	Illustrated Parts Catalog
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmosphere
~~LAAS~~	~~Local Area Augmentation System~~
LDA	Localizer Directional Aid
LDU	Link Data Unit
LNAV	Lateral Navigation
LOC	Localizer
~~LOS~~	~~Line of Sight~~
LP	Localizer Performance
LPV	Localizer Performance with Vertical Guidance
LRC	Long Range Cruise
LRU	Line Replaceable Unit
LSB	Least Significant Bit
LTP	Landing Threshold Point
MAHP	Missed Approach Holding Point
MAP	Missed Approach Decision Point
MASPS	Minimum Airborne System Performance Standards
MCDU	Multi-Purpose Control Display Unit
MCU	Modular Concept Unit
MDA	Minimum Decision Altitude
MDH	Minimum Decision Height
MEA	Minimum Enroute IFR Altitude
MLS	Microwave Landing System
MMO	Maximum Operating Mach
MMR	Multi-Mode ~~Landing System~~ Receiver
MOCA	Minimum Obstruction Clearance Altitude
MOPS	Minimum Operational Performance Standards
MORA	Minimum Off-Route Altitude
MP	Middle Plug
MSB	Most Significant Bit

APPENDIX B
ACRONYMS

MTBF	Mean Time Between Failure
MTBUR	Mean Time Between Unit Removal
MU	Management Unit
NAK	Negative Acknowledgement
ND	Navigational Display
NDB	Non-Directional Beacon or Navigation Data Base
NFF	No Fault Found
~~NOTAM~~	~~Notice to Airmen~~
~~NUC~~	~~Navigation Uncertainty Category~~
~~OCM~~	~~Oceanic Clearance Message~~
PBD	Point Bearing/Distance
PBN	Performance-Based Navigation
PDC	Predeparture Clearance
PDMV	Procedure Design Magnetic Variation
PFD	Primary Flight Display
PVT	Position Velocity and Time
QFE*	Local station barometric pressure setting which provides an altimeter reading of indicated altitude of the airplane above the station
QNH*	Local station barometric pressure setting which provides an altimeter reading of indicated altitude of the airplane above mean sea level
RAIM	Receiver Autonomous Integrity Monitoring
~~RCP~~	~~Required Communications Performance~~
RF	Constant Radius Arc to a Fix
~~RMP~~	~~Required Monitoring Performance~~
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RTS	Request to Send
RVSM	Reduced Vertical Separation Minima
SARPS	Standards and Recommended Practices
~~SATCOM~~	~~Satellite Communication~~
SBAS	Satellite Based Augmentation System
~~SCAT~~	~~Special Category~~
SDI	Source Destination Identifier
~~SICASP~~	~~SSR Improvements and Collision Avoidance Systems Panel~~
SID	Standard Instrument Departure
~~SITA~~	~~Societe International de Telecommunications Aeronautique~~
~~SMGCS~~	~~Surface Movement Guidance and Control System~~
STAR	Standard Terminal Arrival Route
SUA	Special Use Airspace
TACAN	Tactical Air Navigation System

APPENDIX B
ACRONYMS

TAWS	Terrain Awareness and Warning System
TCC	Thrust Control Computer
~~TCP~~	~~Trajectory Change Point~~
~~TDMA~~	~~Time Division Multiple Access~~
TOAC	Time of Arrival Control
TP	Top Plug
TTE	Total Time Error
~~TWIP~~	~~Terminal/Enroute Weather Information for Pilots~~
UIR	Upper Flight Information Region
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
~~VG~~	~~Vertical Gyro~~
~~VMC~~	~~Visual Meteorological Conditions~~
VMO	Maximum Operating Speed
VNAV	Vertical Navigation
VOR	VHF Omni-Range Navigation
VORTAC	Co-Located VOR and TACAN
~~WAAS~~	~~Wide Area Augmentation System~~
WBS	Weight and Balance System